EARTH AND SEA

FROM THE FRENCH OF LOUIS FIGUIER.

Translated, Edited, and Enlarged

BY

W. H. DAVENPORT ADAMS.

ILLUSTRATED WITH 250 ENGRAVINGS BY FREEMAN, GIACOMELLI, YAN D'ARGENT, PRIOR, FOULQUIER, RIOU, LAPLANTE, AND OTHERS.

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Preface.

THE present volume is founded upon M. Figuier's "LA TERRE ET LES MERS;" but so many additions have been made to the original, and its aim and scope have been so largely extended, that it may almost be called a new work. These additions and this extension were deemed necessary by the Editor in order to render it more suitable for the British public, and in order to bring it up to the present standard of geographical knowledge. It is but fair to observe, however, that the original *plan* has been in no wise altered; that the *framework* remains as M. Figuier built it up; and that the Editor's task has simply been that of the architect who enlarges and adapts a well-built mansion to the wants of a new proprietor.

The title of the present volume indicates with tolerable clearness what its subject is: a comprehensive survey of the configuration of the Earth and the Seas, viewed from the stand-point of Physical Geography. It does not concern itself with the political divisions of the world, or distinguish between different nations now commits the present volume, in the hope it will meet with a favourable reception.

> " Ego apis Matinæ
> More modoque,
> Grata carpentis thyma per laborem
> Plurimum circa nemus uvidique
> Tiburis ripas operosa parvus
> Carmina fingo."
>
> HORAT. *Carm.* iv. 2.

The portions for which the Editor is more immediately responsible are enclosed in brackets.

W. H. DAVENPORT ADAMS.

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Introduction.

WE propose to ourselves, in the following pages, a task of equal interest and importance; namely, to describe the EARTH AND SEA, the present condition of the land and the seas, and the aspects which they have now assumed. Considering it, in the first place, as an individual planet, we shall fix its position in the universe, its distance from the sun, and its other relations with that radiant orb—the source of heat, and light, and life. We shall afterwards unroll the picture of the different countries of the globe. We shall ascend the mountains to their wrinkled summits, to their peaks enshrouded in eternal snows. We shall investigate the awful and imposing phenomena of the volcano and the earthquake; we shall descend into the burning craters, to examine closely the mouths of those colossal shafts which bring the surface of the earth into communication with its interior; we shall plunge our eager glances into the incandescent waves which boil in their seething depths. We shall track the great rivers to their sources, and follow them throughout their impetuous careers. We shall penetrate into the subterranean grottos; those vast internal recesses, those immense and shadowy hollows, where hang the multiform and many-sided crystals which have never sparkled with the fires of day. We shall rapidly traverse the area of the two hemispheres, to learn how the uniform and regular action of the sun, modified by the accidents of the soil, determines the climates, and prepares the conditions necessary for the sustenance of life among organized beings. We shall finally extend our survey over the vast bosom of the waters, and investigate the different aspects of that ocean, which is one and yet manifold, and which varies so strangely from the warm circle of the equatorial seas to the frozen regions of the polar latitudes.

It has needed the accumulated efforts of many generations to collect the mass of details which we shall here examine; it has needed thirty centuries of labour and research to render possible such a description of the earth as we are about to offer to our young readers. Science is almost as old as the human race ; but its march has been singularly slow and gradual.

"Science moves but slowly, slowly, creeping on from point to point."

Man has only conquered the earth by degrees, and with measured steps. His geographical knowledge has gradually extended, just as the horizon of every individual enlarges from his early years to his "last scene of all." The child begins by familiarizing himself with the things around him, under his paternal roof. Then he descends into the garden and the street ; in time he explores the surrounding country and neighbouring towns. Arrived at manhood, he travels. His curiosity carries him beyond the seas ; he traverses remote lands, and eventually returns to his birth-place, able to exclaim with the *Ulysses* of Tennyson,—

"Much have I seen and known ; cities of men
And manners, climates, councils, governments."

Analogous has been the march of humanity in progressively acquiring a knowledge of the domain allotted to it by Providence as the sojourn of its fugitive life. The horizon of the ancient geographers, at first restricted to the narrowest circle, gradually developed in proportion as those "skirmishers" or "pioneers of science," whom we call "travellers," penetrated further into unknown régions ; in proportion as the Ptolemies and the Strabos revealed to their surprised contemporaries the extent and the splendours of lands unknown. The day that the crew of the immortal Genoese hailed, with cries of gratitude and joy, the mist-shrouded shores of the New World, that day Geography broke from its leading-strings, and flung aside its childish toys ; a new life commenced for Science, as for Humanity.

FIG. 1.—COLUMBUS.

[The grandeur of the work which Columbus did can hardly be over-estimated, nor the extent of its beneficial influence upon the destinies of the human race. By revealing the New World, he perfected the physical oneness of the globe. It was his, observes Lamartine,* to advance far beyond what had been previously accomplished, the work of God—the moral unity of the human race. Mohammedans date from the Hegira ; philosophers and humanitarians should reckon from the day that Columbus discovered the first land of the American hemisphere, October 12, 1492.]

Before presenting a summary of our physical knowledge of the present terrestrial globe, it will not be uninteresting if we cast a rapid glance at its successive developments ; that is to say, at the history of geography.

* *Alphonse de Lamartine, "Christophe Colomb."*

In the early days of the race, man was only acquainted with that limited portion of the earth which supported him and his flocks and herds. His science did not extend beyond the dense forest which surrounded him, the mountain which had invited his first wandering steps, the banks of the river and the green pastures where his hours of youth had glided by: the valley wherein he was born, and wherein his dust would sleep—that, for him, was the Earth. But as the number of families augmented—as contiguous tribes began to share among themselves the soil, and to determine the boundaries of their respective territories—the idea of *fatherland* was introduced, and, gradually, that of geographical divisions. Agricultural industry came in due time to consolidate the existence of these territorial demarcations, whose importance was increased by the creation of the first kings or simple chiefs of tribes.

Sprung from the necessity of exchange and barter, Commerce gradually grew bold, and carried its products to various unknown nations. On returning from his adventures, the navigator charmed and dazzled his friends with stirring tales of the wonders he had seen and the perils braved in his remote peregrinations. Thus arose the mixture of fable and truth, a legend or a tradition, which represents the *limbo* of Geography.

But where shall we place the cradle of that science? Of all the nations of antiquity, which was the first to conceive a precise idea of the extent of the countries bordering on its own?

According to an old writer, there existed a geographical chart laid down in the time of the Egyptian Sesostris (Rameses III. ?), and dating, therefore, some fifteen centuries before Christ. But what grounds are there for believing that the Egyptians, who were no navigators,* could have ever so far extended their geographical investigations as to draw up any other maps than those of their own country? It is, then, probable that this first chart was confined to Egypt. And within such narrow local boundaries, for some centuries, were restricted the knowledge of the ancient Asiatic peoples, and even of some of the modern. The Hindus in their world-maps only delineate Hindustan, Persia, and the island of Ceylon; and the Chinese know nothing more than their own Flowery Land.

"Genesis" is the first book of antiquity which affords any geographical indications. Moses places in the west of Asia the second cradle of the human race, when it was renewed after the Noachian deluge. The sacred writer speaks of Mount Ararat—he names some great rivers, as the Nile and the Euphrates—but he furnishes no information relative to the extent of our globe.

After Moses, Homer, the inspired poet of ancient Hellas, is the most ancient author who has transmitted to us in a summary form the geographical ideas of his contemporaries. The long description which occurs in the eighteenth book of the

* [Yet it is certain that Egyptian ships ploughed the Mediterranean as early as the reign of Thothmes III.; while at a later date, the Phœnicians obeyed the commands of Necho in circumnavigating the African peninsula.]

Iliad of the shield forged by Vulcan, is a miniature pictorial encyclopædia of those wonders of the world with which the ancient Greeks were familiar.*

The Homeric cosmography as we see it engraved on the shield of Achilles, represents the Earth as a flattened disc, surrounded everywhere, and in a circular form, by the sea, or rather by the river of Ocean ('Ωκεανός †), which defines the limits of the known world. Above this terrestrial disc is outspread the solid sky, like a dome; a dome supported by two massive pillars, which rest on the shoulders of the god Atlas. Here let me remark that a similar absurdity prevails in the cosmography of several ancient peoples. The Scandinavians balance the earth on nine posts. The Brahmins figure it as propped upon four elephants. But on what foundation do these nine posts and four elephants repose? What Anak of a god can support on his brawny shoulders the burden of the terrestrial mass?

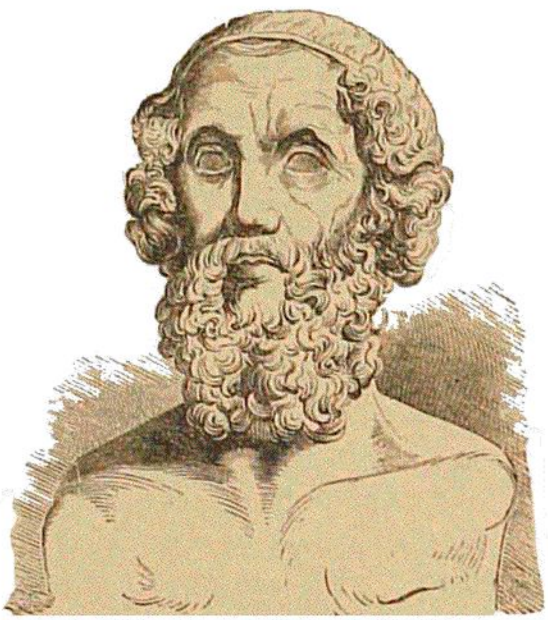

FIG. 2.—HOMER.

In his "Pluralité des Mondes," FONTENELLE‡ has given the reins to his witty fancy on the subject of these ancient cosmographical absurdities. Without pausing over his facile caricatures, let us complete our outline of the Homeric geography:—

The solid vault of the heavens is traversed by the stars in chariots of silver, impelled by the rapid clouds. When the sun bursts upon human eyes, he emerges from the ocean on the side of the east; in the evening, he re-plunges, on the west, into the same great river. During the night, borne in a golden car, he re-ascends,

* ["And first a shield he fashioned, vast and strong,
With rich adornment; circled with a rim,
Three-fold, bright-gleaming, whence a silver belt
Depended; of five folds the shield was formed;
And on its surface many a rare design
Of curious art his practised skill had wrought.
Thereon were figured earth, and sky, and sea,
The ever-circling sun, and full-orbed moon,
And all the signs that crown the vault of heaven;
Pleiads and Hyads, and Orion's might,
And Arctos, called the Wain, who wheels on high
His circling course, and on Orion waits;
Sole star that never bathes in the ocean wave."
Earl of Derby's Translation, vol. ii. pp. 109, 110].

† [There is reason to believe that 'Ωκεανός is not a Greek word, but allied to the Sanskrit roots "ogha" and "ogh."—HUMBOLDT, *Cosmos*, ii., Note 210.]

‡ [Bernard le Bovier de Fontenelle was born at Rouen, February 11, 1657, and died at Paris, 9th January 1757. His "Entretiens sur la Pluralité des Mondes" is now obsolete; but its playful wit renders it agreeable reading. It has been translated into English by Miss Gunning, under the title of "A Week's Conversation on the Plurality of Worlds."]

beneath the earth, the course of the eternal 'Ωκεανός. There—that is to say, below the earth—spreads another vault, corresponding in its curvature to that of the sky: the vault of Tartarus—the tenebrous realm of the Titans, those rebel and vanquished angels of the Pagan mythology. Sombre and silent, Tartarus is shrouded in everlasting night.

Such is the first cosmographic system, so far as we know, imagined by man. To render it more intelligible to the reader, we subjoin a map of the world, drawn in accordance with it. He will see that the river 'Ωκεανός on all sides encloses the continents. In the midst of the circle formed by the waters of this immense river,

FIG. 3.—THE EARTH ACCORDING TO HOMER.

Homer naturally places Greece, with its archipelago of sunny islands, gilded by eternal summer, and for *their* centre stands Mount Olympus, the dwelling-place of the mythologic deities,—

> "The twelve gods of Plato's vision,
> Crowned to starry wanderings."

The Mediterranean Sea and the Euxine divide the earth into two unequal portions: one to the north, the other to the south. The strait, on whose either shore rise the Pillars of Hercules, connects these seas with the western ocean, and the river *Phasis* in Colchis forms the channel of communication on the east.

But that kind of cosmographical fancy which, in all antiquity, fixed the "Pillars of Hercules" as the barrier and westernmost extremity of the world, was doomed eventually to disappear, like the winter snows which in sequestered regions linger until the very advent of the spring. The adventurous mariners who sailed from the Phœnician harbours, clearing the strait of Hercules, saw before their astonished vision an apparently boundless ocean; and along the newly-discovered route—that is, along the coast of Africa—they planted enterprising maritime colonies. Of these the most brilliant in its prosperity, and the most tragic in its fall, was Carthage. The immense commerce of the Carthaginians, their extended relations, their frequent intercourse with Phœnicia, brought the East into close contact with the West, and powerfully contributed to dissipate the obscurity which brooded over the existence or extent of countries lying far from Greece and Italy. Nevertheless, other nations were slow to participate in the geographical researches of the Phœnicians, who sedulously preserved the secret of their discoveries, clearly perceiving that they were the key to their wealth and the secret of their cosmopolitan

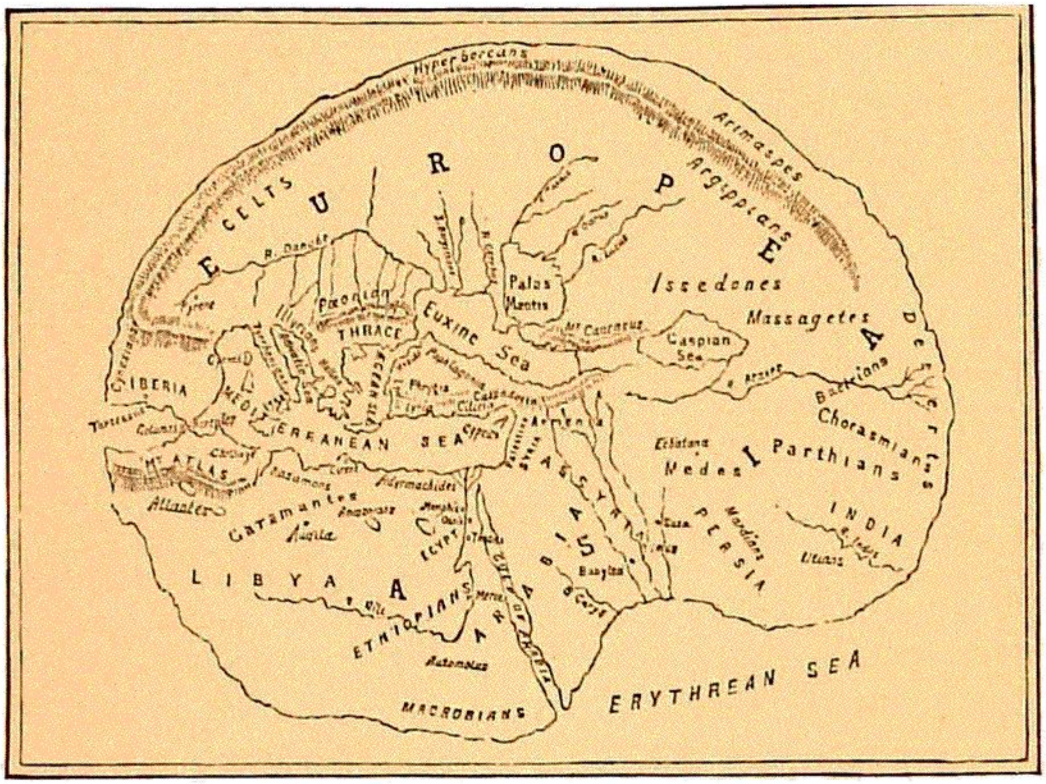

FIG. 4.—THE EARTH ACCORDING TO HERODOTUS.

commerce. HERODOTUS himself,* when he undertook those protracted voyages [about B.C. 450–430] which enabled him in his writings to speak with so much authority of strange countries, could obtain, on his visit to Phœnicia, but few particulars relative to the inhabitants of Tyre.

From the facts which he had accumulated, Herodotus was able to show the exact condition of geographical science in his own times. We set it before the reader in the accompanying map (Figure 4.) The world is divided into two parts: Europe and Asia. The positions of the "midland ocean" and the Euxine are indicated with tolerable accuracy; but we find the Red Sea extended far beyond its natural boundaries, and the north of Europe is a dream and a chimera.

Gradually, however, the information gathered by the Phœnicians ceased to be their peculiar property: the Greeks, their neighbours, became their rivals in the

* [Herodotus (Ἡρόδοτος), the father of history, was a native of the Doric colony of Halicarnassus, and born B.C. 484. He wrote his great work at Thurii, in the last years of his life, being prevented from completing it by his death in B.C. 408.]

practice and spoils of navigation. Commerce and colonies were no longer the exclusive appanage of the Phœnicians: Greece claimed her share. The brilliant campaigns of Alexander threw an unexpected light on the interior and east of Asia. Commerce linked together the Atlantic and the Indian Oceans. In the martial footsteps of the warrior followed the scarce less adventurous merchant, and in the track of the merchant trod the ardent disciple of science. Thanks to the labours of Eratosthenes, Strabo, Polybius, and Ptolemæus, who traversed every known land collecting the precious grains of knowledge, Geography began to assume the character of a positive science.

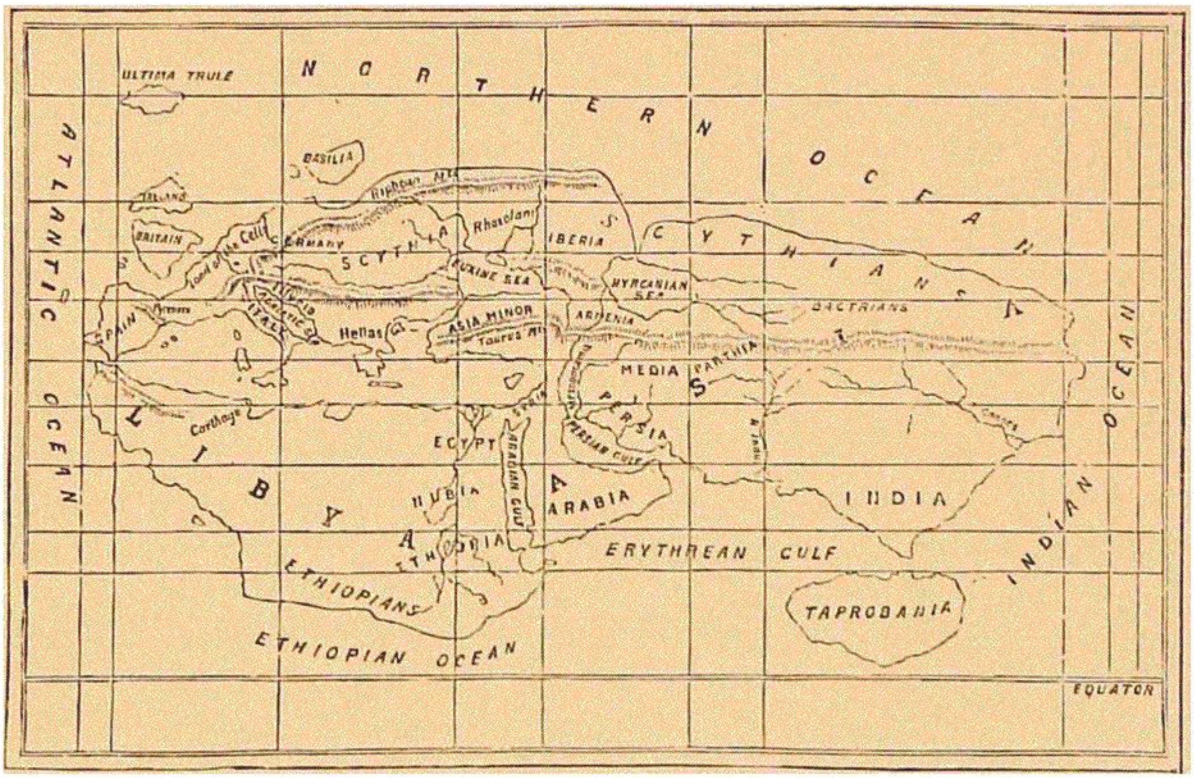

FIG. 5.—THE EARTH IN THE TIME OF ERATOSTHENES.

In the three maps here presented to the reader, we figure the state of geographical information in the days of ERATOSTHENES [B.C. 274–194], PTOLEMÆUS [died about A.D. 161], and STRABO [died about A.D. 21], respectively. ERATOSTHENES extended the boundaries of Libya, and defined a third quarter of the world, which, at a later period, received the name of Africa. STRABO and PTOLEMÆUS also divided the world into three parts: Europe, Asia, and Africa, forming a single continent.

A careful examination of these maps will render any elaborate description unnecessary, for they show in the clearest possible manner how much of the world was known at each successive epoch.

The geographical map in Strabo's time, a *resumé* (so to speak) of the geographical acquisitions of the Romans, indicates that for *them* the Earth terminated eastward with the frontier-lands of Asia. That torrent of Northern barbarism which submerged the civilization of the West and swept away the landmarks of their mighty empire, proved to the Romans that the world was larger than they had supposed. They gave place to the new-comers, freshly launched from the unknown steppes

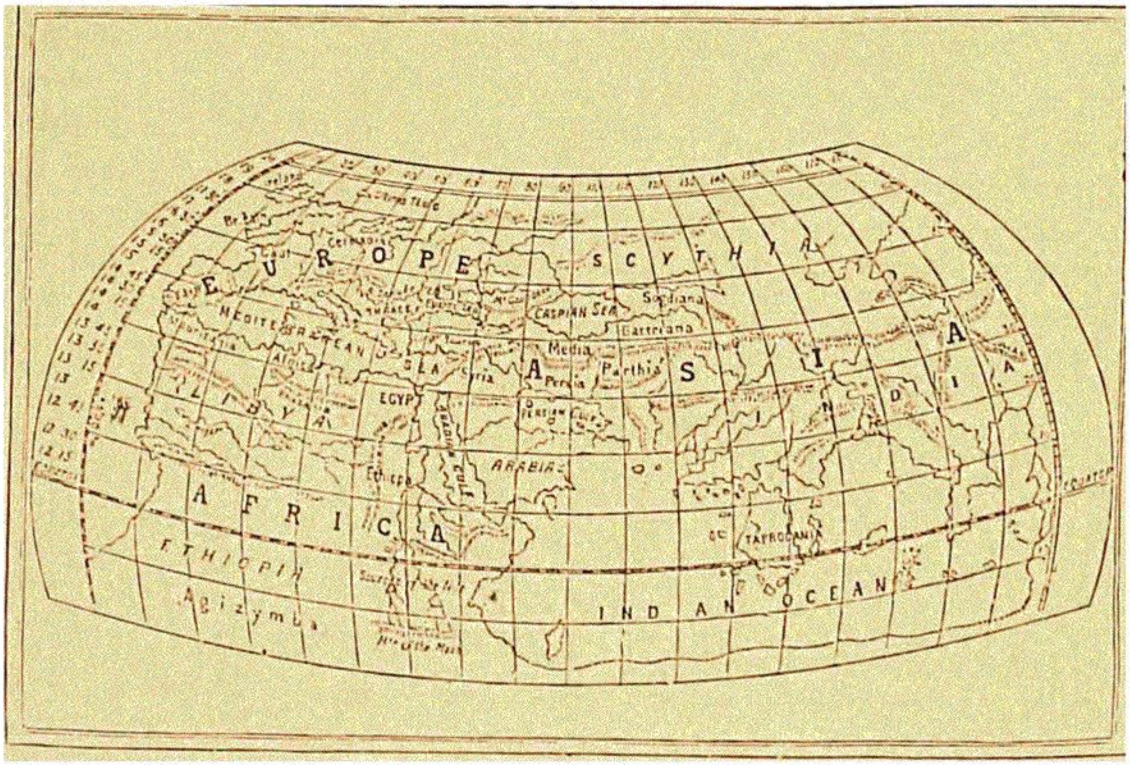

Fig. 6.—The Earth in the time of Ptolemæus.

of extreme Asia; from those hyperborean regions whose existence, on the testimony of Strabo, they had been reluctant to admit.

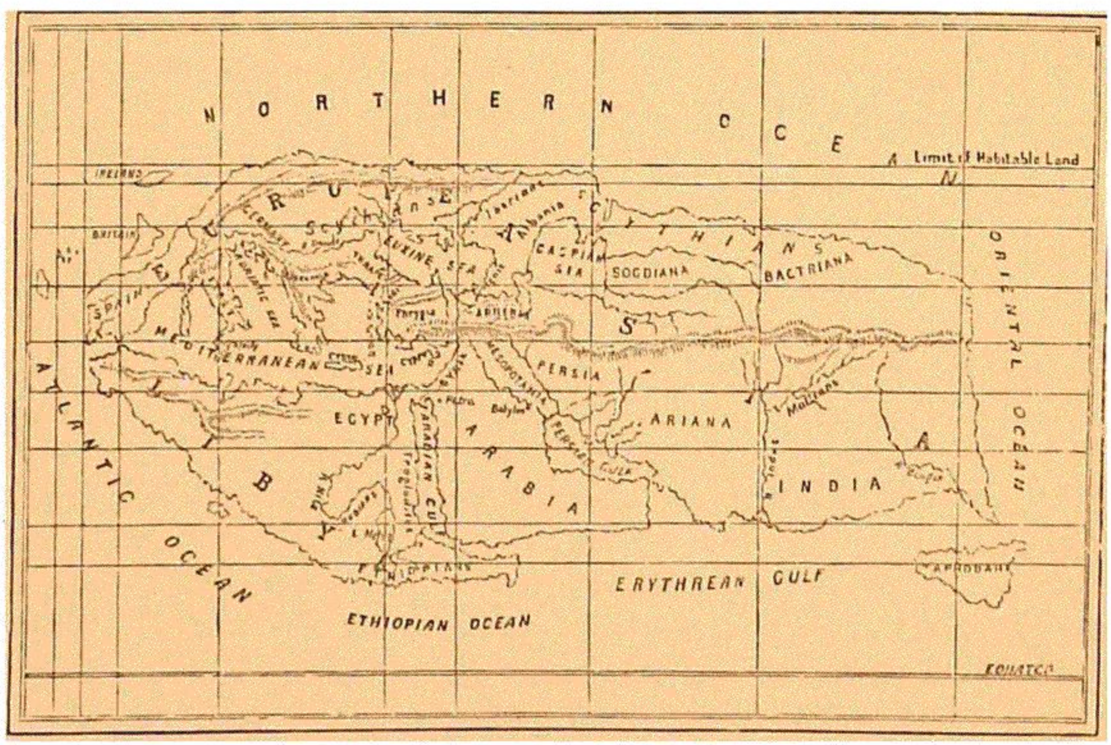

Fig. 7.—The Earth in the time of Strabo.

Nearly one-half of the Earth was then known with some degree of fulness. Men even began to suspect its real form; for the astronomer and the mathematician—

the one by the globular aspect of the stars, the other by numerical deductions—were led to conceive the idea of a terrestrial globe, and the possibility of circumnavigating the entire Earth. At length, directed by the magnetic needle, the grand and prolific achievement of the twelfth century, the Portuguese navigators trusted themselves intrepidly to the open seas, and theirs was the glory of discovering that "Cape of Storms" which was afterwards more fitly designated the "Cape of Good Hope." * In 1492 Christopher Columbus revealed to man the New World; a revelation which soon doubled the extent of the known Earth, and added to our charts two immense continents—immense in area, immense in resources, immense in the prospects and capabilities of their future—which hitherto had remained as inaccessible as the Solar World or the Milky Way.

Since that epoch human genius has been free to spread itself over the whole extent of our planet; and the combined efforts of innumerable voyagers will speedily leave no corner of its inhabitable regions unexplored. According to the calculations made by those geometers who have defined the exact form of the Earth, the direct measurement of a part of two meridians taken at the equator and at the poles demonstrates, beyond all doubt, that it is really a flattened (or oblate) spheroid. Finally, during the last century, the contour of the mountains, the depth of the seas, the geological and mineralogical character of the successive formations, and the circumstances which have determined the great "accidents"—the lights and shades, as it were—of the terrestrial crust, the true configuration of the ocean-bed, have been scrutinized with the most rigorous exactness. All this is, at present, actually familiar to us in its general features; it only remains for our generation to fill in the details of the picture. The external edifice of the glorious palace of science is raised; we have but to perfect its internal arrangement and decoration.

What, in our days, chiefly contributes to geographical progress is the fact that the immense distances, which formerly prevented any extensive exploration of the globe, have, as it were, disappeared. Space is no longer an insurmountable barrier. We have almost realized the boast of Shakspeare's "Puck," and put "a girdle round about the earth in forty minutes." Owing to the facility and rapidity of our modern communications, the steam-car and the steam-ship, Earth has been examined even into its furthest recesses, and man has become a cosmopolitan being. Through the mutual and reciprocal contact and intercourse of peoples, nationalities vanish; † the human race, like the individual, tends more and more to make itself free of the entire world; to throw off the narrow sympathies of particular countries, to assume an uniform type of character and thought. Let us take an example. In the era of the Roman people, the Alps formed an unconquerable barrier, which separated the

* [The Cape of Good Hope was doubled, in 1487, by Bartolommeo Diaz. In 1497, Dom Vasco du Gama sailed round the Cape, crossed the Indian Ocean, and arrived at Calicut, in India, May 20, 1498.—COOLEY, *History of Maritime Discovery*.]

† [In the face of recent events (1868), and the rapid spread of the "doctrine of nationalities," our readers will hardly accede to M. Figuier's proposition.]

empire of the Cæsars from the wild forest-lands and barren plains of the barbarians. But to-day, tourists from all parts of the world wander in security over the romantic and savage scenes which, for so many generations, were the undisputed domain of the chamois and the eagle. The iron road has surmounted or penetrated the granitic flanks of the mighty mountains, and through the very heart of a snow-crowned Alp the Mont Cenis Tunnel carries the punctual train. The rampart which so long defied the rage of the warrior, which a Hannibal and a Napoleon made it their greatest glory to have traversed, has been levelled by the genius of Steam. Soon, too, shall the Ural chain throw open its gates to the unresting march of civilization, and the steppes of the nomadic Kirghiz become familiar as the European highways. The seas, which so long opposed a formidable obstacle to international communications, are now the most facile intermediary of their relations. The Cape of Good Hope, which it cost the maritime power of Portugal in the sixteenth century a hundred years to attain, is now for ship and steamer a mere station of relief; a frigate accomplishes the entire distance, some 4000 leagues, in two months. At the close of the last century, the China voyage occupied ten months; now, a steam-vessel achieves in four a traject which represents one-half of the voyage round the world; and this period will be diminished by a moiety when the Suez Canal shall be opened up to navigation. The channels or ocean-arms which separate any two countries are nothing more than the ports of both. London touches Paris, Marseilles lies contiguous to Algiers, Stockholm shakes hands with St. Petersburg. The great American rivers—the Mississippi, the St. Lawrence, the Ohio, and even the Amazons—are covered with steam-ships, which display on their busy waters the mingled flags of every civilized nation of the two hemispheres; all these vessels blend and unite, as the interests of men, everywhere correlative and consolidated, are to-day united. It is impossible to anticipate the transformations and prodigies which human society will see realized, in a more or less neighbouring future, when Science, in possession of even more potent instruments than it now disposes of, shall have opened broad and convenient routes across the mountain-chains of the Cordilleras and the Himalayas, the Caucasus and the Ural, across the isthmuses of Suez and Panama; or, aerial navigation, reduced into practice, and regularly established, shall have fulfilled the poet's ardent aspiration: "Wings! O give us wings!"

BOOK I.

ON THE SITUATION OF THE TERRESTRIAL GLOBE IN SPACE.

Nature's great works no distance can obscure,
No smallness her near objects can secure:
Ye 'ave taught the curious sight to press
Into the privatest recess
Of her imperceptible littleness.
Ye 'ave learned to read her smallest hand,
And well begun her deepest sense to understand.

ABRAHAM COWLEY, *To the Royal Society.*

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BOOK I.

ON THE SITUATION OF THE TERRESTRIAL GLOBE IN SPACE.

CHAPTER I.

SITUATION OF THE EARTH IN THE UNIVERSE AND IN THE SOLAR WORLD—RELATIONS OF THE EARTH TO THE OTHER PLANETS AND TO THE SUN—SURVEY AND ANALYSIS OF THE PRINCIPAL THEORIES PUT FORWARD IN EXPLANATION OF THE MOVEMENTS OF THE CELESTIAL BODIES—THEORY OF PTOLEMÆUS; EGYPTIAN THEORY—COPERNICUS, KEPLER, AND SIR ISAAC NEWTON DISCOVER THE TRUE MECHANISM OF THE SOLAR SYSTEM—GENERAL OBSERVATIONS AND REFLECTIONS.

THE Earth is a grain of *seed* which the Divine Sower has flung forth on the field of space, to germinate, as it were, in the solar light, to flourish, and to fructify.

Human pride has long exaggerated the importance of the part which our Earth plays in the grand economy of the universe; and has persisted in representing it as the centre of the world. For man both sun and moon, the planets and the stars, were but secondary bodies, constrained by a divine law to pass in eternal procession before the throne of the immovable Earth, as if their only mission were to charm the eyes of its inhabitants, to exercise a vigilant watch and ward over their fortunes, to inspire their songs and pæans, to illuminate their days, and brighten their nights with inextinguishable splendour. Nothing was ever more false than this wild romance of human vanity. Earth, in the great whole of the solar world, occupies but an inferior place; it is only one, and not the most glorious, of the numerous planets which gravitate round the central orb. Wondrous as are its beauties of vale and hill, of wood and lea, of lake and stream, of emerald pastures and flashing waters, it is conceivable that far more brilliant are the scenes of either or all of those remote suns which the magic glass barely brings within the reach of scientific curiosity, and which, nevertheless, hang but on the dim frontiers of the Infinite.

Since the Earth is a planet (πλανητες, "a wanderer"), it becomes necessary that we should accurately ascertain what ideas are usually conveyed by that designation.

The Planets, then, are stars which incessantly revolve around the sun, the central orb of our limited system. The Sun retains the planets in somewhat similar fashion as the groom holds at the end of his curbing rein the horse swift wheeling round his circular manége. This image—a vulgar one, undoubtedly—does, nevertheless, convey an accurate idea of the kind of action which the Sun exercises on the Earth ; the latter completing its revolution round the former in the space of one year [365 days, 6 hours, 9 min., $10\frac{75}{100}$ sec.] Only, while the rein of the groom is a material and visible bond, that of the Sun is invisible, mysterious, not appreciable in its nature, and not recognizable except by its effects, like the influence which an electricised body possesses over light insubstantial objects. Its attractive power suffices to compel the terrestrial globe to describe around it a constant and regular orbit.

We must distinguish the Planets from the Stars. While on the celestial vault the latter blend together,—for their dimensions and their splendours seem alike,—an abyss, as it were, intervenes between their function and that of the planets. A star is nothing less than a sun, which shines, like our own Sun, with a light peculiar to itself, and owes its resplendence to the fires which it evolves from its body. Thus, the fixed stars are the luminous centres of systems resembling our solar world, while the planets are only secondary stars revolving around our Sun.

The Earth, then, as we have said, is but one of the planets which the immutable laws of nature constrain to gyrate incessantly in their prescribed course. Like its sister spheres, it obeys a twofold movement: a *movement of rotation* upon its own axis, which it accomplishes in a period of 24 hours [23 hours, 56 min., 4 sec.], and a *movement of translation* round the Sun, which it performs in the space of 365¼ days nearly.

The Earth's *movement of rotation* upon its axis produces the regular alternation of day and night. During a part of the twenty-four hours that this rotation endures, the luminous disc of the Sun is hidden from the inhabitants of one-half the Earth, which is then involved in a more or less complete darkness. In our next chapter we shall explain why the night increases and decreases at different epochs of the year.

The Earth's *movement of translation* round the Sun is accomplished, as we have stated, in the course of twelve months. The ideal track of this movement of translation in space is called the *terrestrial orbit*, or *ecliptic*;* which is not an exact circle, with the Sun for its centre, but a nearly circular ellipse, one of whose foci is occupied by the Sun. In geometry, we call a slightly elongated circle an *ellipse*, or *oval*; let a cylinder be cut obliquely, and the contour of the section will represent the figure we mean.

The ellipse not being, like a circle, symmetrically disposed around a centre, it results that the Earth is not always at the same distance from the Sun. On the 2nd of July, it attains its extreme distance from the Sun [or its *aphelion*]; on the 1st of January, it comes nearest to it [or reaches its *perihelion*]. The mean distance between the two bodies is attained on the 1st of April and the 2nd of October. In midwinter, the Earth is nearer the Sun by 5500 million yards (nearly 3,100,000 miles) than in midsummer. This circumstance appears paradoxical; but we must not forget that at the epoch of our European summer the inhabitants of the opposite hemisphere are suffering the rigour of winter. Moreover, the annual

* [Ecliptic, from Eclipse (Gk., ἐκλειπτικος), because all eclipses of the Sun and Moon take place when the Moon crosses the line of the terrestrial orbit.]

variations of our distance from the Sun have no influence upon the course of the seasons, for they are compensated by the simultaneous variations arising from the angular rapidity of the Earth. The spring and summer of the northern hemisphere, taken together, being seven days and a half longer than the spring and summer of the southern hemisphere, this inequality re-establishes the equilibrium between the total quantities of heat which the Earth receives from the Sun during these two intervals of time, since the longer interval corresponds to the greater distance of the Sun and the less intensity of the heat.

What is the mean distance—in other terms, what is the extent of space—which separates the Earth from the Sun? According to the old value of the Sun's parallax, it was estimated at 95,298,260 miles; but recent observations have proved that these figures are excessive. What is called the "new value," as obtained by Foucault and others, places the void between us and our life-giving luminary at 91,678,000 miles.

It is impossible to form an idea of such immense distances without suggesting to the mind some standard of comparison. To conceive the distance of the Earth from its great luminary, we must ask ourselves in what time it would be traversed under certain prescribed conditions.

A man walking on foot at the rate of $4\frac{3}{4}$ miles an hour, and never resting day or night, would require 2000 years to reach the Sun. If he had started on his mysterious journey when Scipio was razing Carthage to the ground, he would, by this time, have just completed it. A locomotive at full speed, travelling at the rate of 38 miles an hour, would occupy three centuries in reaching its magnificent goal. A cannon ball, if it could preserve its initial velocity of 1500 feet per second, would require ten years. Sound would be fifteen years traversing the gulfs of space, if air existed in the void, and that air were of the same density as our terrestrial atmosphere. Finally, the most rapid of agents, light, which is commonly considered endowed with an almost instantaneous rapidity of transport, so that we say "swift as light" to describe the passage of a thought, would need eight minutes to penetrate from the Sun to the Earth.

The Earth, meanwhile, revolves in its orbit with astonishing speed. It yearly describes an elliptical path of upwards of 596 millions of miles; that is, 33,290 yards, or 19 miles in a second. Its swiftness is sixty times that of a cannon ball.

We must add, to complete our remarks on this subject, that in addition to these two movements of *translation* and *rotation*, the Earth participates in that common motion which carries the entire solar system through space. The Sun, with all its glorious retinue of planets, describes in the heavens, around some unknown centre which lurks far away in the depths of the Infinite, a curve with

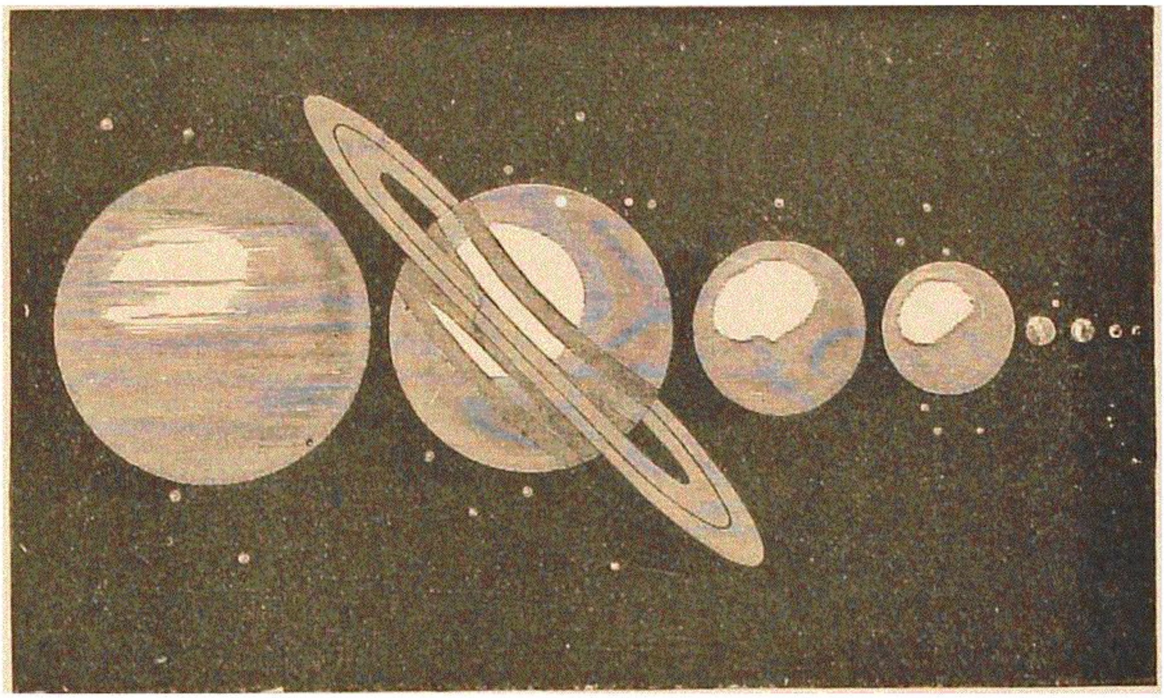

FIG. 8.—RELATIVE DIMENSIONS OF THE PLANETS.

so extensive a radius that it seems to our eyes rectilineal. In company with the other planets composing the solar system, Earth obeys this aggregate movement, whose rate of speed is about 10,936 yards a second.

If we now compare our globe with the other planets of its system, it will readily be seen that, so far as regards its distance from the Sun, and consequently its temperature, and, finally, as regards its mass, the Earth represents a kind of *juste milieu*, or medium, between the extreme terms of the solar world. It is neither the nearest to, nor the most distant from the Sun; it neither burns under the scorching temperature of Venus, nor freezes under the icy cold of Saturn or Uranus.

Figure 9 exactly represents the distance of the various planets from the Sun. If we designate by 10 the mean distance of the Earth from the Sun, the mean distances of all the planets from the latter will prove approximatively the following series :—

Symbol.		Mean Distance.	Or taking the Earth as Unity = 1.
☿	Mercury...	4	0.387098
♀	Venus	7	0.723331
⊖	Earth	10	1.000000
♂	Mars	15	1.523691
♈	Asteroids	21 to 35	———
♃	Jupiter	52	5.202767
♄	Saturn	95	9.538850
♅	Uranus	192	19.182390
♆	Neptune...	300	30.036270
	Vulcan	—	———

The more distant the planets from the Sun, the longer, of course,

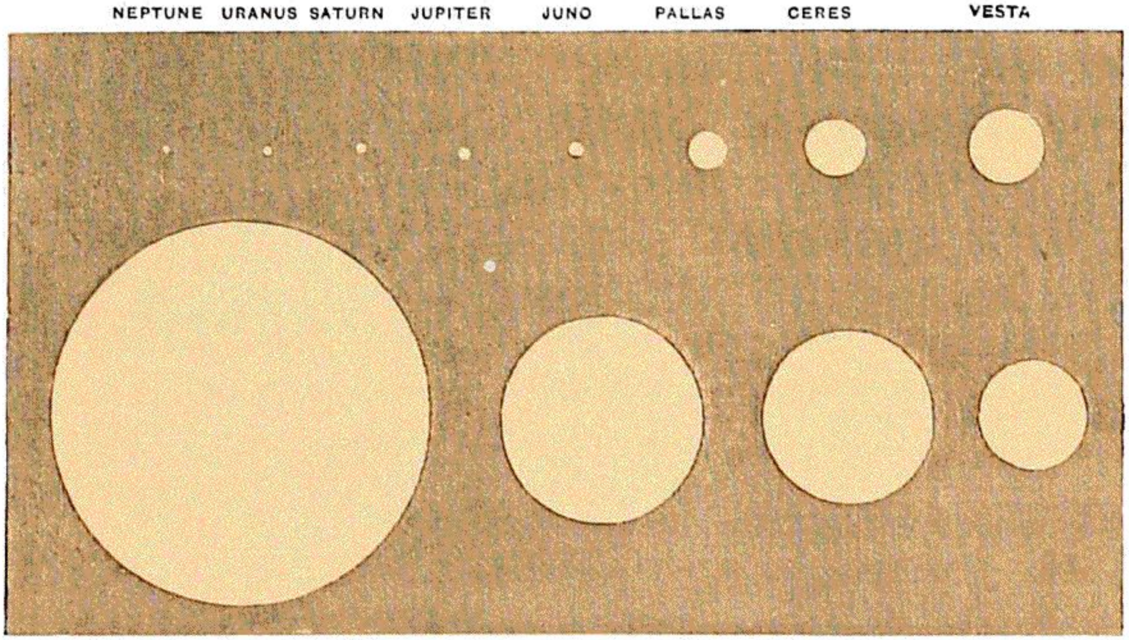

FIG. 9.—APPARENT MAGNITUDES OF THE SUN AS SEEN FROM THE VARIOUS PLANETS.

will be the period of their revolution round that central star. Thus, Mercury accomplishes his orbit in 87.9692824 days; Venus in 224.7007754 days; Mars in 686.9794561 days; the Asteroids in from 3 to 6 years; Jupiter in 4332.5848032 days; Saturn in 10759.2197106 days; Uranus in 30686.8205556 days; finally, Neptune, the planet discovered by Adams and Leverrier in 1846, employs 60126.722 days in completing its sidereal revolution.

The Earth weighs nearly as much as the planet Venus. Compared with that of the Sun = 1, it is represented by $\frac{1}{354936}$. [Young students are often astonished at the idea of weighing the Earth; yet the process is simple, and without it we could never ascertain the density of our globe. The best known method is called Cavendish's Experiment, because first made by Henry Cavendish, on the suggestion of Michel. It has also been confirmed by Reich of Freyberg, and by Mr. Francis Baily of London. In Baily's apparatus two small balls at the extremities of a fine rod are suspended from the roof or ceiling by a wire, and their position carefully observed by the aid of a telescope. Large balls of lead placed on a revolving frame are then brought near them in such wise that they can affect them only by the force of their attraction. On the large balls being so arranged, the small ones move towards them through a limited space, which is accurately measured. The position of the large balls is next reversed, and the change of position of the small balls again noted. These observations are repeated until the exact amount of deviation of the small balls has been indisputably established. Then, by calculation, the amount of attraction of the large balls to produce this deviation is readily attained; and the next question, What would be their attraction if they were as large as the Earth? is no less easily answered. Hence, the attractive force of the Earth being known, we can at once compare its mean density with that of lead. The result of Mr. Baily's experiments was to give the Earth's mean density as 5.67 times that of water.*]

The mass, or weight, of Mercury is 6 times less than that of the Earth [1 = 0.073]. Mars is 8 times lighter [0.132]; Uranus 14 times [14.251]; and Neptune 18 times [18.900] heavier than our planet. The weight of Saturn is equal to that of 101 terrestrial globes [101.364]; it would take 338 [338.718] to produce a planet equal to Jupiter. On the other hand, the Asteroids are 800,000 times lighter than Earth. These small masses of body, frequently not exceeding a few leagues in diameter, are perhaps the wrecks of shattered planets, whirled along in the common vortex of the solar world.

* [The Earth's mass equals 6,669,000,000,000,000,000,000 tons. Its density, as compared with water = 1, is 5.6747. Its volume, 259,800,000,000 entire miles.]

In Figure 8, we represent the relative size of the planets, from the massive Jupiter to the modest Mercury. We have shown the Earth, attended by her satellite, the Moon; the other planets are likewise escorted by their appropriate trains.

The mountains form, on the surface of our globe, eminences of very moderate elevation. If we picture to ourselves the Earth as an orange, the small rugosities, or wrinkles, on its rind, may represent, to a certain degree, the comparative height of the loftiest terrestrial mountains.* In truth, the most considerable elevation of our snow-girdled peaks does not exceed 29,000 feet. But the mountains of Venus, whose mass nearly equals that of the Earth, probably attain 350,000 feet. The average height of the lunar mountains is from 18,000 to 20,000 feet; the mass, however, of the Moon is far inferior to that of the Earth.

All these comparisons prove that a greater harmony prevails in the plasticity, in the superficial variations of the Earth, than in those of the other celestial bodies with which we are acquainted. They confirm also the remark we have made above, as to the part played by our Earth in the midst of the solar system, that it represents a sort of middle state, equally distant from all the extremes: equally distant, so far as regards its dimensions, from the very great and the very small; as regards its movement, from swiftness and from slowness; as regards its temperature, from excessive heat and surpassing cold. This harmony, this admirable equilibrium of all the conditions destined to favour the existence and development of life, is peculiarly characteristic of our globe, which seems to have been pre-ordained by the Creator as the birth-place and home of the human race. Man could have found upon no other planet the means of satisfying, with so much facility, the varied necessities of his manifold nature, and of preparing himself for that eternity which will succeed to his terrestrial career.

Like all the great planets, the Earth is escorted by a *satellite.* This name we bestow upon certain celestial bodies, which are attached to the great stars as their invariable companions, and constantly follow them in their eternal course. Saturn and Uranus have each eight satellites; Jupiter has four; the Earth, a planet of medium importance, only one—the Moon.

This bright and beautiful star, which has awakened the purest minstrelsy of the poets from the days of Homer to those of Keats, is situate in space at a distance of 238,793 miles from the centre of the Earth, which represents a distance 400 times less than the distance of the Earth from the Sun, and could be traversed by an express train in 300 days. The Moon, 50 times smaller than our planet,

* [Kunchinjinga and Guarisankar, two of the Himalayan colossi, are only elevated above the surface of the earth the $\frac{1}{2000}$th part of its diameter; Mont Blanc about half as much.—GUILLEMIN, *The Heavens*. p. 99.]

accomplishes in 28 days [27 days, 7 hours, 43 min., 11½ sec.] its revolution around it.

Such is the general system of the solar world. Such are the mutual relations of the stars which beam upon us with holy ray from their watch-towers in the silent skies of night. This system, admirably simple, satisfies the mind; it explains, even in their smallest details, all the phenomena which human investigation has discovered.

Our young readers, nevertheless, would deceive themselves greatly if they imagined that this noble conception had been received by the minds of men without opposition. At the outset, the self-sufficient pride of our species, led astray by a false philosophy, shrunk from the idea of placing the Earth in a secondary rank. Man could not bring himself to believe that everything here below was not subordinated to his little globe; or that the worlds which surround him had quite another mission to discharge than that of charming the eyes of men with the spectacle of a radiant, starlit firmament. Afterwards, an erroneous interpretation of the Bible (one is ashamed to confess it) so successfully arrested Truth in her moral progress, that the system of the world which we are about to explain has only been generally accepted within the last two centuries.

Although the theory of converting our globe into a simple satellite of the sun was always displeasing to the ancients, it is nevertheless worthy of remark, that several Greek philosophers enunciated it. The sublime PYTHAGORAS,* for example, who may almost be regarded as the father of European science, placed the Sun, or Fire, in the centre of the world. Another philosopher, the Pythagorean ARISTARCHUS,† of Samos, expresses himself as follows, in a fragment of his writings which has descended to posterity: "The Earth turns round on its

* [Pythagoras was the son of a merchant named Mnesarchus, and born at Samos. He was a contemporary of Polycrates and Tarquinius Superbus (B.C. 540–510).—See GROTE, *History of Greece*, vol. iv.]

† [Aristarchus, of Samos, flourished about B.C. 280–264. None of his works remain, except a treatise on the Magnitudes and Distances of the Sun and Moon (*περὶ μεγεθῶν καὶ ἀπούτημάτων ἡλίου καὶ σελήνης*), of which there is a Latin translation in Willis's Works, vol. iii., Oxford, 1688.]

axis, and at the same time describes an oblique circle round the Sun. This star is only to the distance of the stars properly so called as the centre to the circumference, which is the cause that the movements of the Earth is not revealed to us by the fixed stars."*

Aristarchus wrote these profound remarks three centuries before Jesus Christ, more than eighteen hundred years prior to the mathematical demonstration of his grand conception. The views of a philosopher so far in advance of his age, could only excite the satirical criticism of his contemporaries. If they gave a moment's serious consideration to the ideas of this ancient Copernicus, it was to accuse him of impious audacity. Such was the office with which a certain Cleanthes charged himself, who publicly hurled at Aristarchus the bitterest reproaches, for "having troubled the repose of Vesta and the Lares."—Vesta signified the Earth. It was in these mythological metaphors that the wise men of antiquity clothed their opinions.

The speculations of a few ancient philosophers were a truly feeble barrier to that haughty sentiment of man which induced him to believe himself the centre and the object of everything in the visible world. It may justly be said that up to the seventeenth century no variation was admitted in the doctrine which gave to the Earth a majestic superiority; which made it the nucleus, the soul, the animating principle of the universe. The fixed stars, the wandering planets, the Moon, the Sun itself, were only accessories, apparitions, which never travelled beyond the limits of the atmosphere. A similar idea everywhere prevails in the history of the early races; we discern it even in the names by which they designated their respective countries. The Hindus inhabit the *midhiama*, the Scandinavians the *midgard;* two names which signify the "mid-earth"—that is, the middle or centre of the countries known to these peoples: just as the Chinese denominate their fertile territory the "Central Empire."

The geographers and astronomers of antiquity reduced this prin-

* [This does not occur in Aristarchus, περὶ μεγεθῶν, and the probability is, that he put forward the statement as a *hypothesis* for certain purposes, rather than as a positive system of the universe.]

ciple into a doctrine, and elaborated each their system, differing only from one another in minor details, and all agreeing to place the Earth in the centre of the world which their imagination created.

Of all these systems, the most famous, and the one which enjoyed the longest term of favour, is that of PTOLEMÆUS, a philosopher of the Alexandrian School, who accomplished his life-work about the years 139–161 of the Christian Era, and who profited largely by the observations of HIPPARCHUS, a great Greek astronomer flourishing 300 years before him.*

Ptolemæus represents the celestial vault as a solid and material whole. What he entitles the *primum mobile* consists of a sphere of crystal animated by a continuous and uniform movement. In this movement, the sphere of crystal involves not only the stars, sparkling points set in its concavity, but, moreover, a certain number of inferior spheres which, in their course, include and conduct the planets, the Sun and the Moon. The star-gemmed sphere revolves around the Earth in 24 hours. The Sun and Moon travel in movable orbits, which they traverse, the one in 365, the other in 28 days. More complex, indeed, are the planetary movements: these stars do not simply describe circles in their sphere; each also circles round an imaginary centre which, in its turn, is constrained to accomplish a circular orbit—a movement whose track is a curve—forming a series of *knots* or *epicycles*, which correspond in some degree to the apparent motions of the planets. Jupiter has 12, Saturn 19 epicycles; and so on.†

* [The truth is, we owe almost all our knowledge of Hipparchus, justly styled "the first and greatest of Greek astronomers," to the statements concerning him in the writings of Ptolemæus. He appears to have been a Bithynian, who flourished about B.C. 160–145, and devoted himself with intense enthusiasm to astronomical pursuits. It was he who drew up the first catalogue of stars, assigning to those he numbered their places and magnitude. For an account of his labours in the cause of science, see Delambre, "Histoire de l'Astronomie Ancienne;" and Sir G. Cornewall Lewis, "On the Astronomy of the Ancients."]

† [On this theory of Epicycles a vast amount of unnecessary ridicule has been lavished. "The common notion," says Professor de Morgan, "is, that it was a cumbrous and useless apparatus, thrown away by the moderns, and originating in the Ptolemaic, or rather Plutonic, notion, that all celestial motions must either be circular and uniform motions, or compounded of them. But, on the contrary, it was an elegant and most efficient mathematical instrument, which enabled Hipparchus and Ptolemy to represent and predict much better than their predecessors had done; and it was probably at least as good a theory as their instruments and capabilities of observation required or deserved. And many readers will be surprised to hear that to this day the modern astronomer resolves the same notions into epicyclic ones. When the latter expresses a result by series of sines and cosines (especially when the angle is a mean motion or a multiple of it), he uses epicycles; and for one which Ptolemy scribbled on the heavens, to use Milton's phrase, he scribbles on twenty. The difference is, that the ancient believed in the necessity of these instruments, the modern only in their convenience; the former, used those which do not sufficiently represent actual phenomena, the latter knows how to choose better; the former taking the instruments to be the actual contrivances of nature, was obliged to make one set explain everything; the latter will adapt one set to latitude, another to longitude, another to distance. Difference enough, no doubt; but not that sort of difference which the common notion supposes."—PROFESSOR DE MORGAN, article "Ptolemæus," in Dr. Smith's "Dictionary of Greek and Roman Biography and Mythology," vol. iii. p. 576.]

Figure 10 explains the cosmographic system of the same astronomer. In the centre we see the Earth, externally surrounded by fire [which is precisely opposite to the truth, according to the fundamental principles of modern geology; but the reader will understand that we are not attempting here to expose the errors of Ptolemæus; we confine ourselves to a description of his system]. Above the Earth spreads the first crystalline heaven, which carries and conveys the Moon. In the second and third crystal heavens the planets Mercury and Venus respectively describe their epicycles. The fourth heaven belongs to the Sun; wherein it traverses the circle known as the ecliptic. The three last celestial spheres include Mars, Jupiter, and Saturn. Beyond these planets shines the heaven of the fixed stars. It rotates upon itself from east to west, with an inconceivable rapidity and an incalculable force of impulsion, for it is *this* which sets in motion all the fabulous machine.

Ptolemæus places on the extreme confines of his vast Whole the eternal abode of the blessed. Thrice happy they in having no further cause to concern themselves about so terrible a system; a system far from transparent, notwithstanding all its crystal!

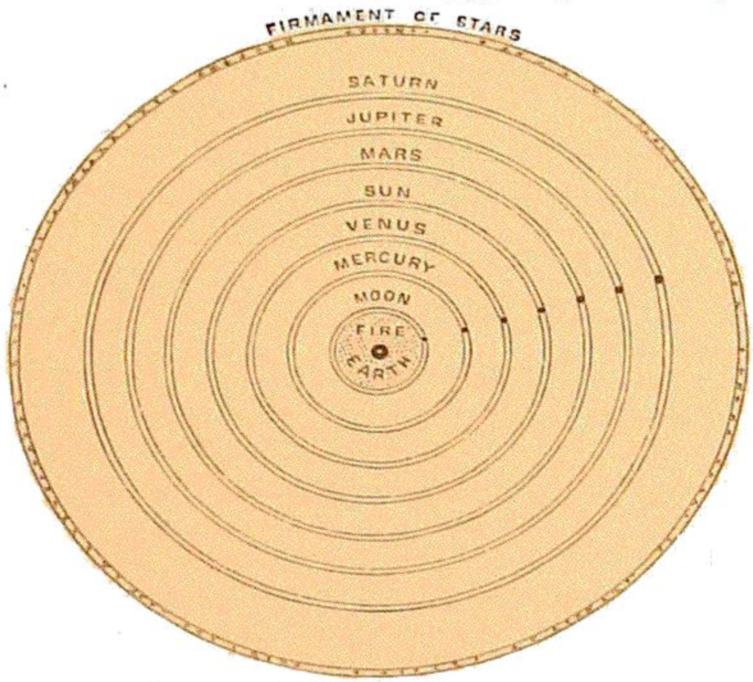

FIG. 10.—COSMOGRAPHY OF PTOLEMÆUS.

The treatise in which the Greek astronomer summed up his labours remained for generations in high favour with the learned, and especially with the Arabs, whose privilege and renown it is to have preserved intact the precious deposit of the sciences, when the Europe of the twelfth and thirteenth centuries was plunged in the night-shadows of the profoundest ignorance. The Arabs designated the work of Ptolemæus, *Almagest*—that is, the Great Book, the Book *par excellence*. [The Greek title runs, Μεγάλη Σύνταξις τῆς 'Αστρονομίας, and the Arabs probably named it Μεγίστη, the "Greatest," to distinguish it from another work by Ptolemæus of inferior value. From Megiste, by prefixing the Arabic article *al*, "the," would come *Almagest*. It is divided into thirteen books. An admirable edition was issued at Paris, by Halma, in 1816–20. The great geographical treatise of Ptolemæus is entitled Γεωγραφικη 'Υφηγησις (Geōgraphikē Hyphēgēsis). It is in eight books.]

Mohammed, the founder of Islam, endorsed the system of Ptolemæus as a dogma which God himself had sanctioned. It is, therefore, still accredited and venerated throughout the East.

We have, nevertheless, to note one discordance in the universal favour which crowned the cosmography of the Greek. The unbeliever was a king of Castile, whose surname of "The Wise" has been ratified by posterity—Alphonso X., the Wise, or the Astronomer, who lived in the thirteenth century. The complexities of the Ptolemean system disquieted our sagacious prince, and under the influence of this feeling he permitted himself, one day, to exclaim, "If God had called me to his councils when he created the world, I could have given him some good advice to construct it in a simpler fashion." This sally, meant not irreverently, but as a satire on the scientific maze of the Alexandrian astronomer, cost the sagacious monarch dear—he lost his crown, in no small degree through his imprudent speech.

The theory put forward by Ptolemæus did not deal with an evident difficulty; why Mercury and Venus always preserved their proximity to the Sun. The desire of explaining this particular fact led to a certain modification of the original doctrine, and a movement of revolution round the Sun was attributed to these planets. Thus, to two minor spheres was granted what was denied to the Earth. The system which thus represents the beginning of a concession to the new spirit is known as the Egyptian cosmography. It is shown in Figure 11.

But not one of these magnificent schemes, as the reader perceives, found any place for the comets. Their authors would have been grievously embarrassed with such erratic stars flashing among their spheres of crystal. The comets—the Bohemians, as Lord Wrottesley called them, of the solar system — would assuredly have dashed open not a few windows in each fragile edifice!

FIG. 11.—COPERNICUS.

To a German monk who lived in the sixteenth century, to NICHOLAS COPERNICUS, was reserved the unfading glory of overthrowing all this glittering but insubstantial structure of dreams, guesses, and errors; to cut, like Alexander, with the bright sword of his genius, the Gordian knot of the Ptolemean epicycles, and to lay the foundation of a system which has become the breviary of astronomers.

Born in 1473, at Thorn in Prussia, Copernicus did not publish until 1543,*—that is to say, in his old age,—the great work which was destined to uproot the secular theory of the schools, and to substitute in its place that which forms the basis of modern astronomy. It was entitled "De orbium cœlestium Revolutionibus;" and it was dedicated to Pope Paul III. The first copy was placed in the author's hands as he lay upon his deathbed, only a few hours before he expired [24th May 1543].

Copernicus placed the Sun, immovable, in the centre of the world, and made the planets, with Earth among them, circle round this central orb. He gave to the Earth a movement of rotation on its axis, which it accomplished in twenty-four hours. The diurnal and nocturnal movement of rotation of the stars which glittered in the celestial vault was thenceforth explicable with marvellous facility. And thus the German astronomer stripped our planet of the brilliant spheral train which had been accorded to it from the first faint dawn of science; he reduced it to one solitary satellite (and yet that, in itself, how beautiful!), the Moon, which illumines the night by the reflected rays of the Sun, sunk beneath the other hemisphere.

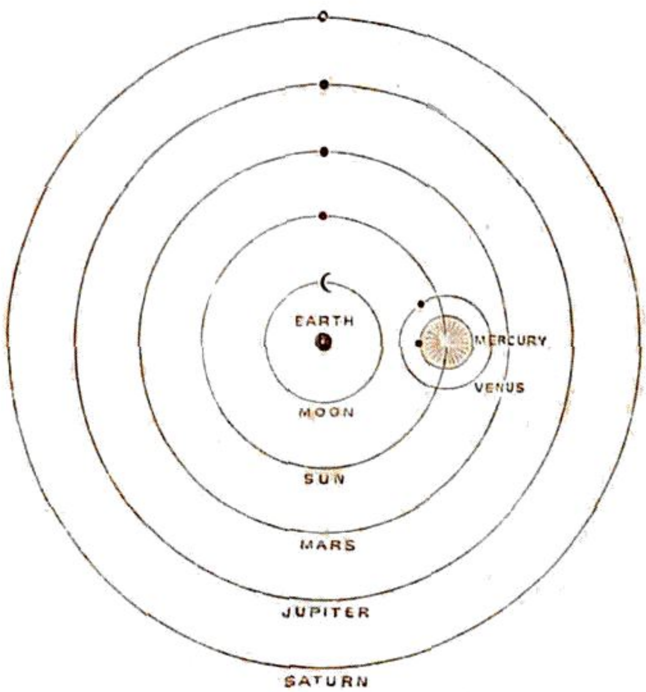

FIG. 12.—SYSTEM OF EGYPTIAN COSMOGRAPHY.

Copernicus thus expresses himself in his dedication to the "Celestial Revolutions" (*De Revolutionibus Orbium*):—

"I am certain that philosophers will proclaim the truth of my discovery when they shall have attentively examined the proofs

* [It was completed, however, in 1530. Probably Copernicus delayed its publication from a just fear of the persecution in which it might involve him, as its views were presumed to be contrary to the science of the Bible.]

which I furnish. And if ignorant or volatile minds would fain oppose me with certain passages from the Holy Writings, whose meaning they misconstrue, I shall despise their attacks. Mathematical truths can only be judged by mathematicians."

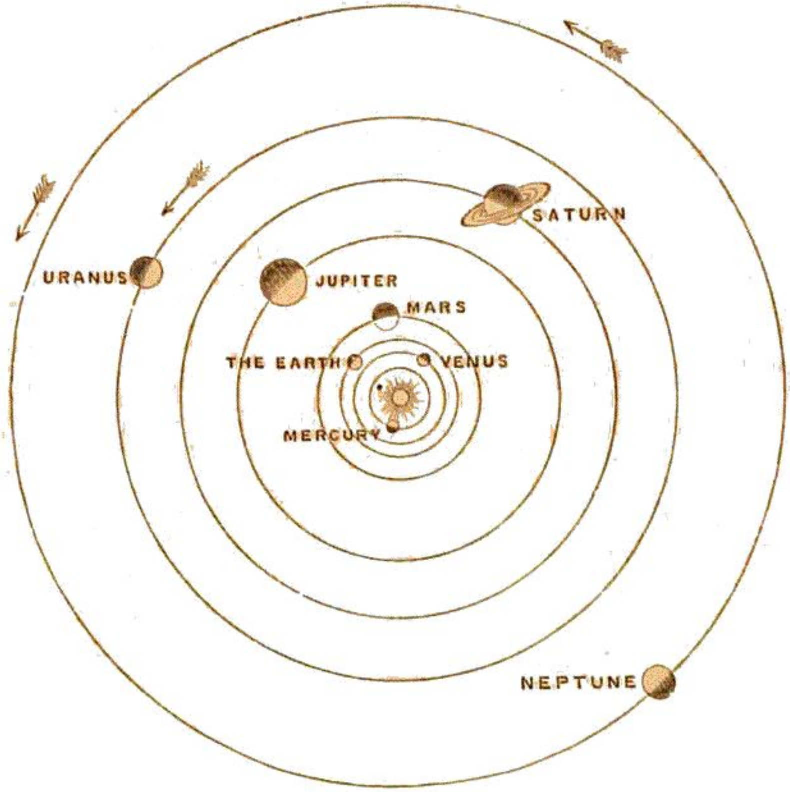

FIG. 13.—SYSTEM OF COPERNICUS.
Course of movement of translation for the entire system.

The astronomer of Thorn did not deceive himself when he foresaw a determined opposition to his opinions. Shortly before the publication of his book, Father Riccioli put forward a series of arguments in contradiction of the Earth's movement. These arguments, seventy-seven in number, were marvellously absurd. "Would the birds," said Father Riccioli, for example, "dare to rise in the air if they saw the earth passing away from beneath them?" From such a specimen we may judge of the rest of the egregious structure.

The book "De Revolutionibus Orbium" has been placed by the Church of Rome on the condemned list of its *Index Expurgatorius.** Another learned monk, Father Boscovich, who printed at Rome, in 1746, a work on the course of the comets, thus expresses himself: "As for me, I look upon the Earth as immovable. Nevertheless, for the sake of simplifying my explanations, I shall treat of it *as if it did revolve*" (!)—[Was there ever a finer instance of the subtlety of the serpent combined with the gentleness of the dove? Did ever man

* [The "Index Librorum Prohibitorum" is a catalogue of the books which the Roman Church interdicts to its members on religious, moral, or doctrinal grounds. The first catalogue of the kind was issued, under Pope Gelatius, in 494; but the formal Index may be dated from 1564, when it was published by Pope Pius IV.]

light upon a happier mode of reconciling the claims of Science with the prejudices of the Church?]—As late as 1829, when Warsaw raised a monument to Copernicus, no priest had the courage to celebrate the religious rites announced for the occasion;—Copernicus had died without confessing his sin!

FIG. 14.—TYCHO BRAHÉ.

TYCHO BRAHÉ,* could not refuse his admiration to the simplicity of the Copernican cosmogony; but was unable to comprehend the initial movement impressed on so considerable a mass as the Earth. Nay more, the text of Holy Writ was wholly opposed to such a doctrine. Did not Joshua bid the sun stand still over Gibeon? To promote a fitting concord between religion (or rather theology) and the new cosmography, Tycho Brahé devised a middle term—a *Via Media*—a kind of *eclectic* system. He permitted the planets to revolve around the Sun, according to the views of Copernicus; but he fixed the Earth fast and firm, and made the Sun circle round this immovable terrestrial sphere. Thus he granted to our minor planet that immovability which he refused to the Sun. In such wise did the greatest intellects of the seventeenth century, enthralled by their melancholy concession to a theological scruple which had no real foundation, hesitate between the clear and indisputable evidences of religious truth and an error resting only on the mistaken interpretation of a few lines in the Bible.

By discovering the true laws or rules of the movements of the

* [Tycho Brahé was born on the 14th December 1546, at Knudsthorp, near Helsingborg. He studied at Copenhagen and Leipzig. He built his observatory of Uraniberg, or "The City of the Heavens," on the island of Huen, in 1576; and died at Prague, 24th October 1601.—SIR DAVID BREWSTER, *Martyrs of Science*, pp. 128–200.]

celestial bodies, the illustrious Kepler * brought to the system of Copernicus the support and confirmation which it most required; and thenceforth the rotation of the Earth was accepted by all enlightened minds as an established certainty. It was Kepler who discovered that the planetary orbits are not actual circles, but really ellipses; it was he who enunciated the exact mathematical laws which the stars obey in their courses.

Kepler, a man of vast mental powers and remarkable force of character, was astronomer to the Court of Prague. His labours and his misfortunes have made him one of the grandest figures in the history of the seventeenth century. The terrible charge of sorcery which constantly impended over him and his mother involved him, throughout his vexed career, in trials, perils, and sufferings over which he could only triumph by dint of a severe constancy and an impregnable courage. Happily, a glowing imagination, which made him conqueror of all the obstacles in his path, inspired him with the strength needful for fulfilling the high destiny of his genius.

Fig. 15.—Kepler.

We quote a sublime passage from his immortal work,† which throws a vivid light on his strong and resolute nature. After he had discovered the third astronomical law which bears his name, he decided on publishing his treatise, and in the preface he wrote as follows :—

"The die is cast; the book is written. It will be read now, or by posterity. What matters which? It can well wait a century

* [Johann Kepler was born at Magstatt in Würtemburg, 27th December 1571. He died at Ratisbon, 15th November 1630.]

† ["The Harmonies of the World," published at Ling in 1619.]

for its readers, since God himself waited fully six thousand years until there came a man capable of comprehending and admiring his works."

The immortal GALILEO GALILEI * was one of the most ardent believers in the Copernican system. Making use, for the first time, of the simple astronomical telescope which he had constructed on the mere hint of the discovery of such an instrument, Galileo established the movement of rotation of the planet Venus, and that of the planet Mercury, around the Sun. Reasoning by analogy, he concluded that the Earth moved; confirming this fundamental truth by those other arguments which Kepler had laid down.

FIG. 16.—GALILEO.

The religious bigotry of his age compelled the immortal Florentine to expiate by cruel sufferings the presumed iniquity of his scientific convictions. Alas! who is not familiar with the melancholy tale of

"The starry Galileo, with his woes"?

In 1633 the Roman Inquisition decreed the arrest of the philosopher, and he was condemned to imprisonment for having professed and enunciated the principle of the Earth's motion in space, contrary, as they were pleased to assert, to the statements of the Scriptures. Threatened with the rack, the feeble old man, worn with seventy winters and physical infirmity, humbled himself before his persecutors, and on his knees abjured the glorious truths of the new philosophy. We subjoin the formula to which he affixed his signature, after

* [Galileo Galilei was born at Pisa, of an ancient Florentine family, on the 15th of February 1564. His great discovery of the four satellites of Jupiter was made on the night of the 7th of January 1610. He died at Arcetri, January 8th, 1642, at the age of 78.]

reading it in a loud and audible voice before the conclave of the Inquisition :—

"Ego Galilæus, filius Vincentii Galilæi Florentinus, ætatis meæ annorum 70, constitutus personaliter in judicio, et genuflexus coram vobis eminentissimis et reverendissimis Dominis cardinalibus, universæ Christianæ Reipublicæ contra hæreticam pravitatem generalibus inquisitoribus . . . corde sincero et fide non ficta, Abjuro, Maledico et Detestor supradictos Errores et Hæreses."

[I, Galileo, son of Vincenzo Galilei, a Florentine, aged seventy years, brought personally into judgment, and now kneeling before you, most eminent and very reverend cardinals, inquisitors-general of the Christian commonwealth against the depravity of heretics . . . with a sincere heart and an unfeigned faith, I abjure, I curse, and I detest the afore-mentioned errors and heresies.]

[Happily for the welfare and honour of humanity, the verdicts of an unenlightened past are subjected by posterity to a stern revisal. To every schoolboy the illustrious name of Galileo is familiar ; how few even of the learned remember the names of his persecutors !

It is not well, however, that any fictions, though of the gracefullest and fairest character, should be suffered to grow parasitically about the plain and simple fact ; and of the story of Galileo it may justly be said that its intrinsic interest requires no romantic colouring. Nevertheless, it was long pretended that the philosopher, on rising from his knees, stamped the earth with his foot, and exclaimed, *E pur si muove* (And yet It Moves !), as if ashamed of his weakness, and resolved, in spite of all things, to do homage to the truth.* This is one of those historical legends which the searching analysis of modern criticism dismisses into the limbo of unreal things. It is, indeed, impossible that the aged and frail sufferer, who had just escaped the agony of the rack by his uncompromising abjuration, should have had the heart or the mind to give utterance to such a defiance. On the contrary, he retired in silence from the presence of his judges to conceal his sorrows and his shame in a secluded retreat, near Florence. †

But whether Galileo made, or did not make, this tardy protestation, in the face of his judges and would-be executioners, the celebrated phrase—

E PUR SI MUOVE—

has since been accepted by all the followers of science as the precious formula of

* [Drinkwater, "Life of Galileo," Lib. Useful Knowledge, Part ii. p. 63.]

† [See Philarète Chasles, "Galileo Galilei : sa Vie, son Procès, et ses Contemporains" (Paris, 1862).]

their faith. Yes; the earth moves, and in the following chapter we shall see the consequences that flow from this great principle, and the facile and intelligible explanation which it affords of all the grand terrestrial pheuomena. "Speak to the earth," said Job, "and it shall teach thee." We are still learning its wondrous lessons; we are still turning over its truth-illumined pages. Its scenes are present with us in our highest mental efforts, in all our endeavours to solve the mysteries of the universe. It is our Mother and our Teacher. All the circumstances of earth, says a recent writer, may be regarded as the oil which feeds the flame of thought, burning continually in the secret shrine of man's mind; and countless affinities, mental and corporeal, earthly and spiritual, verify the saying of the Greek poet: "O earth! earth! how art thou interwoven with that nature that first came from thee!" To the young student, as to the mature scholar, there will always be a subtle inspiration in the historic words—

E PUR SI MUOVE!]

CHAPTER II.

THE TERRESTRIAL SEASONS—DAY AND NIGHT—THEIR CAUSES—THE EARTH NEARER THE SUN IN WINTER THAN IN SUMMER—THE ZONES, AND THEIR CHARACTERISTICS—THE EQUINOXES AND SOLSTICES—THE ZODIAC.

THAT system of the Solar World which we have explained in the preceding pages enables us to account for the climatic changes known as SEASONS,—

> "These, as they change, Almighty Father, these
> Are but the varied God;—"*

and to explain the cause of the inequality of the terrestrial DAYS and NIGHTS:—

> "There came the Day and Night,
> Riding together both with equal pace;
> The one on palfrey black, the other white;
> But Night had covered her uncomely face
> With a black veil, and held in hand a mace,
> On top whereof the moon and stars were pight,
> And sleep and darkness round about did trace:
> But Day did bear upon his sceptre's height
> The goodly sun encompassed all with beamès bright."†

The terrestrial orbit, as the reader will remember, is an ellipse differing somewhat from a circle, and bearing the astronomical designation of the Ecliptic. The Earth traverses the ecliptic in the course of 365¼ days, revolving on an axis constantly inclined towards the two same points of the heaven, or, in other terms, always parallel to itself. Hence it follows that the plane of the celestial equator, which is perpendicular to the terrestrial axis, invariably preserves the same inclination in relation to the plane of the ecliptic wherein the earth revolves: this inclination, equal to 23° 27′ 28″, is termed "the obliquity of the ecliptic."

The continuous parallelism of the Earth's axis of rotation upon itself is the determining cause of the seasons. The same cause pro-

* Milton, *Paradise Lost.* † Spenser, *Faery Queen.*

duces the periodical variations of the length of the days and nights; or rather, these two effects, the summer heat and the long summer-days, the winter cold and the dull brief winter-days, are referrible to a common cause—a cause which we shall now proceed to elucidate.

[E is the Earth ; G H I its elliptical orbit round the Sun. If the centripetal force of attraction were destroyed, the Earth would fly off in the tangent E F; if the centrifugal force failed, the Sun would at once draw the Earth to itself.]

In Figure 18* we show the Earth in the twelve positions which correspond to the twelve months of the year. During one-half the year, the northern extremity of the terrestrial axis (the upper extremity in our illustration) inclines towards the Sun, and the southern extremity is turned eastward. During the other half, it is the south pole which inclines towards the Sun, while the northern extremity is directed from it. We see, in our engraving, that the north pole, or Arctic, is

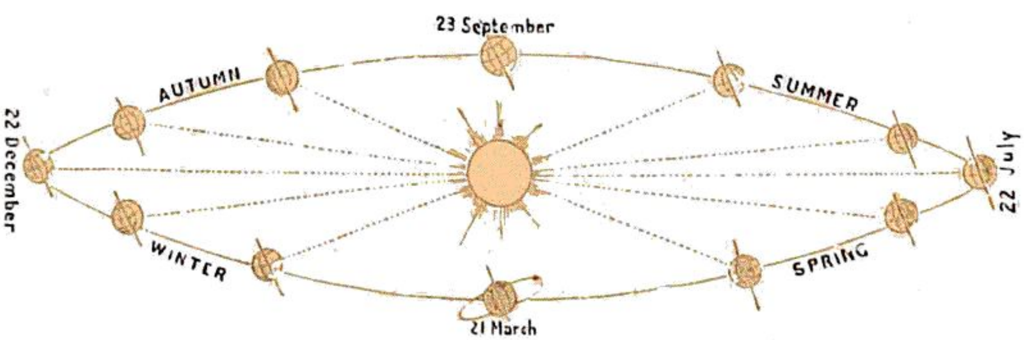

FIG. 18.—POSITION OF THE EARTH IN RELATION TO THE SUN DURING THE TWELVE MONTHS OF THE YEAR.

farthest from the sun about the 22nd of December, and approaches the nearest to it about the 21st of June. The two poles are at an equal angular distance on the 21st of March and the 23rd of

* From the "Atlas Universel de Géographie Physique," by Bourdin and Hachette. Paris, 1861.

September; at which epochs the plane of the terrestrial equator, if prolonged, would pass precisely through the centre of the Sun. [The two poles of the planet are then symmetrically placed with regard to the radiant body, and the circle of separation of the illuminated hemisphere and the dark hemisphere lies in a meridian. It results from this particular position that each part of the Earth, whatever its latitude, describes half the daily journey imposed on it by the Earth's rotation in shade, and half in sunshine. Thus, at the time of the equinoxes, as these two epochs are called, the length of the day is equal to that of the night all over the world. The Sun remains twelve hours above and twelve hours below the horizon.]

The great circle separating day and night, the illuminated from the darkened hemisphere, is called the "circle of illumination."

Figure 19, which represents the Ecliptic in a "front view," will illustrate the preceding observations.

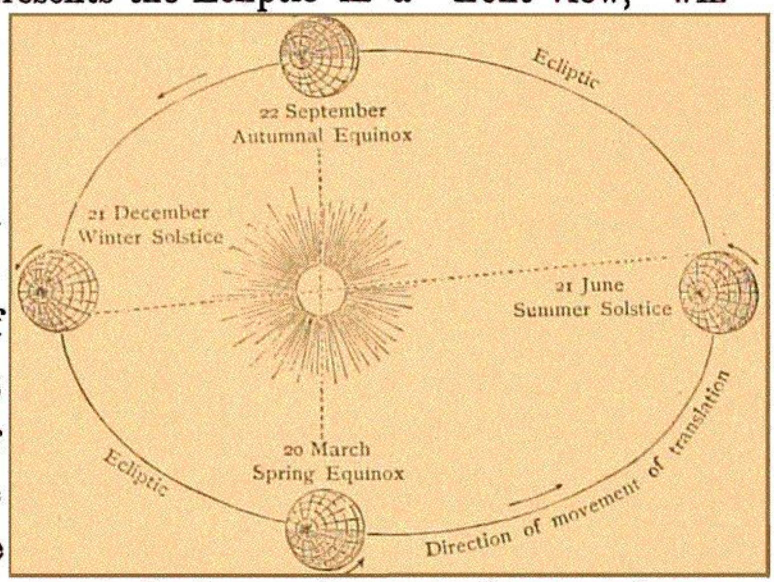

FIG. 19.—THE ECLIPTIC; SHOWING THE TERRESTRIAL SEASONS.

On the 21st of December the north pole is in shade, and so continues throughout the period of one rotation of the Earth; the Sun does not appear on its horizon. On the 21st of June, it is the south pole which remains in obscurity, while the north pole continues illuminated throughout one rotation of the globe.* The north side of the Earth is then inclined towards the Sun, and the entire northern hemisphere continues longer exposed to the "darts of Apollo" than plunged in shadows; our days are, therefore, longer than our nights, and we bask in the genial influences of summer. The contrary is the case

* [Mr. Whymper, in his "Travels and Adventures in the Territory of Alaska," remarks that on the 21st of June the sun set at a few minutes after eleven, and rose at a quarter to twelve. "How near we were to the Arctic Circle," he says, "I leave to those who understand the subject; suffice it to say, the sun was absent from our gaze not over 45 minutes."]

in the southern hemisphere; its nights, at this time, are longer than its days, and winter prevails. On the 21st of December, all is changed; it is winter and dreary nights in the north, summer and long hours of splendour in the south.

The epochs of the 21st of June and the 21st of December are called, respectively, the *summer* and *winter solstices*, because the sun then appears to remain stationary for several days (*sol*, "sun," and *sto*,* "I stand"); it is then at its maximum distance from the north and south poles, and before resuming its celestial journey to regain the pole from which it has started, it seems to repose awhile.

[Winter, then, must be the shortest, and summer the longest of the four seasons; and the two other seasons of intermediate length, with spring the longer of the two. And such would be the case, even if the Earth travelled with equal velocity over every part of its orbit. But its rate of speed is really less during the summer season of the northern hemisphere than during the winter season, and the arcs travelled over are also unequal. The result is, that the mean duration of the seasons are as follows:—

Spring, 92.9 days.	Autumn, 89.7 days.
Summer, 93.6 days.	Winter, 89.0 days.

Spring, therefore, exceeds the autumn by 3 days, 4 hours, 48 min., and summer the winter by 4 days, 14 hours, 24 min.

But as the Sun is at its aphelion—that is, at its fullest distance from the Earth—in summer, the reader will wonder why our globe then enjoys the greatest amount of heat. One reason is, that the sun remains so much longer above the horizon of any place, and produces a consequently greater effect on the temperature. Another is, "the diurnal" arc described by the great Light-Giver rises higher and higher from the time of the spring equinox to the summer solstice, returning in inverse order from the summer solstice to the autumnal equinox. The rays that he sheds on the divers points of the northern hemisphere traverse the atmosphere less obliquely than in winter and autumn; and the intensity of the heat received is much greater when this obliquity is less, a circumstance easily explained by the inferior density of the atmospheric strata they traverse. Besides, if we leave the thickness of the atmosphere out of the question, the obliquity of which we speak is in itself a cause why the heat received should be less considerable.]

That the reader may the more readily comprehend the distribution of the seasons on our globe, we subjoin two diagrams representing

* [It would be more correct to say "June solstice" and "December solstice," since the winter and summer of *our* hemisphere correspond to the summer and winter of the opposite hemisphere.]

the Earth as seen in profile at the solstitial epochs. The circle of illumination is shown in both by a vertical line. In Figure 20 we see an arc of a circle having for its centre the north pole, and touching the boundary of the shade; it circumscribes the region which, during the rotation of the Earth, remains exposed to the solar rays; it is called the Arctic Circle (from the Greek ἄρκτος, the bear, a polar constellation). In Figure 21 the same region is found entirely involved in shadow; wherein it continues for at least four-and-twenty hours, on the occurrence of the winter solstice. An analogous circle, with the south pole for its centre, is called the Antarctic (as if we said, the counter-arctic). It limits the region which remains obscured at the epoch of the summer solstice, and where daylight prevails for fully twenty-four hours at the solstice of winter.

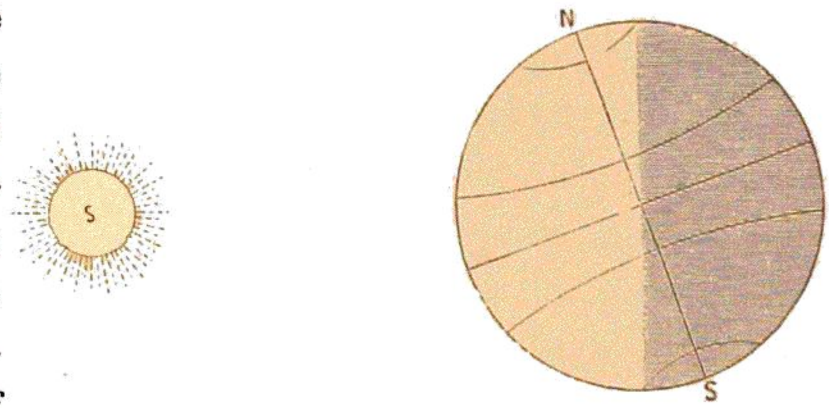

FIG. 20.—SUMMER SOLSTICE.

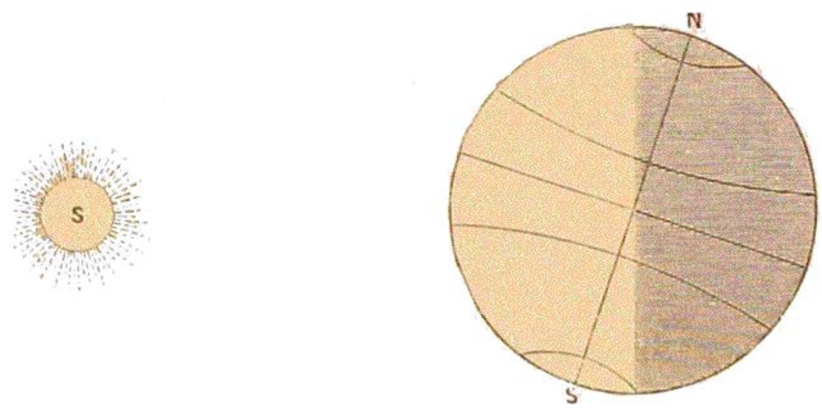

FIG. 21.—WINTER SOLSTICE.

The circles distinguished by the name of *Tropics* ("turning-points" or "limits") have the noonday sun at the *Zenith*—that is, immediately above the head of their inhabitants, on the occurrence of a solstice; a phenomenon which, for the inhabitants of the equator, occurs at the equinoxes. The Tropics define the limits upon the Earth of those regions which receive the sun's vertical rays. The belt lying between them is known as the *Torrid Zone*, and is bounded by the twenty-third parallel of latitude, both north and south of the equator. The regions circumscribed by the polar circles, and which are deprived of the Sun during a part of the year, are not inaptly called the *Frigid Zones.* And, finally, the two belts comprised between each polar circle, and one or other of the Tropics—or between 23° and 66° lat.—are named the *Temperate Zones.*

In the two illustrations 20 and 21, the "circle of illumination" divides the equator into two equal halves; on each of its points, day will prevail for twelve hours, and night for twelve, at every epoch of the year. The regions above are more advantageously situated than those below in the first, and less advantageously in the second diagram. The northern hemisphere will have summer, and days of upwards of twelve hours' duration; the southern hemisphere winter, and days of less than twelve hours, in June: the reverse will take place in the month of December.

[The order and dates of the succession of the four seasons are as follows:—

Towards the 21st of March, the Earth reaches the *Spring Equinox;*

Towards the 21st of June, the *Summer Solstice;*

Towards the 22nd of September, the *Autumnal Equinox;* and,

On the 21st of December, the *Winter Solstice.*

The precise dates vary every year; but, as the following Table shows, to no very great extent:—

COMMENCEMENT OF THE FOUR SEASONS.

	1870.	1865.	1864.
SPRING:	March 20, 7h. 32m. P.M. ...	March 20, 8h. 19m. A.M. ...	March 20, 2h. 15m. P.M.
SUMMER:	June 21, 3h. 56m. P.M. ...	June 21, 5h. 25m. A.M. ...	June 21, 10h. 55m. A.M.
AUTUMN:	Sept. 22, 6h. 9m. A.M. ...	Sept. 22, 7h. 1m. P.M. ...	Sept. 22, 1h. 8m. A.M.
WINTER:	Dec. 21, 12h. 12m. A.M. ...	Dec. 21, 1h. 13m. P.M. ...	Dec. 21, 6h. 59m. P.M.]

In the North and South Polar regions, day endures one-half of the year, and night for the other half, if we omit the twilight, which to some extent abridges this protracted darkness. The "star-bespangled heaven" there revolves once in four-and-twenty hours, like an immense dial; the stars neither rise nor set.

For six whole months the sun describes an apparent spiral movement above the horizon, at first approaching the celestial pole, and afterwards gradually receding from it, until, about the epoch of the equinox, it disappears below the horizon.

Figure 22 represents the *apparent* course of the Sun in the heavens during any year. It shows also the Celestial Tropics, which correspond to the Terrestrial Tropics, and, like them, derive their name from the Greek τροπή, "a return,' because the Sun, when he has reached them, seems to return on his steps and trace his path anew. They are called the Tropic of Cancer and the Tropic of Capricorn, because the Sun, at the epoch of the solstices (when he touches one of the tropics), is found either in the sign of Cancer or that of Capricorn.

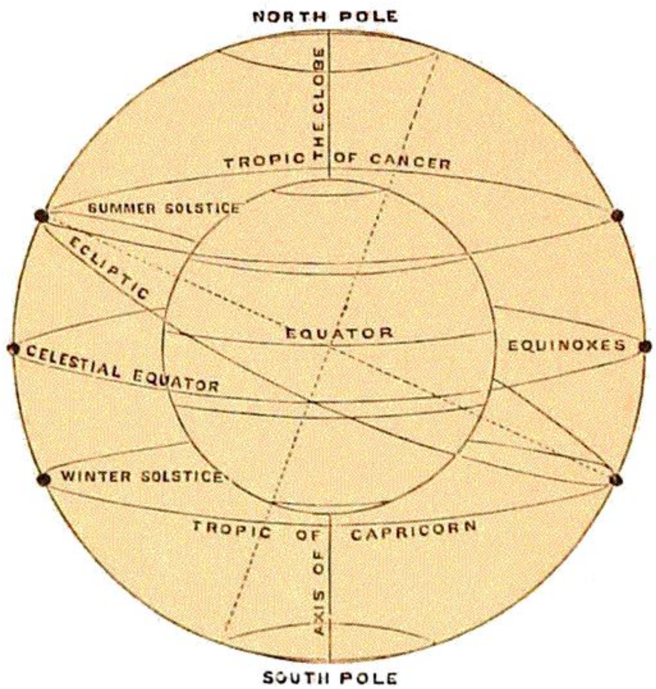

FIG. 22.—APPARENT COURSE OF THE SUN.

The Celestial Signs are twelve constellations, which as a whole have received the name of the *Zodiac*,* and which the Sun appears to traverse successively, in consequence of the yearly motion of the Earth. In Figure 23 we show the names,† symbols, and corresponding months of the twelve signs.

In his apparent movement, then, the Sun travels in the midst of the heavenly constellations; he completes his pilgrimage in 365¼

* [The term ZODIAC is derived from the Greek ζωδιακος (ζοόν, an animal), and was applied by the ancients to an imaginary belt stretched round the celestial sphere, which included the paths of the Sun and the then known planets, five in number. Its width was fixed at 16°. The planets since discovered are called *ultra-Zodiacal*, because their orbits are not comprehended within this narrow space.]

† The poet Ausonius enumerates them in the following Latin couplet:—

"Sunt, Aries, Taurus, Gemini, Cancer, Leo, Virgo.
Libraque, Scorpius, Arcitenens, Caper, Amphora, Pisces."

days, and, in the same time, alternately approaches and retires from the celestial equator, which he traverses at the epochs of the equinoxes.

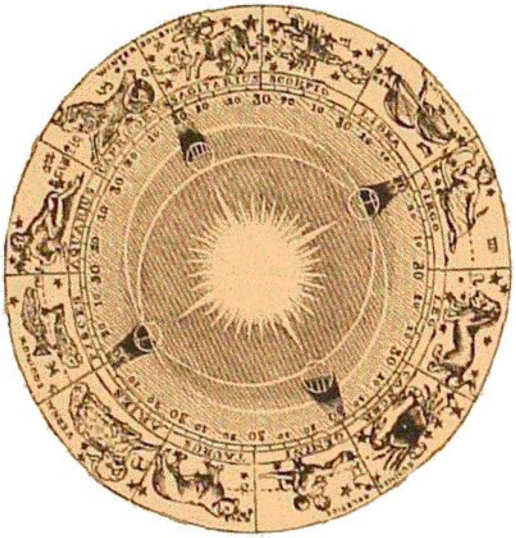

FIG. 23.—THE ZODIAC, WITH ITS SIGNS.

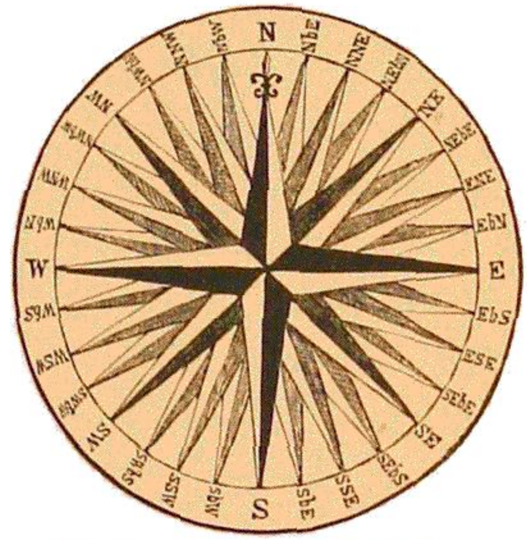

FIG. 24.—THE MARINER'S COMPASS.

The celestial equator bisects the horizon at two points, named respectively the *east* and the *west*. The east lies to the left, and the west to the right, of a spectator who looks towards the south.

We give the name of the Mariner's Compass Card to the plan or chart on which are indicated, with their subdivisions, the relative positions that have received the names of N., S., E., and W.

BOOK II.

FORM AND DIMENSIONS OF THE TERRESTRIAL GLOBE.

In his hand
He took the golden compasses, prepared
In God's eternal store, to circumscribe
This universe and all created things;
One foot he centred, and the other turned
Round through the vast profundity obscure;
And said, "Thus far extend—thus far thy bounds—
This be thy just circumference, O world!"

MILTON, *Paradise Lost.*

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BOOK II.

FORM AND DIMENSIONS OF THE TERRESTRIAL GLOBE.

CHAPTER I.

FORM OF THE EARTH—PROOFS OF ITS CONVEXITY—ACCOUNT OF VARIOUS ATTEMPTS TO ASCERTAIN THE EARTH'S DIMENSIONS—ARISTOTLE—POSIDONIUS—ERATOSTHENES—PTOLEMÆUS—THE CALIPH AL-MAMOUN—THE PHYSICIAN FERNEL, IN THE SIXTEENTH CENTURY, MEASURES A DEGREE OF LONGITUDE—SNELLIUS—LONGITUDE AND LATITUDE—METHOD OF TRIANGULATION—THE ACADEMY OF SCIENCES OF PARIS—LABOURS OF NEWTON IN REFERENCE TO THE FLATTENING OF THE POLES—SCIENTIFIC COMMISSIONS DESPATCHED, IN 1736, BY THE ACADEMY OF SCIENCES, TO THE POLE AND THE EQUATOR—MODERN MEASUREMENTS—DELAMBRE AND MECHAIN—BIOT AND ARAGO—METRICAL SYSTEM—TRUE DIMENSIONS OF THE TERRESTRIAL SPHEROID—DETERMINATION OF THE LONGITUDE BY ASTRONOMICAL OBSERVATIONS—GLOBES AND MAPS.

TO a spectator whose standing-point should be the Sun, or some other fixed star, the Earth would appear like a glittering point in the heavens, a sphere among the spheres.

To a lunarian, or inhabitant of the Moon,* the Earth would shine as a luminous disc, fourteen times greater than the lunar disc as seen by us, and always occupying the same position in the sky, while the Sun and the whole procession of the stars would defile before it. The inhabitant of the moon would see the Earth suspended to the firma-

* ["That the moon is inhabited has been always a favourite fiction; according to Athenæus, Neochs of Crotona maintained that the women in the moon lay eggs, and that the men children hatched from them grow to fifteen times our stature."—*Athenæus Deipn.*, lib. ii., p. 57.]

ment like an immense clock-dial, whose daily volution would indicate to him the four-and-twenty hours. The *phases of the earth* would mark his months. In Figure 25, our globe is shown as it would appear when viewed from the Moon.

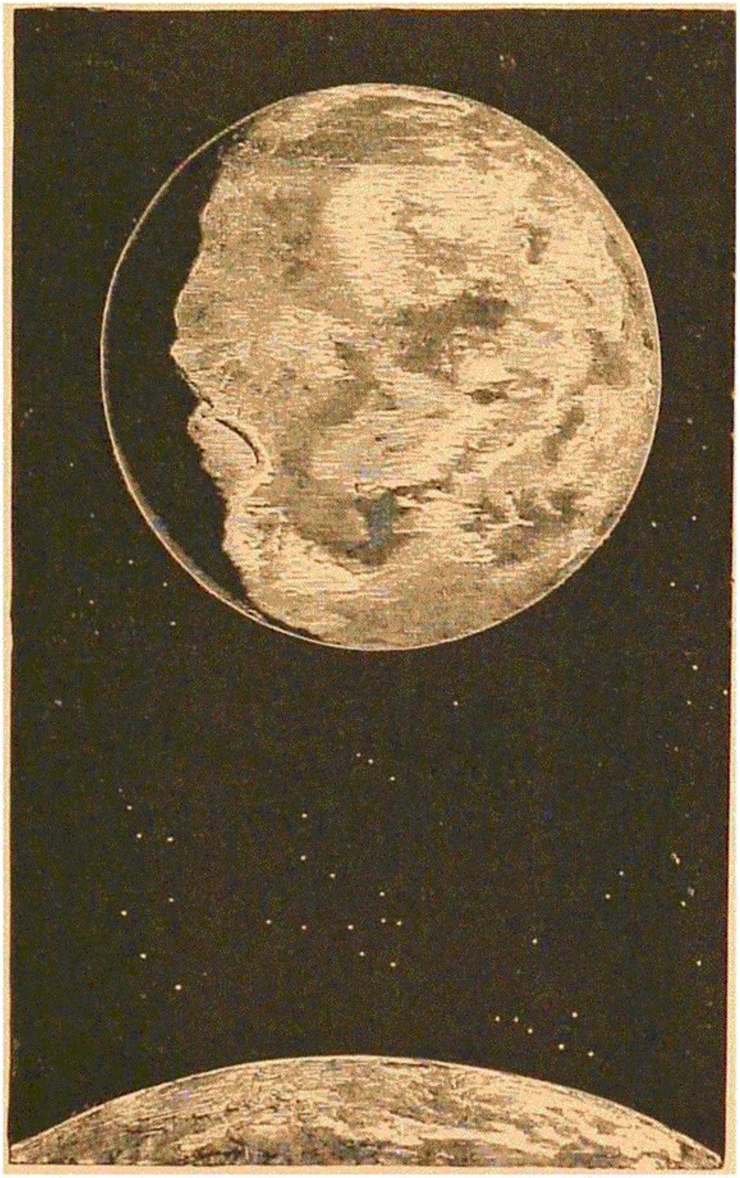


Fig. 25. —The Earth seen from the Moon.

The determination of the true form of the Earth has cost, from the earliest days of science, an incredible amount of laborious effort. If we climb to some elevated ground,—to the summit, for instance, of a hill situated on a vast plain, —or, still better, to the mast-head of a ship,—the broad expanse which lies before us assumes the outline of a circular plain, on whose borders rests the celestial dome. For many centuries, therefore, men figured to themselves the Earth as a kind of limitless plain —that is to say, as a level and horizontal surface. It needed all the scientific learning of a series of successive generations to conquer and dispel this error of the senses; to place the human mind, as it were, at an abstract view-point; and to contemplate, with the inner gaze, the Earth floating in space, under the form of a globe freely suspended in the planetary regions.

The first practical demonstration of the spheroidal form of our planet was furnished by the navigatomors who accplished the entire circuit of the world, and, by continuing in an invariably onward course, eventually returned to their place of departure.

It was MAGELLAN who first achieved this glorious enterprise. Sailing, in the month of September 1519, from the coast of Portugal, he discovered, early in the following year, the strait which bears his name, and is situated at the southern extremity of South America. He afterwards fell in with the fertile archipelago of the Philippines, where he perished in an engagement with the natives. His lieutenants, continuing their westward voyage, regained Europe in safety. Were the earth a level surface, this return to the point of departure would have been impossible.

But proofs of the earth's rotundity are easily multiplied. One of the most common is the following. If walking across a level country, we draw near a village, we perceive at first the summit of the church-spire, then the roof of the church, and finally the lowest buildings. We must conclude from this fact that in walking towards the village we ascend a curved line, instead of preserving always the same level with reference to that point.

[The curvature of the surface of the sea is very strikingly manifested. Suppose yourself on land, at the summit of a high tower, a hill, or on a steep rocky shore; a vessel appears on the horizon, you see only the tops of the masts, the highest sails; the lowest sails and the hull are invisible. As the vessel approaches, its lower part comes into view above the horizon, and soon the whole of it appears. The curvature of the ocean being the same in every direction, it follows that the earth has really the form of a sphere, or differs but slightly from it.

Another proof is seen daily in the movement of the stars, which set on one side of the horizon, to re-appear, twenty-four hours afterwards, on the opposite side.

A star of the northern heavens—the Pole-star—remains nearly immovable, and at the same height in the heavens above the horizon of any given place. Now, when we move towards the south, it gradually approaches the horizon; while, on the other hand, it rises if we approach the north.

"This is a fact," remarks Guillemin,* "which can be explained very naturally by the convexity of the earth's surface, for if this change of height were held to be the result of a real approach of the traveller to, and removal from, the observed star, the known distance of the stars from the Earth shows that the displacement of the observer is, so to speak, indefinitely small, compared to the distance of the star, and

* Guillemin, "The Heavens," pp. 95, 96.

cannot in any way account for its apparent movement. Besides, if, instead of walking from north to south, the observer travels from east to west, the Pole-star will always appear at the same point of the heavens as referred to the movable horizon, and at the same height above this horizon. But, in this case, it will be the hour of the rising and setting of the stars that will vary ; as should happen if the curvature of the terrestrial surface is in every direction ; and if, as indeed is known, our globe every day performs an entire rotation round one of its diameters.

"We may announce, then, as a fact, demonstrated by experience and observation, that the Earth, in spite of the irregularities of its surface, which seem to us so considerable, is a spheroid, and, seen in space, appears as well-defined, regular, and smooth, as the discs of the other planets."]

That mysterious boundary where heaven and sea, to a spectator on the shore, seem to blend in a line of dim, dull gray, is called

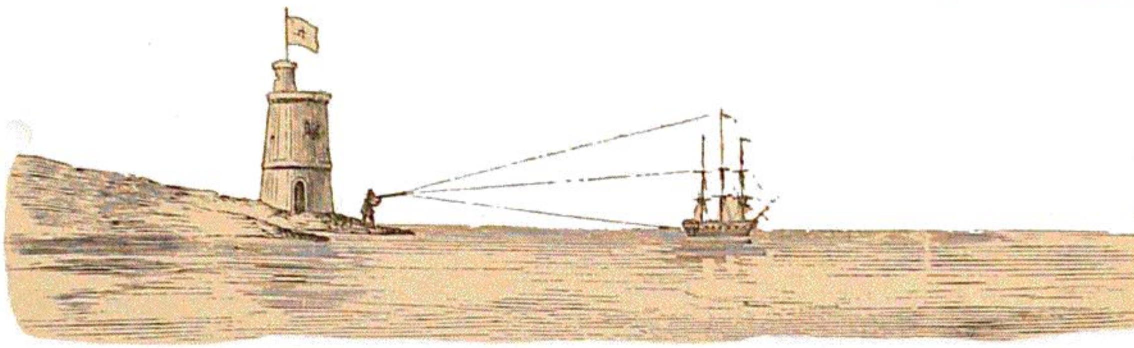


FIG. 26.—ILLUSTRATION OF THE EARTH'S SPHERICAL FORM.

the *apparent horizon*. And the higher his point of view, the remoter it seems to be, for this boundary occurs at the distance where

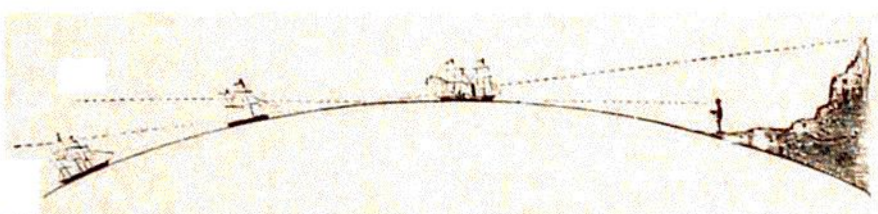


FIG. 27.—ILLUSTRATION OF THE EARTH'S CONVEXITY.

the visual ray proceeding from the eye of the observer is tangent to the terrestrial sphere. For example: the greater the elevation of a lighthouse, the greater the distance at which its rays will be visible. If 300 feet in height, it will dominate over an extent of sea measuring upwards of twenty miles.

An eclipse of the Moon occurs in the firmament at a fixed moment; but if we observe it about half-past nine in the evening at London, it will be nearly eleven before the same eclipse shall be visible at

Vienna. The Sun, therefore, rises an hour and a half earlier at Vienna than at London, whence it follows that the Earth curves from east to west.

Finally, let us add that, in a lunar eclipse, the shadow of the Earth projected on Diana's darkened disc presents a circular form, is the shadow of a spherical body. Therefore, the Earth resembles all the other "orbs of heaven" which all reveal themselves to our eyes as spheres.

Several Greek philosophers, who had attained to a just notion of the Earth's figure, attempted to calculate its magnitude. ARISTOTLE* asserts that its circumference measures 400,000 stadia. This round number indicates sufficiently that he had made no exact geometrical determination, but simply an approximative estimate. Moreover, we do not know of what kind of stadia Aristotle speaks. Some stadia numbered 400, some 600, some 1100, to a degree. Other Greek writers compute the terrestrial circumference at 300,000, 400,000, and 250,000 stadia; and, spite of the profoundest researches of our geographers, we have not ascertained as yet the precise value of these ancient calculations. All we can say is, that the Greeks had a tolerably accurate idea of the Earth's rotundity and dimensions.

FIG. 28.—ARISTOTLE.

Thus, for example, POSIDONIUS† having remarked that the star Canobus appeared at Rhodes on the horizon, while at Alexandria it was elevated to a point equivalent to the forty-eighth part of a circle, he concluded that the distance between Rhodes and Alexandria was exactly this forty-eighth part; and he made use of this observation to determine the length

* [Aristoteles, the greatest of the ancient philosophers, whose influence upon science has extended even to our own days, was born at Stageira, in the district of Chalcidice, B.C. 384. He visited Athens in his seventeenth year, and resided there until B.C. 347. In B.C. 342 he was summoned to the Court of Philip of Macedon, to superintend the education of the youthful Alexander, whose genius he developed with brilliant success. He returned to Athens, B.C. 335, and remained until B.C. 322. He died at Chalcis, in Eubœa, in August of the latter year.]

† [Posidonius, a distinguished Stoic philosopher, was a native of Apameia (now Kŭlat-el-Mudik) in Syria. He was a contemporary of Pompeius and Cicero, and died at Rome soon after B.C. 51.]

of a terrestrial meridian.* But Posidonius erred in supposing that both cities were on the same meridian.

ERATOSTHENES † approached much nearer to the truth. He knew that the Sun at Syene (the modern Assouan),‡ on the occasion of the summer solstice, did not cast any shadow at the bottom of the wells, when it was at the meridian; while at Alexandria, and at the same epoch, the Sun passed 7° 12′ to the south of the zenith. In fact, a gnomon, or style, elevated vertically in the centre of a concave hemisphere, projected at noon its shadow over the fiftieth part of the circle. He therefore arrived at the conclusion that the distance of Alexandria from Syene was 5000 stadia, or the fiftieth part of a meridian circle, and that the circumference of the entire meridian, consequently, was $5000 \times 50 = 250,000$ stadia.

[This number Eratosthenes altered into 252,000, that his result might give an exact number of stadia for the degree—namely, 700; which should, of course, have been $694\frac{4}{9}$. According to Pliny, these figures are equal to 31,000 Roman miles, and he supposes the stadium to be the eighth part of a Roman mile; and that Eratosthenes employed the Olympic stadium. In such a case, the degree of Eratosthenes is more than 79 miles, or upwards of 10 miles too great. But it is quite as probable that he employed the Egyptian stadium; only, unfortunately, as before said, of the Egyptian stadium we possess no measurement.

Plutarch (*de Plac. Phil.* ii. 31) states that Eratosthenes computed the Sun to be 804,000,000 stadia, and the Moon 780,000 stadia, from the Earth; while Manobius represents that he made the diameter of the Sun 27 times that of the Earth.]

We owe to Ptolemæus the collation and co-ordination of all the measurements of the Earth's magnitude attempted before his time.

The caliph AL-MAMOUN,§ a prince of enlightened sympathies and great natural powers, whose memory will always be cherished in the history of science, essayed, at a later period, to verify all these ancient estimates. He caused the length of a degree to be measured. The geometers whom he entrusted with this task selected for the scene of their operations the plain of Sennaar, in Mesopotamia. They formed themselves into two bodies, one of which proceeded northward, and the other towards the south. After they had retired one degree from their point of departure, they measured the distance traversed; it was $56\frac{1}{2}$ Arabic miles. Thus, according to this calculation, the length of a degree = $56\frac{1}{2}$ Arabic miles. What then is the

* ["His calculations were actually made in Spain, and not at Rhodes."—See *Strabo*, ii. p. 119].

† [Eratosthenes, of Cyrene, was born about 275 B.C., and died in B.C. 196, at the age of eighty, of voluntary starvation, having lost his sight, and grown weary of life. Fragments of his works have been collected by Bernhardy, in his "Eratosthenica."]

‡ [Lat. 24° 5′ 28″ N.; Long. 32° 59′ E.]

§ [The caliph Abul Abbas Abdalla Al-Mamoun, of the Abbaside dynasty, and son of the famous Hârûn Al-Raschid, was born at Bagdad in 786. He ascended the throne, 4th October 813. His reign, though disturbed by revolts and intestine convulsions, was productive of great benefit to the Arabian empire. He was a liberal patron of learning, and expended a sum equal to £187,500 on the translation of the works of the Greek philosophers into Arabic. He also founded observatories at Bagdad and Kasuin (near Damascus). Al-Mamoun died 9th August 834.]

value of an Arabic mile? An Arabic mile contains 4000 *aunes* of 24 inches each, and each inch equals 6 barleycorns. What is the value of a barleycorn? To this question no exact reply can be offered, but most physicists estimate the Arabian mile at 1200 yards (nearly); and this estimate would give somewhat more than 42,000,000 yards for the perimeter of the earth as calculated by the Arabs.

It was a French physician who, in the middle of the fifteenth century, took up the question of our planet's dimensions at the point where the ancients had left it. FERNEL* enjoys an immortal reputation in the annals of medicine, as the restorer of the writings of the Arabs and Galen, as himself an elegant writer and profound dialectician; and, in general history, he is known as the physician of Diana of Poitiers and of Henry II. of France, whom he accompanied to the siege of Calais. But what is not generally known is the operation, truly astonishing in its results, which it was his good fortune to carry out for the measurement of the terrestrial meridian. The means which he employed is so simple, one might almost say so rude, that one is still constrained to ask oneself how much of chance and guess-work it may conceal.

Fernel fitted to his carriage a regulator, to record the number of revolutions made by the wheels. Then he measured the length of a degree on the road from Paris to Amiens, noting, with the help of his calculator or pedometer, the number of rotations of his carriage-wheels. And it is singular enough that this rough mode of calculation gave him for the value of a degree 57,070 toises (364939.8220 English feet), a value not far removed from that determined by the latest geodesical researches.†

At the commencement of the seventeenth century, astronomers for the first time began to apply to the ingenious method introduced by Eratosthenes all the resources of their largely extended science.

* [JEAN FERNEL was born in 1497; died April 26, 1558. He early acquired a distinguished reputation as a physician, and was remarkable for the boldness of his views and the originality of his practice. He was the teacher of Vesalius, whom he inspired with his own passion for anatomical study. His principal work, "Medicina," was published in 1556. It has passed through more than thirty editions, and been translated into French.]

† [M. Figuier, in the text, falls into the error, made by other French writers, of assuming that Fernel employed in his measurements the Parisian foot, contrary to his own distinct statement. The fact is, his result was much further removed from the truth than even that of Eratosthenes.—See article "Weights and Measures" in the *Penny Cyclopædia*.]

In 1617, the Dutch astronomer SNELLIUS measured, by means of a series of continuous triangles, the terrestrial arcs comprised between the towns of Alkmaar, Leyden, and Bergen-op-Zoom, and compared their length with the number of degrees they obtained.

But here we are obliged, in order to render intelligible the remarks that will follow, to pause for a moment, and enter into a few explanatory details respecting *latitude* and *longitude*—that is, the geographical relations of any particular locality.

What is to be understood by the latitude of a place? Suppose that we wish to indicate with precision the position of a point of the Earth situated, let us say, on the equator itself. It will suffice for this purpose to make known its distance in regard to a certain fixed point on the equator, adopted, once for all, as the point of departure or return, specifying whether the distance from it is calculated in the direction of west to east or east to west.

The Equatorial Circle is divided, like every other circle, into 360 degrees (360°), and every degree into 60 minutes (60′), the minutes into 60 seconds (60″)—that is, until at some future time we return to the decimal and centismal division of a quarter of the circle.

We should say, then: such and such a place is distant from the fixed point of departure so many degrees, minutes, and seconds, counted towards the east, or towards the west. This distance is called the *longitude* (east or west) of the place which we wish to indicate.

Now suppose a series of circles to traverse the Earth from pole to pole, cutting the equator at equal intervals: these we call the *terrestrial meridians*. One of these meridians must be taken for the *first*, and the point where it bisects the equator will be the origin or starting-point of the longitudes. All the terrestrial points situated on the first meridian will have the longitude of Zero (0°). All the points situated under any other meridian have the longitude of the point where that meridian cuts the equator.

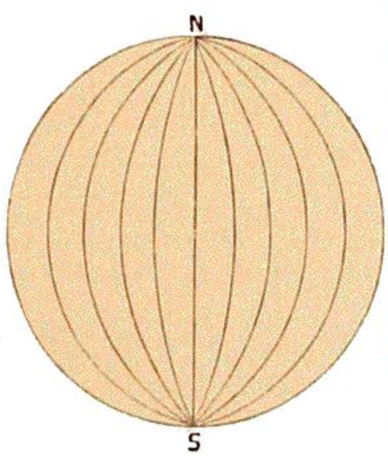


FIG. 29.—LONGITUDES OF THE GLOBE.

In England, and by all States of English origin, the first meridian is assumed to be that which passes through the great observatory of Greenwich, and the longitude of a place is said to be so many degrees east or west of Greenwich. France, and some other European countries, assume as the first meridian that which passes through the observatory of Paris. The point where the Parisian meridian cuts the equator is situated in the Atlantic at a short distance from the Guinea coast. The Dutch formerly adopted as their starting-point the meridian of the peak of Teneriffe. Most ancient geographers chose that of the island of Ferro, which lies in 18° 9′ W. longitude from Greenwich; but this custom, which had no rational foundation, has fallen into desuetude.

It would be desirable that all nations should agree on the adoption of a universal first meridian; but routine and national jealousy will long oppose themselves to this simplification.

Let us now pass to the consideration of what is understood by the word *latitude*. It expresses the distance from the equator valued in degrees of the circle. It is north latitude when referring to a place situated north of the equator, and south latitude in the contrary case. All places having the same latitude are situated on a circle *parallel* to the equator. The number of degrees of the circle indicates the distance of the equator in north and south latitude. Thus, London is 51½° N. latitude, or 51½° north of the equator.

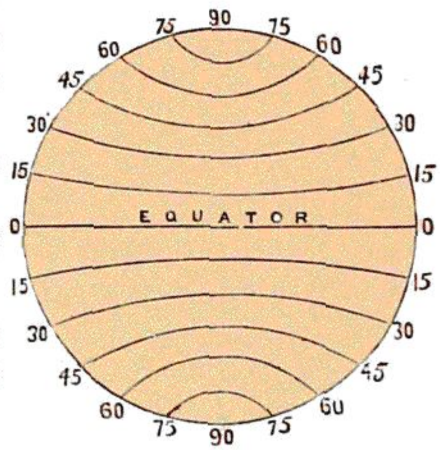


FIG. 30.—LATITUDES OF THE GLOBE.

It is evident that by the employment of both latitude and longitude we can indicate with exactness the situation of any place on the surface of the globe.

But latitude is often considered from an astronomical point of view, and in this sense we think it desirable to regard it briefly, because it affects the determination of the Earth's figure—the special object of this chapter.

The latitude of a terrestrial place is equal to the elevation of the celestial pole above the horizon of that place, or rather to the distance of the zenith from the celestial equator. This is shown in Figure 31, where the reader may study the relation of the terrestrial equator and poles to the celestial equator and poles.

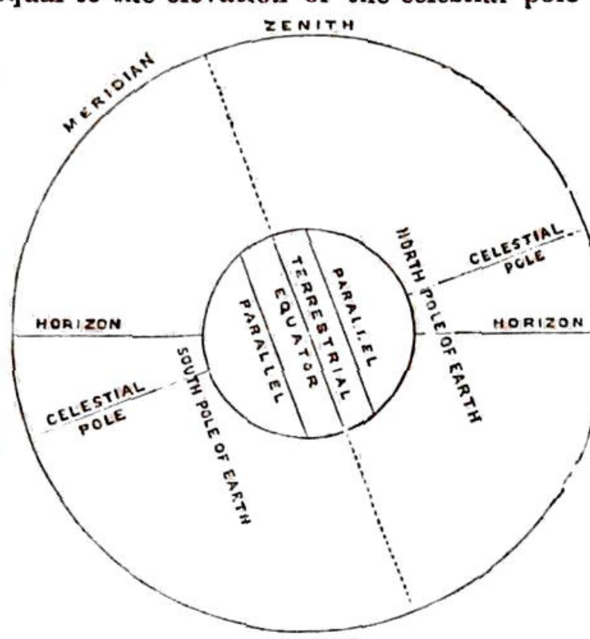


FIG. 31.—CELESTIAL EQUATOR, POLES, AND ZENITH.

Astronomers determine the latitude of a place by measuring the elevation of the Polar star above the horizon; or, rather, they calculate it by the elevation of the other stars and of the Sun at the moment that these stars traverse the meridian. Ascertaining the Sun's meridian elevation by observation, and its distance from the celestial equator by the astronomical tables, they deduce the altitude of the equator, subtracting from it 90°, the distance from the equator to the zenith—that is, the *geographical* latitude.

This last process furnished Snellius with the latitudes of the three Dutch towns already mentioned, and which lie nearly on the same meridian (say 4° 30′ W.)* The difference of their latitudes would have been their distance measured on the celestial vault, if all three had had the same longitude; but as their condition was not fulfilled, it became necessary, by a process of arpentage, to find the absolute difference which corresponded to the difference of the latitudes of these three towns.

This procedure is called *Triangulation*. We furnish a few explanations of the manner in which it is carried out.

To perform an experiment in *triangulation*, we must first procure a *base*, by measuring, as accurately as possible, the length of a line traced upon the ground; then we observe the angles made by the base, at its two extremities, with two visual rays which abut on one and the same distant point. We have thus secured the figure of a triangle, whose three sides are formed by the base and two visual rays; we may trace it upon paper, and read, by a simple proportion, the distance of the apex from the two extremities of the base (Fig. 32). Suppose, for example, that the base measures 1000 yards; if, in the tracing of the triangle, one of these sides should be found equal to double the base, we conclude that the true distance of the summit from either extremity of the base is 2000 yards. On one of the two sides we afterwards construct a second triangle, having for its apex another distant view-point, as a church-spire, or a pyramid raised for the purpose; and continuing in this way, we eventually form an uninterrupted chain of triangles extending in the direction of the meridian.

We have now nothing more to do than to note the points where the meridian encounters the sides of those triangles whose length has been calculated, and by a very simple process we obtain the length of a portion of the meridian itself. Having, at the same time, determined astronomically the latitude of some of the trigonometrical stations (as A, B, C), we deduce the distance in latitude of the two extremities of the meridian measured on the ground, and this distance, expressed in degrees, and compared with the corresponding number of yards or miles, gives us the value of a degree of the meridian. Suppose, for example, that the extreme latitudes of the meridian be 48° 10′ and 51° 25′, and that the distance between these points be measured at 3° 15′, or about 393,500 yards, we conclude that the degree will equal about 121,300 yards.

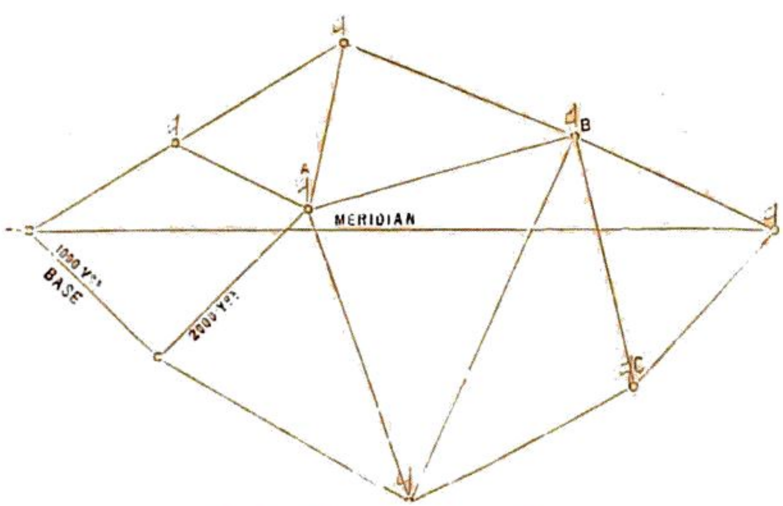


Fig. 32.—Trigonometrical Survey.

It was by the employment of these trigonometrical processes that

* [Alkmaar, long. 4° 43′ W.; Bergen-op-Zoom, 4° 17′ W.; Leyden, 4° 29′ E.]

Snellius, to return to that observer, calculated the value of a degree at 55,020 toises (about 260,000 English feet). Shortly after his time, RICHARD NORWOOD, an English mathematician (about 1635), measured the meridian between London and York, and arrived at a result much nearer the truth, 57,300 toises (270,000 feet nearly).

But in 1665 was established the French Academy of Sciences,* and its inauguration corresponded with a great scientific movement, simultaneous with the *renaissance* of French literature. Of all the questions with which scientific men then busied themselves, not one was worthier of their consideration than that of the figure of the Earth. The members of the new Academy believed their honour, so to speak, engaged in clearing up the uncertainties that prevailed with respect to its dimensions. One of them, M. PICARD [born 1620; died 1682], was charged with the task of measuring in France an arc of the meridian. He laid down a network of triangles between Malvoisin and Amiens, and found, as the final result of his operations, 57,060 toises to represent the value of a degree of the meridian. The base employed by Picard measured 5663 toises (12029.93 yards, or 6 miles 6 furlongs); *it was laid down on the road from Villejuif to Juvisy.*

This new determination of the length of the terrestrial meridian was generally accepted, and had a result which deserves to be here recorded, because it is very little known. It redeemed from nothingness, so to speak, the principle of universal gravitation. To verify, by direct measurements, the law of the attraction which the Earth exercises on the Moon, Sir ISAAC NEWTON had employed a very erroneous measurement of the terrestrial degree (49,540 toises = 297,240 yards), and as these figures conducted him to a result incompatible with the law of gravitation (the law of the universal square of distances), Newton had already renounced that law. When Picard published his new measurements, the illustrious English philosopher resumed his calculations by the rectified standard, and found them

* [Our own Royal Society, which has done much for the development of scientific truth, was established three years earlier (1662). It issued the first volume of its "Transactions" in 1665.]

accurate. Thus, the great law of universal attraction, momentarily lost to science, was again and for ever re-established.

However, the French *Académie des Sciences* was, as yet, only on the threshold of its labours and its triumphs. In 1672, it had despatched the astronomer RICHER [died 1696], to Cayenne, to complete certain physical observations. That astronomer discovered with surprise, that a clock pendulum regulated at Paris lost at Cayenne no less than two minutes and a half per day. The discovery excited universal astonishment.

For NEWTON was reserved the glory of searching out the cause of this unforeseen anomaly, and deducing from it a magnificent consequence. In his immortal work, the *Principia*,* occurs his celebrated explanation of the retardation and acceleration of the movement of the pendulum at different points of the globe. The pendulum slackens its movements as we approach the equator, because the density of the Earth is less at the equator than at the poles, and this for two reasons :—

FIG. 33.—SIR ISAAC NEWTON.

First, on account of the centrifugal force, which increases towards the equator ; and

Second, because there the terrestrial surface is further removed from the centre than at the poles.

The centrifugal force acts in a direction contrary to the density ; originating in the rotation of the globe, it is less on a parallel than on the equator, because the rate of speed of the displacement of the points on any parallel is inferior to that of the equatorial points.

* [The *Philosophiæ Naturalis Principia Mathematica* was first published in quarto in 1687. There are English translations by Motte, Thorp, Carr, and Whewell. It was translated into French by Madame la Marquise du Chastelet, in 1759, with a preface by Voltaire.]

The second reason for the retardation of a pendulum when transported to the equator—namely, the increased distance to the centre of the earth—was inferred by Newton from his theory that the earth was originally fluid, and as it solidified became flat at the poles from the effect of its rotation; a fact observable in all soft globular masses made to revolve rapidly.

It was thus that Newton arrived at the conclusion that the Earth is a spheroid, slightly flattened at the poles, and bulging at the equator.

This beautifully simple mathematical deduction was not universally accepted. On the contrary, it met with violent antagonists. The measurements of Cassini, who, in 1683, had extended his triangulations from Paris to the Pyrenees, had led astronomers to suppose that a degree was smaller in the north than in the south of France, and they had naturally concluded that the earth bulged at the poles and was flattened at the equator—that is to say, precisely the inverse of Newton's hypothesis. Riccioli in Italy, the three Cassinis in France, Fontenelle and his school, distinguished themselves among the adversaries of the Newtonian theory by their virulence. The war of words was not speedily terminated; the English philosophers espoused the cause of their illustrious countryman, the French maintained the elongation of the terrestrial spheroid; these attributed to it the form of an egg, those of an orange. It became necessary to solve the question, for it had degenerated into a veritable national quarrel.

In 1736 the French Government despatched a scientific expedition to Peru, and another to Lapland, for the purpose of measuring there an arc of the meridian. La Condamine and Bouguer were at the head of the geometricians who repaired to the equator. Maupertuis, the physician, who had warmly embraced the Newtonian system, and who even permitted its discovery to be attributed to himself, was chief of the commission despatched to the North Pole. Voltaire celebrated, with his usual sarcastic grace, in an epistle addressed to Count Algarotti, this celebrated scientific expedition:—*

* [Voltaire, *Œuvres Complètes*, tome x., Epitres xli., p. 351.]

"Lorsque ce grand courrier de la philosophie,
Condamine l'observateur,
De l'Afrique au Pérou, conduit par Uranie,
Par la gloire et par la manie,
S'en va griller sous l'équateur,
Maupertuis et Clairaut, dans leur docte fureur,
Vont geler au pôle du monde :
Je les vois d'un degré mesurer la longueur,
Pour ôter au peuple rimeur
Ce beau nom de machine ronde,
Que nos flasques auteurs, en chevillant leurs vers,
Donnaient à l'aventure à ce plat univers."

[When that great courier of philosophy, Condamine the observer, led by Urania from Africa to Peru, partly inspired by glory and partly by madness, repaired to broil himself under the equator, Maupertuis and Clairaut, in their learned fury, went to freeze at the north pole. I see them measuring the length of a degree, and all to deprive the rhyming race of that beautiful phrase of a round machine, which our feeble authors, while strumming out their verses, bestow haphazard upon the level sphere.]

The North Polar commission, under the orders of Maupertuis, and composed of Clairaut, Camus, and Lemonnier, to whom was added the Abbé Outhier, long a laborious worker at the observatory of Paris, suffered severely from the cold; but were compensated for all inconveniences by the glorious auroras, whose myriad-hued fires illuminate the long nights of those sombre climates. Their return was impatiently expected, and Voltaire wrote :—

"Revole, Maupertuis, de ces déserts glacés
Où les rayons du jour sont six mois éclipsés;
Apôtre de Newton, digne appui d'un tel maître,
Né pour la vérité, viens la faire connaître !
Héros de la physique, Argonautes nouveaux,
Qui franchissez les monts, qui traversez les eaux,
Dont le travail immense et l'exacte mesure
De la terre étonnée ont fixés la figure."

[Fly back, O Maupertuis, from these frozen deserts, where the solar rays are for six months eclipsed. Apostle of Newton! worthy support of such a master! Born for the service of truth, come thou and make it known! Heroes of physical science, new Argonauts, who cross mountains, traverse seas, and with immense labour and accurate measurement have fixed the shape of the astonished earth!]

It is true that Voltaire, impatient perhaps of a stir and an excitement in which he himself did not share, altered his tone hereafter, and when the success of the Argonauts of the Academy was assured, chanted this palinodia :—

"Vous avez confirmé, dans ces lieux d'ennui,
Ce que Newton connut sans sortir de chez lui,

Vous avez arpenté quelque faible partie
Des flancs, toujours glacés, de la terre aplatie."

[You have confirmed, in deserts full of dreariness, the truths which Newton knew without issuing from his seclusion; you have surveyed (*arpenté*) some trifling portion of the flanks, covered with eternal ice, of the flattened earth.]

But here Voltaire was unjust. Not only had the new measurements, though disfigured with a few errors, confirmed the calculations of Newton—which, indeed, was something—but they had furnished the means of rectifying them. In fact, the result of the geodesical operations of La Condamine, Maupertuis, and Bouguer, was to prove that the Earth is somewhat flatter at the poles than our English philosopher had supposed in his calculations.

Cassini, as we have said, was distinguished as one of Newton's most vehement critics. The French, however, felt no little difficulty in supporting his attack upon the illustrious man who held the sceptre of astronomy, and they gaily sought a recompense for their unwelcome task in the humiliation of his fortunate rival, Maupertuis, on whom they conferred the sobriquet of "the great flattener!"

Since that epoch, triangulations and measurements of the arcs of meridians have been multiplied *ad infinitum*. Lacaille has made them at the Cape of Good Hope, Boscovich between Rome and Rimini. Mason and Dixon have measured degrees in Pennsylvania; Roy and Mudge, in England; Hamilton and Everest, in Hindustan; Gauss, in Hanover; Bessel, in Prussia; and Struve, in Russia.

[This magnificent aggregate of labours undertaken during the eighteenth and nineteenth centuries has established with exactness the dimensions of the Earth, and its true general figure. It is now certain that the Earth is not accurately represented by an orange, unless, indeed, the orange be slightly squeezed, for the equatorial circumference is not a perfect circle, *but an ellipse*, whose major and minor equatorial diameters are respectively 41,852,864 and 41,843,896 feet. In other words, the equatorial diameter which pierces the Earth from longitude 14° 23′ E. to 194° 23′ E. of Greenwich, is two inches longer than that at right angles to it.

The length of the successive degrees of the meridian increases continuously from the equator to the pole.

The following table* shows the differences of length of the arcs of a degree,

* Guillemin, "The Heavens," p. 98.

measured in the northern hemisphere of the Earth, at increasing latitudes—that is to say, at gradually increasing distances northward from the equator :—

	MEAN LATITUDE OF ARC.	LENGTH OF ONE DEGREE IN ENGLISH FEET.
India	12° 32′ 20″	362,956
India	16° 8′ 21″	363,044
America	39° 12′ 0″	363,786
Italy	42° 59′ 0″	364,262
France	44° 51′ 2″	364,572
England	52° 2′ 19″	364,951
Denmark	54° 8′ 14″	365,087
Russia	56° 3′ 55″	365,291
Sweden	16° 20′ 10″	365,744

The lesson taught by these differences is one which the dullest and most prejudiced mind cannot refuse to accept. Their relative smallness, however, proves that the polar compression is not very great, as may be seen from the following figures, which give the polar and equatorial diameters respectively :—

Equatorial diameter	41,852,864 feet.
Polar diameter	41,738,710 ,,

The surface of the Earth contains about 196,626,000 miles, and its mass 259,800,000,000 cubic miles. That is : conceive a cube, exactly a mile in length, breadth, and height. It would take 259,800,000,000 of such cubes to form a globe of the same magnitude as that on which man lives, and moves, and dies. The mean equatorial diameter of the Earth, according to the new value, is 7901 miles.]

Among the great achievements of triangulation, the most celebrated is that which was completed in France towards the close of the last century, by the "Bureau des Longitudes," with the view of fixing a basis for the present metrical system. In this new system, designed to replace all the ancient weights and measures, an exact fraction of the length of the meridian was required for unity. It was needful, therefore, to determine that circumference with the utmost possible precision, and, consequently, to measure for a third time a portion of the meridian of Paris. To DELAMBRE and MECHAIN* was entrusted the task.

And it was a task neither easy nor without peril which these two intrepid geometers undertook. For at this epoch the French revolution had filled every mind with a feverish, vehement restlessness, which regarded with cruel and suspicious eyes the slightest move-

* [Jean Baptiste Joseph Delambre, author of the "History of Astronomy, was born at Amiens, 19th December 1749, and died at Paris, 19th August 1822. Pierre François André Mechain was born in 1774; died, 20th September 1805.]

ment, the most trivial operation out of the track of ordinary life. Delambre and Mechain, while laying their surveying chains along the ground, were frequently arrested and imprisoned in the municipal dungeons as "suspects," and became the involuntary victims of the mistrust of a people uneducated in the art of the engineer. Wholly absorbed in their peaceful labours, our two geometers remained strangers to the agitation which raged around them, and which, on more than one occasion, endangered their lives.

Delambre had not yet completed the system of triangulation between Dunkirk and Rodez, when he was excluded from the *Commission du Mètre*, and only obtained permission, as a favour, to finish himself the portion of the work which he had undertaken. Meanwhile, Mechain, arrested at Barcelona owing to the war which had suddenly broken out between France and Spain, determined the latitude of that town, and ascertained that that of Mont Jouy * was three and a quarter seconds greater than the result he had forwarded to the Académia. This fatal error he durst not divulge, for fear of prejudicing the character of all his calculations, and the secret preying upon his mind, doomed him to a premature death. But when we reflect on the difficult conditions under which Delambre and Mechain pursued their trigonometrical labours—when we consider that they required to devote as much care and caution to the preservation of their lives and liberty as to the conduct of their measurements and angular surveys, we can easily excuse the error which cast a fatal shadow over the last days of the French geometer.

BIOT and ARAGO,† two names of imperishable renown in the annals of science, were entrusted with the responsibility of concluding Mechain's task, and brought it to a successful termination in 1806 to 1808. The reader will probably be familiar with the stirring story of Arago's sufferings; how he was regarded as a spy in the Balearic

* [A fortified hill, south-west of the town, which commands the harbour.]

† [Jean Baptiste Biot was born at Paris, 21st April 1774; and died 3rd February 1862. His great works are "Traité Elementaire d'Astronomie Physique" (Paris, 1805); and "Traité de Physique" (Paris, 1816).—Dominique Arago, born at Estagel near Perpignan, 26th February 1786, died 3rd October 1853; will be remembered as the founder of "chromatic polarization," and for his discoveries in electro-magnetism.]

Islands, made prisoner by the Spaniards, then thrown into servitude on the coast of Barbary, restored to liberty through diplomatic intervention, and, finally, how he returned home, after so many mischances, in possession of his instruments and papers.

The new measurement of the arc of the meridian which traverses France, gave for the length of a quarter of the meridian 5,130,740 toises.* This number served as the base of the metrical system, legally constituted in 1799.

The mètre (= 39.3079 inches Eng.), the fundamental unit of the present system of weights and measures, is the ten thousandth part of the quarter of the meridian; its length has been fixed at 0.513074 toise, or 3 French feet, 11 lines. We are compelled to add that the figure obtained for the length of the meridian has since been somewhat modified. If the mètre is no longer, in strictness, the natural unit, it does not the less remain a measure perfectly defined by the fundamental standard (*étalon*), and the system of which it is the base must always be regarded as one of the finest conceptions of the human mind.

The metrical system is now in operation in France, the Low Countries, Italy, Switzerland, Spain, and Portugal, and its introduction into England and America will probably not be long delayed.

Cassini de Thury, the third of his name [born, 1714; died, 1784], the same who laid down the great map of France, conceived the idea of measuring the parallel which extends from Strasbourg to Vienna, by means of thirty-eight gunpowder signals, whose respective positions should be previously decided upon; but this great operation was not carried out until our own times.

In 1804, the French Government commissioned Colonel Henry, who had skilfully executed the triangulation of Switzerland, to perform the experiment. As the point of departure of his operations, Henry measured a base of remarkable length. He afterwards laid

* [The toise is here the length of the *étalon de fer* (or iron standard), which Condamine and Bouguer had employed in measuring the meridian of Peru; it is called the *toise du Pérou*.]

down a chain of triangles in the direction of the meridian, by Geneva and the Alps; this was the commencement of the grand French trigonometrical surveys which have only recently been concluded.

From this rapid historical sketch the reader will perceive that, since the epoch of Newton, our men of science have not rested from their efforts to arrive at an accurate determination of the Earth's figure. All the resources of geometry and astronomy have been called into requisition; and the precision of measurement has everywhere been carried to an extraordinary degree. The labours of these ardent minds, wholly and enthusiastically devoted to science, and a great part of whose career has been consecrated to such arid researches, are unknown to the public: is a brief allusion to their work a sufficient recompense for a life of sacrifice, suffering, and unremitting toil?

[It may not be; but such earnest spirits find their best reward in the very nature and character of their pursuits. The acquisition of knowledge, says Halifax, has a pleasure in it, like that of wrestling with a fine woman. Its votaries feel the divine enjoyment which belongs to the worshipper of Brahma, or Vishnu, when he proves his devotion to his god by cheerfully undergoing the severest tortures. True scholar he will never be whose search after knowledge is dictated by any mean love of fame or power; who does not enter upon the struggle in all simplicity of soul; who does not feel that no recompense the world can give is equal to that which knowledge herself bestows.]

The result of the numerous geodesical and astronomical measurements made at different parts of the world, the aggregate of the great operations which we have so briefly glanced at, has brought us to a very rigorous estimate of the dimensions of the terrestrial globe. As we have previously placed the exact figures before the reader, it will be unnecessary to repeat them here.

These great trigonometrical experiments have not only served to determine the elements of the terrestrial spheroid, that is, to fix the value of the polar flattening and the actual dimensions of our planet;

they have also been immensely useful in facilitating the progress of that minuter and more local geography which we call topography. Geodesy has furnished the absolute and relative positions of a very great number of important points on the globe, with a precision previously unknown. It is in this way we have obtained the greater part of the geographical data which are yearly inserted, for the use of navigators and astronomers, in the collection entitled, "Connaissance des Temps" (answering to our English "Nautical Almanac").

Longitudes are sometimes expressed *by time.* Let us explain this last peculiarity.

The Earth rotating upon its axis in four-and-twenty hours, all these meridians successively pass under the sun during that period. Their differences can therefore be computed by the time which elapses between the passage of two meridians before the sun (or between the passages of the sun at the two meridians, to employ the language of astronomers). Consequently, we may either say: two meridians differ by one hour, or (and this is better), they are fifteen degrees apart (one twenty-fourth of the circumference of the globe). An hour of longitude is equal to fifteen degrees; one minute of time to fifteen minutes (15′), of the arc; one degree to four minutes of time, and so on.

The difference of meridians or of longitudes may be determined astronomically by the observation of instantaneous phenomena which are reported at the solar hour. Signals effected by the ignition of gunpowder, or by the electric telegraph, are means of instantaneous observation; for the swiftness of light and electricity may be regarded as infinite. A signal given at Greenwich, by electric telegraph, is observed in Paris, despite of distance, at the very moment of its departure. Therefore, if we note at Paris the arrival of the telegraphic signal sent from Greenwich, we obtain by this means the desired longitude. If, for example, a signal despatched from Greenwich at noon should be observed at Paris at 9 min. 21 sec. past noon, it follows that the sun had already quitted the meridian of Paris nine minutes and twenty-one seconds, when it was on the meridian of Greenwich; or, in other words, Greenwich is nine minutes twenty-one seconds west from Paris.

It was by this method that Professor Airy, the Astronomer Royal, and M. Le Verrier, Director of the Imperial Observatory of Paris, determined, in 1858, the exact difference of longitude between Paris and Greenwich.

The further eastward any locality lies the earlier will it have the sun. Any place one degree east of London will have the sun four minutes earlier than will London; any place one degree west, four minutes later.

[Places situated at the extremities of the same diameter of the globe we call *Antipodes* (Greek, αντι, over against, and πους, ποδος, a foot). They must necessarily be on one and the same meridional circle, but separated from each other by half the circumference. They must differ in longitude, therefore, exactly 180°; but their latitude will be the same, except that while one is northern, the other will be southern, and *vice versâ*. Thus: London is in lat. 51° 30′ *N.*, and long. 0° 5′ W. Its antipodes, therefore, must be in lat. 51° 30′ *S.*, and long. 180° 5′ W., or rather 179° 55′ E.; coinciding pretty closely with a small island to the south-east of New Zealand, and known as *Antipodes Island*. The antipodes of Paris will be in about lat. 49° S., and long. 177° 40′ E. That of Edinburgh lies in lat. 55° 57′ S., and long. 183° 11′ W. (= 176° 49′ E.)

We shall close this section with a few words on Globes and Maps.

The most natural method of representing the surface of our earth is by constructing an artificial globe, on which we indicate the relative positions of places by means of their latitudes and longitudes.

[These globes are usually hollow spheres of cardboard, india-rubber, or gutta percha, coated with a composition of whiting, glue, and oil, on which paper, properly delineated, is laid, coloured, and varnished. In order to adapt the plane surface of the plane to the curvature of the sphere, it is printed in pieces; small circles for the Arctic and Antarctic regions, and the rest in lens-shaped gores, which vary from 20° to 30° of longitude. Great care is requisite to prevent these from overlapping, and yet to bring their edges accurately together.

FIG. 34.—A TERRESTRIAL GLOBE.

In maps, a larger or smaller portion of the Earth (or heavens) is delineated on a plane surface, according to a certain definite scale, and with as much accuracy as the mode of delineation renders possible. But as the Earth is spherical, no considerable area of it can be represented on a plane without distortion. To remedy this grave defect, geographers employ certain methods of representation called *projections*, which are of five kinds: the orthographic, the stereographic, the globular, the conical, and Mercator's, or the cylindrical. In the *first* of these, the eye is supposed to be at an infinite distance from the Earth's centre, so that all rays of light proceeding from every point in its surface are parallel and perpendicular. The effect of this projection is to give the central parts accurately, but towards the circumference to diminish the countries in size.

In the *stereographic*, the eye is assumed to be placed on the surface of the sphere *opposite* the one to be represented. The centre of the map is, therefore, contracted, and the circumference enlarged.

The *globular* is a modification of the two former, and supposes the eye to be removed from the surface to a distance equal to the sine of 45°.

The *conical projection* is, however, the more accurate, because the cone approaches nearer to the character of the sphere. Any portion of the sphere between two parallels not very remote from each other corresponds closely with a similar conical zone.

Mercator's projection is based on the fact that as all meridians on the globe are great circles passing through the poles, consequently the north and south points at any place correspond with the poles of the earth. In Mercator's chart all the meridians are drawn as straight lines *perpendicular* to the equator, and all the parallels of latitude as straight lines *parallel* to the equator. This necessarily gives a disproportionate magnitude to the polar regions; but the distortion is rectified, as far as the position of places is concerned, by increasing the degrees of latitude commensurately with those of longitude.]

CHAPTER II.

DISTRIBUTION OF THE LAND ON THE SURFACE OF THE GLOBE—POSITION AND OUTLINE OF THE CONTINENTS—MAP OF THE WORLD—OCEAN, AND ITS DIVISIONS.

THREE forms of matter divide among themselves the surface of the terrestrial sphere. The *gaseous*, represented by the atmosphere and the clouds, envelops and surrounds its mass; the *liquid*, that is to say, the ocean, covers nearly three-fourths of its entire area; and, finally, the *solid*, or "terra firma," is distributed over about one-fourth.

It is worthy of remark that all matter condenses in proportion as we approach the centre of the Earth. Externally, the "world of air" encircles and enshrouds our globe as with a light transparent mantle; next come the waters, considerably heavier than the air; and, last of all, the solid rocks, which, as they lie nearer to the centre, also increase in density. It is a well-established fact that the materials of the most ancient eruptions, such as granite,* are less dense than the more recent igneous rocks, such as the trachytes and the basalts. Thus the materials occupying the interior of the globe augment in weight in the same ratio as we approach the centre; and there may come a time when the Earth shall pour forth from her "torn entrails" eruptions of far heavier matter than even those which at present we regard as the heaviest—namely, gold and platinum.

The study of the complex phenomena of the air is called *Meteorology*, and it is, perhaps, the least advanced of the sciences. It interprets for us the signs and warnings of the clouds, and the pregnant language of the atmosphere, as conveyed to our eyes by means of the barometrical column.

* [The reader should here be reminded that some eminent geologists have lately put forth the theory that granite is not an *eruptive* but a *sedimentary* rock.]

Geology brings us acquainted with the nature of the various strata that compose the terrestrial crust; it penetrates into the profundities of the globe, to enlighten us respecting its progressive formation and different modifications.

[*Physical Geography*, as an eloquent writer remarks,* is a description of the earth, the sea, and the air, with their inhabitants animal and vegetable, of the distribution of those organized beings, and the causes of that distribution. "Political and arbitrary divisions are disregarded, the sea and the land are considered only with respect to those great features that have been stamped upon them by the hand of the Almighty, and man himself is viewed but as a fellow-inhabitant of the globe with other created things, yet influencing them to a certain extent by his actions, and influenced in return."]

In the present work we shall confine ourselves to an examination of the superficial forms of the Earth, which, perhaps, may be justly entitled Physical Geography *proper*. We shall commence by considering the relative distribution of the continents and the waters.

In the early ages of our young world its surface was entirely covered by the primeval ocean. The formation of the continents by marine sediments, or by eruptions from the terrestrial interior, has since confined the waters within the great depressions of its solid crust—that is, its principal *basins*.

Strictly speaking, there exists but one single ocean, one single continuous liquid mass, spread all around the Earth, and bathing without interruption the icy shores of the two opposite poles. All the mediterraneans, the gulfs, the bays, the channels, are but detached, not isolated, portions of this universal sea. It is only, then, in deference to long-established custom, and to facilitate our daily usages, that geographers distinguish so many separate oceans, with their innumerable branches and ramifications—bays, straits, rivers, and streams.

* Mrs. Somerville, "Physical Geography," vol. i. chap. 1.

Water is, to some extent, a bond or link between the atmosphere and the solid earth. In fact, it frequently changes its physical condition, and approximates one or the other of two extreme forms: it is reduced into vapour, and rising towards the sky, accumulates in clouds; or it solidifies into ice, and in this state hems in the continents, whose extent it increases.

The quantity of water which exists on the earth is not known to us with any degree of certainty. Notwithstanding recent experiments, we have not ascertained the greatest depth of the ocean; for there are points, as in the Southern Ocean, where it has been impossible to reach the bottom, although soundings have been carried down to 46,236 feet (in lat. 36° 49′ S., and long. 37° 6′ W.) We shall enter into details upon this subject in another chapter.

It is generally admitted that the vertical height of the stratum of air which surrounds the earth, and which follows it in all its movements through space, is about 45 miles. But there is nothing precise in this estimate. All that we can with safety affirm is, that it is impossible to rise in a balloon higher than six or seven miles.*

The thickness of the earth's crust is about 73,000 yards. The ratio of this thickness to its entire diameter is that of the yolk to the mean diameter of the egg. The greatest depth to which man can penetrate does not exceed 3000 feet; that is, about a one-hundred-thousandth part of the terrestrial radius. What we really know of the planet of which we call ourselves the lords is only equivalent on an artificial globe of four and a half feet in diameter to .00393707904 of an inch,—that is, to the thickness of a sheet of paper. Earth, therefore, is known to us very imperfectly. Let us add, nevertheless, that the rocks vomited by volcanoes are projected from very considerable depths, and that these erupted products afford us indisputable specimens of strata of the globe lying very near its central nucleus.

* [One of the most remarkable balloon ascents was that accomplished by Messrs. Coxwell and Glaisher, September 5, 1862, when they reached the elevation of 5¾ miles. Both of the daring aeronauts nearly perished. Gay Lussac, September 15, 1804, ascended to the height of 22,977 feet. Perhaps the greatest distance ever traversed by a balloon was the journey of 1150 miles, achieved by Mr. Wise, an American, in June 1859.]

The total superficies of the earth amounts, as we have already stated, to about 150,000,000 square miles, or 41,000 square degrees. The water occupies nearly three-fourths, or 30,000 degrees; the dry land covers an area of upwards of one-fourth, or 11,000 degrees—nearly 38,000,000 of square miles.*

Much uncertainty prevails as to the exact territorial extent of the continents, the labours of modern geometers daily introducing important changes into the estimates put forward in our geographical treatises. It was thus, for example, that at the commencement of the present century the map of the Ottoman empire was so modified by the astronomers Beauchamp and Zach, that the territory of the Sultan gained an addition of 500,000 square yards.

[Taking as our guide the map of the world as laid down by Berhaus and Keith Johnston, in their Physical Atlas, we arrive at the following conclusions:—That Africa is about three times larger than Europe, America four times, and Asia five times. The great continent—by which we mean Europe, Asia, and Africa—has an area of 24,000,000 square miles, while the extent of the New World is 11,000,000, and that of Australia, with its islands, scarcely 3,000,000. The superficies of the continents is twenty-three times greater than that of all the islands taken together. The following table may be of assistance to the reader, since it gives a more precise estimate:—

	Area in Square Miles.
Europe.	3,700,000
Asia,	17,500,000
Africa,	12,000,000
America, North.	8,600,000
America, South.	7,000,000
Australia,	3,00,0000

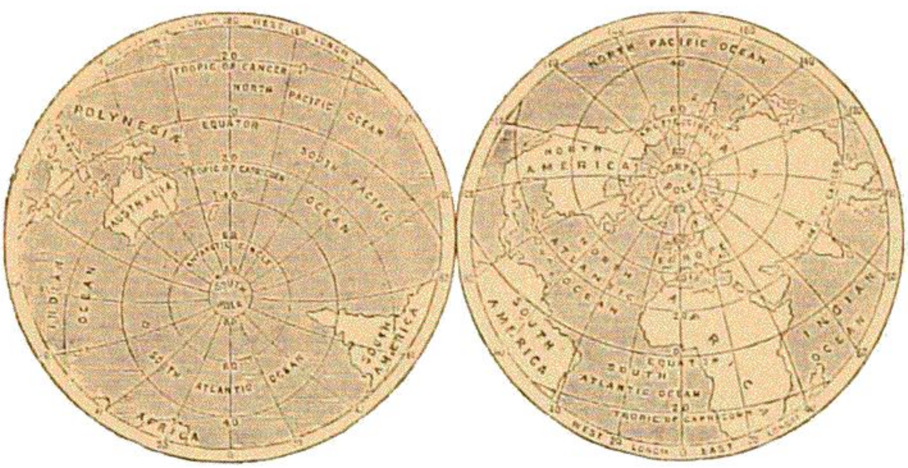
The distribution of the land is, however, very unequal. One half the earth is almost wholly covered with water; in the other, land largely predominates; so that we may, not inaccurately, speak of an *aqueous* in opposition to a *terrestrial hemisphere.* The quantity of land in the northern hemisphere is, in fact, three times greater than in the southern, as the most cursory glance at a map of the world will show the reader. In the latter it occupies only one-sixteenth of the area between the Antarctic Circle and the thirtieth parallel of south latitude; while between the Arctic Circle and the corresponding parallel of north latitude the extent of land and water is nearly equal. Let us suppose our earth divided into two hemispheres by a meridian passing through the island of Teneriffe: what is the result? That to the *east* of this imaginary demarcation the land greatly predominates; and to the *west* the water.

From this startling inequality it arises that England, as Sir John Herschel, we believe, first pointed out, is nearly in the centre of the greatest mass of land; and London, therefore, becomes the natural focus, as the industry of its sons has made it the artificial capital, of the civilized world. Our antipodes, or, roughly speaking,

* [According to Mr. Gardiner's computations, the extent of land is about 37,573,000 square British miles, independently of the South Polar continent; and the sea occupies 110,849,000. Hence the sea is to the land as 4 to 1 nearly.]

New Zealand, is in the centre of the greatest mass of water. Hence a person raised above Falmouth, which is almost the geographical central point, until his gaze could comprehend an entire hemisphere, would see the greatest possible expanse of land; while, if he were elevated to the same altitude above New Zealand, he would survey the greatest possible extent of ocean. In fact, as Mrs. Somerville remarks, only one twenty-seventh of the land has *land* directly opposite to it in the antipodal hemisphere, and under the equator five-sixths of its circumference is water. It may be observed that the effect of this arrangement has been to facilitate the intercourse of nations, and to expedite the progress of humanity in art, science, literature, and religion. Had Asia been separated from Europe by an ocean as vast as the Atlantic, or Egypt from Greece by such a barrier of water as divides Spain from Mexico, how slow would have been the march of civilization! A Columbus, at this very epoch, might be venturing across the unknown seas to reveal to Europe and America the existence of an Asiatic continent! Or, as we owe our religion and our learning to Asia, Europe might still be involved in a worse than Cimmerian darkness.]

In the *aqueous hemisphere*, delineated in the accompanying illustration, the earth appears like islands scattered over the surface of the water; in the *terrestrial hemisphere*, the seas appear like close basins surrounded by the earth—like, for instance, the Mediterranean and the frozen ocean of the North Pole. The geographers of the eighteenth century, to explain this striking inequality, supposed the existence of some great Austral continent, which counter-balanced the



Aqueous Hemisphere. Terrestrial Hemisphere.

FIG. 35.—HEMISPHERES, AQUEOUS AND TERRESTRIAL.

mass of the northern lands. But the voyages of Captain Cook [1772–75] put an end to these speculations. That illustrious navigator proved that what had been mistaken, at the south pole, for *the promontories of a continent, were but small islands, or floating* fields of ice.*

The outline of the terrestrial hemisphere is only twice interrupted by the sea, in the vicinity of the north and south poles.

This outline forms, as it were, a vast belt of coast around the globe, an *amphibious zone*, participating in the climatic conditions both of the continents and the seas. Starting from the Cape of Good Hope, it strikes across the equator, touches the eastern and southern borders of Asia, circles the north pole, and descends along the western coast of America to Cape Horn. It forms on the earth a great circle inclined towards the equator, like the ecliptic to the celestial equator. It plays, to a certain extent, an analogous part to that of the temperate zones, which represent the passage from the torrid to the glacial climate; the riverine zone is the reunion of the continental climates and of the maritime climates of the islands. This intermediary situation gives birth to an organic life, richer and more varied than exists in other regions of the globe.

A fact well worthy of notice is, that the structure of the great continents—"the pyramidal form of their extremities," as Humboldt calls it—is in some measure radiated towards the south. Towards the north, the great masses of land converge and accumulate; on the other hand, in the direction of the south, they open out like a fan, and terminate in points or in conical peninsulas. The south of Europe exhibits a similar disposition; it is cut up into wedges, pointed southward, as Spain and Portugal, Italy and Greece. The continents of Africa, South America, and Greenland, are, in truth, gigantic peninsulas. In Asia, the Indian and Indo-Chinese peninsulas; in North America, those of Kamtschatka, Corea, Florida, California, and Alaska, have a southern direction.

[It may be further observed that at the extremity of most peninsulas lies an island, or group of islands, as Tierra del Fuego at the base

* [It is not, however, improbable that a considerable extent of land *does* surround the *south pole, in the shape of a continent of uninhabitable ice and snow.*]

of South America; Sumatra and Banca in connection with Malacca; India with Ceylon. A chain of islands, in like manner, stretches from the end of the peninsula of Alaska, and a group is planted off Greenland; while close to the foot of Italy is situated Sicily, the ancient *Trinacria*. It has been remarked as another peculiarity in this peninsular conformation, that it generally terminates with bold abruptness in a promontory or mountain. Cape Horn, the last off-shoot of the Andes, guards the extremity of South America; Table Mountain and the Cape of Good Hope, that of the African continent; Australia ends with South-East Cape in mountainous Tasmania; in India, the Ghauts extend their lofty range to the sea at Cape Comorin; and the ultimate point of Greenland is the barren but lofty bluff of Cape Farewell.

The cause of this peninsular configuration is unknown; but we do not think it presumptuous to conjecture that it was designed by an all-wise Creator to promote civilization and commerce by increasing the amount of available coast-line. And it will be found that the greatness—moral, intellectual, and material—of a country, depends upon this very circumstance. Look at Greece, in the ancient; at Great Britain, France, and the Low Countries, in the modern world. That continent which exhibits the greatest mental activity on the part of its inhabitants, is Europe, which, in proportion to its area, possesses a greater extent of littoral than any other quarter of the world. Its coast-line from the Straits of Waigatz, in the Polar Ocean, to the Strait of Kaffa, at the entrance of the Sea of Azov, is about 19,500 miles. That of Asia measures about 35,000 miles; that of Africa, whose contour is singularly uniform, except perhaps at the Gulf of Guinea and in the Mediterranean, 16,000 miles; the American continent, 39,000 miles. In round numbers, the ratio of the number of square miles in the extent of surface, to the number of linear miles in the coast-line in each of those great portions of the globe, is 190 for Europe, 500 for Asia, 750 for Africa, and 416 for America.]

The general direction of the land differs, however, in the old and the new continents. America extends from one pole to another, while the Old World lies almost parallel to the equator. The most extended straight line which can be traced on the great continent, keeping as far as possible to the land, begins, according to Bergmann, under the 64th degree of northern latitude, near the mouth of the river Ponaschka, in the Gulf of Anady; traverses Lake Aral, and the southern part of the Caspian Sea; passes near the Persian Gulf and to the north of the Strait of Bab-el Mandeb; crosses Africa, following the Lupata Mountains, which were formerly called the "Backbone of the World;" and terminates at the Cape of Good Hope. It is 148 degrees, or 2400 miles in length, and cuts the equinoctial line at an angle of 65°, dividing the ancient continent into two nearly equal halves. On the new continent it becomes very difficult to draw an analogous line: which would have a length of 12,300,000 yards; following a broken line, we obtain an extreme of 18,200,000 yards from the north to the south of America.

Geographers differ greatly in their classification of the great waters. The following is recommended by its simplicity :—

[The *Arctic Ocean* extends from the North Pole to the Polar Circle. Situated between Asia, Europe, and America, it comprises a multitude of gulfs or bays. It is for a great portion of its surface a sea of ice—

"Here let the billows stiffen and have rest."

The *Atlantic*—so called either from Mount Atlas, or the fabulous island of Atlantis—divides the Old World from the New, and stretches from the Arctic Circle to Cape Horn. Its total area is 25,000,000 square miles. Its extreme breadth may be estimated at about 5000 miles; its narrowest part, between Cape St. Roque in Brazil, and the nearest point in Africa, measures 1600 miles. The greatest depth yet discovered is 25,000 feet, equal to 4¾ miles.

The *Pacific* Ocean, so named by its discoverer, Magellan, on account of its supposed tranquillity, lies between America on the east, and Asia, Malaysia, and Australasia on the west. Its greatest length from the Arctic, at Behring's Strait, to the Antarctic Circle, is 9200 miles; its extreme breadth in latitude 5° N. 10,300 miles; its area, 80,000,000 square miles, or about two-fifths of the whole surface of the earth.* Its form is that of a slightly imperfect rhomboid, and its surface is studded with numerous islands and archipelagoes, many of which, by their beauty of aspect, remind one of Tennyson's exquisite lines,—

* [Compare Professor Ansted, "Physical Geography;" Mrs. Somerville, "Physical Geography;" A. K. Johnston's "Physical Atlas."]

"Slides the bird o'er lustrous woodland, swings the trailer from the crag;
Droops the heavy blossomed bower, hangs the leafy-fruited tree—
Summer isles of Eden lying in dark purple spheres of sea."*

The first European who beheld the Pacific was Nunez de Balboa, in September 13th, 1513—

"Silent, upon a peak in Darien;"

the first who traversed it, Magellan, in 1521; its more celebrated explorers have been Captain Cook, Anson, Bougainville, La Perouse, D'Entrecasteaux, Cartier, Vancouver, Wallis, Krugenstern, Kotzebue, Dumont d'Urville, and Beechy.

The *Indian Ocean* may be defined as bounded southward by an imaginary line drawn from the Cape of Good Hope to the southernmost extremity of Tasmania. Its other limits are, Australia, the Indian Archipelago, Hindustan, Persia, Arabia, and Africa. It bifurcates, at Cape Comorin, into an eastern and a western branch—the Bay of Bengal and the Arabian Sea respectively. In latitude it extends from 30° N. to 43° 35′ S.; and in longitude, from 18° 29′ to 146° 12′ E. Its broad expanse is besprinkled with myriads of isles.

From a remote antiquity it was employed as a channel of communication between Arabia and Hindustan; but to Europeans it was first made known by Vasco de Gama, the Portuguese seaman, in May 1498. He again visited it in 1502-3.

The *Antarctic Ocean* holds the same relation to the south as the Arctic Ocean to the north pole. It is sometimes called the Southern Ocean, and comprises all the sea to the south of the Atlantic, the Indian, and the Pacific oceans. The most northerly isles comprised within its boundaries are New Georgia, at the mouth of the Atlantic, with its cliffs of eternal ice and snow; and Kerguelen's Land at the mouth of the Indian Ocean, whose sombre aspect is epigrammatically described by its secondary title of "The Island of Desolation."

The dreary Antarctic has been explored by Cook, Kerguelen, Wilkes, and Sir James Ross. The southernmost limit reached as yet is only 79°. Owing to the formidable difficulties of its navigation, it is less known than any other region of our globe; far less known than the Frozen Ocean of the north.] †

* Tennyson, "Locksley Hall."

† [Captain Cook discovered Sandwich Land in 1772-75; Captain Smith, of the brig *William*, New South Shetland, 1819; Captain Billingshausen discovered Peter's Island and the coast of Alexander the First; Captain Weddel, the Southern Orcades; Captain Bisco, Enderby's Land and Graham's Land, in 1832; Admiral d'Urville, La Terre d'Adélie, 1841; and Sir James Ross, Victoria Land (lat. 70° 31′ S., and long. 165° 28′ E.), in the same year.]

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BOOK III.

SURFACE OF THE GLOBE.

And every gulf, and every chasm old,
And every height, and every sullen depth,
Voiceless, or hoarse with loud tormented streams.

KEATS.

Blue, and baseless, and beautiful,
Did the boundless mountains bear
Their folded shadows into the golden air.
The comfortlessness of their chasms was full
Of orient cloud and undulating mist,
Which, when their silver cataracts hissed,
Quivered with panting colour.

RUSKIN.

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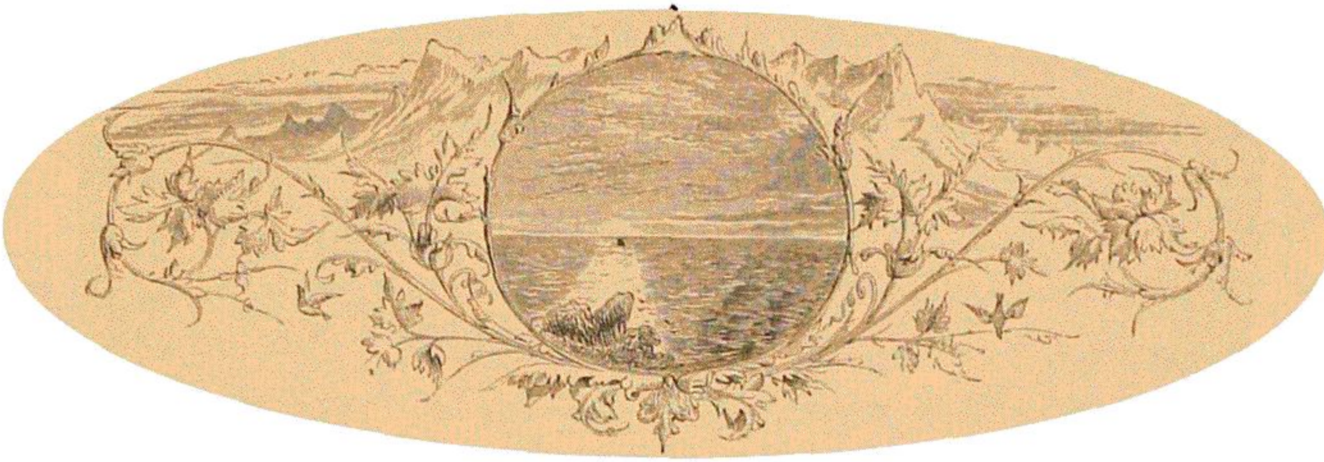

BOOK III.

SURFACE OF THE GLOBE.

CHAPTER I.

THE MOUNTAINS—PRINCIPAL MOUNTAIN-CHAINS OF THE GLOBE—DIFFERENT FORMS OF THE MOUNTAINS.

THE mountains which, at different points, and following a varying linear direction, relieve the surface of the earth, have been formed by two geological effects, each resulting from the same cause—the progressive cooling of the globe. The cooling of the terrestrial mass, the transition of a portion of the liquid interior nucleus into the solid state, by diminishing the volume of the internal aggregate, unduly enlarged its consolidated envelopment. Accordingly, this envelopment, or crust, has sunk at certain points and risen at others; it has produced *wrinkles*, and *folds*, and *protuberances* on the earth's surface. When an apple dries—that is, when it diminishes in size through the evaporation of its aqueous particles—its rind shrinks and shrivels; the image is a vulgar one, but it will explain to the reader the formation of mountains and valleys on the terrestrial crust when contracted by cooling.

This refrigeration of the interior mass of the globe, however, has not only produced ridges and wrinkles, but numerous fissures. The immense crevasses which, at certain epochs, yawned wide in the thickness of the terrestrial crust, were soon filled up by the slow or sudden irruption of the materials seething in the Earth's furnace; by granite, porphyries, basalts; and finally, by lavas. The Eastern Alps, for instance, have been formed, at a comparatively recent period, by the eruption of the *protogene*, of which Mont Blanc is composed, through the transition and secondary formations originally constituting the plains of the Alpine region. The Pyrenees are erupted masses of granite and serpentine, which, surging up from below, have elevated

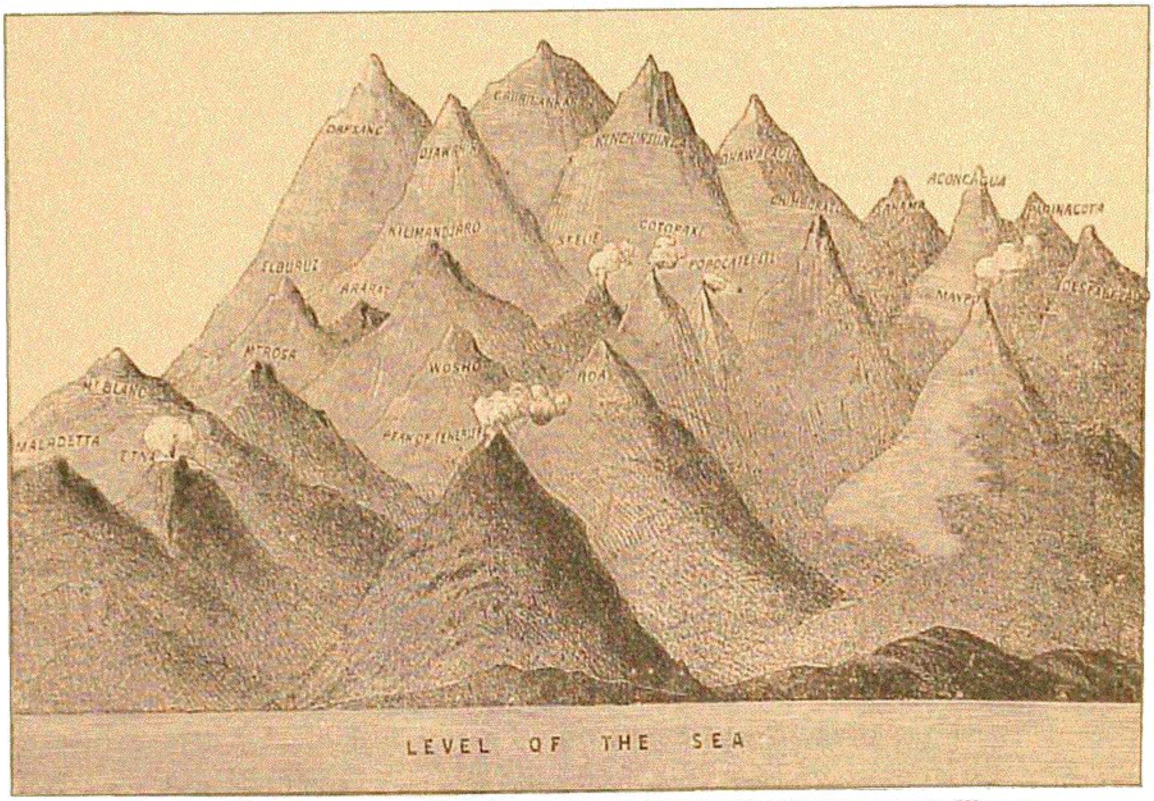

FIG. 36.—MAP SHOWING THE ELEVATION OF THE HIGHEST MOUNTAINS OF THE WORLD

and overthrown the cretaceous and tertiary rocks which formerly lay in horizontal strata in that part of the world, and have thus created the great Pyrenean chain.

Let us endeavour to form, in the first place, a general idea of the direction and relative position of all the mountain-ranges of our Earth.

Place yourself, for an instant, in the centre of the Pacific Ocean, at a great elevation above New Zealand, and direct your glances towards the northern stars. On your right lies America, on your left the coasts of Asia and Africa.

Southern Africa forms a vast table-land, whose three faces, the western, southern, and eastern, descend towards the sea in bold abrupt terraces, which are broken up by numerous clefts, and surrounded here and there by a few elevated peaks. The eastern escarpment of this great plateau, which stretches due north, having on the east Cape Guardafui opposite the Gulf of Aden, was considered by the elder geographers a vast mountain-plain, which they christened the Lupata Mountains, or "Backbone of the World;" but the name of Lupata, which signifies "a gorge," is only applied by the natives themselves to the group of rocks traversed by the river Zambesi. These mountains are clothed with noble forests; the plains with palm-tree groves; the river-banks with marish-plants and mangroves. Between Zanguebar and Cape Guardafui the African coast seems to be a ravine-intersected plateau, with no inferior mountains. The chains of Arabia Felix and of Persia run from south-east to north-west, and link themselves to the grand Asiatic range, which begins in Asia Minor under the name of Taurus, skirts the southern shores of the Caspian Sea, and, under the name of Hindu-Kush, joins the mighty mass of the Belor-Tagh ("Mountains of the Mist").

[This mass is spread over the countries of Koonduz, Budakshan, and Kafferistan. Seen from the south it appears composed of four distinct ranges running one above another, the last of which abuts on the great central table-land, and is so high that its snow-crowned summits are visible at the distance of 150 miles. A stupendous ridge encloses the fairy vale of Cashmere, to the east of which the chain assumes the well-known name of Himálaya, "the dwelling of snow." Its mean height is enormous, not less than 16,000 feet; while not a few colossal summits tower to the elevation of 29,000 feet.

More to the north runs the volcanic chain of the Thian-Shan, or "Celestial Mountains;" beginning at the Belor-Tagh, extending along the 42nd parallel, and sinking into the desert of the Great Gobi; whence it rises again under the name of Shan-Garjan, strikes to the north-east, and terminates on the shores of the Japan Sea.

The Thian-Shan attach themselves by various mountain-links to the Altai range, which stretch in a serpentine line to the Pacific, south of the Gulf of Okhotsk, dividing the high lands of Tartary and China from the frozen wastes of Asiatic Siberia. Under various names, its branches skirt the north-west side of the gulf of Okhotsk, and thence extending to Behring's Straits, project into the ocean at East Cape, the easternmost extremity of the old continent—the entire length of the chain being 4500, and its breadth varying from 400 to 1000 miles.

Crossing Behring's Strait, our survey next embraces the western coast of the New World, which throughout its whole extent, with but few intervals, is lined by a barrier of lofty mountains, occasionally retiring a short distance inland, but more generally bordering on the sea, and confronting its waters with stupendous cliffs. These are the Rocky Mountains of North America, and the Andes of South America. On the eastern coast the land slopes gradually towards the Atlantic, as is shown by the course of the great rivers. A range of moderate elevation, however, occurs in Brazil, and the Alleghany Mountains in the United States.

We now cross to Europe, where a mountainous zone, lying between the 30th and 45th parallels of north latitude, strikes across the continent from W.S.W. to E.N.E., from the coast of Portugal to the Ural Mountains. The Pyrenean chain, between Spain and France, is of moderate elevation. The Alps, which in Mont Blanc attain a culminating height of 15,759 feet, lie at the head of Italy, extending from the Gulf of Genoa to the Adriatic, and thence, under various names, running east till they join the Balkan, under the 18th meridian.]

The loftiest mountains of the world surround a vast basin, whose centre is occupied by a mass of level islands. The waters of this basin frequently bathe the foot of the chain which form their margin; but, at a few points, the mountains are separated from the sea by gradual slopes. The fertile regions of India and China extend between the rocky cincture and the Great Ocean; the peninsulas of Southern Asia are like so many fragments of the isthmus which

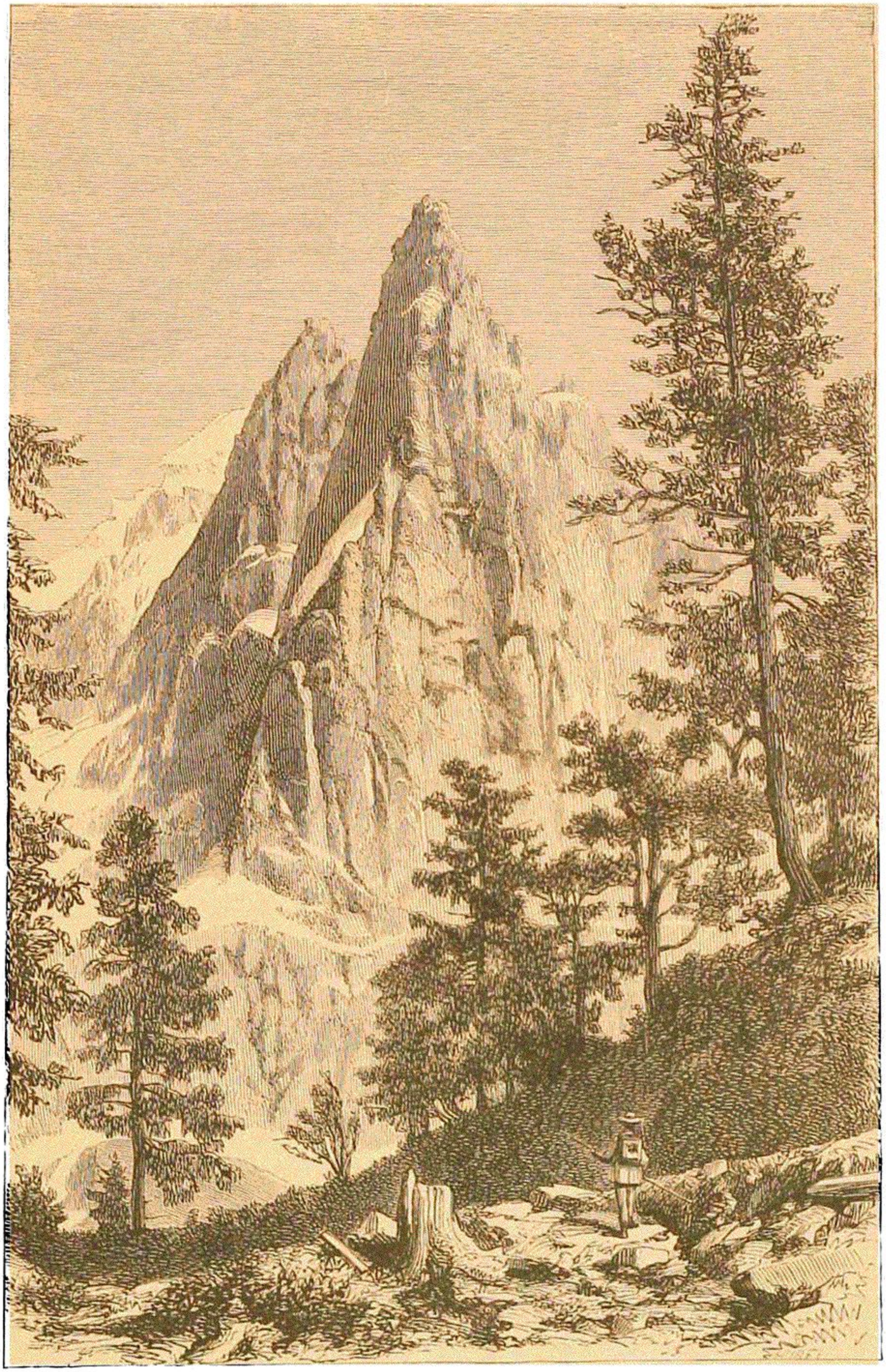

FIG. 37.—THE AIGUILLE DU DRU AND AIGUILLE VERTE, IN THE MONT BLANC CHAIN.

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connected them with the group of broken and dispersed lands filling the centre of the great basin, and of which Australia is the most important. They resemble the wrecks of a shattered continent.

The strata composing the soil of the continents gradually subside under the sea, re-appear on the other side, and in the interspace form the bed of the vast basins of the Pacific and the Atlantic.

The shores of the Atlantic by no means exhibit such bold escarpments as the eastern and western cliffs of the Pacific, with their chains of Cordilleras and Andes. The general inclination of the table-lands surrounding the Atlantic is much more gradual, and this sinuous basin, notwithstanding its vastness, seems but a stupendous canal or a colossal Mediterranean!

Having completed this rapid general survey, we may proceed to a more detailed examination of the different mountain-systems of the globe.

The terrestrial summits are far from being so lofty as those of the Moon or of the planet Venus; nevertheless, such peaks as Mount Everest and Guarisankar in Asia, exceeding 28,000 feet, present no contemptible aspect. Only the reader must not suppose that the protuberance of these masses sensibly affects the spherical form of the earth; since, as we have remarked in a preceding chapter, the greatest height of any known mountain does not exceed 29,000 feet, or about $\frac{1}{1500}$ of the diameter of the globe. Now, the diameter of an average-sized orange is from 4 to $4\frac{1}{2}$ inches, and this figure ($\frac{1}{1500}$) corresponds, therefore, to a wrinkle on the rind of about the thickness of a sheet of paper. But we must not forget that this calculation is based on the height of the loftiest mountains of the Earth. How shall we represent the ordinary mountain-chains, 5000 to 7000 feet high, in proportion to their exact dimensions, on a sphere of the size of an orange? They would be imperceptible. Despite, then, its valleys and its mountains, the Earth is perfectly rounded; the most skilful turner could not throw off his lathe so complete a sphere.*

* When we speak of the height of a mountain-chain, it is advisable to distinguish the elevation of the peaks and the mean elevation of the passes, or *cols*, which represent the

In speaking of mountains, we have frequently employed the word *chain*. What are we to understand by this term? A *chain* is a series of mountains, extending principally in a longitudinal direction. When the transversal dimensions of such a system become as considerable as those of its length, we define it as a *mass;* as, for example, the Harz, the Scotch Highlands, and the Ardennes.

One noteworthy fact is this: that in proportion to the loftiness of a mountain-system will be the broken character of its summits, the depth of its valleys and ravines, the steepness of its precipices, and the rapidity of its slopes.

The flanks of a mountain-chain are termed its faces, or *versants*, because they are regarded as the starting-point of the waters which diverge or descend into the valleys and plains.

The two flanks, or slopes, often present the most remarkable differences; while one may sink with a gentle and gradual inclination, the other will be rudely scarped, rough, and precipitous. For example: the Alps descend much more rapidly on the Italian side than on that of France or Switzerland. Mount Lebanon offers a very gentle declivity towards the Euphrates, but opposes a steep cliff towards the Medi-

actual height of the backbone or ridge of the mountains. From Humboldt ("Kosmos," v.) we borrow the following data referring to the principal chains of the globe, adding the elevation of their base above the level of the sea:—

HIMALAYA.	Feet.	ALPS.	Feet.
Kinchinjanga, ...	27,900	Mont Blanc, ...	15,600
[Colonel Waugh, ...	28,178]	[Piedmontese Survey, ...	15,739]
Ridge, ...	15,500	Ridge, ...	7,600
Base (at Delhi), ...	975	Base, ...	1,300
CORDILLERAS, OR ANDES.	Feet.	PYRENEES.	Feet.
Aconcagua, ...	23,700	Mont Maladetta, ...	11,300
[Admiral Beechey, ...	23,910]	[Annuaire du Bureau des Longitudes,	10,886]
Ridge, ...	11,700	Ridge, ...	7,920
Base (sea-level), ...	100 to 300	Base (sea-level), ...	2,200

Thus, in the Alps—and also in the Caucasus—the height of the entire mass is double the mean elevation of the passes; in the Cordilleras of Quito and the Himalaya Mountains, the ratio is that of 9 to 5; in the Pyrenees, that of 3 to 2. The Pyrenees are the least accessible rampart in Europe; the Alps, on the contrary, while offering the deepest depressions, are much easier to traverse.

The preceding figures are those laid down by Humboldt in 1825. According to recent measurements, some modifications should be made, but they will suffice to give an idea of the comparative height of the principal chains.

Subjoined are more exact valuations of the same heights. The brothers Schlagintweit have given the following comparisons for the Himalayan, the Karakorum, and the Alpine ranges.

HIMALAYA.	Feet.	KARAKORUM.	Feet.	ALPS.	Feet.
Height of Guarisankar, ..	28,730	Height of Dispang, ...	28,000	Height of Summit (average),	15,630
Passes of Do., ...	17,640	Passes of Do., ...	18,525	Do. of Passes (average), ..	7,475

We owe to Berghaus the following estimate of

THE ANDES.	Feet.
Chimborazo (summit), ...	20,020
[Humboldt, ...	21,424]
Western Passes, ...	14,305
Eastern Passes, ...	13,300
Average Elevation, ...	13,927

terranean. This general correspondence of structure is readily explained by the theory respecting the geological formation of mountains, already discussed in these pages. The point at which the matter was suddenly erupted from "the bowels of the earth" presents a steep and abrupt face, while the rocks which have been raised over a wide area, starting from this point, sink with a slow and gradual decline, according to their distance from the centre of elevation; hence one abrupt and even precipitous side, and another with a prolonged slope. A similar effect is also produced when the mountains result from a simple break or "fold" in the terrestrial crust; if you raise a fold in a piece of cloth, one side will be comparatively steep, the other smooth.

[It should be remembered, however, that our vision plays fantastic tricks with our judgment in calculating the steepness of a declivity. Precipitous as the Alps appear to every traveller, and toilsome as is their ascent, they do not possess a single rocky face of 1600 feet in perpendicular height, or a vertical slope of 90°. None who have gazed upon the soaring sides of Mont Blanc, in the direction of the Allée Blanche, have failed to shudder at its apparent terrors; yet the declivity does not really amount to 45°; and the mean inclination of the Peak of Teneriffe, which, from the sea, appears like a colossal pyramid, the sepulchre of the Titans of the old mythology, does not exceed 120° 30′. The nearest approach to perpendicularity of any great height yet known is the Silla of Caraccas, which rises grandly from the Caribbean Sea, at an angle of 53° 28′, to an altitude of nearly 7000 feet.

The variety observable in the summits of mountains is very curious, and scarcely less suggestive to the geologist than to the artist. The general form and outline of a rock depends in no small degree upon its composition and internal structure, and upon the manner in which it is affected by atmospheric influences. The geological character of a mountain may often be inferred from its configuration. Thus, dolomite usually assumes a serrated form, like the teeth of a saw, whence the *Sierras* of Spain; crystalline schists shoot upward in pointed circular spires, like the Alps; calcareous rocks are smoothly rounded, as every traveller among the Sussex downs will have noticed; slates and quartziferous schists break up into triangular wedge-shaped masses; serpentine and trachyte are strangely bent and contorted; phonolites take a pyramidal outline; basalt is reared in shapely columns, and trap in dark sombre walls; while volcanoes are indicated by truncated cones and craters.]

We distinguish, in one and the same mountain, the *foot* or *base*, which reposes on the undulations of the plain; next, the *flanks;* and, finally, the *summit*, *crest*, or *crown;* sometimes, when the elevation is roof-shaped, we call it a *ridge*.

The denomination "mountain" is not usually given to elevations of less than 1500 feet, but no rigid accuracy has been observed in its employment. To the Alpine chamois-hunter the mountains of Scotland seem insignificant heights; to the Scotch peasant the Wharfedale, the Ingleborough, and the Skiddaw, are little better than hills.

Nothing, as we have said, is more infinitely varied than the form of the mountains, and consequently an immense variety of denominations describes their different shapes: thus, "peaks," "needles," "domes," "paps," and, in French, *dents*, *quilles*, *cornes*, *tours*, *mamelons*, *trompes*, *brèches*, and the like. That the reader may the more vividly conceive an idea of these various and characteristic configurations, we shall give a few examples, and call to our aid the artist's pencil in illustration.

Of the spiry, needle-like mountain summit, an impressive example is *Mont Aiguille*, in the Dauphiné.

In the chain of Mont Blanc a series of peaks are appropriately named Aiguilles (or needles): as the *Aiguille de Charmoz*, the *Aiguille du Dru*, the *Aiguille Vert*—needles of bare and almost perpendicular rock, soaring from fields of snow and rivers of ice to an elevation of 14,000 feet. In Figure 37 we represent the *Aiguille du Dru* and the *Aiguille Verte*, both of which fling their coldly serene shadows on the rugged crystalline surface of the *Mer de Glace*.

FIG. 38.—THE MER DE GLACE, OR SEA OF ICE, WITH ITS AIGUILLES.

[Another mountain, with a toothed or dentelated peak, is *Mont Cervin*, which overlooks both the French and Italian slopes of the great Alpine range. This, the *Matterhorn* of the Germans, and the *Monte Silvio* of the Italians, forms the dominant mass of the Pennine chain, about 40 miles E.N.E. of Mont Blanc, and between the Valais

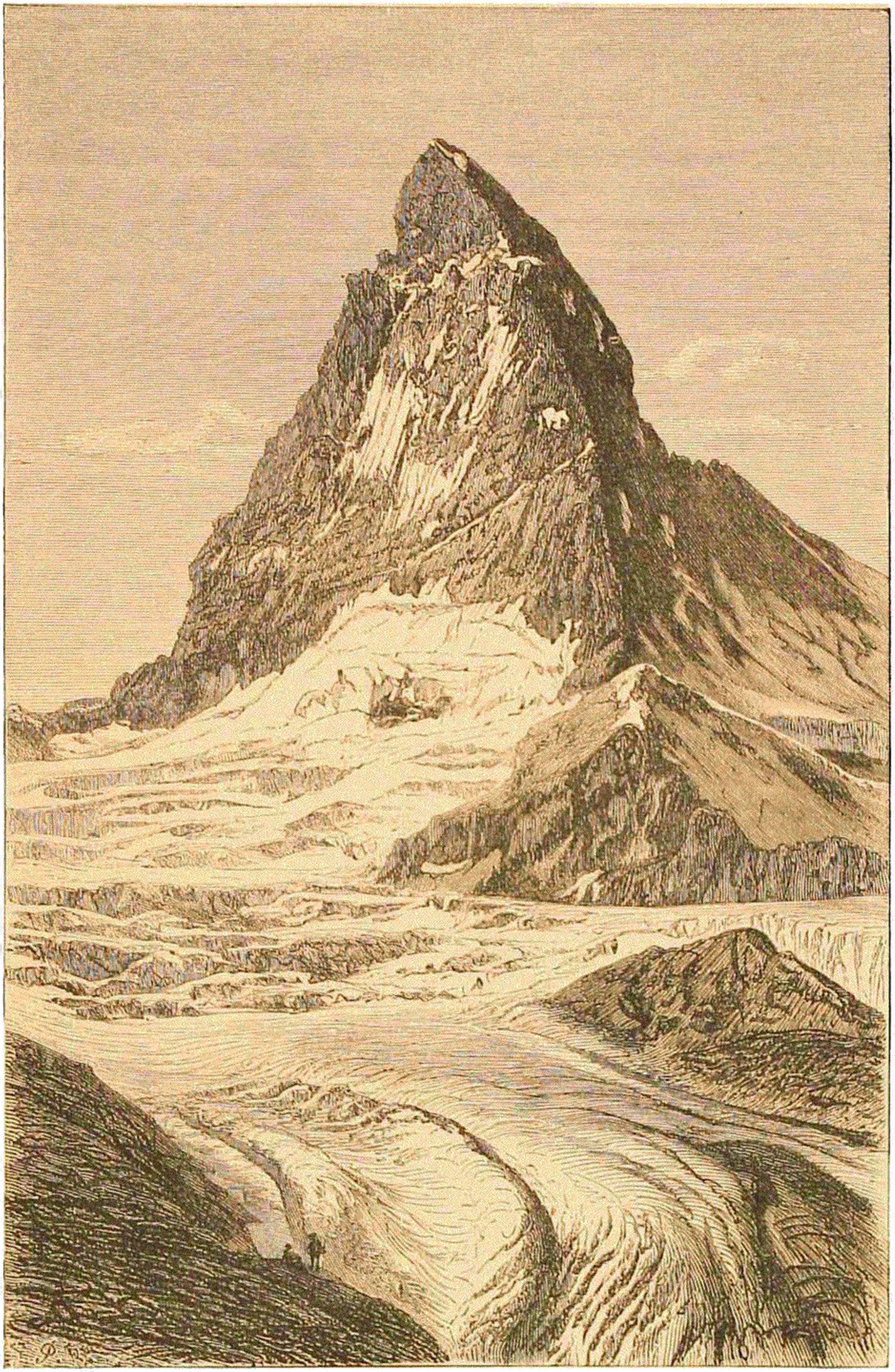

FIG. 39.—MONT CERVIN (THE MATTERHORN), IN THE PENNINE ALPS.

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of Switzerland and the Val d'Aosta in Piedmont. Above an unbroken line of steel-blue glaciers, 11,000 feet high, it rears an almost inaccessible obelisk of rock to a total elevation of 14,836 feet, forming one of the grandest memorials ever raised by Omnipotence to its own honour.]

In 1865 the conquest of this virgin summit was attempted by four English tourists, but their enterprise terminated in a melancholy catastrophe. It was on the 15th of July that Lord Douglas, Messrs. Hadow, Hudson, and Whymper, accompanied by three guides, undertook this perilous adventure. They succeeded in gaining the summit, and after remaining there some time they began the descent, each person being fastened to the other by a long rope. On arriving at a peculiarly dangerous portion of their journey Mr. Hadow lost his footing. He fell, and in his fall dragged down his companions. The guide who came last, with his pole, had just time to fasten the end of the rope round a projecting crag. Unhappily, the weight of the four persons in advance caused the rope to break between the third and fourth of the party. Mr. Whymper alone was saved. Our three countrymen, and one of the guides who led the way, were precipitated from rock to rock, from a height of upwards of 3000 feet.

This calamity produced a very powerful impression, not in England only, but on the Continent. It seems to us, therefore, that the reader will not be displeased if we supply a more detailed narrative of it, based on the tale told by Mr. Whymper, the survivor, in the columns of the *Times*.

On Wednesday morning, July 12th, Mr. Whymper, accompanied by Lord Francis Douglas, crossed the Col (or Pass) of St. Théodule, for the purpose of procuring guides at Zermatt. After emerging from the snows on the northern side, they skirted the base of the Great Glacier, passed the Furgge glacier, and left their tent, ropes, and other *impedimenta* in the little chapel which stands near the Lac Noir. Thence they descended to the aforementioned village, and engaged the services of Pierre Tauggwald, authorizing him to procure a second guide.

In the evening the Rev. Charles Hudson, and his friend Mr. Hadow, arrived at the hotel where our travellers were staying; they informed Mr. Whymper of their intention, on the following morning, to attempt the ascent of the Matterhorn, and Mr. Whymper and Lord Douglas invited them to make one party, after assuring themselves of Mr. Hadow's capability to undertake so dangerous an adventure. On this point they consulted Mr. Hudson, and he gave them the most satisfactory assurances. They then increased the number of guides by engaging Michel Croz.

On Thursday at 5h. 35m. A.M., the adventurers quitted Zermatt. At the express desire of their father, the two young Tauggwalds accompanied them. They carried a three days' supply of provisions. They bought no rope in the village, as a sufficient stock had been deposited at the chapel on the Lac Noir. But repeated inquiries were afterwards made of Mr. Whymper why he did not take some iron-wire rope, invented by Mr. Hudson, which made a part of his baggage. To this Mr. Whymper simply replies, that he never saw it, nor heard of it until after the catastrophe. The rope which the party actually carried consisted of 200 feet of the kind approved by the Alpine Club; of 150 feet of another kind, reputed even stronger; and 200 feet of a thinner and weaker cord, which Mr. Whymper had formerly been in the habit of using.

On the first day of the ascent their progress was very leisurely, but by noon they had gained a point on the north side of the mountain about 11,000 feet above the sea. Here they fixed their tent, while Croz and the two Tauggwalds went forward as pioneers, so as to save time on the following day.

They returned after awhile with the welcome intelligence that they had encountered no insurmountable difficulties, and that if the Englishmen had accompanied them, they might easily have ascended to the summit, and returned to their tent in the evening. The rest of the day was spent in admiring the glorious prospect, in warming themselves in the sun, and in pleasantly chatting. The sunset was indescribably splendid, and everything promised the adventurers a brilliant morrow.

Before night closed in, Hudson prepared some tea, and Whymper coffee, and each incased himself in the sack or bag that, in Alpine excursions, replaces a proper bed. Mr. Whymper, Lord Douglas, and the Tauggwalds occupied the tent; the others preferred to rest in the open air. But it was midnight before the rocks and chasms ceased to echo their shouts, songs, and laughter. They were happy, and none of them apprehended the slightest peril.

Before dawn they arose and commenced their march, with the exception of the younger Tauggwald, who went no further. At 20 minutes past 6 they had attained an altitude of 12,800 feet, and halted for half an hour. Then they continued the ascent without interruption until 59 minutes past 9, when they had arrived at a height of 14,000 feet. They paused here for fifty minutes. Up to this point they had escaladed the northern side of the mountain, and had made no use of their rope.

Sometimes Whymper led the way, and sometimes Hudson. They had reached the base of that portion of the peak which, seen from Zermatt, appears perpendicular, and which proved wholly impracticable. By common consent they now ascended for some distance by the ridge, one of whose extremities inclines towards the village; then they turned to the right, and faced north-west.

They had changed their order of march: Croz moved at the head; Whymper followed; then Hudson, Hadow, Douglas, and, finally, Tauggwald and his son. The utmost caution and steadiness now became indispensable. At certain points they could scarcely find the slightest stay or support. In the fissures and crevasses of the rock a hard snow lay encrusted, and the rock itself was clothed with a thin layer of ice. Nevertheless, a mountaineer or an Alpine club-man could accomplish the passage.

But here they discovered that Mr. Hadow was not sufficiently familiar with this kind of labour; at every moment one or other had to run to his assistance. No proposition, however, was made to leave him behind, and, in fact, the difficulty he felt in advancing arose from inexperience, and not from weakness or fatigue.

Mr. Hudson, meanwhile, performed the entire ascent without requiring or receiving succour. And this difficult stage of the enterprise was of no very extended duration. The space traversed did not exceed 300 feet in elevation; at its extremity the inclination somewhat diminished; and in order to gain the summit, Whymper and Croz quitted their party and ran forward to the topmost point of the Matterhorn. It was then 40 minutes past 1 P.M.; ten minutes later, all the members of the adventurous band stood in safety on the icebound peak.

With respect to the physical condition of each adventurer, Mr. Whymper asserts that none appeared fatigued, or complained of any exhaustion. In truth, they had not been more than ten hours *en route*, and their progress had been very slow and leisurely. On Mr. Whymper's making a remark to this effect to Croz, the old mountaineer replied,—

"Yes, we were in the right not to hurry ourselves; but I confess that in the descent I should prefer to be alone with you and a guide."

"My countrymen and myself," says Mr. Whymper, "were already discussing in what manner we should employ the evening on our return to the village.

"Our halt on the summit lasted an hour. I agreed with Hudson how we should undertake the descent. We both resolved that Croz should be placed at the head, as he was the strongest. Hadow was second. Hudson, who in sureness of foot was equal to a guide, went third. Next followed Lord Douglas, and in his rear the elder Tauggwald. I suggested to Hudson that when we came to the difficult portion of our route, it would be well to attach a rope to the rock, as, grasping it with both hands, we should find it a great additional security. He approved of the idea; but we did not positively decide upon carrying it into execution. All set to work fastening themselves to one another, while I completed a sketch of the summit. They waited for me. I attached myself only to the younger Tauggwald; and we were about to commence the return journey when some one remarked that we had not left our names in a bottle.

"They begged me to write them, and while I was so engaged, began their march. A few minutes afterwards I overtook them; they were defiling over the most difficult part of the passage. They took the utmost precautions. Only one man moved at a time; as soon as he had taken his stand, the next advanced in silence. The average distance between us amounted to scarcely twenty feet. We had not, however, attached to the rock a supplementary rope; no one spoke of it, and I do not believe that any person then thought of it.

"As I have explained, I was apart from the others, and following them; but at the end of about a quarter of an hour Lord Douglas begged of me to fasten myself to the elder Tauggwald, fearing, he told me, that if he should happen to slip, the latter would not suffice to support him. I did so immediately; it was some ten minutes before the catastrophe, and it is to this precaution, taken for another's sake, that Tauggwald owes his life.

"At the moment of the accident all were motionless; at least I think so; but I cannot say with certainty, nor can the two Tauggwalds, because the two men in advance were partly hidden by a shoulder of the rock. Poor Croz had thrown away his hatchet, and to give Hadow more security, took him by the legs and put his feet one after the other in the positions they should occupy; and to judge by the movements of their shoulders, I think that Croz was turning round to descend a step or two; it is at this moment Mr. Hadow must have slipped, and then fallen upon him.

"Croz gave a cry; I saw him glide forward with the swiftness of an arrow, followed by Hadow; a second after, Hudson was torn from his place, and Lord Douglas with him; it was the affair of two seconds. But at the very moment that we heard the exclamation of Croz, both I and Tauggwald threw ourselves down, and held ourselves as firm as the frightful inclination of the rock permitted.

"The rope which held us was stretched to its uttermost, and the shock struck us like one man. We kept steady; the rope broke at about mid-distance between Lord Douglas and Tauggwald! For two or three seconds at the most we could see our unfortunate companions glide downwards on their back, with outstretched arms, then disappearing one after the other, and falling from precipice to precipice, upon the glacier, 4000 feet beneath! . . . .

"For half an hour," continues Mr. Whymper, "terror rendered us motionless. Paralyzed with alarm, the two Tauggwalds wept like children, and trembled like a leaf. Descending a little lower, I asked to see the broken rope; alas! to my consternation, I found that it was the weakest of the three. Our unfortunate friends having tied themselves together while I was drawing, I had not noticed which kind of rope they had taken. . . . . It has been pretended that it was broken by its friction on the rock. Such was not the case; and the end remaining in my possession does not justify this mode of viewing it.

"During the two hours which followed, each moment seemed to me the last of my existence. Not only were the Tauggwalds completely unnerved, and in no condition to render me any service, but they tottered at every step. I ought to add, however, that no sooner had we arrived at an easier stage of the descent, than the young Tauggwald began to laugh, smoke, and eat, as if no great misfortune had occurred. I have no more to say in reference to the descent.

"Continually, but vainly, I stopped to seek some traces of the passage of my unfortunate companions. In consequence, night surprised us while we were still at an elevation of 13,000 feet. We did not enter Zermatt until Saturday, at half-past 10 o'clock, A.M.

"Immediately on my arrival I summoned the *maire*, and requested him to send as many people as possible to the heights over the place where I was certain my friends had fallen. Several men set forth, and returned after about six hours: they had seen the bodies, but without being able to reach them that day. They proposed to start again on Sunday evening, so as to get near the bodies at daybreak on the following Monday. In my anguish, I decided on re-ascending, on Sunday morning, accompanied by the Rev. Mr. MacCormick. Threatened with excommunication if they were not present at the first mass, the guides of Zermatt could not follow us.

"I am convinced that several suffered as much as we did; I judge by the tears of regret with which their eyes were filled. Messrs. Robertson, Phillpols, their guide Frantz Andermatt, Mr. Puller, and the brothers Lochmatter, F. Payot and J. Tairraz, of Chamouni, escorted us. We proceeded on our journey, following the direction which we had taken four days previously. From Hornli we descended to the right of the ridge, and having scaled the moraines of the Matterhorn glacier, arrived at the plateau which terminates the latter, in sight of the angle where we knew the bodies lay.

"On seeing each of our guides successively direct his telescope towards a certain spot, grow pale, and in silence hand the instrument to his neighbour, we understood that there was no ground for hope. We drew near. My unfortunate companions lay in the order which they had adopted during the descent; Croz, a little in advance; Hadow, near him; and Hudson, a few paces in the rear; as for Lord Douglas, it was impossible to find him. To my great astonishment, I discovered that they were fastened with the rope of the Alpine Club, or the second in point of strength; consequently, a considerable portion, that which had extended between Tauggwald and Douglas, was the frailest of all!

"By order of the Consul d'Etat of the Valais, four days after the event, twenty-one guides were despatched to find and bring back to the village the bodies of our friends. These brave men accomplished the dangerous task with an intrepidity which did them honour.

"They could discover no trace of Lord Douglas's body, which had probably been arrested in its fall by some projecting rock. No one can deplore his loss more profoundly than myself; for, though young, he was a skilful mountaineer; danger, for him, had ceased to exist.

"I remained at Zermatt until the 22nd of July, to assist in the inquiry instituted by the government.

"Such, sir," says Mr. Whymper, in concluding his letter to the editor of the *Times*, "such is the sad story I have to tell. A simple slip, or a single false step, has been the cause of a misfortune which I can never forget. I will add one word. If the rope had not been broken, you would not have received this letter, for we should not have had sufficient strength to counterbalance the weight of four men, all falling simultaneously.

"But I am convinced that no accident would have occurred if the rope which tied Tauggwald to the last of our friends had been taut like that which fastened the guide to myself. The rope is a great assistance; but it should never form a coil; for if a person falls or slips, his descent gradually acquires a momentum which it is difficult to resist."

Table Mountain [3582 feet], at the Cape of Good Hope, may be compared in form to an immense altar.

One of the most curious configurations is that of *Peter Botte's Peak* (Figure 41), in the Isle of France (the Mauritius). It bears the name and perpetuates the memory of one Peter Botte, who, after

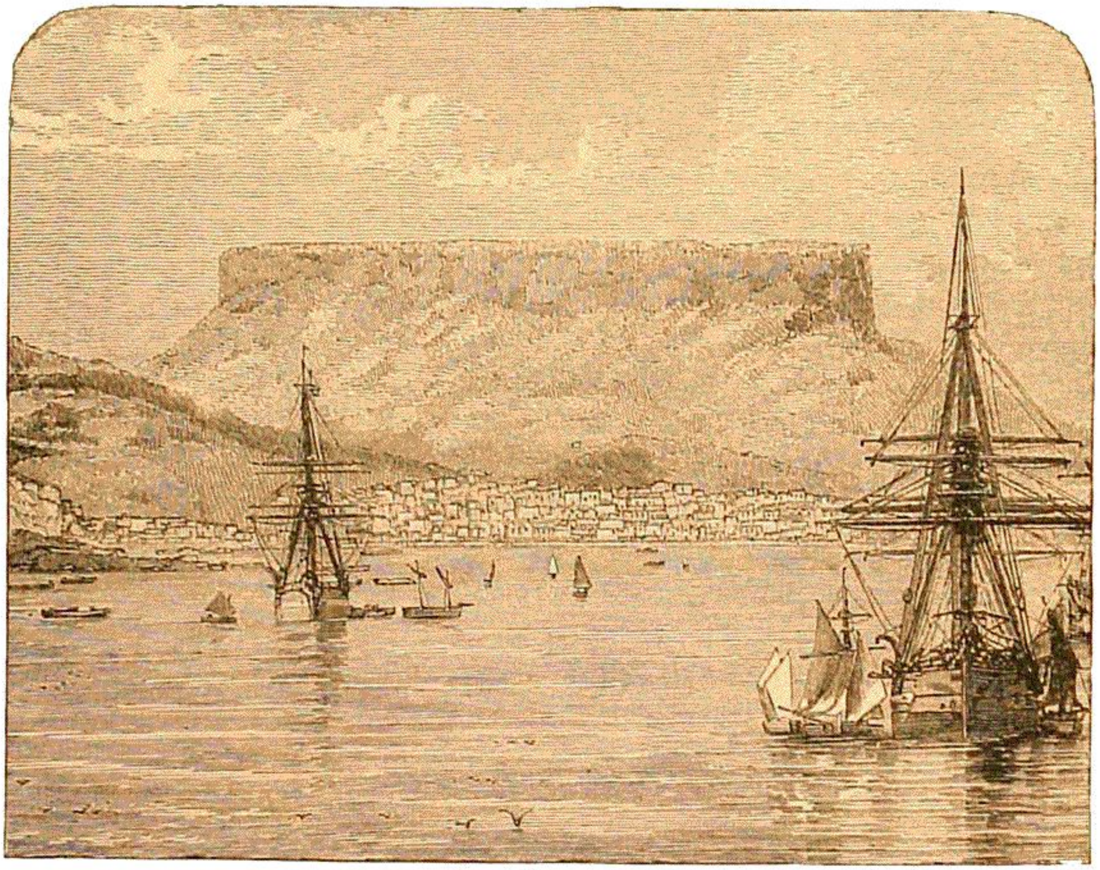

FIG. 40.--TABLE MOUNTAIN (CAPE OF GOOD HOPE).

having succeeded in gaining its summit, perished in re-descending. An enormous block of stone hangs poised on the very crown of the peak, and raised more than 300 feet above it. In 1832, an English adventurer, more fortunate than Peter Botte, ascended to the summit of this great natural spire, and accomplished the descent without accident.

In China occur some mountain-summits which offer the rude image of a dragon's head, a tiger, or a bear; just as Arthur's Seat, near Edinburgh, from some points of view, bears a striking resemblance to a lion *couchant*. Sometimes we meet with a labyrinth of rocks, elevated like "quills of the fretful porcupine," as is the case at Adersbach, in Bohemia. Near Envionne, in the Valais, certain *mamelons* remind the traveller of the ancient full-bottomed perukes.

A yet more remarkable conformation is that of the Basaltic

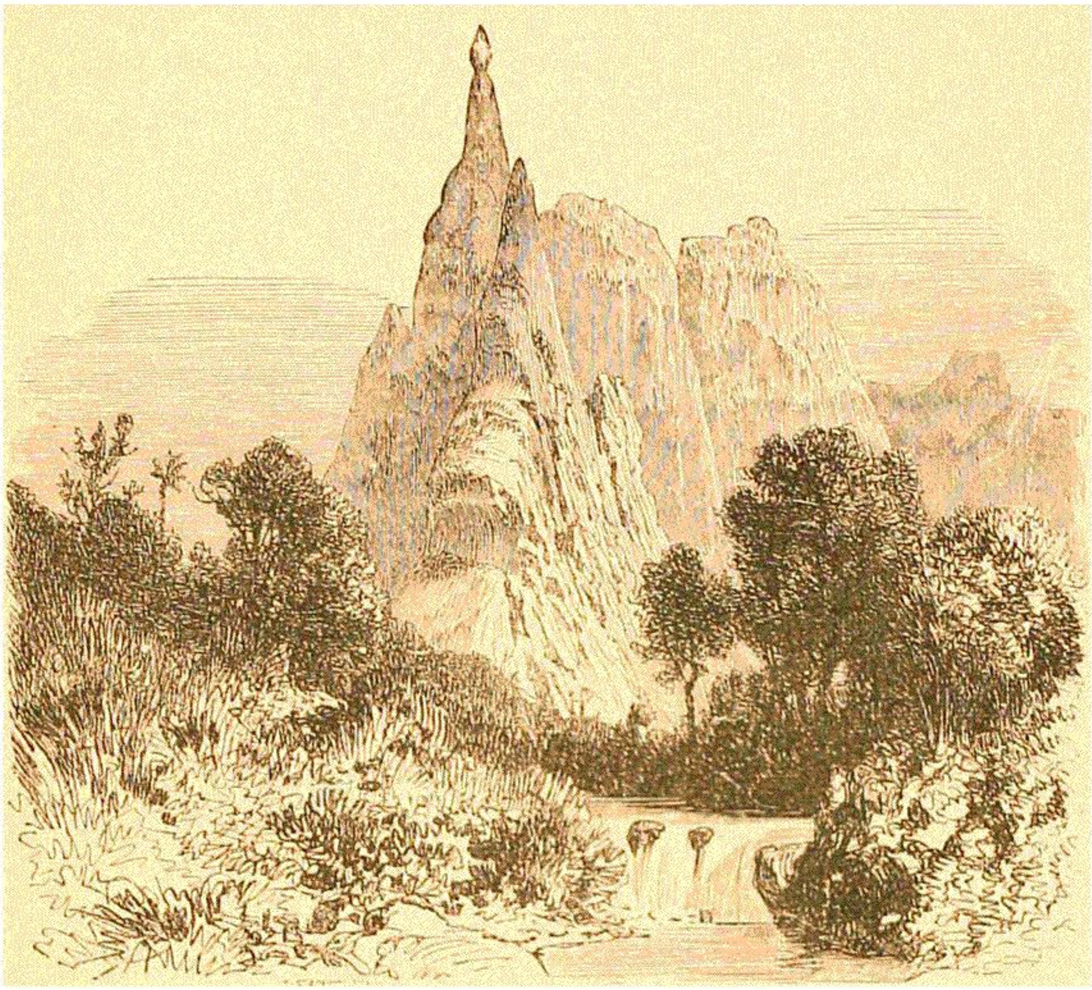

FIG. 41.—PETER BOTTE'S PEAK (ISLAND OF MAURITIUS).

Mountains. These serried rows of immense columns, forming entire mountains, seem like colossal palaces built by Titanic hands. The common people generally designate these basaltic deposits by the not inappropriate name of *Giants' Causeways*.

[A splendid instance is familiar to every traveller who has visited the northern coast of Antrim, in Ireland. There, at a point of about fifteen miles from Coleraine, a species of pier or mole, of basalt, projects into the stormy ocean, as if originally intended to connect the Irish shore with that of Scotland. It is, in reality, but a part of the extensive basaltic mass, from 300 to 500 feet in thickness, which overspreads almost the whole county of Antrim and the east of

Londonderry, for a total extent of 1200 square miles. Three layers of the basalt, where it touches the coast, bear a remarkable columnar appearance. The first is seen at the promontory of Fair Head, where the massive pillars are truly Cyclopean in character, and upwards of 200 feet high. The other two rise above the sea-level at Burgne Head; the lower, forming the *Causeway*, and exhibiting above the surging waters and the shining diamond-spray, an irregular pavement—fit place for sea-nymphs to disport—composed of the tops of polygonal columns, collocated together with

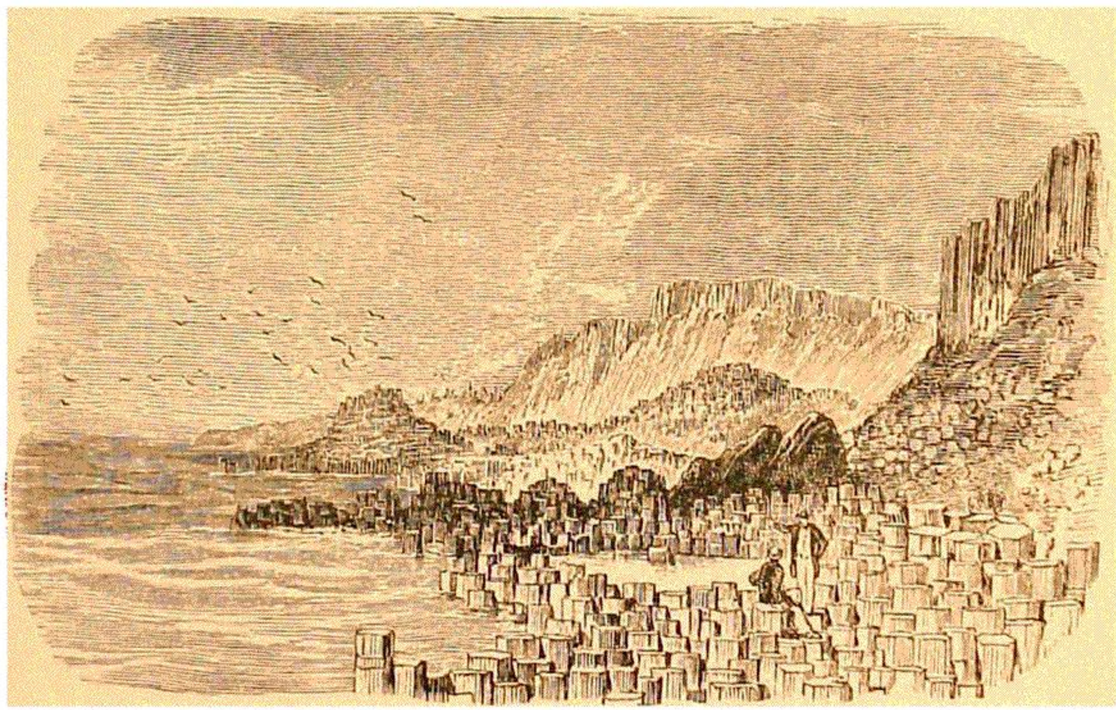

Fig. 42.—The Giant's Causeway (Ireland).

such admirable exactitude that the blade of a knife can scarcely be thrust between them. The average diameter of each pillar is from twelve to fifteen inches.

The Causeway is divided into the Large, Middle, and Little Causeways; the former is the lowest of the three columnar beds, about 30 feet wide, and 600 feet in length, from the cliff to its submersion in the sea.

But perhaps this columnar structure is nowhere more beautifully exhibited than in *Fingal's Cave;* a locality of such marvellous natural splendour that we need not wonder it has given birth to a vast number of myths and fanciful legends. Here a tremendous arch is supported on either hand by ranges of mighty pillars, which flash and gleam with a thousand hues, as the sea dashes into the echoing recess, and irradiates the darkness with rainbow-coruscations. The roof is composed of pendent pillars which glitter with an incrustation of calcareous stalagmites. The portal to this haunted cavern, which

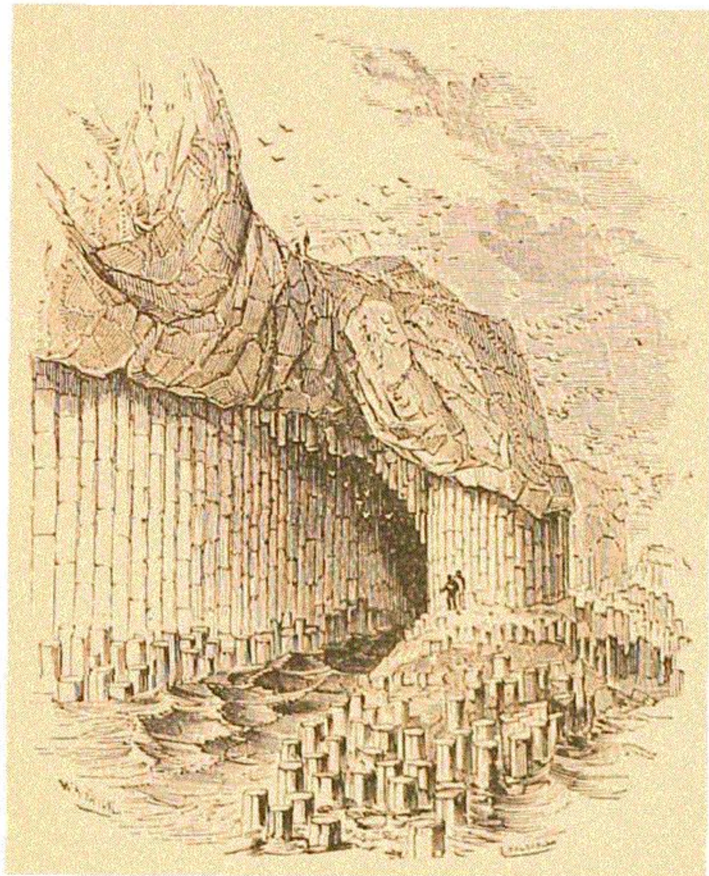

FIG. 43.—FINGAL'S CAVE (SCOTLAND).

an old Greek would have fancied to be the palace of his god Poseidon, is 33 feet in width, and 60 feet in height. The palace-hall measures 212 feet in length.]

In Figure 44 the artist puts before us a representation of one of the *Islands of the Cyclops*, lying in the "blue Mediterranean," at no great distance from the coast of fertile Sicily, and consisting of volcanic mountains formed by eruptions of basalt.

Examples of *Mamelons* or *Croupes Montagneuses* are too numerous and too well known for any particular description to be necessary.

Perforated Mountains ("Montagnes percées à jour") form one of

Nature's most fantastic peaks. The *Pierre pertuis* in the Jura range, *Pausilippo* near Naples, *Monte Tafonato* in Corsica, and the *Torghat* in Norway, may be named as remarkable illustrations.

Pausilippo is an ancient and a celebrated site, for tradition places there the tomb of the poet Virgil. It rises on the margin of the sea, at the eastern extremity of the beautiful Parthenopean Bay. It is pierced from flank to flank by a tunnel, through which the road from Naples to Pozzuoli is carried, forming an arcade of gigantic dimensions. Originally it was a stone quarry, and the continual working of it has terminated in boring through the mountain from

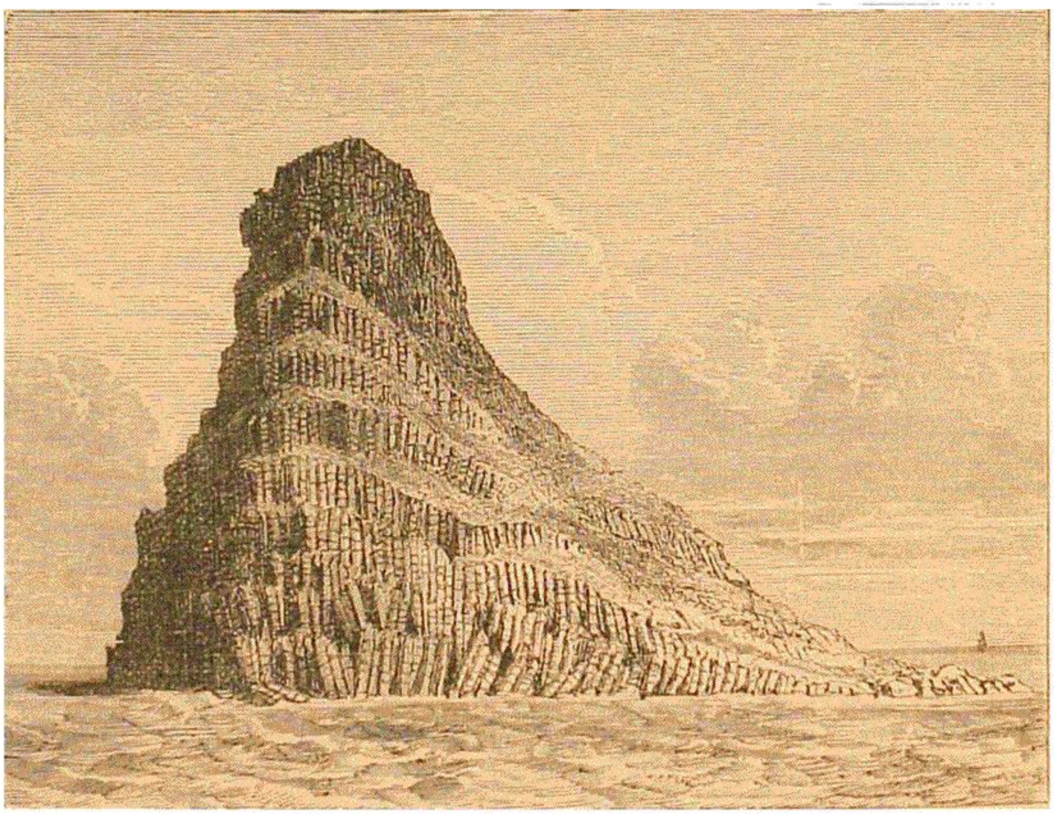

FIG. 44.—CYCLOPS ISLAND.

one side to the other. Towards the middle of the fifteenth century, Alphonso, king of Naples, caused it to be enlarged; at a later period it was again extended in size, and furnished with shafts in the roof to facilitate the ventilation. About one thousand yards in length, the subterranean way of Pausilippo is thirty yards in height, and from eight to ten in breadth (Fig. 45). Midway stands a chapel to the Virgin. Above the grotto are the ruins of an ancient aqueduct, and the so-called "Tomb of Virgil."

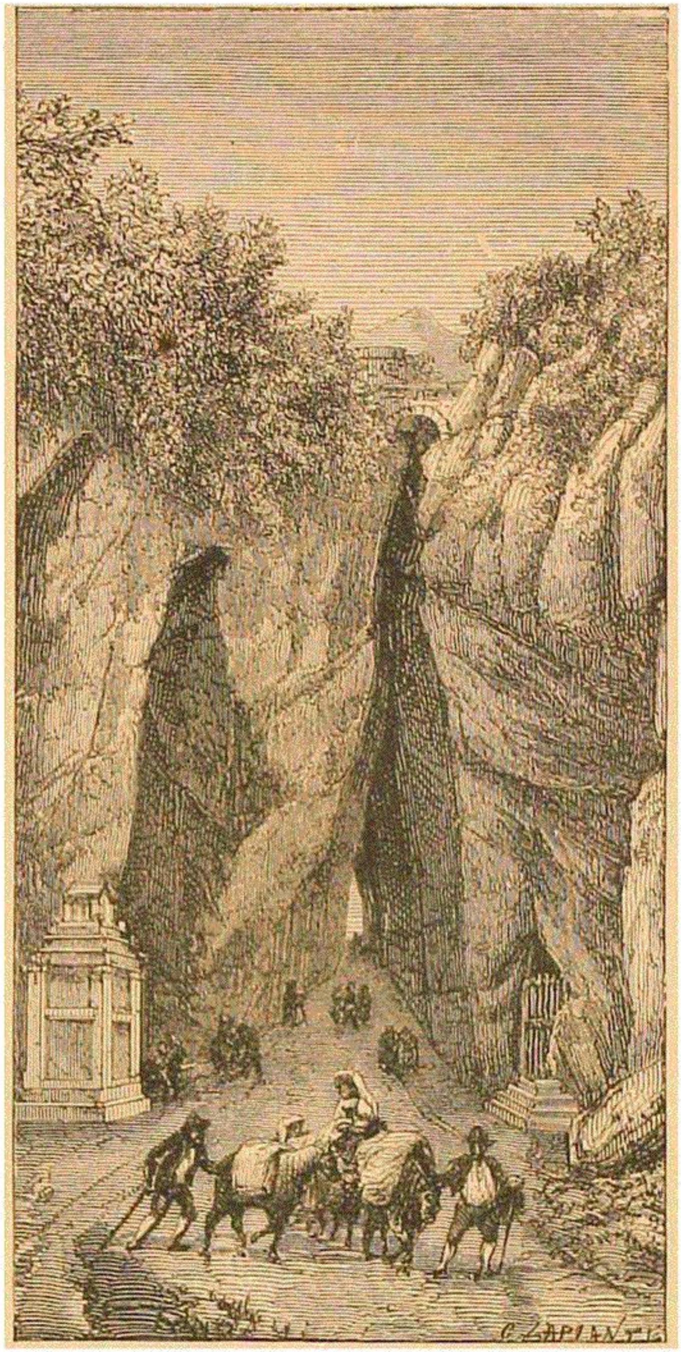

FIG. 45.—THE GROTTO OF PAUSILIPPO (ITALY).

Figure 46 represents Monte Tafonato, one of the loftiest summits in Corsica.

Consisting of a fine red porphyry, Monte Tafonato (that is, the "pierced mountain") is 7400 feet above the sea-level; it serves as a huge buttress to Monte Paglia-Orba, which reaches an elevation of 8650 feet. Near its crest may be seen an opening, several yards both in height and width. When the "orb of day" has already disappeared behind the surrounding mountains, the traveller beholds with delight a sudden gleam of radiance strike through this orifice.

It is impossible to explain with any degree of certainty this singular perforation of the porphyry on the summit of Monte Tafonato. In his "Histoire Illustrée de la Corse," the Abbé Galetti offers us a legend as his sole explanation of this geological phenomenon. As a general rule it is difficult to imagine anything duller or balder than a legend. In all the countries of the world, legends tell the same story—breathe the same spirit—which does not fail to imprint a disagreeable monotony upon the works in which they are collected. In all, we find the Devil represented as the principal artificer; he builds every bridge remarkable for its bold span, raises heavy rocks to the summit of lofty hills, excavates the vast natural chasms really produced by the subsidence of the soil; is active everywhere, and in everything foremost. Thus the aperture in Monte Tafonato was produced by a single blow of the Devil's hammer, one day when he was in a fit of ill-humour with St. Martin. The worst of the legend, in such cases, is, that it makes us wholly neglect the scientific explanation. The Abbé Galetti thinks he has contented us with his old, old story of the Devil and St. Martin. But M. Galetti is wrong. A little geology would not have been thrown away.

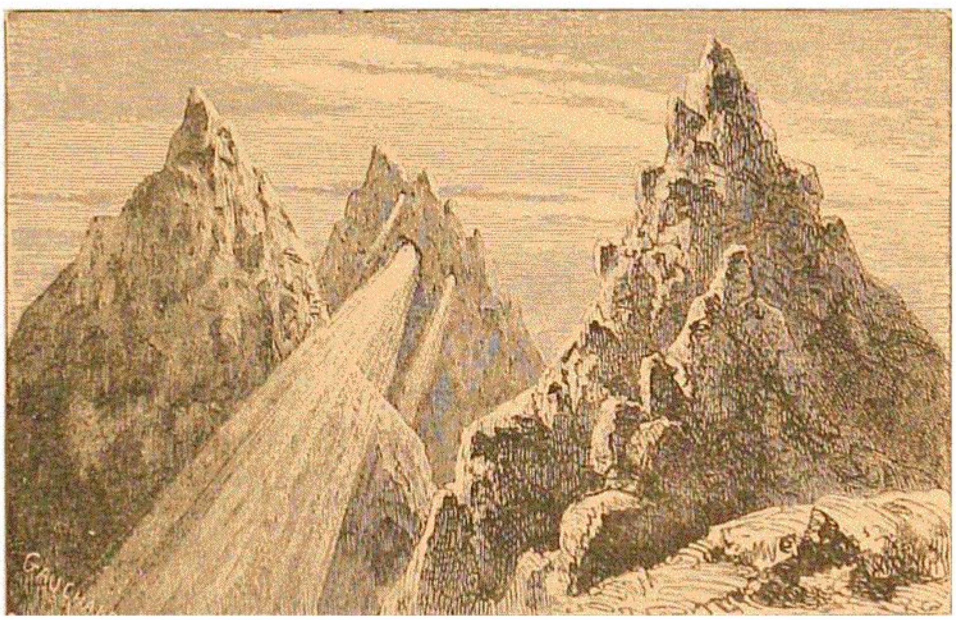

FIG. 46.—MONTE TAFONATO (CORSICA).

The Torghat, in Norway, is pierced with a passage 1300 feet long, 80 feet wide, and 52 yards high; at certain epochs of the year the sun is visible through it. The rock ("the Hat of Torgat") rises to the height of 756 feet above the sea-level, and is situated on the coast of the small island of Torgat, in latitude 65° 30′ N. It furnishes the mariner with a note-worthy landmark.

A splendid example of the perforated mountain is represented in Figure 48. It is an enormous mass of granite, which the ingenious hand of Nature has fashioned into an admirable triumphal arch, and occurs in the valley of Baskan, among the Alatou Mountains, on the frontiers of Siberia and Chinese Mongolia. Our adventurous travel-

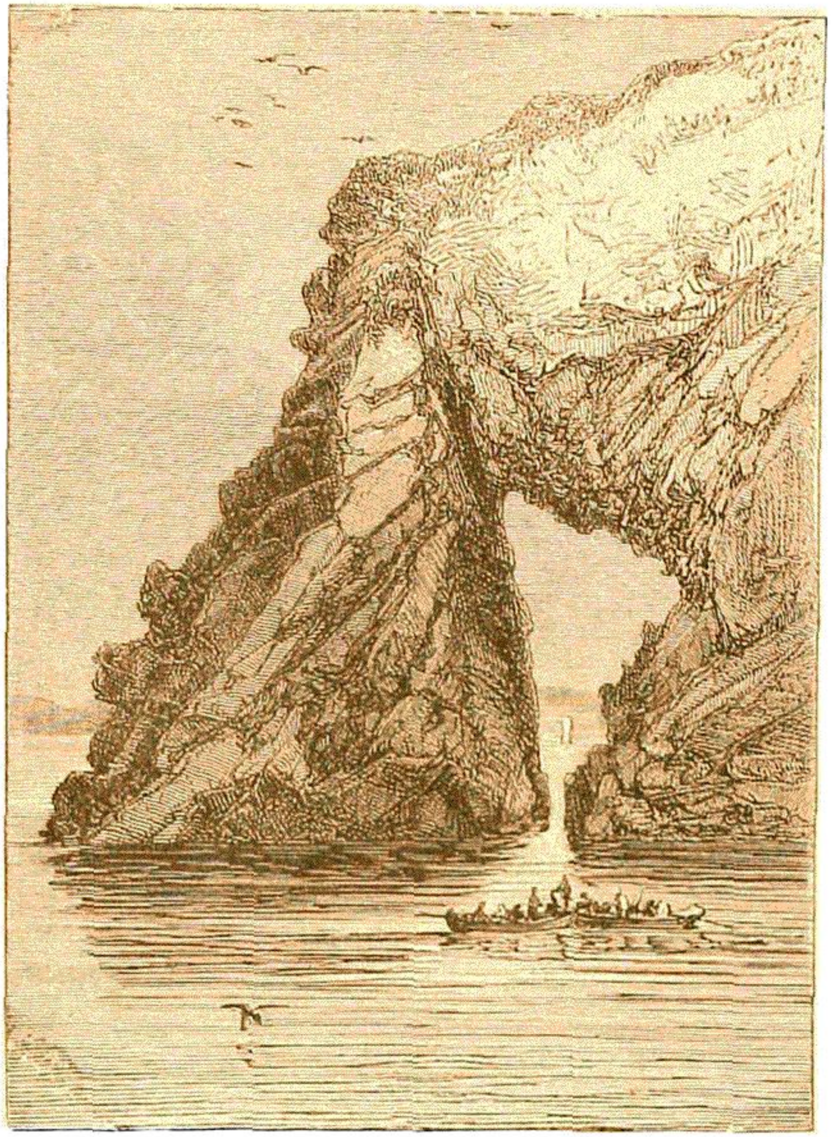

FIG. 47.—ROCKS OF THE ISLAND OF THOULOU (IN THE GULF OF SIAM).

ler, Mr. T. W. Atkinson, in the second volume of his "Travels in Siberia," has engraved the sketch which we here reproduce.

Near the shores of New Zealand a bold series of rocks is arranged in numerous natural arches, under which, at high tide, the waters go on their way rejoicing. Captain Cook has furnished us, in the third volume of his most interesting "Voyages," with representations of these curious perforated mountains, these fantastically-formed rocks, which awaken the wonder and the admiration of the voyager in the South Pacific.

We show the reader, in Figure 47, a fine specimen of the same kind: we refer to the remarkable rocks which rear themselves from the deep sea on the coast of the island of Thoulou, in the Gulf of

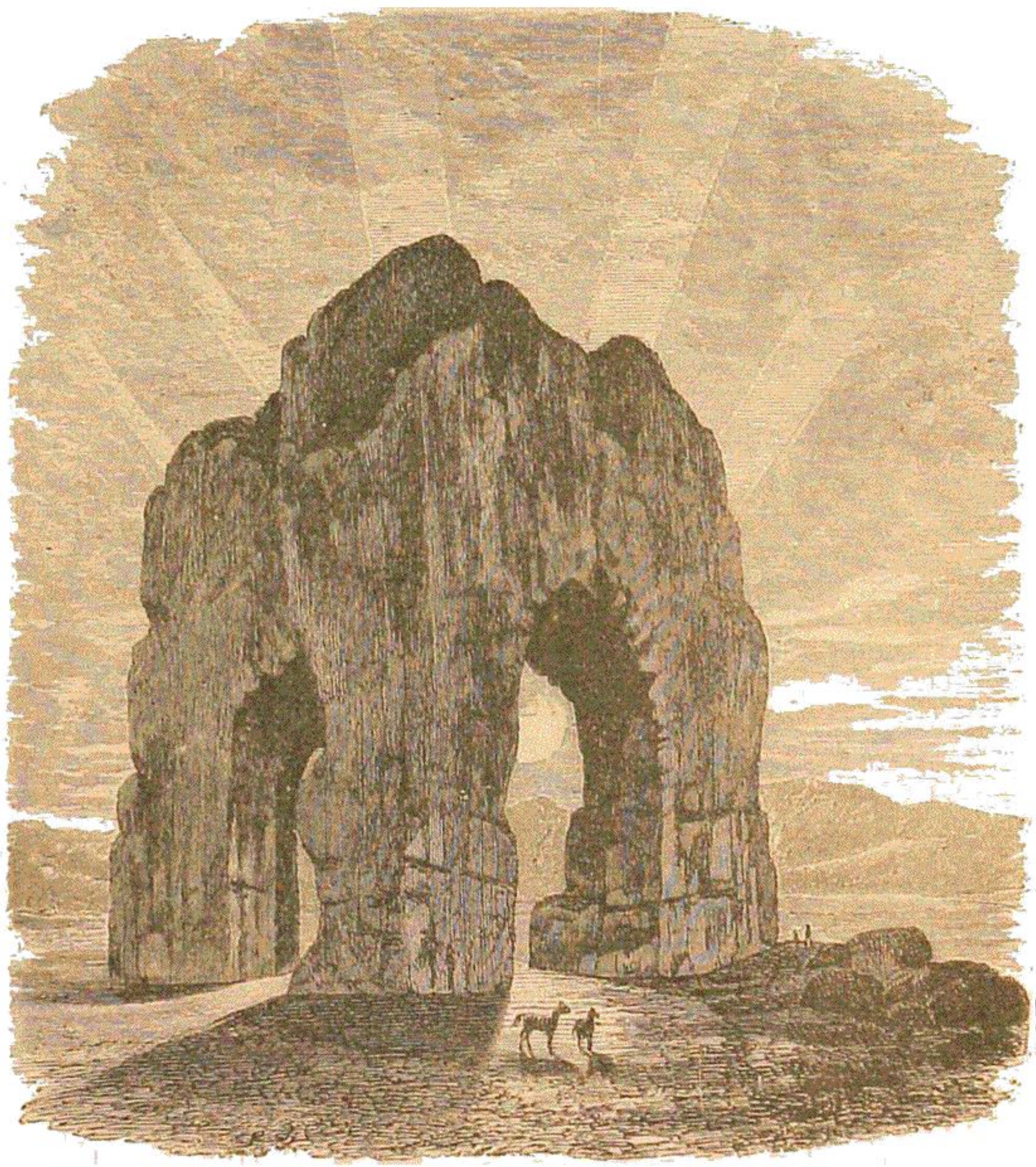

FIG. 48.—NATURAL ARCH OF GRANITE IN THE VALLEY OF BASKAN (CENTRAL ASIA).

Siam, and through whose bold irregular arches the Siamese steer their barks.

[The same phenomenon, on a smaller scale, may be seen on our British shores, as at—to take two very opposite instances—Freshwater Bay, in the Isle of Wight, and Flamborough Head, in Yorkshire. In the latter vicinity the rocks have been fashioned by "wind and wave" into a variety of fantastic forms, among which that of the arch is the most frequent, and, certainly, the most impressive.* The wonders of the coast, however, are known but to few, though their examination could not fail to interest the dullest imagination, and fill the memory with unfading images of sublimity and loveliness.]

* [" Where the chalk is depressed, and the diluvial clay thickened upon it, the cliffs are wasted by the sea in a very remarkable manner: broad and lofty arches appear in the projecting masses, caves are formed, which open upwards to the day, and romantic islets of chalk are surrounded by the full swell of the waves.

"The origin of many inland caverns in limestone is exceedingly obscure. Though water flows through many of them, and by incessant attrition smoothes their surfaces and modifies their forms, yet, perhaps, we ought rather to believe that the cave, previously existing, directed the course of the stream, than that the water excavated the cave. By the sea-side it is otherwise; the destructive action of the sea is not doubtful; the cliffs crumble before its salt vapours, and waste away under its furious waves. One loosened stone beats down another, and thus the soft parts are hollowed out, whilst the harder portions jut into promontories or stand naked in the water. If the soft parts, exposed to the waves, be enclosed in firmer matter, caves and arches are formed, which are afterwards liable only to slow alteration; but if these yielding materials extend far in a horizontal direction, the cliff undergoes rapid diminution. These observations are of general application."—Professor Phillips, *Geology of the Yorkshire Coast*, pp. 44, 45.]

CHAPTER II.

MOUNTAINS OF EUROPE—TABULAR SUMMARY OF THE LOFTIEST EUROPEAN HEIGHTS—MONT BLANC—HISTORY OF THE PRINCIPAL ASCENTS OF MONT BLANC—GENERAL ELEVATION OF THE EUROPEAN CONTINENT—THE PYRENEES—THE APENNINES—THE SCANDINAVIAN MOUNTAINS—MOUNTAINS OF SCOTLAND—GENERAL REMARKS.

WE now proceed to a general study of the mountains in the world's five great divisions, commencing with Europe.

Sir John Herschel divides the European Mountains into six groups, or principal systems :—*

a. The *Scandinavian;*
b. The *Britannic ;*
c. The *Iberian ;*
d. The *Alpine ;*
e. The *Slavo-Hellenic ;*
f. The *Sarmatian*, or *Table-land of Valdai.*

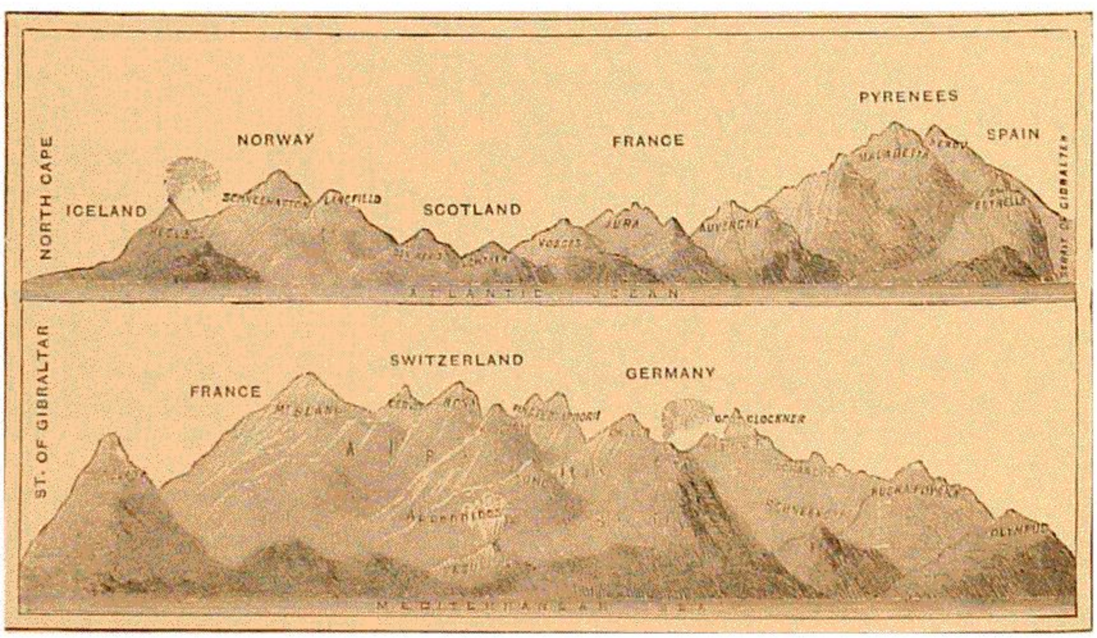

Fig. 49.—Mountains of Europe.

Of the *Britannic group*, as it is not remarkable for loftiness, we do not think it necessary to offer any detailed description ; it includes the well-known peaks of Snowdon, Bow-Fell, Cross-Fell, Ben Nevis, Ben Arthur, Benvenue, and Ben Wyvis.

* Sir J. Herschel, "Physical Geography" (ed. 1862), p. 144.

The *Scandinavian* comprehends the mountains of Norway and

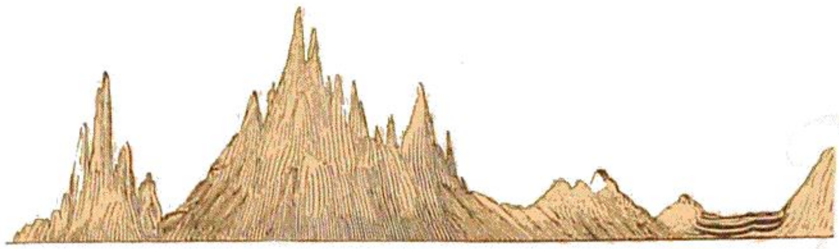

FIG. 50.—ELEVATION OF THE BRITANNIC MOUNTAINS.

Sweden, composed of broad and elevated table-lands, which are frequently intersected by deep valleys, exhibiting the gloomiest and wildest landscapes.

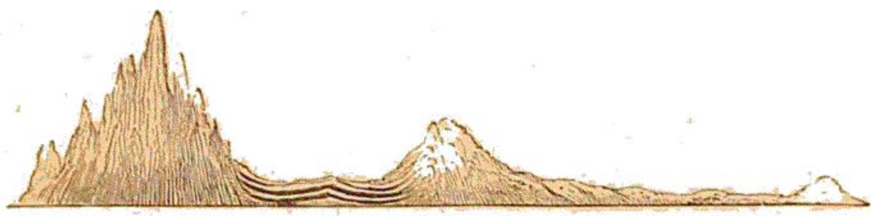

FIG. 51.—ELEVATION OF THE SCANDINAVIAN MOUNTAINS.

The *Iberian* system embraces the Pyrenees, some of whose summits aspire to a noble elevation: as the Malahite or Nethou, 11,000 feet; Mont Perdu, 10,500 feet; the Malora, 10,300 feet; and the Maladetta, 10,250 feet.* Spain itself is considerably raised above the sea-level; its mean height is computed at upwards of 2200 feet. The peak of Mulhacen, to the south-east of Granada, attains an elevation of 11,600 feet; it is the culminating point of the Sierra Nevada, or Snowy Range, which dominates over the southern coast of Spain. The Strait of Gibraltar separates it from the parallel group of the Atlas.

The mean elevation of the great chain of the Pyrenees is 8000 feet, while that of the Alps, whose isolated peaks frequently attain a surprising altitude, is only 7700 feet; it is, therefore, a more massive, and, so to speak, a more compact chain than the Alpine.

But as the *Alpine* system extends over a considerable portion of Europe, and is the vastest and most important of the European systems, while in Mont Blanc, the highest point, we also meet with

* For more exact measurements, see *post*.

the apex of elevation of the continent, it is to this we shall first direct the reader's attention.

In the accompanying chart is given a comparative view of the loftiest summits of the mountain-chains of Europe. In the subjoined Table we have indicated their situation and exact height in English feet :—

NAME.	LOCALITY.	ABOVE THE SEA-LEVEL. ENGLISH FEET.
Mont Blanc, ...	Pennine Alps, ...	15,739
Monte Rosa, ...	Lepontine Alps, ...	15,210
Mont Cervin, ...	Pennine Alps, ...	14,836
Finsteraarhorn, ...	Bernese Alps, ...	14,026
Jungfrau, ...	Bernese Alps, ...	13,672
Mont Combin, ...	Pennine Alps, ...	14,124
Monte Viso, ...	Cottian Alps, ...	13,599
Ortler Spitz, ...	Rhætian Alps, ...	13,150
Great Glockner,...	Noric Alps, ...	12,700
Mulhacen, ...	Spain, ...	11,483
Malahite Peak, ...	Pyrenees, ...	11,168
Mont Perdu, ...	Pyrenees, ...	10,994
Maboré, Cylinder of, ...	Pyrenees, ...	10,899
Maladetta, ...	Pyrenees, ...	10,886
Etna (Volcanic), ...	Island of Sicily, ...	10,874
Monte Rotondo, ...	Corsica, ...	8,767
Pic de Sancy, ...	France, ...	6,188
Monte Corno, ...	Apennines, ...	9,521
Mount Guiona, ...	Greece, ...	8,538
Mount Parnassus, ...	Greece, ...	8,568
Ruska Poyana, ...	Carpathians,...	9,912
Budosch, ...	Transylvania, ...	9,593
Riesenkoppe, ...	Riesenbirge (Germany), ...	5,394
Skaglöttend, ...	Scandinavian Mountains, ...	8,101
Schneehattan, ...	Scandinavian Mountains, ...	8,120
Koldetind, ...	Scandinavian Mountains, ...	7,224
Ben Nevis, ...	Scotland (Inverness-shire), ...	4,375
Ben MacDhui, ...	Scotland (Aberdeenshire), ...	4,296
Cairn Toul,...	Scotland (Aberdeenshire), ...	4,223
Ben Avon, ...	Scotland (Aberdeenshire), ...	3,931
Ben More, ...	Scotland (Grampians), ...	3,819
Snowdon, ...	Wales (Caernarvonshire), ...	3,557
Cader Idris, ...	Wales (Merionethshire), ...	3,550
Cross Fell, ...	England (Cumberland), ...	3,383
Helvellyn, ...	England (Cumberland), ...	3,313
Skiddaw, ...	England (Cumberland), ...	3,038
Curran Tual, ...	Ireland (Kerry), ...	3,412
Mount Rona, ...	Shetland Isles, ...	3,593
Snæfjeld, ...	Iceland,...	5,115
Hecla (Volcanic), ...	Iceland,...	3,324
Vesuvius (Volcanic), ...	Naples, ...	4,257*
Stromboli (Volcanic), ...	Lipari Islands, ...	3,100

* [This is the estimate formed by Professor Palmieri in 1868.]

FIG. 52.—MONT BLANC, SEEN FROM MONT BUET. (*From a Photograph by M.M. Bisson Brothers.*)

1. Mont Blanc, 15,739 feet.—2. Dôme du Gouter, 14,400 feet.—3. Aiguille du Gouter, 15,550 feet.—4. Glacier des Bossons. 5. Glacier de Tacconay.—6. Aiguille du Midi, 12,850 feet.—7. Chaine du Brévent et des Aiguilles Rouges.

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It is evident that we cannot describe in detail each mountain whose name is inscribed in the foregoing Table.* We shall confine our remarks to a few of the more remarkable. And, in the first place, we shall speak of Mont Blanc, which, as far as Europe is concerned, may justly be sung as—

"The monarch of mountains,"

which the genius of nature crowned

"Long ago,
On a throne of rocks, in a robe of clouds,
With a diadem of snow."

Let us examine, then, the narratives of the different attempts

FIG. 53.—MONT BLANC, FROM THE MER DE GLACE.

which have been made at different epochs to climb this immense colossal mass, regarded as inaccessible by man until the close of the last century. We show, in Figure 52, the panorama of the Mont Blanc chain, taken from the Buet mountain, which is situated at a distance of several leagues.

The summit of Mont Blanc is 15,739 feet above the sea-level. Prior to the

* [The figures in this Table, we may add, are offered as the result of a careful comparison of the best authorities.]

celebrated Horace Benedict de Saussure, no person had conceived the idea of climbing its scarped flank. It was not even known whether the rarefaction of the air at elevations so lofty would not prove fatal to human life.

Saussure was not twenty years old when he first dreamed of attacking the giant of the Alps. In his first visit to Chamounix, in 1760, the young naturalist published it abroad in all parts of the valley that he would give a sufficient reward to the guides who discovered a practicable route to Mont Blanc. He even promised to pay the day's wages of those whose attempts proved fruitless. But his liberal offers led to no result.

It was not until fifteen years afterwards, in 1775, that four guides of Chamounix succeeded in reaching Mont Blanc by the mountain De la Côte, which rises above the village Des Bossons. This mountain, situated between the glaciers Des Bossons and De Tacconay, abuts on the waste of snow and ice which stretches uninterruptedly to the very summit of Mont Blanc. After triumphing over the obstacles which opposed their progress on the glaciers, incessantly intersected by immense crevasses, the four guides penetrated into a great valley of snow, which seemed as if it would directly approach Mont Blanc. The weather was exceedingly favourable ; they encountered neither too precipitous slopes nor too wide crevasses, and apparently all things promised success. But the rarefaction of the air, and the reverberation of the sun's rays on the dazzling surface, fatigued them beyond endurance. Succumbing to weakness and weariness, they found themselves constrained to re-descend, without having met with any insuperable obstacle.

Seven years later, in 1783, three other guides of Chamounix—Jean-Marie Cottet, Jorasse, and Joseph Carrier—made the same attempt, following in the track of their predecessors ; only they took the precaution of passing the night on the Montagne de la Côte, and did not venture until the following morning upon the glacier which ascends from it.

After traversing it in safety, they followed up the vale of snows which rises towards Mont Blanc. They had already reached a great elevation, and were pressing forward in blithe confidence, when the boldest and most courageous among them was suddenly seized with an unconquerable longing for sleep. He begged of his comrades to continue the ascent without him ; but they refused to abandon him in such a condition, or to suffer him, as he wished, to sleep on the snow. Renouncing their enterprise, they all returned to Chamounix.

It is certain that even without the accident of this inopportune lethargy, these three men could never have reached the goal of their adventurous expedition. They would have still had a long distance to travel before arriving at Mont Blanc, and the heat fatigued them excessively. Moreover, they were without appetite ; the wine and the provisions which they carried possessed no attractions for them. So that Jorasse said seriously that if he had to recommence the enterprise, he would not load himself with any provisions, but take only an umbrella and a smelling-bottle. When we picture to ourselves a robust mountaineer scaling the slopes of the Alps with an umbrella in one hand, and a flask of eau de Cologne in the other, we gain, by this singular image, a vivid idea of the anomalous difficulties and unfamiliar conditions which are associated with the adventure.

Despite of the non-success of the gallant mountaineers, a naturalist, to whom we owe some excellent descriptions of the Alps, Pierre Bourrit, canon of Cologne Cathedral, resolved on attempting the same route before the end of the season. He slept for the night on the top of the Montagne de la Côte; but at the moment he entered upon the Glacier des Bossons, a sudden tempest arose and compelled him to retrace his steps.

Bourrit, however, was not a man to give up so quickly a cherished design. Recognizing the proved impossibility of attaining the goal by that route, he set to work gathering information from all parties in the Chamounix valley, and discovered that, on the side of the Glacier de Bionnassay, three chamois hunters had arrived, by keeping along the ridge of rocks, at such an elevation that they had almost gained the summit of Mont Blanc.

In possession of this intelligence, Bourrit hastened to the village of La Grue, inhabited by these hunters, and engaged them to accompany him in an ascent by the same route.

With the three hunters he set out that very evening. On the morrow, at day-break, they had reached the base of the rock scaled by the hunters in pursuit of the chamois, and which opened up a road to Mont Blanc. But the morning was very cold, and Bourrit, whom the night-march had overwhelmed with fatigue, had not strength to follow his guides. One of them remained with him; the two others mounted to the summit of the rocks, and penetrated far into the everlasting snows. They boasted that they had thus arrived very near Mont Blanc.

This attempt rendered probable a complete success. Bourrit therefore prepared to renew the enterprise, and De Saussure undertook to join him. Unhappily, the summer of 1785 was cold and rainy; and it was not until the month of September they had any opportunity of realizing their project.

Horace de Saussure and Bourrit, the latter accompanied by his son, had agreed to meet, on the 12th of September, at the village of Bionnassay, which lies about four leagues from Chamounix. Bourrit conceived the felicitous notion of sending forward three Chamounix peasants to construct, in a rocky recess, at the foot of the Aiguille du Goûter, a kind of hut or cabin of dry stones, which might serve as a sleeping-place and for shelter in case of a storm. The first day's journey, therefore, was limited to reaching the height where this hut was situated.

On the 12th of September 1785, at eight o'clock in the morning, Bourrit and De Saussure, accompanied by five mountaineers loaded with provisions, furs and coverings, philosophical instruments, straw, and fuel, began their march to the conquest of Mont Blanc.

They followed at first a gentle slope skirting a ravine whose bed is washed by a torrent issuing from the Glacier de Bionnassay. A swift ascent conducted them next to the foot of this glacier. They followed it for some time, and then diverged to the north-east, by a rather difficult ascent. This ascent brought them to a place named the Round Stone (*Pierre-Ronde*), which is situated 4750 feet above Chamounix. Here had been constructed the cabin intended for their accommodation. They reached it at half-past one o'clock, P.M.

Placed at the foot of the Aiguille du Goûter, this station was very happily chosen for so wild a region. The hut was built at the bottom of a rocky angle, about fifty feet above a small glacier which poured forth a rill of translucent water—

> "Fons, splendidior vitro,
> Dulci digne mero. non sine floribus" *—

fit for every want of the travellers. About four feet high, and from seven to eight in length and breadth, this cabin had only three walls; the rock against which it leant formed the fourth. Rude were these walls, consisting of smooth stones superimposed upon one another without the aid of any cement. Exactly similar stones, supported by four trunks of firs, formed the roof of the rough asylum. There was no door, but a simple opening, three feet square, so that one could not enter without almost bending double. An umbrella opened and placed before this opening served as a substitute for a door. The beds consisted of two palliasses provided with woollen coverlets.

It is by the Aiguille du Goûter that Mont Blanc is most easily approached. Our adventurers profited by what remained of daylight to send four guides to climb the mountain, select the easiest route, and mark their steps in the indurated snow.

Some blocks of granite rose about four hundred feet above the mountain-hut. Saussure and his companion hastened to ascend them and enjoy one of the most splendid spectacles which can be witnessed in the Alps. These rocks are quite precipitous on the side of the Chamounix valley, over whose southern extremity they dominate at a height of 5850 feet. The view embraces that portion of the valley bordered by the aiguilles of the Mont Blanc chain, which seem to enclose the great peak in a kind of circus, and which glitter around it like a forest of granite pyramids. On this side the marvellous panorama extends as far as Gemmi. An enormous labyrinth of mountains, which it is impossible to number or distinguish, may be surveyed from the summit of this incomparable observatory.

De Saussure passed an excellent night sheltered in his rustic cabin. When he lifted up the umbrella placed before the opening, he could see from his rude couch the snows, the glaciers, and the peaks beneath in the cold calm moonlight. Illuminated by the rays of the "silver huntress, chaste and fair," this frozen amphitheatre presented the most singular spectacle.

The guides spent the night in rocky crevices, or enveloped in their mantles or coverlets; a few kept watch around a fire which they fed, very sparingly, with the wood brought from Chamounix.

At six o'clock on the following morning, after having equally apportioned among the guides the burden of provisions, clothes, and instruments, the route was resumed. As the site of the Pierre Ronde proved to be 9050 feet above the sea-level, they had before them an ascent of nearly 6700 feet before the summit of Mont Blanc could be trodden. The greater portion of this traject would be made upon the Aiguille de Goûter, and the remainder upon the snows.

Our travellers crossed in twenty minutes a glacier which separated them from

* [Horace, "Odes," Book iii., Ode 13.]

the base of the Goûter. They then mounted a ridge of tolerable steepness, whose rocks, broken or dislocated by the action of the atmosphere, did not offer an easy road. But the temperature was not very low—it never touched zero—and in an hour they had crossed the ridge. Arriving at a certain elevation, they discovered the Lake of Geneva, which can only be seen from the loftiest points of the foundations of Mont Blanc.

A glacier forms the plateau which extends at the foot of the Aiguille du Goûter. It was seven in the evening when they reached this advanced position. The glacier abutted on a bridge of snow, which it was absolutely necessary to traverse, but which, as it overhung a frightful precipice, presented a most perilous traject. In crossing it, each traveller placed himself between two guides, who held between them a long alpenstock, forming on the side of the precipice a sufficient support to steady his steps and re-assure him against danger.

After crossing the narrow snowy isthmus, they attacked the ridge, or backbone, of the Aiguille du Goûter. But here their progress became both slow and painful. The acclivity was far steeper and more abrupt than that which had brought them to the base of the Aiguille. The rocks, loosened and disintegrated by the action of the atmosphere, crumbled under their feet, or gave way in their hands, when they sought to assist themselves by grasping hold of them. Frequently, when at a loss for some slight stay or holdfast, the traveller was forced to seize the leg of the guide who preceded him. Freshly fallen snow filled the hollows or interstices of the rocks. The middle of the ridge was often inaccessible, and they were constrained to traverse the dangerous *couloirs* which bordered it. All these obstacles increased as they drew near the summit of the Aiguille.

After five hours of this fatiguing labour, the incline gradually grew steeper, and the quantity of fresh snow augmented at each step.

Balmat, therefore, went forward to survey the remainder of the ascent, but speedily returned with the information that the newly fallen snow was so dense in the upper parts that the summit could not be attained except at the risk of life, and that the mountain-peak was covered two feet deep in snow, which rendered progress impossible. His gaiters were, in fact, covered with snow even above the knee.

Great as was the regret which they experienced in abandoning an enterprise so auspiciously commenced, Saussure and Bourrit wisely resolved to prosecute it no further. At the point where they halted the barometer showed an elevation of 11,250 feet.

The guides now urged an immediate departure. The sun's rays had melted the snows and rendered the descent dangerous. But walking cautiously, and supported by their guides, the travellers returned without accident to the plateau at the base of the Aiguille du Goûter, and thence re-descended to the cabin.

The rock on which this enterprise had been wrecked was the lateness of the season. Saussure resolved to repeat the attempt in the following year, but at an epoch which should render less probable and less formidable the obstacle of fresh-fallen snow. As a preliminary, and to lighten as far as might be the fatigue of the last day's ascent, he ordered his favourite guide, Pierre Balmat, to construct a new hut at a point considerably above the Pierre-Ronde—that is, at the foot of one of the ridges of the Aiguille du Goûter. He recommended him at the same time to make various explorations on that part of the mountain, so as to determine on the most feasible route.

Pierre Balmat took to himself two other guides, and on the 6th of July 1786 they went to pass the night in the hut at the Pierre-Ronde. They started at day-break, and following the same track which Saussure had taken, ascended to the Aiguille, and finally to the Dôme du Goûter; but not without severe suffering from the rarefaction of the air.

While Pierre Balmat and his friends were ascending the Aiguille du Goûter by the incline of the Pierre Ronde, three other Chamounix guides attempted it by another route—that is, by the Montagne de la Côte. As it was then believed that the Dôme du Goûter was the only way by which Mont Blanc could be approached, some of the Chamounix guides had divided into two troops, to test the comparative facilities of the two routes leading to the Dôme. François Paccard, Michel Cachat (surnamed *The Giant*), and Joseph Carrier, composed the second detachment. They were joined by another guide, Jacques Balmat, who for some years had been independently seeking the road to Mont Blanc, and for whom was reserved the glory of first discovering it.

The two groups of guides having reunited, traversed a vast snow-field, and gained the long ridge which connects the Dôme du Goûter to Mont Blanc. But this ridge, which strikes between two precipices, each 6000 feet in height, is so narrow, and of so abrupt an ascent, that it proved utterly impracticable to reach Mont Blanc by it. The guides only acknowledged this evident fact with much reluctance. Jacques Balmat, however, persisted in continuing the adventure. He risked his life on the narrow ridge, and to move forward was obliged to place himself on all-fours upon the species of *dos d'âne* (ass's back) formed by this terrible escarpment. His companions, frightened at his temerity, abandoned him, and redescended to Chamounix.

After brave but fruitless efforts, Jacques Balmat was forced to desist from his impossible enterprise. He retraced his steps, still straddling along the ridge, like a child on his grandfather's stick. But he found himself deserted by his companions, who, we may add, felt no great sympathy for him, because he had followed them without their consent. The gallant mountaineer, piqued by their cowardly abandonment, resolved to remain alone in these frozen wastes and desolate wildernesses until he had discovered a practicable mode of ascending Mont Blanc.

Instead of returning to Chamounix, he descended to the Grand Plateau, where he resolved to pass the night.

The Grand Plateau of Mont Blanc is a slightly-inclined plane, of about 2000 square acres, situated upwards of 9750 feet above the sea; swept by continual avalanches and exposed to the most biting winds; for it is surrounded on all sides by peaks of snow, where the traveller can find neither rock nor stone to serve as a shelter or a resting-place. Even during the summer, and in the sun, the thermometer here marks always zero. In this awful desert Jacques Balmat, without covering, having only his mantle and his alpenstock, spent the night, crouching under a crag, and but poorly defended against a small, drizzling, frozen snow, which fell incessantly.

At daybreak he resumed his explorations of the mountain. It was thus that he discovered the proper direction in which to climb the "sovran peak"—namely, by following up the valley of snow which stretches from the point now known as the *Grands Mulets*, and ascending from thence to Mont Blanc by a moderately steep acclivity. The bad weather, snow, excessive cold, and want of provisions prevented Jacques Balmat from pushing forward to the goal; but, in redescending the valley, he ascertained with exactitude the actual course to be pursued in order to gain the summit.

On returning home, Jacques Balmat slept for eight-and-forty hours without once awaking.

The incessant refraction of the sun's rays upon the snow had so fatigued his sight, that he suffered severely from diseased eyes. A physician, named Paccard, who resided in Chamounix village, relieved him from the ophthalmia. In gratitude for his cure and acknowledgment of his skill, Balmat revealed to him his great discovery, and proposed to him to share the glory of accomplishing the First Ascent of Mont Blanc. Dr. Paccard accepted the proposal joyfully.

On the 8th of August 1786 the two adventurers commenced their daring expedition. They had only confided to two persons the secret of their project before carrying it into execution. So they accomplished alone this lengthened and dangerous route, which our Alpine climbers now-a-days do not attempt except with a numerous and well-provided escort. All their stores consisted of a couple of woollen coverlets, in which to wrap themselves at night under the shadow of some projecting rock. It is difficult to understand how these two men, reduced to their own resources, in the midst of these desolate wastes, these ice-bound deserts, which had never before been trodden by human foot, could reach the goal they had proposed to themselves, in spite of the snows and the precipices, the cold, and the rarefaction of the atmosphere. But it is certain that, after passing the night under a rock on the plateau of the Grands Mulets, they ascended, on the following day, to the "monarch of mountains."

The inhabitants of Chamounix, meanwhile, had assembled in crowds, and, by means of their telescopes, could perceive the two heroes on the topmost peak of Mont Blanc—that is, of the loftiest mountain in Europe, which had hitherto been considered utterly inaccessible to man.

Jacques Balmat and Paccard remained for half an hour on the horse-shoe ridge which forms the actual summit.

But, owing to the continual reflection and dazzling gleam of the sunlit snows, Paccard, when he regained the valley, was almost blind; while Balmat's face was swollen, his lips were congested with blood, and his eyes were sorely fatigued.

"It is strange," said Paccard to his companion next morning; "I hear the birds sing, and it is not day!"

"That is because you cannot see," replied Balmat; "the sun has risen, but the swelling of your eyelids renders you temporarily blind."

Happily, this accident had no fatal consequences. Dr. Paccard died in 1830, at the ripe age of seventy-nine. As for Jacques Balmat, he perished miserably, in 1834, at the bottom of a precipice. Some vague rumours had induced him to believe that a vein of gold existed on the flank of one of the lofty peaks which shut in the valley of the Sixt on the north-east, and he started in search of it. But the place indicated proved inaccessible; it was necessary to advance along a narrow cornice, beneath which descended, sheer and sombre, into the abyss a precipice nearly 400 feet in depth. The sight froze his blood with terror. But some time afterwards, accompanied by a chamois hunter, as rash and as intrepid as himself, he renewed the attempt. He ventured on the narrow cornice—a few steps—and he disappeared in the abyss! His body was never found.*

But this is a digression.

FIG. 54.—ROCK OF THE GRANDS MULETS. (*After a Photograph by Tairraz.*)

As soon as he had recovered from his fatigue—that is, in about four days after his successful ascent—Jacques Balmat betook himself to Geneva, to announce to De Saussure the result of his expedition. De Saussure had already been informed of it, and wished, without a moment's needless delay, to follow in the footsteps of the mountaineer.

On the 20th of August 1786, Jacques Balmat attempted, in company with De Saussure, the grand and extraordinary enterprise which he had accomplished with Dr. Paccard. They passed the night in a cave above the Glacier de Tacconay. But

* Michel Carrier, "Notice Biographique sur Jacques Balmat" (Geneva, 1854, 8vo edition).

there came on so violent a storm of rain, accompanied by snow and hail, that they were compelled to renounce their enterprise, and defer it until the following year.

It was on the 1st of August 1787 that De Saussure, accompanied by eighteen guides and a servant, accomplished the first ascent of Mont Blanc undertaken for scientific purposes. The first day was spent in ascending the Montagne de la Côte, and they passed the night on its summit. De Saussure slept under a tent, with his servant and a couple of guides, in the very place where Jacques Balmat and Dr. Paccard had passed the first night in their expedition; a place which, as we have already stated, now bears the name of the *Grands Mulets*, and serves as a night-

FIG. 55.—HUT ERECTED ON THE GRANDS MULETS. (*After a Photograph by Tairraz.*)

station for travellers ascending Mont Blanc. The other guides disposed themselves among the granite boulders, so as to obtain some slight shelter from the piercing cold.

In Figure 54 we delineate the rock of the *Grands Mulets*, with the modern hut which has been erected there, and which serves as a night-hostelry for excursionists *en route* to the mountain. Figure 55 is a view of the hut.

The difficulties of our adventurers did not begin until the second day; for, on setting out from the Grands Mulets, they were compelled to traverse the ice and snow.

On this second day they commenced by traversing the Glacier de la Côte—a glacier whose passage is attended with much danger. It is intersected with deep, irregular crevasses, often of great width, and which are only passable upon bridges of frozen snow suspended over the abyss.

We shall now leave De Saussure himself to relate the story of his famous ascent, and to acquaint us with its different incidents, both with respect to his scientific observations and the physical impressions which he received in an atmosphere more and more rarefied by the elevation.

"On the 2nd of August," says De Saussure, "despite the great interest we all had in starting at an early hour, the guides raised so many difficulties in reference to the distribution and arrangement of their various burthens, that we were not in full

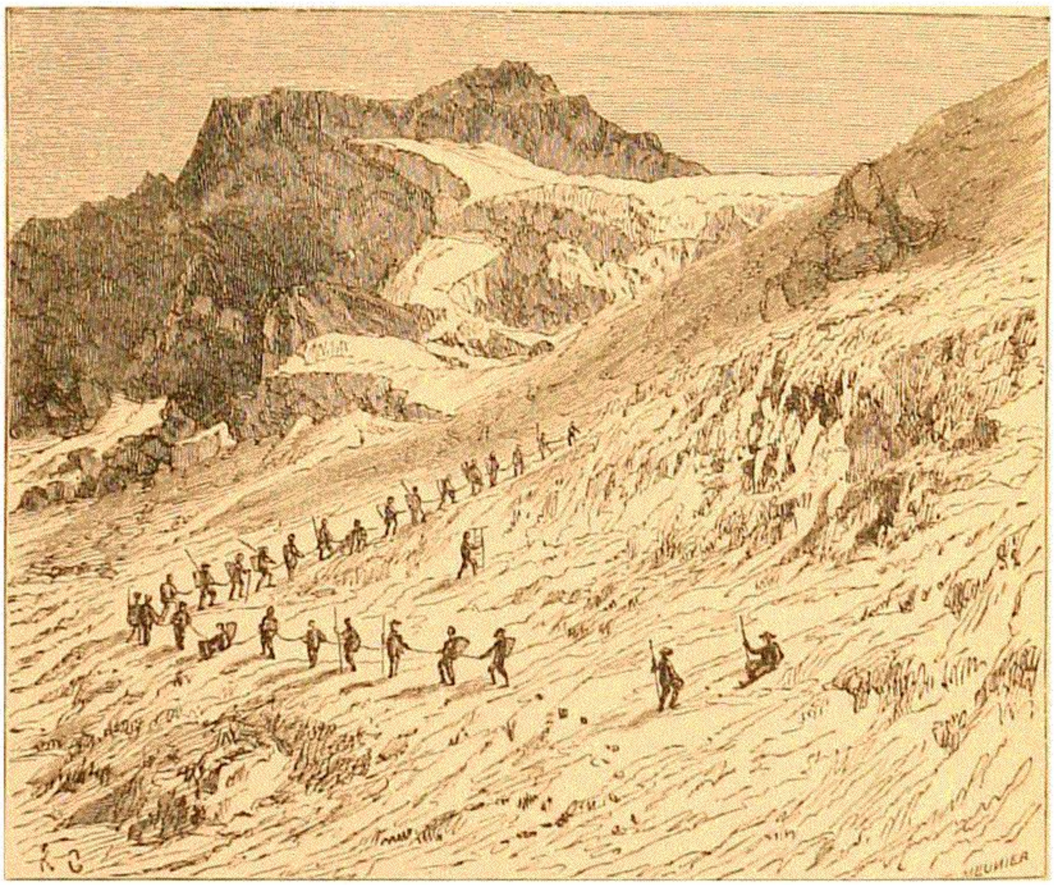

FIG. 56.—DE SAUSSURE'S CARAVAN ASCENDING THE DÔME DU GOÛTER.
(*From a photograph by Tairraz.*)

march until about half-past six. Each was afraid of overloading himself, less through dread of fatigue, than from an apprehension that he might sink in the snow under too heavy a weight, and so fall into a crevasse.

"We entered upon the glacier, face to face with the blocks of granite under whose shelter we had slept. The approach to it is easy, but travellers soon find themselves entangled in a labyrinth of ice-rocks, separated by crevasses, here entirely covered, there only partially concealed by the snows which frequently accumulate in fantastic arches, hollow beneath, and yet very often the sole means of traject; in other places, a sharp ridge of ice serves as a bridge for crossing them. Occasionally, where the crevasses are wholly unfilled, you are compelled to descend to the very bottom, and afterwards to remount the opposite wall by steps hewn with a hatchet in the living ice. But nowhere do you ever see the rock; the bottom is always ice, or snow; and there are moments when, after having descended into these abysses surrounded by nearly perpendicular walls of ice, you cannot conceive in what manner you shall escape from them (Fig. 57). While progressing on the living ice, however narrow may be the ridges, however steep the declivities, our intrepid mountaineers, whose head and feet are equally sure, seem neither terrified nor disquieted; they gossip, laugh, jest at one another; but in passing along these frail vaults suspended above profound abysses, one sees them march in the profoundest silence, the first three bound together by cords at the distance of five or six feet from each other, the remainder supporting themselves two by two by their staves, their eyes fixed on their feet, each person endeavouring to plant himself firmly and lightly in the track of his predecessor. When, after crossing one of these suspicious snow-tracts, my caravan found themselves on a rock of living ice, an expression of joy and serenity brightened every physiognomy; the babble and the jokes recommenced; then they consulted what route it were best to follow, and reassured by past successes, exposed themselves with the greater confidence to new dangers. Thus we spent nearly three hours in traversing this formidable glacier, although it was scarcely a quarter of a league in breadth. Thenceforth, our progress was wholly on the snows, fre-

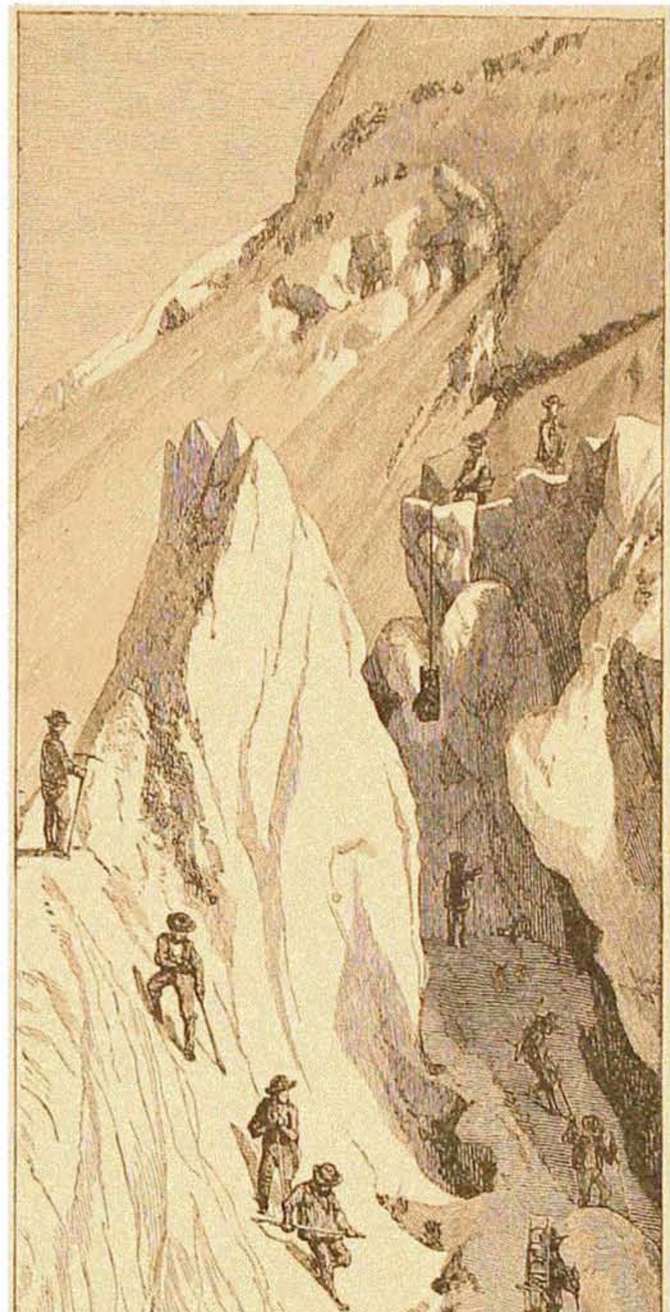

FIG. 57.—GREAT CREVASSE AT THE FOOT OF MONT BLANC.
(*From a photograph by Bisson.*)

quently rendered very difficult by the rapidity of their incline, and sometimes dangerous when these inclines terminated upon precipices, but where at all events we had no dangers to dread but those which we saw, and where we incurred no risk of being swallowed up without either skill or strength being of any service."

[Not to prolong our narrative, we suppress the minute details which De Saussure gives of the various circumstances that distinguished the ascent, and proceed at once to its conclusion. On the second day, he attained the summit of Mont Blanc, after braving a thousand perils.]

"My first glance," says De Saussure, "was directed towards Chamounix, where I knew that my wife and her two sisters, with eyes fixed to their telescopes, followed my steps with an anxiety undoubtedly excessive, but not, on that account, less painful; and I experienced a tender and consoling emotion when I saw the flag displayed which they had promised to hoist as soon as, perceiving me on the summit, their fears should be for a time suspended.

"I could then enjoy without any feeling of regret the great spectacle displayed before me. A light vapour, floating in the lower regions of the atmosphere, concealed, it is true, the lowest and most distant objects, such as the plains of France and Lombardy; but I did not much lament this loss; for what I had come to see, and what I saw with marvellous clearness, was the grand whole of all the lofty peaks whose organization I had so long desired to know. I could not believe my eyes—it seemed to me a dream, a vision—when I beheld beneath my feet those majestic summits, those formidable spires, the Midi, the Argentière, the Giant, whose very bases had been so difficult and dangerous of approach. I seized upon their positions, their connection, their conformation, and a single glance dispelled the doubts which years of labour had been unable to solve.

"Meantime, my guides were raising my tent, and preparing the little table on which I intended to experiment with boiling water. But when I set to work to arrange my instruments and take my observations, I found myself every moment compelled to interrupt my work, and give all my thoughts to the actual labour of breathing. If the reader reflects that the barometer was here at 16 inches 1 line only, and that the air was not at above half its ordinary density, he will understand how I was forced to supplement the density by frequency of respiration; while, at the same time, this frequency so accelerated the movement of the blood that the arteries were no longer counterbalanced externally by a pressure equal to that which they usually experience. Therefore we were all attacked with fever, as will be seen in the record of my observations.

"While I remained perfectly tranquil, I experienced but a slight uneasiness, a tendency to pain about the heart. But when I used any exertion, or when I fixed my attention for a few consecutive moments, and especially when in stooping I contracted my chest, I was obliged to rest, and take breath, for two or three minutes. My guides experienced similar sensations. They had no appetite, and, in truth, our provisions, which had frozen *en route*, were not adapted to stimulate one: they did not even care for wine or brandy. In fact, they had discovered that strong liquors increased their indisposition, undoubtedly by accelerating the quickness of the circulation. Nothing but fresh water did them any good or gave them any pleasure ; but it cost both time and labour to kindle a fire, without which we could not have any.

"I remained, however, on the summit for four hours and a half ; and although I did not lose a single moment, I could not perform in that period all the experiments which I have frequently completed in less than three hours on the sea-shore. But I performed with great care those which were the more important."

We shall now offer a summary of the scientific results obtained by De Saussure on the loftiest observatory which, up to that time, had ever served for the experiments and investigations of a philosopher.

De Saussure calculated by his barometer, simultaneously with his son's computations at Chamounix, the height of Mont Blanc. He found it, according to his corrected calculations, to be 2450 toises (15,756 feet) ; whence it claims the rank of the monarch of European mountains.

The thermometer marked at noon in the shade—1° C., and in the sun, 2° [that is, 33° 48′ and 35° 36′ F.].

To ascertain the relative humidity or dryness of the atmosphere, De Saussure experimented with an instrument of his own invention—the hair hygrometer, which he first placed in the sun, then in the shade. At noon, the hygrometer in the sun marked 44°, and in the shade 51°, a difference far greater than is generally observed in the plains, because the solar heat much more considerably increases evaporation in a rarefied than in a condensed air.

Simultaneous observations with the hygrometer at Chamounix and Geneva showed, at noon, 73° 4′, and 76° 7′. On consulting the hygrometrical tables which identify the degrees of the instrument with the *hygrometrical condition* of the air, and the absolute quantities of watery vapour contained in a given volume of it, we find that the air at noon, on the summit of Mont Blanc, contained six times less humidity than the air at Geneva. This extreme dryness was undoubtedly the cause of the burning thirst which De Saussure and his companions experienced during their sojourn on the Alpine heights.*

The atmospheric electricity was very weak ; the balls of the electrometer did not diverge more than an inch and a quarter, a fact which was assuredly due to the dryness of the air ; rendered a bad conductor by the absence of the aqueous vapour, the atmosphere did not establish a communication with the electric fluid contained in the upper regions.

One of the most curious spectacles which awakened the admiration of our travellers, on the crest of Mont Blanc, was the extreme intensity of the colour of the sky.

Every person who has ascended a lofty mountain knows that from its summit the sky appears of a deeper, darker blue than in the plain, which is owing to the greater purity and transparency of the air. To obtain an accurate indication of the colour of the sky of Mont Blanc, De Saussure had taken the precaution of preparing a series of strips of paper, tinted with six graduated shades, from the palest azure

* We must add that there are exceptions to this rule ; for Boussingault found the air of Chimborazo more humid than the air of the plain.

to an almost blackish blue. At noon, on Mont Blanc, the sky appeared of the second shade—that is, of nearly the darkest blue; the observers who simultaneously made the same comparison at Chamounix and Geneva, found that the colour of the sky at Chamounix appeared of the fifth, and at Geneva of the sixth shade.

Lime water and caustic potash [Hydrate of potash, KO,HO], exposed to the air, infallibly demonstrated the presence of carbonic acid. This experiment, which now-a-days would be considered of little importance, was intended to verify a conjecture hazarded by the great chemist, Lavoisier, who had supposed it possible that the upper regions of the atmosphere contained gases unknown to us, their specific lightness holding them suspended at an extreme altitude.

One of the most important experiments, in verification of an important theory of physics, was the determination of the degree at which water boiled upon these lofty heights. The physician De Luc had formerly ascended, not without serious difficulties, the Mont du Buet, with the sole purpose of performing this experiment, which, up to that time, had never been attempted at any great elevation. The height of Mont Blanc being double that of the Buet, this experiment was one of great interest.

De Luc had found it a matter of no little difficulty to kindle charcoal on the Buet, owing to the extreme rarefaction of the air. To get rid of this obstacle, De Saussure had constructed a spirit of wine lamp provided with a wick for a double current of air and a single *cheminée de tôle*, according to Argand's invention, then quite novel. The spirit of wine burned very well. The water nevertheless took half an hour to boil; while in the same apparatus, on the sea level, it would not have occupied more than 12 or 13 minutes. The heat of the boiling water on Mont Blanc was only 85° C. [185° F.]

He had taken the precaution to provide himself with charcoal, in case the lamp had not worked properly. He had no occasion to make use of it for the boiling water experiment, but found it exceedingly useful in melting the snow to obtain drinking water, which the extreme thirst of the travellers called every moment into requisition.

The declination of the magnetic needle did not present any remarkable feature. The same may be said of the observations made by De Saussure on the thickness of the snowy mantle which enshrouds Mont Blanc, and on the disposition of the strata of snow along the flanks of the remainder of the mountain.

No sign of animal life was apparent near the frozen peak of the Alpine giant. Two butterflies which fluttered across the last incline of the mountain, about 650 feet beneath its summit, were the only living creatures which our explorers encountered in those silent and lonely deserts. It is probable that a gust of wind from the plain had carried them to this unwonted elevation.

The slight intensity of sound on lofty mountains is easily explained by the rarefaction of the air; this rarefaction, diminishing the mass of the air, necessarily diminishes the intensity of its vibrations. On an isolated peak, the absence of echoes is another cause which reduces the force of the sound. The human voice consequently seems very feeble on Mont Blanc; the discharge of a pistol makes no greater report than a small cracker.

But of all the effects of the non-density of the air, the most manifest was the extreme acceleration of human respiration. Upon Mont Blanc, where the barometrical column undergoes a depression of nearly one-half, and where the lungs consequently receive at each inspiration just half the quantity of oxygen which they would receive in the plain, it is obvious the respirations must necessarily be twice as numerous for the blood-making to be maintained in its normal and physiological conditions. The necessity of these continually-repeated respirations explains the anguish and fatigue which men endure at great elevations.

But at the same time that the respiration is accelerated, the circulation of the blood is quickened in the same proportion. De Saussure wished to assure himself of this fact in an accurate manner, and to prevent any erroneous ascription of the accelerated pulse to the fatigue of the ascent, he did not make the trial until after four hours of almost tranquil rest on the mountain's summit. Then he found that his servant's pulse beat 112 times in a minute, his own 100, and that of Pierre Balmat 98. This trial, repeated next day at Chamounix, after some hours' repose, gave for the same individuals respectively, 60, 72, and 49 pulsations.

Thus the intrepid explorers of Mont Blanc were incessantly in a feverish condition, which explains the thirst that tormented them, as well as their antipathy to wine, strong liquors, and even to every kind of food. They longed only for cold water, and nothing else would they endure; eating snow did but increase their pain. However, when they kept themselves perfectly tranquil, they did not suffer seriously.

Some of the guides and men engaged in the expedition could not endure so many varieties of torture; they were compelled to descend to a more condensed air.

"Nature," says De Saussure, "has not made man for these lofty regions; the intense cold and rarefied air drive him from them; and as he can find neither animals, nor plants, nor even metals, nothing attracts him thither; curiosity and an ardent desire of instruction are the sole impulses which ever lead him to surmount for a brief period the numerous obstacles in his way.

"I remained, however, upon the summit until half-past three o'clock, P.M., and although I lost not a single moment, I could not perform in these four and a half hours all the experiments which I have frequently completed on the sea-level in three hours. It was with much regret I set out without having accomplished my entire project, but it was absolutely needful to allow ourselves a sufficient margin of time to cross before night the dangerous passages we had to traverse. . . . .

"I quitted, with great reluctance, at half-past three, this magnificent *belvédère*.

"We passed near the spot where, on the preceding night, we had, if not slept, at least reposed, and we pushed forward another league to the rock in whose vicinity we had halted on our ascent. I determined to pass the night there; I caused my tent to be raised against the southern extremity of the rock, in a truly singular situation. It stood on a snowy declivity overshadowed by the Dôme du Goûter, with its crown of pinnacles, and terminating southward in the peak of Mont Blanc. At the bottom of this declivity yawned a broad and deep crevasse, which separated us from the valley, and swallowed up everything that fell in the neighbourhood of our tent.

"We had chosen this position in order to escape the peril of the avalanches, and because the guides finding shelter in the gaps of the rocks, we were not crowded within the tent as on the preceding night.

"I occupied myself in the evening with observing the barometer, which gave, as the elevation of the rock, 12,000 feet. Afterwards I amused myself with contemplating the cloud-masses hovering beneath us, though far above the valleys and mountains less elevated than ourselves. These clouds, instead of presenting broad and even surfaces, as we see them from below, displayed the most fantastic outlines of towers and castles, and giants, and appeared uplifted by vertical winds which issued from different points of the subjacent countries.

"We supped merrily and with a good appetite; after which I passed an excellent night on my little mattress. It was then only that I enjoyed the pleasure of having accomplished the design which I had formed twenty-seven years previously—namely, on my first visit to Chamounix, in 1760; a design which I had so often abandoned and resumed, and which had been a continual source of anxiety and disquietude to my family. It had, indeed, become with me a species of disease; my eyes never rested upon Mont Blanc, which was visible from so many points near my dwelling, without my undergoing a fresh attack of melancholy. At the moment that I attained the summit my gratification was not complete; it was still less so when I was about to commence my descent, for, until then, I only realized how much I had been unable to complete. But, in the silence of night, and after thoroughly recovering from my fatigue, when I recalled the observations I had made, and especially when I retraced the splendid picture of the mountains eternally imprinted on my brain, and while, finally, I nourished the well-founded hope of finishing on the Col du Géant what I had not yet done, and what, in truth, could never be done on Mont Blanc, I tasted a real and unalloyed satisfaction."

The sensation awakened throughout Europe by the brilliant success of Saussure's enterprise soon called forth numerous rivals of his glory. We shall say but little in reference to ascents almost all undertaken from motives of curiosity, or as enterprises of adventure, and not by scientific men desirous of settling some uncertain points in the physics of the globe. Little good can result from such undertakings; on the contrary, their record is overshadowed by many sad tales of death and disaster; and if they escape the censure of the moralist, unquestionably they do not merit his approbation.

From this judgment, however, we must except the naturalist Bourrit, canon of the cathedral of Geneva, whose vain attempts we have already recorded. The day after the triumph of De Saussure, Pierre Bourrit, escorted by a few guides, climbed the acclivities of Mont Blanc; but a storm forced him almost immediately to retrace his steps.

He was not much more successful in his essay in the following year. It seemed written by an inexorable Fate that the indefatigable Bourrit should pass his life in showing his rivals the route to Mont Blanc, without ever arriving thither himself. A hard and contradictory fortune for one who justly entitled himself the Painter of the Alps, and whose merit it was to be the first to attract by his works (particularly by his descriptions and his remarkable drawings of the Glaciers) the attention of Europe to the beauties of these mountains, then unexplored by tourists.

On the 5th of August 1788, the year following De Saussure's expedition, an Englishman and a Dutchman, Mr. Woodley and M. Camper, undertook the same ascent, accompanied by twelve guides. Unfortunately, they conceived the notion of accepting Bourrit as a companion, and it seems to have been his miserable privilege to cast a fatal shadow upon every enterprise of this kind. Mr. Woodley had his hands and feet frozen; some of the guides, too, had the joints of their hands and feet frost-bitten. Bourrit, stricken half-blind, only recovered his sight by applications of snow continued for thirteen days.

It was an Englishman, however, Colonel Beaufoy, who was the first to follow successfully in the footsteps of De Saussure, and to reach the summit of Mont Blanc (August 9th, 1790). On his return he was in danger of losing his sight. Alpine climbers did not then protect themselves, as they now-a-days do, by a simple veil of blue or green gauze, from the dazzling reflection of the sun's rays upon the snows, and consequently they were exposed to dangerous ophthalmic attacks and swellings of the face.

In 1797, four of Colonel Beaufoy's countrymen made the same attempt; but the bad weather compelled them to re-descend, all having suffered more or less severely, and experienced some dangerous falls. One of the guides broke his leg; another split his skull open.

On the 10th of August 1802, Baron Doorthesen, a Russian gentleman, and M. Forneret, of Lausanne, attained the summit of the mountain; but they had incurred so many dangers, and endured so many sufferings, that they declared no power on earth should force them to repeat the ascent.

Let us note an attempt on the 10th of September 1812, successfully carried out by M. Rodaz of Hombourg; and another, August 4th, 1818, by a Polish gentleman, the Count Matezecki.

No American as yet had followed in the arduous footstep of the conquerors of Mont Blanc. The charm was broken, June 17th, 1819, by Dr. Van Reusselaer of New York, and Mr. Howard of Baltimore. They suffered greatly both from heat and cold, and were long ill with an affection of the eyes and face.

It was with a purely scientific object that Dr. Hamel, councillor of the Russian court, betook himself, in 1821, to the foot of Mont Blanc, to escalade its snowy peak.

This eminent man of science travelled at the cost of the Russian Government, to undertake certain inquiries into the physical condition of the globe, and was everywhere attended by a train of all kinds of instruments of observation. We shall describe the ascent of Mont Blanc attempted by the Russian physicist, not for any scientific results obtained from it, but on account of the catastrophe which abruptly terminated it, and whose sad recollections are still fresh in the valley of Chamounix.

On the 3rd of August 1820, the anniversary of Saussure's successful enterprise, a first attempt was made by Dr. Hamel, *viâ* the glaciers of Bionnassay and the Aiguille du Goûter; but the outbreak of a storm, and the cloud-masses which hung upon the mountain, compelled him to descend.

It was on the 18th of August that he recommenced his ascent. He was accompanied by two English gentlemen, Mr. Dornford (?) and

Colonel Gilbert Henderson. Twelve guides escorted them, under the leadership of Marie Coutet; namely, Julien Devoissous, David and Joseph Folliguet, the two brothers Pierre and Mathieu Balmat, Pierre Carrier, Auguste Teiraz, David Coutet, Jacques Coutet, and Pierre Favret.

Having started from Chamounix at six A.M., it was four P.M. when they arrived at the *Grands Mulets*. It is here that travellers always halt to pass the night. A part of this rock is shaped like the letter L; a ladder and some poles covered with canvas were arranged against it so as to form a sort of triangle, in whose interior Dr. Hamel and his companions spent the night, lying upon straw. But in the evening the weather grew stormy, and the rain began to fall. The atmosphere was heavily charged with electricity, and the balls of the electrometer danced so rapidly to and fro as to excite alarm.* Throughout the night the thunder never ceased to peal.

All the following day the rain continued, and the snow, which at first only fell upon Mont Blanc, began to approach the region where our travellers had encamped. The bad weather lasted through the second night, which was spent, like the preceding, under the miserable shelter of the tent.

The commonest prudence should have dictated to the travellers an immediate return to Chamounix. The guides, having consulted together at daybreak, were unanimously of this opinion; but when they intimated their decision to Dr. Hamel, he formally rejected it. It was then determined that three guides, Jacques Coutet, Joseph Folliguet, and Pierre Favret, should go to Chamounix for a supply of provisions, which were now running short.

It had been settled that they should rest quietly in their encampment until fair weather returned; but at eight A.M., on the sky brightening, Dr. Hamel decided he would immediately set out.

* [The Electrometer is an instrument designed to give evidence of the presence of electrical excitement, and, also, to measure its force. It consists of a conducting rod, of brass or boxwood, to which a graduated semicircle is attached. In the centre of the latter a straw, carrying a pith-ball at its outer end, rotates on a pivot. When the ball is charged with electricity, the height to which it rises is necessarily shown on the graduated semicircle. The Electroscope is now used for a somewhat similar purpose.]

The guides, who realized all the peril of traversing in the midst of frightful precipices the fresh fallen snows, refused to obey so imprudent an order: one of them, Auguste Teiraz, burst into tears; he threw himself into the arms of a comrade, exclaiming, "I am a lost man! I shall perish on the mountain!"

This sinister presentiment was verified, for Auguste Teiraz was one of the victims of the catastrophe. Colonel Henderson himself was of the same opinion as the guides, but Dr. Hamel, stamping his foot, and looking the Englishman full in the face, muttered the word "Cowards!"

An Englishman, after that, could no longer hesitate—*Noblesse oblige!* Each person made his preparations in silence, and they began the ascent.

The first part of the journey was accomplished without accident, and the weather became very bright and beautiful. Without much difficulty they ascended the Dôme du Goûter, and reached the great plateau which extends at the base of Mont Blanc.

"Here," says Dr. Hamel, in his narrative of the event, "our guides congratulated us, saying that we had now surmounted every danger; no more crevasses, no more hazards. Never had an ascent been accomplished more quickly or with less difficulty; in fact, the snows had just the degree of consistency suitable for easy marching; they were not too hard, and yet the feet did not sink too deeply in them. No one felt ill, though all of us had for some time experienced the effect of the rarefaction of the air; my pulse beat one hundred and twenty-eight times in a minute, and I felt an incessant thirst. Here our guides invited us to breakfast, for, said they, up higher you will have no appetite. A tablecloth was spread on the snow at the threshold of the great plateau, and it served both for chairs and table. Everyone ate with gusto his half of a fowl; I made various arrangements for my experiments, and the observations which I proposed to take on the summit. I wrote two notes to announce our successful achievement, leaving only a blank to be filled up with the exact hour. It was my intention to attach them to a pigeon which I had brought with me, and which I proposed to release on the summit, to see how he flew in so rarefied an air, and also to ascertain if he could retrace his way to Sallanches, where his mate awaited him. We preserved a bottle of our best wine to drink on the peak to the memory of De Saussure.

"At nine o'clock precisely we resumed our journey, and toiled towards the summit which rose before our wistful eyes. 'Would you take a thousand pounds,' said one of my companions to his countryman, 'to go back, instead of ascending?' The reply was, 'I would not return for any sum that could be named.' We were so full of hope and joy at seeing immediately within our reach the goal of our enterprise." *

At this moment the travellers were ascending what the guides call "the hood of Mont Blanc;" that is, the last snowy incline which leads to the topmost peak. At the foot of this glacis yawns an immense crevasse of ice, 20 yards in width and 50 in depth. It is the great crevasse which we delineate in Figure 52. They now marched in single file, one after another; the first guide was Pierre Carrier, the second, Pierre Balmat, and the third, Auguste Teiraz. Next came Julien Devoissous and Marie Coutet. Behind these, still in single file, marched five other guides, Dr. Hamel, and the two Englishmen.

It was probably this order of march which led to the catastrophe. By advancing in a single line, they furrowed, as with a ploughshare, the newly fallen snow, which had not yet had time to consolidate with the old. Thus divided by a long section, the portion of snow which the caravan escaladed separated suddenly; it glided over the older snow. All the party was carried with this avalanche down the steep declivity at whose base opened, as if to engulf them, the immense crevasse to which we have referred. The mass of frozen snow which in this wise broke loose was 1000 yards in length, by 70 in breadth, but not 3 feet in depth.

* Bibliothèque Universelle de Genève, tome xiv., p. 317.

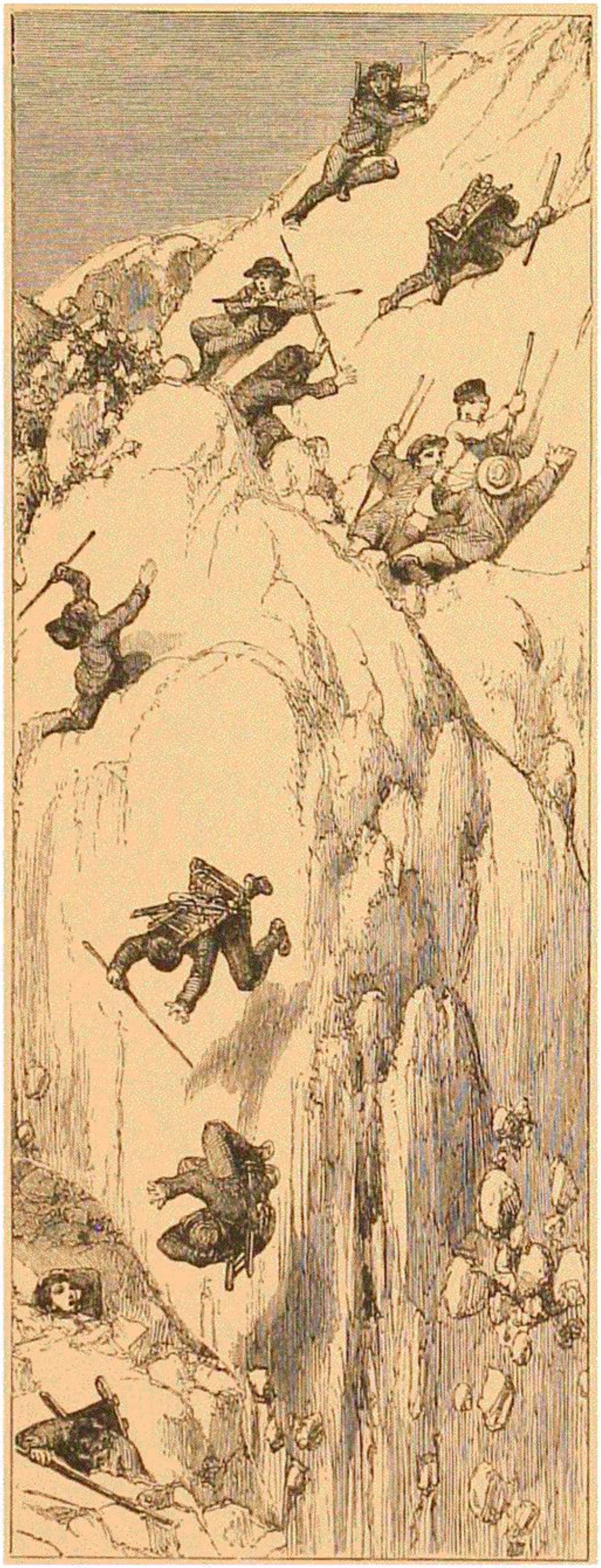

FIG. 58.—THE GREAT CREVASSE OF MONT BLANC. CATASTROPHE OF AUGUST 20TH, 1820.

Everybody was thrown down and rolled in the snow. The three guides who led the way, Pierre Carrier, Pierre Balmat, and Auguste Teiraz, were dashed headlong into the crevasse. Julien and Marie Coutet, propelled by a more violent impulse, were fortunate enough to sweep across the abyss, and fall into another crevasse, happily not so deep, and half full of snow, from which they were easily extricated. By a merciful Providence, the other guides, Dr. Hamel, and the two Englishmen, arrested their descent on the border of the gulf. They had rolled over and over from a height of 300 feet.

Julien Devoissous and Marie Coutet remained a moment without consciousness. Julien, with his head beneath him, was wounded all over with blows received against the narrow sides of the crevasse. Marie Coutet was half buried in the snow, which filled this chasm for a depth of 60 feet. Embedded up to his neck, he was unable to make any movement, and his face wore the purple colour of asphyxia. He called with a struggling voice to his companion; Julien, having succeeded in liberating himself, made use of his alpenstock to clear away the snow which covered his friend's body. The two mountaineers remained for some minutes seated opposite one another without uttering a word; they thought that they alone had survived this horrible fall.

Happily it was not so. Several of their comrades, having almost miraculously escaped the avalanche, clung to the edge of the crevasse which had so nearly proved their tomb. One of them, Mathieu Balmat, contrived to slide along it, and to carry assistance to the others. He threw to them a hatchet, with which they hewed out steps in the ice. When they had gained a sufficient height he extended to them an iron-tipped pole, and drew them out of danger.

The travellers now found themselves assembled in one spot; they counted their numbers. Three guides were missing; the three who had formed the vanguard, Pierre Carrier, Pierre Balmat, and Auguste Tieraz. They had fallen into the great crevasse. Mathieu Balmat had seen them precipitated into its abyss; and Julien Coutet, at the very moment of his own fall, and while rolling over and over, had noticed something like a black-coloured leg flash rapidly before his eyes, and descend in the crevasse; undoubtedly it was Auguste Tieraz, who wore black gaiters—the same who had shown so lively an apprehension when Dr. Hamel, in defiance of warnings and counsel, had given the imperious order of departure.

Doctor Hamel was prostrated with regret and pain. As for the two Englishmen, words cannot describe their keen remorse. They flung themselves down upon the snow; they seemed temporarily bereft of reason. They declared they would not quit the accursed spot until they had recovered, dead or alive, the three unfortunate men of whose loss they accused themselves.

In spite of the remonstrances of the guides, Mr. Dornford and Dr. Hamel descended into the great crevasse, their bodies half buried in the soft snow. They sounded everywhere with their iron-tipped staves, but encountered no resistance. With all their strength they shouted the names of the missing guides; but at so immense an elevation the rarefied air produced but feeble sounds.

Presuming that they were buried under a thick stratum of snow, Hamel thrust in his staff to its entire length, and stretching himself on the surface, he held the staff firmly with his teeth; then he listened with profound attention. But there came no answer; nothing troubled the silence of that lugubrious sepulchre.

They were compelled to discontinue the fruitless search. Dr. Hamel and his companion returned to the plateau. The unfortunate guides were lying at least 150 feet deep in the snow. There was no resource but to abandon them, and, since that epoch, no tourist who makes the ascent of Mont Blanc can pass without a throbbing heart the abyss of ice where perished so miserably the three inhabitants of the valley.

As the day advanced the cold became icy; for at that elevation our travellers had nearly attained the height of Mont Blanc itself. They had spent two hours in fruitless search on the borders of the great crevasse; it was absolutely necessary they should begin the descent, if they did not wish to be overtaken by night and darkness in the midst of the precipices, and incur the hazard of being frozen to death.

The guide Mathieu Balmat then drew near to Dr. Hamel, and looking him full in the face, even as the doctor had confronted him on the morning of that fatal day,—

"Well, sir," he exclaimed, "are we *cowards;* and will you still ascend?"

The doctor replied by giving the signal of return. He would fain have persuaded some of the guides to pass the night on the edge of the crevasse, and there await the succour which was hastening up from Chamounix. It was, perhaps, to doom them to death. The suggestion, therefore, was received by the guides with indignant remonstrances, and they reproached the foreigner with having caused by his obstinacy the death of their comrades.

On their homeward route each related the sensations he had undergone at the moment of the descent of the avalanche. Julien Coutet had rolled over thrice before, bounding across the great crevasse, he fell into the small one. He attributed his safety to the circumstance that he carried, slung across his back, the barometer-case of the doctor, which had held him momentarily suspended on the brink of the abyss, whence he had rebounded like a ricochet shot. Marie Coutet had seen four of the five guides who preceded him fall with their feet uppermost; only one seemed to preserve his upright attitude. As for himself, he had felt hurled along like a cannon-ball, and in the twinkling of an eye, lo, he was lying half buried on a bed of snow! A second afterwards, another of his comrades seemed to drop from heaven by his side; it was Julien Devoissous.

The only one of the guides not swept away by the avalanche was Mathieu Balmat. Divining what had happened; comprehending, with the instinct of a mountaineer, that the new snow had separated from the old, and was gliding in one mass down the incline; gifted, moreover, with prodigious physical strength, he thrust his long iron-tipped pole through the recent snow, which was not above three feet deep, and planted it in the older and indurated soil. By exerting all his energy he was able to cling to the pole, while the avalanche carried away beneath him his companions and his brother, Pierre Balmat, to find a sudden and terrible death at the bottom of the abyss.

Thrown down and rolled over like the others, Dr. Hamel had found himself fortunately checked on the edge of the crevasse. Colonel Henderson was driven much nearer the fatal brink, and had only been arrested in his headlong course by the mass of snow which surrounded him. He was completely interred in it, even his head being covered, and was only extricated from it with great difficulty.

On arriving at the Grands Mulets they met the three guides despatched in the morning to obtain a supply of provisions, and who now returned with the rest of the expedition. All these brave mountaineers, struck with a kind of stupor, deplored with one voice the death of their comrades, and the distress into which the event had plunged their families.

The two Englishmen contributed very generously to their relief, but Dr. Hamel, whose conduct throughout was characterized by want of feeling and a headstrong arrogance, took no part in providing for them. Nothing, however, could console the mother of one of the three victims, Pierre Balmat. She wept incessantly; three months afterwards she died.

On the 15th of August 1861 was fulfilled the last episode of this sorrowful tragedy. A Chamounix guide discovered on the glacier des Bossons two human skulls with their integuments, and an arm with the hand still adhering, the whole clothed in ruddy flesh. A few fragments of bags, and clothes, and other signs, left no doubt that these ghastly wrecks had belonged to the two guides, Pierre Balmat and Pierre Carrier. Finally, on the 1st July 1863, the glacier des Bossons surrendered some additional human remains; a foot, covered with its flesh and nails, still attached by the muscles to a fleshless tibia. By the side of the foot lay a compass, probably Dr. Hamel's, which the guide Auguste Tieraz had carried. It was a grandson of the victim, Joseph Tieraz, photographer of Chamounix, who chanced upon this sad discovery.

Many ascents of Mont Blanc have been undertaken since those described in the preceding pages. Mountaineering has, in truth, become a mania; in England an "Alpine Club" has been formed for its scientific development; and the Mont Blanc route is now so well defined that it has been successfully accomplished by ladies. Few adventurers, however, escape without some more or less dangerous mishap; and there seems much good sense in the words with which Captain Sherwill, one of the number, concludes his narrative:—"I advise no one to undertake an ascent, for the result can never have an importance proportionate to the dangers which you must incur, and in which you must involve others."

"Des guides payant la conduite,
Paul au Mont Blanc est parvenu . . .
Bravo! Mais qu'a-t-il fait ensuite? . . .
Ensuite?—Il en est revenu!"

[IMITATED:—

With guides to point out the way,
See Paul to the summit attain!
Bravo! and what does he next?...
Why, faith, sir, he comes down again!]

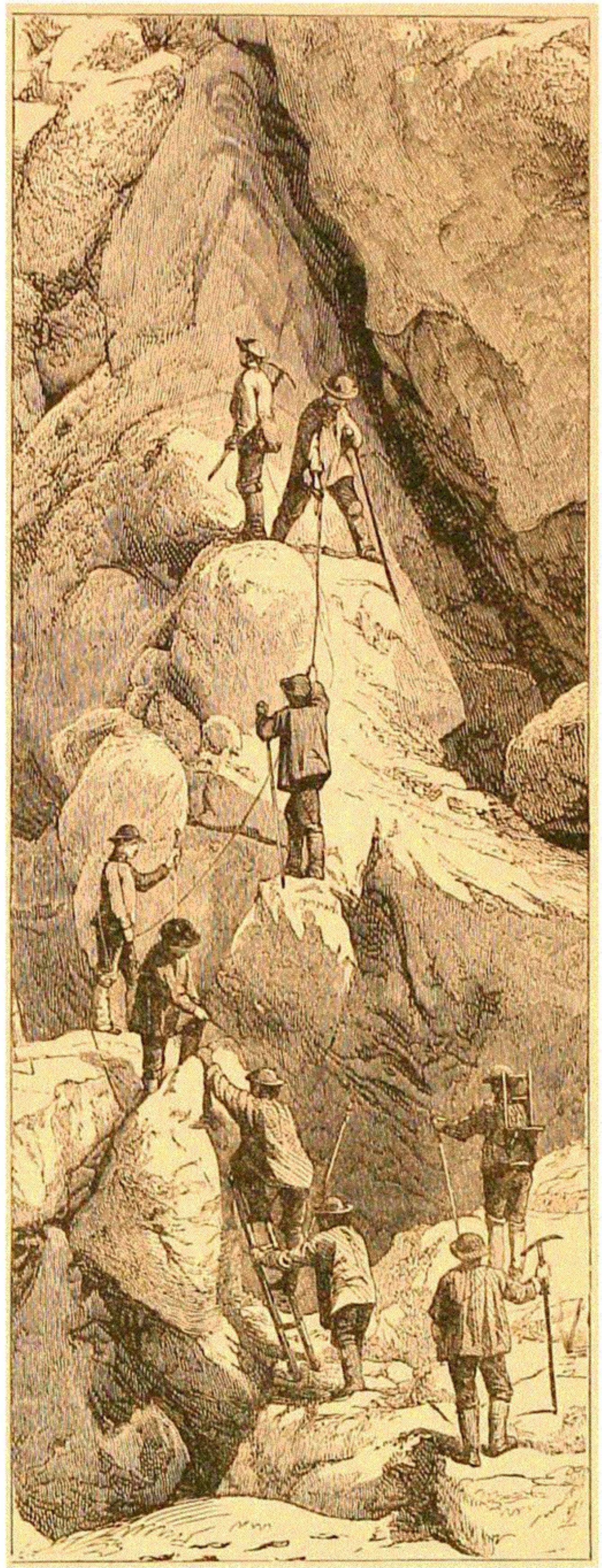

FIG. 59.—PASSAGE OF THE ECHELLES BY M. BISSON, 1861.
(*From a Photograph by Bisson.*)

Such, according to Arago, is a summary of all those ascents whose sole object is to gain the summit of almost inaccessible heights, to remain there for a few minutes, and as speedily as possible to redescend, after having braved terrible dangers, and carrying away as souvenirs severe ophthalmic affections, erysipelas in the face, and sometimes frozen feet.

The ascent made in 1814 by Messrs. Charles Martins, Bravais, and Le Pileur is the most interesting of all inscribed on the Alpine record, because the only one undertaken since that of De Saussure with a purely scientific purpose.

Having gained the summit of Mont Blanc, Messrs. Martins and Bravais took a certain number of measurements of the elevation and distances of the mountains situated around it, and made some important thermometrical and physiological observations.

A physician of Berlin, Dr. Pitschner, resided at the Grands Mulets for three weeks in 1861, to devote himself to meteorological experiments. He has published at Berlin some rough bold views of the principal portions of the route to Mont Blanc.

We shall not extend any further our account, already too protracted, of the principal ascents of this celebrated mountain.* As we have already remarked, the enterprise has now become common enough. About forty take place annually. French tourists, however, whose purses are not so well filled as those of the English or Americans, are much inconvenienced by the excessive tariff of the company of guides. The regulations of the local authorities forbid any attempt to be undertaken unless three guides accompany every tourist. For each guide 100 francs is paid, besides additional expenses. If the tariff were more moderate, the number of excursionists to Mont Blanc would be very considerable. During a week which we spent in the Chamounix valley in 1863 to visit the glaciers of the Mont Blanc chain, we witnessed the departure and arrival of a dozen *societies* (such is the authorized term); and on the 20th of August, at ten A.M., we counted, through the telescope of the *Hôtel de Saussure*, no less than five-and-twenty persons collected on the crest of the Giant of the Alps.

In their eager desire to collect artistic representations of all the wonders of the globe, our photographers, English and French, have not suffered themselves to be daunted by the difficulties presented by the transport to Mont Blanc of all the Daguerrian *materiel*. In July 1861, M. Bisson succeeded in conveying his apparatus to the very summit of Mont Blanc, and obtained some admirable photographic views, from one of which Figure 59 has been copied. It represents the passage of the Echelles by the guides who accompanied M. Bisson and carried his instruments. This *Passage des Echelles* leads up to the *Grands Mulets*.

Next to Mont Blanc, it is MONT PERDU whose first ascent (accomplished by Ramond, in 1802) has excited the greatest interest. The adventure was noteworthy in some of its details, and may be placed before the reader.

Mont Perdu, situated in Spain, is the loftiest peak of the Pyrenees, next to Maladetta and the Pic Posets. It is 11,168 feet in height. It was regarded as wholly inaccessible prior to its conquest by Ramond, the illustrious French naturalist, to whom we owe the beautiful descriptions which have deservedly secured for him the title of "Painter of the Pyrenees."

It was on the 2nd of August 1802, that Ramond succeeded in climbing Mont Perdu, after having failed in three successive attempts.

Ramond started from the valley of Estaubé, and by the route named the Passe des Glouriettes, which leads to a cirque, or amphitheatre, resembling that of Gavarnie. In the eastern part of the

* [The most celebrated are those of Mr. Auldjo, Sir Charles Fellows (in 1827). and Professor Tyndall (in 1857–58). For further information, the reader may refer to the several series of "Peaks, Passes, and Glaciers."]

cirque, a sloping rampart ascends towards a broad *port*, or gap, which opens up an access to the head of the mountain.

When Ramond arrived before this slope, there was no snow upon it to facilitate its ascent. Its bare and slippery surface did not offer a solitary point where the foot could rest. Ramond's grapnels would not hold; his iron-shod poles left scarcely a trace. It became necessary to excavate a flight of steps in the ice, between the edges which rose against the rocks, and the centre where the glacier was hollowed out like a gutter, and broken up by innumerable holes and crevices. Between this Scylla and Charybdis a direct incline, growing steeper and steeper, had to be escaladed.

At the end of two hours Ramond and his companions arrived before an impassable ridge, which could only be turned by mounting on the edge of the glacier. But this edge was keen and narrow as the blade of a knife, and separated from the rock by a precipice which descended into the hollow of the glacier. Nevertheless, perilous as was the path, they could find no other.

They hauled themselves up to the edge by a dozen steps cut almost perpendicularly; but before placing foot upon it, sounded it by heavy blows to make sure that it was capable of bearing the weight of several persons. In this manner they achieved, with great difficulty, some thirty steps in twenty minutes, ascending by careful balancing, and in a zigzag line, with the precipice in their rear and on either side.

Then they halted to consult. A few insects crawled along the icy surface. The Green Woodpecker (*Picus viridis*) hovered from rock to rock, as if to mock the enterprise of these daring mortals.

A guide of Barèges, who had led the advance, declared that his head was turning giddy. Ramond was obliged to place him among the others; not an easy thing on a line which, like a line in mathematics, had no breadth.

However, they continued the advance. Twice were they impeded, and their path blocked up by projecting crags. Each man had literally to bend double in order to pass them, and a false step would have dashed him into the abyss. Soon they had no other help than the rocks themselves, which they had at first pronounced inaccessible.

FIG. 60.—FIRST ASCENT OF MONT PERDU, BY RAMOND, IN 1802.

These rocks are disposed in stages, but the steps are higher than they are broad. Moreover, the line of this natural flight of steps is so directed as to incline them in relation to the horizon. Add to this all the irregularities and projections of the rocks, and the reader may judge whether the enterprise was attractive!

Ramond and his companions nevertheless resolved to attempt it.

They dragged themselves up from step to step, the first being pushed by the second, and lending the latter his hand in turn, as soon as he was safely posted. Those in the rear, however, were exposed to the consequences of every false step made by their predecessors, as well as to the fragments of rock knocked down by their feet. Ramond, indeed, was wounded by one of these missiles, which it was impossible to avoid. The escalade occupied a whole hour.

They drew near the crest, their hearts throbbing with anxiety, their limbs failing from fatigue. But before gaining the summit of a small plateau where they could rest and refresh themselves, each forgot his sufferings in the sublime spectacle revealed to his eyes upon emerging from the gap. The sun lit up the entire prospect with his beams.

"A lake completely frozen," writes Ramond, "reflected a sky of cloudless azure, the glaciers sparkled, and the summit of Mont Perdu, all glittering with celestial lustre, seemed no longer a thing of earth. In vain should I attempt to describe the magical appearance of the picture; in colour and in outline it was equally superior to the views on which our glances ordinarily rest. In vain should I attempt to describe what this scene possessed of the unexpected, the astonishing, and the fantastic; at the moment when the curtain falls, when the gate is thrown open, when one stands on the threshold of this gigantic edifice, the world comes to an end; another begins; a world regulated by the laws of a wholly new existence."

Four or five terraces, piled one upon another, form the first stages of the Mont Perdu properly so called. These steps are rendered practicable by the snows and débris of stones which partly cover them. At the end of an hour they were escaladed, but our adventurers were overwhelmed with fatigue. They found themselves confronting a ridge of rocks, which, gradually enlarging, furnished a convenient access to a kind of valley, where the glaciers that surrounded the peak commenced.

At length the summit of the peak itself was gained. It is so steep on the southern side that the snows incessantly roll off on the lower declivity, and accumulate in a glacier, beneath which the mountain flanks sink with an abrupt incline. To the north the sharp and shattered peaks of other mountains combine in a broad dense belt to shut out the plains of France.

Such is a summary of the difficulties encountered by Ramond in his ascent of Mont Perdu, which produced a great sensation in the scientific world.

We shall close our description of the European Mountains with a few remarks on the average elevation of the entire mainland of Europe.

According to Humboldt, the average elevation of the plains of France is 500 feet. Arago places it at 680 feet, calculating the mean of a great number of French towns. The repartition of the mountains raised the dead mean level by 370 feet, giving 870 feet as the mean general elevation of France, if we adopt the data of Humboldt. If we take Arago's estimate, we obtain 1050 feet. It should be remarked that the annexation of Savoy, by placing the Mont Blanc group in France, augments still further the mean elevation. These variations do not materially affect the calculation of the mean height above the sea of all Europe.

Germany, on the average, is higher than France, 1250 feet representing its mean level. For the European continent Humboldt gives 670 feet.

The mean elevation of Asia is 1150 feet; that of North America, 750 feet; and of South America, 1130. If the ocean rose 1000 feet, it would therefore submerge the greater portion of our globe.

The reader will more readily understand the significance of these figures if he compares them with those set forth in the subjoined

TABLE OF THE ELEVATION OF SOME INHABITED PLACES IN EUROPE.

	FEET.		FEET.
Hospice of St. Bernard, ...	8110	Munich, ...	1764
Village of St. Veran (Alps), ...	6693	Geneva, ...	1450
Village of Soglio (Grisons), ... about	6700	Leadhills (Scotland), ...	1823
Village of Breuil (Mont Cervin), ...	6584	Lima (Peru), ...	520
Village of Baréges (Pyrenees), ...	4072	Vienna, ...	436
Baths of Mont Dore, ... about	3400	Paris (Observatory), ...	213
Village of Chamounix, ...	3350	London (Thames at London Bridge), ...	4 ft. 3 in.
Pontarlier, ...	2710	Edinburgh Castle, ...	443
Madrid, ...	1994		

We may compare with these elevations the heights of some of the more remarkable buildings raised by the hand of man:—

TABLE OF THE HEIGHT OF SOME REMARKABLE BUILDINGS.

	FEET.		FEET.
Great Pyramid of Ghizeh, ...	461	Sainte Chapelle, Paris, ...	114
Strasbourg Cathedral, ...	466	Nôtre Dame, Paris, ...	102
St. Peter's, at Rome, ...	433	The Monument, London, ...	202
St. Paul's, London, ...	404	Salisbury Cathedral, Wilts, ...	400
Victoria Tower, London, ...	346		

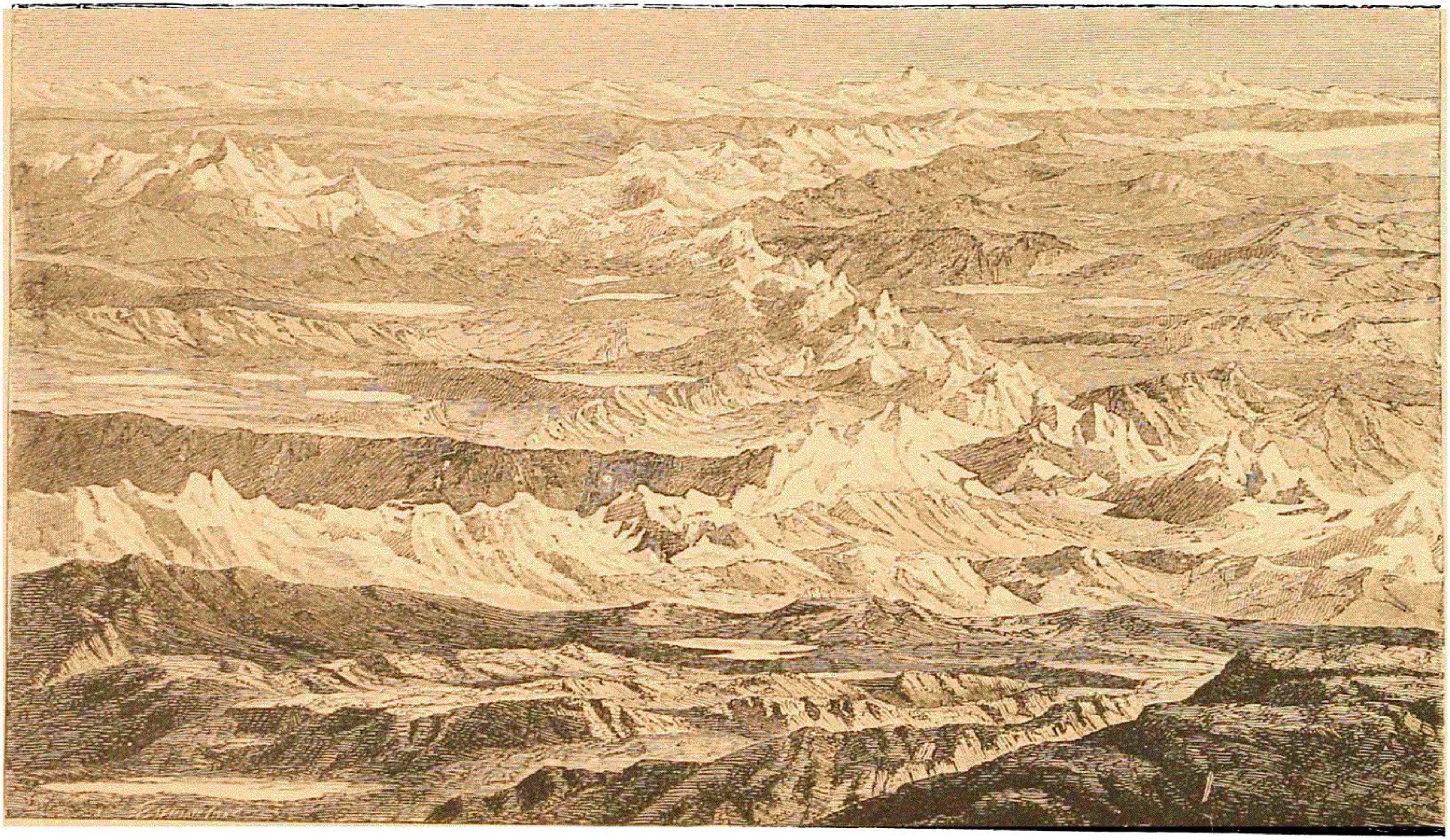

FIG 61. — PANORAMIC VIEW OF THE ANDES.

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CHAPTER III.

THE MOUNTAIN-RANGES OF AMERICA—ASCENT OF CHIMBORAZO BY HUMBOLDT AND BOUSSINGAULT—ELEVATION OF THE AMERICAN CONTINENT.

IN Bolivia, and in the centre of South America, there exists a great table-land nearly 13,000 feet in height, which Pentland has denominated the "Thibet of the New World." It forms an immense valley enclosed between two parallel chains, which belong to the central Cordillera of the Andes. To the north lies Lake Titicaca. Twenty-five times the size of the Lake of Geneva, it was the centre of the ancient empire of the Incas. The river Desaguadero traverses the south of this valley; its affluents springing from the eastern chain, whose opposite declivity furnishes the tributaries of the Paraguay, and which exhibits the snowy peaks, or *nevados*, of Sorata and Illimani. The western Cordillera separates the valley of Titicaca from the shores of the Pacific Ocean, and includes the summits of Sahama and Parinacota, and several active volcanoes, as those of Arequipa and Gualateiri.

In Figure 61, the artist has delineated a panoramic view of the entire chain of the Andes, between the upper lake of Titicaca and the lower lake of Parihuanacocha. Starting from this grand central mass, the Andes are prolonged northward to the Isthmus of Panama, and southward even to the wave-worn rocks of Cape Horn, their configuration being everywhere of the most diversified character, and the main body throwing off numerous spars and branches.

The Peruvian Cordillera contains the lofty mass of Chimborazo; that of Chili the towering peak of Aconcagua, whose summit forms the culminating point of the American continent.

[In the following Table we state the altitude of the principal mountains of America :—

MOUNTAINS OF AMERICA.

	Feet.	According to
In Venezuela—		
La Silla de Caraccas, ...	8,600, ...	Humboldt.
In New Granada—		
Mountains of Santa Martha,...	18,500	
Tolima, Volcano of, ...	18,020, ...	Humboldt.
Purace, Volcano of, ...	17,034, ...	"
Cumbal, ...	15,620, ...	Boussingault.
In Ecuador—		
Cayambe,...	19,535, ...	Humboldt.
Antisana,...	19,137, ...	"
Cotopaxi, ...	18,875, ...	"
Pichincha, ...	15,924, ...	"
Chimborazo, ...	21,424, ...	"
Illinissa, ...	17,380, ...	Bouguer.
Tunguragua, ...	16,424, ...	Humboldt.
In Peru—		
Vilcañota,...	17,525, ...	Pentland.
Apu Cunaranu, ...	17,590, ...	"
Coloro, lat. 14° 58′ S., ...	17,930, ...	"
Arequipa, Volcano of, ...	20,320, ...	"
Quenuta, ...	18,765, ...	"
Chipicani,...	19,745, ...	"
Pomarape, ...	21,700, ...	"
Parinacota, ...	22,030, ...	"
Sahama, ...	22,350, ...	"
Gualatieri, ...	21,960, ...	"
In Bolivia—		
Anchohuma, ...	21,286, ...	"
Chucacomani, ...	20,355, ...	"
Angel Peak, ...	20,115, ...	"
Huayna Potosi, ...	20,260, ...	"
Cacacu, lat. 16° 25′ S., ...	18,210, ...	"
La Mesada, ...	19,356, ...	"
Illimani, ...	21,140, ...	"
Miriquiri, lat. 17° 5′ S.,...	16,100, ...	"
Cerro of Potosi, ...	16,152, ...	"
Cerro of Chorolque,...	16,550, ...	"
In Chili—		
Aconcagua, ...	23,210, ...	Admiral Fitzroy.
Tupungato, Volcano of,...	15,000, ...	"
Antuco, Volcano of, ...	16,000, ...	"
Villarica, ...	16,000, ...	"
Osorno, or Llanquihue.	7,550, ...	"
Yantcho, ...	8,030, ...	"
Minchinmadava, ...	8,000, ...	"
Mount Stokes, in Patagonia,...	6,400, ...	"
Mount Sarmiento, in Tierra del Fuego,	6,900, ...	"
Mount Darwin, ., ...	6,800, ...	"
In Brazil—		
Itambe, ...	5,960, ...	"

	Feet.	According to
In Central America and Mexico—		
Popocatepetl, ...	17,717, ...	Humboldt.
Orizaba, ...	17,374, ...	,,
Iztacihuatl, ...	15,705, ...	,,
Nevado of Toluca, ...	15,542,	
Volcan de Fuego, ...	13,160, ...	Keith Johnston.
Irasu, Volcano of, ...	11,480, ...	,,
In the West Indies—		
Blue Mountains, ...	7,277	
La Souffrière, ...	5,108	
Montagne Pelée, ...	4,132	
In North America—		
Mount St. Elias, ...	16,775	
Mount Moosehillock, Alleghany range,	4,636	
Mount Washington, Alleghany range,	6,634	
Fremont's Peak, Oregon, ...	*13,670*	
Mount Hooker, Rocky Mountains, ...	15,700	
Mount Elias (lat. 61° N.), Rocky Mountains, ...	17,800	
Mount Chasta, California, ...	*14,000*	
Mount Brown (lat. 53° N.), ...	16,000	

This Table has been prepared from a careful comparison of statements, and gives the figures now accepted by the best authorities.]

[The extreme length of South America may be computed at 4020 geographical miles. Throughout this vast extent stretches the colossal chain of the Andes, nowhere of any remarkable width, but always of surpassing height; seldom at any great distance from the coast, to which it descends with a somewhat rapid and unbroken incline; and eastward, dipping towards the vast plains of the Silvas and the Pampas in a series of terraces and deep valleys.

It first emerges from the ocean in the bleak and rocky islands of Tierra del Fuego, where its summits are covered with a dreary-looking peat moss, and its sides with sombre forests of brown beech. A profound valley filled with the waters of the Pacific forms the Straits of Magellan, and the mountains again appear on the west coast of Patagonia, whence they extend in an unbroken line to the Isthmus of Panama. A lower chain, partly submerged by the sea, is represented by the archipelagoes and islands that fringe the iron-bound shore from Cape Horn to the 48th parallel of south latitude. This iron-bound shore is broken up by countless inlets or fiords, between whose rocky walls the billows hurtle with restless violence.

Between the 40th and 31st parallels many of the Andean summits aspire above the limits of perpetual snow; and the conical forms of some indicate that they are or have been vents of the volcanic fires. The Colossus of the range, and the monarch of the mountains of the New World, is Aconcagua, whose frosty crown rises above the Chilian village of the same name, in latitude 32° 39′ S. It must have been extinct for ages, though still designated a volcano by many of our geographers. Its flanks, like those of its sister peaks, are clothed with dense green forests of araucarias and other semi-tropical plants.

On the east, the Andes of Chili are bounded by two secondary chains, which, heavy with luxuriant woods, stretch far away into the undulating pampas. The more southern of these is named the Sierra de Cordova; the more northern, the Sierra di Salta.

The Peruvian Andes begin in latitude 24° S., and are separated from the Pacific by a range of low hills, composed of crystalline rocks and a belt of sandy desert, whose shifting sands are seldom refreshed by genial rains.

North of the 21st parallel, the chain of the Andes strikes across a very elevated longitudinal valley, bounded on each side by a still more elevated wall of mountains. These parallel chains, for their direction varies but slightly, intersect each other at several points, where they form gigantic mountain-knots, or shoot across in transverse ranges "like dykes." The incline on the Pacific side is remarkably steep.

Unlike the table-lands of Asia of a similar elevation, where agriculture can only make its rude essays in a few sheltered spots, or the lower European plateaus, which furnish but a scanty pasturage for cattle, the lofty regions of the Andes, as Mrs. Somerville remarks, yield "exuberant crops of every European grain;" while, at altitudes not inferior to that of the Teneriffe peak, or the Dôme du Goûter of Mont Blanc, are situated populous towns, teeming with busy life, with universities, libraries, and all the institutions of law, order, and religion.

Nor is this a modern condition of things. For centuries prior to the Spanish Conquest, these table-lands were the seat of the civilization of a mysterious race which "bear the same relation to the Incas and the present inhabitants that the Etruscans bear to the ancient Romans and to the Italians of our own days."

To one of those lofty table-lands, the so-called valley of Desaguadero, we have already referred. It is bounded on either hand by a colossal chain of the Bolivian Andes: that on the west forming the Coast Cordillera; that on the east the Bolivian Cordillera proper, or Cordillera Real. The whole breadth of both chains and of the intervening table-lands is only 226 miles. The Coast Cordillera consists of a succession of active and extinct volcanoes. In the northern portion of the Cordillera Real occur the three magnificent peaks of Sorata, Huayna-Potosi, and Illimani, whose upper flanks bristle with enormous glaciers, while far below blooms a world of luxuriant vegetation.

At the mountain-group of Vilcañota, the two chains again unite; and beyond, the lofty passes are traversed by the four ancient Peruvian roads, which converged from different parts of the empire of the Incas to its capital and sacred city, Cuzco.

The elevated plain of Bourbon, and the silver mines of Pasco, are situated at an elevation of 14,000 feet, in latitude 11° S. Here, too, is the lake of Lauricocha, one of the remotest reservoirs of the great Amazons river.

The Andes thereafter divide into three parallel ranges; the more eastern separating the tropical valley of the Yucayali from that of the Huallaga, and the central dividing the latter from the less fertile valley of the Upper Marânon. They re-unite in the group or mountain-knot of Loxa, on the frontiers of Ecuador, in about latitude 5° S.

Between the 4th and 3rd parallels the chain once more breaks up into two parallel masses, which shut in the valleys of Cuença, Tapia, and Quito—the latter remarkable for its majestic scenery—and, after a course of nearly 400 miles, converge in the mountain-group of Los Pastos, on the borders of New Granada.

Beyond the city of Almaguer the chain re-divides into two ranges, which thenceforth continue separate; the eastern range throwing off the branches known as the Central and Eastern Cordilleras of New Granada. Within their basin lie the head waters of the Magdalena, separated by the eastern range from those of the Orinoco, and by the central from those of the Cauca.

HEIGHT OF TABLE-LANDS.

	FEET.
Table-land of Titicaca (Desaguadero), ...	12,700
" Cuzco, ...	8,300
" Pasco, ...	11,000
" Assuay, ...	15,520
" Quito, ...	9,543
" Bogota, ...	8,958

Passing from this rapid survey of the Andes to the other mountains of South America, we observe that they are grouped into two systems: that of Brazil, between the Rio de la Plata and the Amazons, and that of Parimé and Guiana, between the Amazons and the Orinoco.

The Brazilian chains lie nearly parallel, with a general direction of S.W. to N.E. Their total length is about 680, and their breadth 400 miles. On either hand they throw off magnificent spurs; those which dominate above the bay of Rio de Janeiro forming conspicuous objects in a peculiarly sublime panorama. Their lower slopes teem with exuberant forest-growth; tall trees of tropical character, lianas, parasitical creepers, strange blossoming shrubs, and arborescent ferns.

The Parimé mountains are broken up into seven chains, which traverse a table-land about 2000 feet above the sea, between the Orinoco, the Rio Negro, the Amazons, and the Atlantic. Their loftiest peak is the Cerro Duida, which rises from the rich plain of Esmeralda to an elevation of 7155 feet.

In Central America we meet with a continuation of the Andes, irregularly scattered over a wide area in fantastic mixture of mountains and table-lands. Three distinct groups, however, are capable of being recognized—namely, that of Costa Rica, that of Honduras and Nicaragua, and that of Guatemala. The latter is remarkable for its volcanoes. The city of Guatemala lies in the shadow of three of these—Pacayo, del Fuego, and del Agua—and the surrounding country everywhere exhibits traces of violent igneous action.

About sixteen miles south of the once-famous city of Mexico, which stands on the plain of Tenochtitlan, 7430 feet above the sea-level, runs a line of active volcanoes, from Tuxtlu, near the Mexican Gulf, to the lofty cone of Colima, near the Pacific. It includes Orizaba, Cittalapetl, "the Mountain of the Star," Popocatepetl, 17,884 feet, Iztacihuatl, and Toluca.

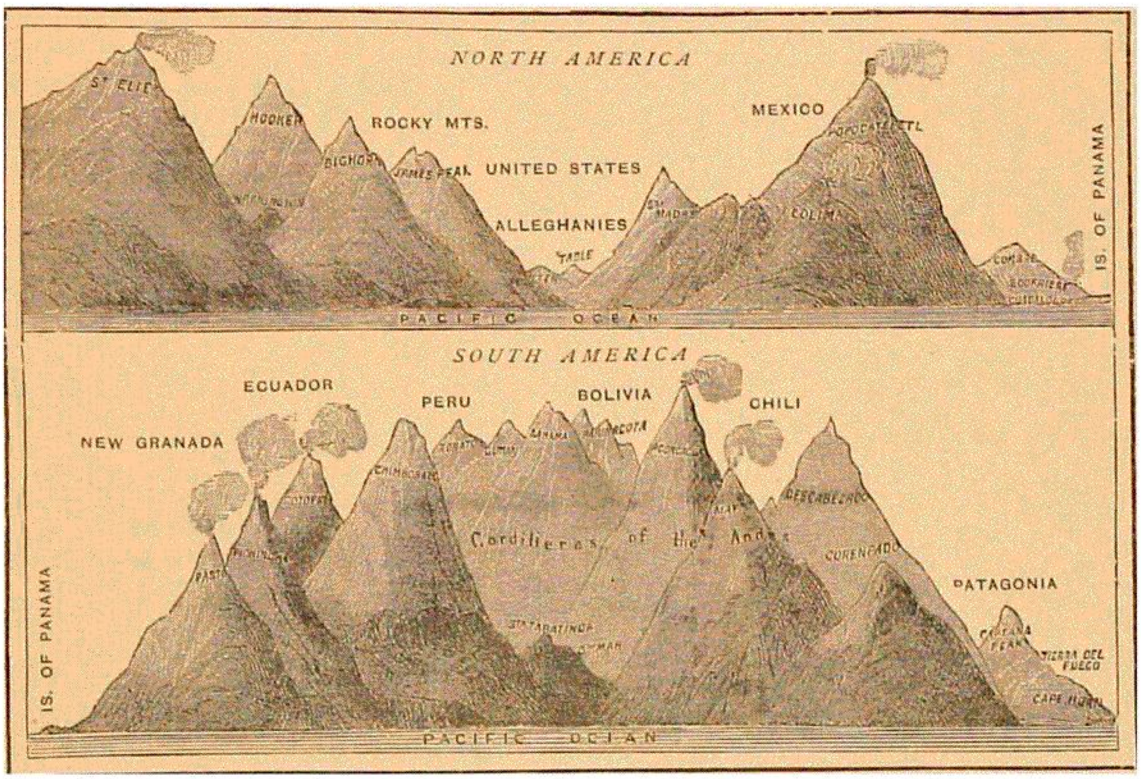

FIG. 62.—CHART OF AMERICAN MOUNTAINS.

In North America a considerable mountain-range, which is virtually a continuation of the Andes, skirts the coast of the Pacific, from the Rio Bravo del Norte to the mouth of the Mackenzie river. Under the general name of the Rocky Mountains it forms two parallel chains, occasionally united by a transverse ridge. In the eastern chain the loftier summits frequently rise to the snow-line, and even above it, as in Mounts Hooper and Brown. The valley between averages 100 miles in width. The southern portion of the Rocky

Mountains lies at a distance of 500 miles from the Pacific, but from the Sound of Juan de Fuca to the 60th parallel the range is not above 350 to 380 miles distant.

Crossing the great American plain to the eastern coast, we observe a barrier rising between the plain and the ocean in the Alleghany or Appalachian range, which rarely exceeds 4000 feet in height, or 100 miles in breadth, and consists of from three to five parallel groups. The area of the whole has been estimated at 2,000,000 square miles. The scenery is of a pastoral or sylvan character, and their western slopes rejoice in a singularly fertile and genial soil.

The mountains of the West Indian islands are mostly volcanoes, in an active or extinct condition.*]

Up to the present time the loftiest summit ascended by man in North America is that of Chimborazo, which was scaled by the illustrious Humboldt, in 1802, to the height of 19,000 feet, and thirty years later, by Boussingault, who reached an elevation of 19,750 feet.

We shall relate the attempts of these celebrated travellers. Their scientific interest was not proportioned to their difficulties and dangers; but there is always something in such enterprises which excites the curiosity of the public. Everybody is desirous of knowing the impressions experienced on these peaks so lone and silent, reputed inaccessible, or, at all events, out of the range of ordinary adventure. Their successful ascent flatters the pride of humanity; it is a new conquest over nature.

It was in the summer of 1802 that Humboldt undertook to plant the standard of geographical discovery on the snowy crest of Chimborazo. Accompanied by his friend Bonpland, by Carlos Montufar, a Spaniard, and some native guides, he set out, on the 22nd of June, from the plain of Tapia, which forms part of an immense

* [The reader is referred for fuller details to Humboldt's "Kosmos;" Mrs. Somerville's "Physical Geography;" Keith Johnston's "Physical Atlas;" Tschudi's "Travels in Peru;" Von Martin's "Travels in Brazil;" Squier's "Central America;" Sir Charles Lyell's "Travels in North America;" Clark and Lewis's "Expedition to the Rocky Mountains," &c.]

valley separating the Eastern Cordillera, distinguished by the majestic mass of Cotopaxi from the western, remarkable for the extinct volcanoes of Illinissa and Chimborazo. By a gentle ascent the travellers reached the Indian village of Calpi, situated at the foot of the mountain, and chosen as their quarters for the night.

The plain of Tapia is itself not less than 9500 feet above the sea-level; it is covered with groves of cactus and echinus, but agriculture cannot be successfully prosecuted on account of the severe nocturnal frosts. It is with difficulty, indeed, that the lama can find a meagre nourishment in these barren regions.

Early in the morning of the 23rd, Humboldt and Bonpland quitted the village of Calpi to attack Chimborazo on the south-east side. The summit of its peak is surrounded by plains, which rise above one another in a series of terraces. These plains, or, to use the American term, *llanos*, blooming with vegetation, surpass in altitude the peak of Teneriffe. Perfectly horizontal, these llanos may be compared

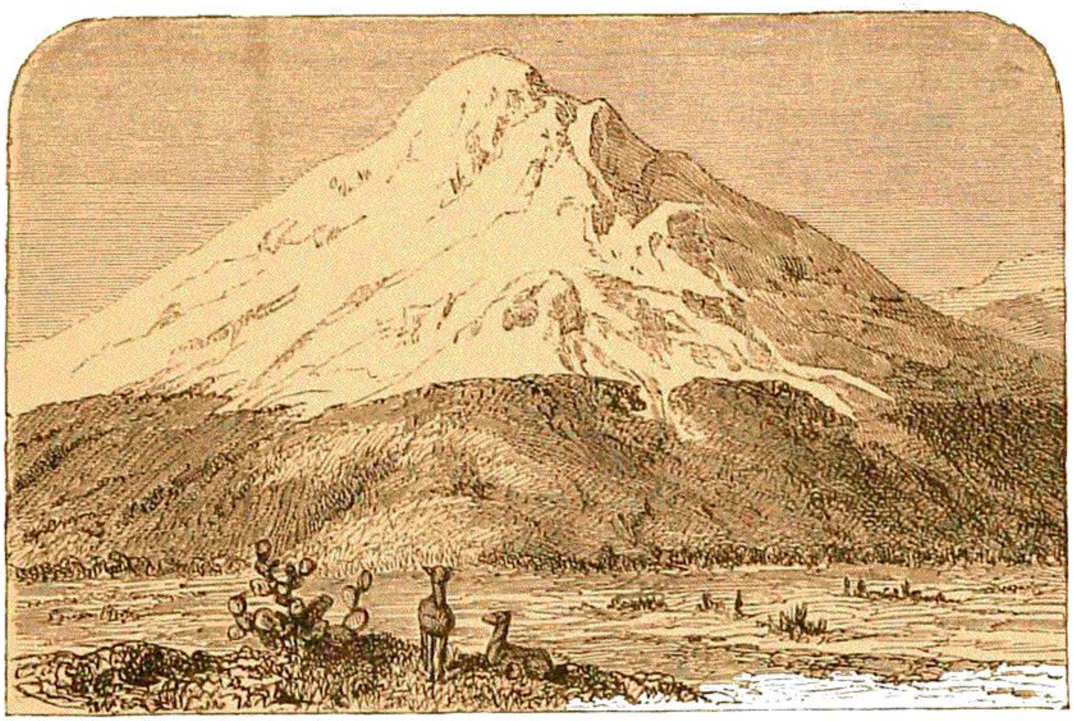

FIG. 63.—CHIMBORAZO.

to the bed of a dried-up lake, and remind the traveller of the steppes of Central Asia. Their vegetation is composed of grasses, purple gentian, and other sub-Alpine species. At this elevation the mean annual temperature is still as high as 9° C.—that is, nearly equal to that of London; but the nights are colder than in England.

Above the plateau of Sisgun, 12,400 feet, lies the lake of Yana-Concha, a mountain-pool, not more than 150 feet in length. The snowy crest of Chimborazo here reveals itself to the traveller in occasional flashes of white light through the clouds and dense mist that closely embrace it. At this elevation, 14,700 feet, Humboldt dismounted from his mule, the snow having fallen heavily on the preceding day. Bonpland and Montufar also left behind their horses, to remount them on their return.

The herbaceous vegetation nourished by the meagre soil ceased at about 950 feet above the lake Yana-Concha. Thenceforth nothing but sombre walls of rocks reared upon foundations of eternal snow. At certain points these rocks arranged themselves in masses of slender and irregular columns, which from afar produced all the effect of a forest of trees, dead, but still standing.

This avenue of black trunks led directly to a very narrow ridge ; the only road by which the summit could be obtained, for the snow lying on the other parts of the mountain was too recent and too soft to bear the weight of a single pedestrian. The ridge narrowing as it ascended, offered but a perilous path, and the incline grew steeper and yet steeper. At the elevation of 16,600 feet all the guides abandoned the enterprise, daunted by its difficulties, and only one native, a half-breed of San Juan, remained faithful to the travellers.

Despite the fog which surrounded them, they mounted to a greater altitude than they had hoped for, though not without incurring the most alarming dangers. The ridge (*cuchilla*, or knife-back, to adopt the expressive word of the Spaniards) along which they fared was only from eight to twelve inches (25 to 30 centimetres) in width. It terminated, on the left, in an inclined plane of thirty degrees, formed of congealed snow which glittered like a mirror ; on the right yawned an abyss, nearly 1000 feet in depth, wherein the sharp rocks rise vertically like spires or pinnacles. "We moved forward, however," says Humboldt, "leaning ourselves on this side ; the peril appeared to us far more formidable on the left, because we had not there even the slight resource of clinging to the projections of the rock, and the sloping stratum of ice would not have saved us from being buried in the snow."

The difficulty of ascent continued, nevertheless, to increase. The rock became more and more friable, and the incline so steep that the travellers were fain to crawl on their hands and feet, at the risk of wounding themselves every moment. They advanced in single file, exploring the path before them at every step, for frequently the huge stones which seemed a compact portion of the soil became detached, and rolled from under the foot instead of serving it for a support.

To ascertain the altitude at which they had arrived, Humboldt halted on a point of the ridge where two persons could scarcely stand side by side : observation of the barometer showed that they were then 18,500 feet above the sea. The temperature of the atmosphere was 39° Fahrenheit ; the ground was very damp, and a dense fog constantly enshrouded the travellers during the hour which they occupied in climbing the terrible *cuchilla*.

Everybody then began to feel *le mal des montagnes*—that is, a desire to vomit, and a kind of vertigo. The native who had agreed to share the fatigues of the ascent suffered far more than the European travellers. All bled from the gums and lips, and their eyes were terribly bloodshot. Similar inconveniences were experienced by De Saussure, and have been felt by all mountain-climbers. But while these phenomena manifested themselves on Mont Blanc at an elevation of only 9000 feet, on Chimborazo they did not become visible except at 18,500 feet. In fact, the *mal des montagnes* varies according to the country and the individual. Many persons suffer from it at less than 14,000 feet. The symptoms, moreover, differ according to the age and constitution of the sufferer, and are aggravated by the muscular effort which he is forced to employ. Gay-Lussac ascended in a balloon to the height of 25,000 feet without feeling any severe pain, and without hæmorrhage, because he was at rest in his aerial car. The rarefied air forces an effusion of blood through the veins and arteries, owing to its insufficient pressure externally on the skin.

All at once the veil of clouds which drooped over the crest of Chimborazo seemed torn aside as if by enchantment, revealing its rounded summit. The road growing somewhat wider, the travellers advanced with surer step, when a deep crevasse, 500 feet deep, and 70 broad, suddenly arrested them with an insurmountable obstacle. The path was continued beyond; but it was equally impossible to flank the abyss or descend into its shades, on account of the softness of the snow which filled it. They were compelled to abandon all hopes of ascending higher.

It was one o'clock P.M. The barometer marked 13 inches 11.2 lines, corresponding with (about) 19,400 feet. The air was 1° C. below zero. A distance of 700 yards only, or ten times the height of the monument of London, separated our gallant explorers from the topmost point of the Colossus of the Andes. La Condamine and Bouguer, on a previous occasion, had not ascended above 15,500 feet; Humboldt and Bonpland, therefore, found themselves at the greatest elevation attained by man up to their time.

It was not possible for them to remain long in this gloomy desert. The fog had again thickened, and neither the peak of Chimborazo nor any of the neighbouring mountains was now visible. They could perceive nothing around them but one vast sea of clouds. Not an organism, not a living being, could be seen. Humboldt did, however, at last discover a species of rock-lichen. At an elevation of 18,000 feet bloomed the *Gyrophora rugosa;* at 15,500 feet he had detected the last of the mosses. At 16,000 feet Bonpland captured a butterfly, and they saw a fly at 17,500 feet. But these insects had evidently been swept away by currents of air, for they sometimes saw tufts of grass raised to this height by the action of the wind.

The sky grew more and more cloudy, and the adventurers addressed themselves to a speedy downward journey, which they accomplished by the same route, but not without the greatest precautions. They had scarcely begun their descent when a thick hail, soon followed by snow, came down in heavy showers. The ground was soon covered ankle-deep—a circumstance which rendered the traject doubly perilous. However, about two P.M., Humboldt and Bonpland rejoined their guides, whom they had left with their horses on the borders of the perpetual snow.

Having resumed their route towards Calpi, the small caravan arrived there about five o'clock in the evening. "According to custom," says Humboldt,* "the fog which had spoiled our expedition was followed by the finest possible weather. On June 25th, Chimborazo unveiled itself to the inhabitants of Nueva-Riobamba in all its splendour, with that calm and impressive dignity which is the natural character of the tropical landscapes." But, spite of this attractive appearance, the philosopher did not consider it requisite to renew an attempt which had succeeded to the desired extent.

From the observations made by Humboldt, it appears that Chimborazo is an extinct volcano, composed of porphyry and trachyte. Its peak consists of labradorite

* Humboldt, "Mélanges de Géologie et de Physique," vol. i., pp. 160, *et seq.*

and augite; an augitic porphyry. He found neither pumice-stone nor obsidian. Although Chimborazo has no actual appreciable crater, the volcanic forces are not extinguished in its womb. Subterranean noises are frequently heard, and shocks of more or less violence convulse the earth. But the natives, accustomed to these phenomena, manifest no alarm.

We pass on to the second ascent of Chimborazo, made about thirty years later (December 1831), by Boussingault, the eminent French traveller and naturalist.

After having completed some valuable physical and geodesical researches in the Andes, Boussingault was resting from his fatigues at Riobamba. The considerable elevation of the plateau on which it is situated, gives to that town a barren and wintry aspect. Against the horizon is displayed a panorama of snowy summits, upon which all the great meteorological phenomena are successively exhibited in their full magnificence—as, for instance, the storm midway up the mountain's colossal side; clouds charged with electricity, forming at intervals around the aspiring pinnacles of each mighty peak, and acting as electric condensers; a twilight produced suddenly, and in open day, by a veil of mist, which in a few moments spreads over the whole line of horizon. Thus, then, in this imposing framework are collected the grandest pictures of the wild and savage nature of the Andes.

After watching so magnificent a spectacle, M. Boussingault not unnaturally felt desirous to terminate his scientific labours by the ascent of Chimborazo, in the hope of discriminating more accurately than Humboldt had done the constituents of the mountain, and obtaining the mean temperature of a very lofty American position. Colonel Hall, who had been his companion in his previous excursions, agreed to join him also on this occasion.

Viewed from Riobamba, Chimborazo * offers two very different slopes—the one, facing the Arénal, very abrupt; the other, descending towards Chillapalla, much more gradual. It was on this side Boussingault resolved to make his attempt.

On the 14th December 1831, Boussingault and his companion took up their quarters for the night at the farm of Chimborazo, which lies on the mountain-side fully 12,400 feet above the sea; and on the morning of the 15th they started, escorted by Indian guides—indifferent guides always, and on whom no reliance can be placed that they will ascend to any considerable height.

Following a limpid brook which flowed shut in by two vertical walls of trachyte, they arrived, not without much difficulty, at an elevation equal to that of Mont Blanc. There they deemed it prudent to cover their faces with veils of taffeta, to avoid the injurious effects on the skin of the solar rays reflected by the ice.

Next they found themselves compelled to climb a narrow ridge which led to a trachyte rock completely bare of snow; but to reach it, they had to cut their way

* The word "Chimborazo" signifies "snow of Chimbo;" the termination *razo*, which is found in the names of other mountains, meaning simply "snow."

through a snow-drift, wherein they sank to the waist. As they advanced, the snow deepened, until it lay nearly five feet thick; they could not get any further, and were compelled to abandon the attempt on that side of the mountain.

They rested on the isolated trachytic eminence which rose out of this ocean of snow. It was half-past one P.M.; the temperature 3° C. below zero; the barometer showing an elevation of 16,700 feet. Having filled a bottle with snow, to be subjected to a chemical analysis, Boussingault and Hall retraced their steps. They reached the farm at six in the evening.

The weather had been magnificent, which made them the more deeply regret the non-success of their enterprise. However, they resolved to renew the attempt on the morrow, but on the side of the Arénal. This was almost the same direction which Humboldt had followed thirty years before. They would gladly have obtained from the inhabitants some exact information as to the route taken by that illustrious *savant*, but all those who had accompanied him were dead.

At seven A.M., on the 15th December, they set out on their journey; at nine they breakfasted, on an enormous block of trachyte, 14,150 feet in altitude, which Boussingault christened with the name of *Pedron del Almuerzo* (*i.e.*, "The Breakfast Stone"). Nineteen hundred feet higher, the mules refusing to proceed on account of the rarefaction of the air, the travellers quitted their steeds, and began to climb on foot a talus or slope of rocks resting upon ice; a mass which seemed the result of some recent landslip, a kind of stony avalanche let loose from the mountain summit.

Towards noon they traversed a sheet of ice of such extreme slipperiness that they were obliged to excavate holes with a hatchet in which to plant their feet.

Already the air was so rarefied that they stopped at every six or eight paces to draw breath.

In this position they made their way to *terra firma*—that is, to some blocks of trachyte not covered with snow. The "forlorn hope" marched in single file—Boussingault at the head, Colonel Hall and his negro servant placing their feet in Boussingault's footprints. While on the march they preserved an absolute silence; and during their halts exchanged but a few words in a low voice—a very essential precaution in an enterprise of this kind, where nothing is so fatiguing as a sustained conversation, and where the agitation of the air resulting from shouts or other noises will often induce the most terrible avalanches.

It was not long before they gained, in this fashion, a ridge which ascended directly to the summit of Chimborazo. There was little snow on it, but it was dangerous to climb on account of its exceeding steepness. After incredible gymnastic efforts, they found themselves at the foot of a wall of trachyte, nearly perpendicular, and some hundreds of feet in height, which seemed to oppose a *ne plus ultra* to their further passage. Resting themselves in front of this "Red Rock," they quenched their thirst by sucking small lumps of ice. It was then three-quarters past noon. Everybody was frozen with the cold, for the thermometer had sunk to zero.

An extraordinary humidity pervaded the air, and the rocks were completely saturated. This hygrometrical condition of the atmosphere on the summits of lofty mountains is fatal to the supposition that the dryness of the skin of the face, so frequently experienced by the climber, can be owing to the dryness of the air. We must rather attribute the accident to the action of the very strong light reflected by the ice and snow. Consequently it may be prevented by covering the face with coloured crape, or even by blackening it. On the glaciers a negro's skin never suffers from the sun.

The mist which had enshrouded the travellers finally cleared away, revealing on their right a horrible abyss, and on the left a projecting rock, which formed a kind of belvedere or observatory. With the assistance of his companions, Boussingault contrived to climb it. Looking around, he ascertained that it was possible to ascend much higher if they succeeded in scaling a slope of frozen snow which was supported against the opposite side of the Red Rock. He ordered the negro to test the strength of the snow; fortunately it proved of sufficient density to bear them all. Colonel Hall and the negro then passed round the belvedere rock, and Boussingault rejoined them by sliding along its icy incline.

As they prepared to attempt the escalade, a stone from the upper part of the mountain fell suddenly at the feet of the colonel, who was thrown down by the shock; but he sprang up immediately to examine the rocky specimen so roughly submitted to his investigation; it proved to be a block of trachyte.

"We now walked with the greatest caution," says Boussingault; "on the right, we were able to support ourselves against the crag; on the left, the declivity was frightful, and before advancing further we began to familiarize ourselves completely with the precipice. This is a precaution which in mountaineering should not be neglected, whenever a dangerous place has to be passed. The advice was given by Saussure long ago, but it cannot be too frequently repeated, and in my adventurous wanderings among the Alps I have never lost sight of the prudent precept." *

At this stage of the journey everybody began to feel the effects of the rarefaction of the air. Every moment they were compelled to pause, and frequently to prostrate themselves on the ground for a few seconds; but the suffering ceased when they were at rest. A fact which was also noted by Saussure.

Suddenly a new danger was added to their previous trials; the soft snow was no longer more than three or four inches deep; beneath it lay a hard slippery ice, and to cross it without falling they were compelled to cut holes for their feet. For this purpose the negro went foremost; but his strength was soon exhausted. Boussingault endeavouring to pass him, and take his place, slipped on the very edge of the precipice. Very fortunately his two companions caught hold of him, and held him suspended. All three incurred the greatest danger; but having succeeded in recovering their equilibrium, they bravely resumed their progress along the perilous path. By a last effort they succeeded in reaching, at three-quarters past one P.M., the end of this most formidable ridge.

It proved impossible, however, to advance beyond. They found themselves at the foot of an enormous trachytic rampart, whose upper portion, shrouded in eternal

* Humboldt, "Mélanges de Géologie et de Physique," p. 199.

snow, formed the actual summit of Chimborazo. The ridges leading to its crest are the flying buttresses visible from the plain, which seem to support on different sides, as if to steady it, this mighty mass of rock. The ridge at whose extremity stood the three adventurers was scarcely a yard in width. On every side it was surrounded by precipices and rocks contrasting strangely with the dazzling whiteness of the snow. Long stalactites of gleaming ice, suspended over their heads, might be compared to a cascade suddenly frozen in its descent. The weather was magnificent; the air calm and pure; the eye embraced a boundless horizon; in a word, the entire situation was one of surpassing sublimity.

The barometer remained firm at 14·606 inches, corresponding to an absolute elevation of 19,600 feet. Boussingault and his companions had, therefore, overpassed the greatest height attained by Humboldt. None of their predecessors had carried the barometer to an altitude of 19,000 feet. And we shall see that this latter limit has been only exceeded by the brothers Schlagintweit in their passage across the snowy summit of the Himalaya.

Colonel Hall was overwhelmed with joy, and never ceased to joke and jest while sketching the "hell of ice" (*l'enfer de glace*). The voice seemed completely changed; and sound had so little intensity that the clash of a hammer on the rock would scarcely have been audible.

It is a noteworthy circumstance that the effects of the *mal des montagnes* which our adventurers had so painfully experienced at the bottom of the ridge disappeared on the summit of Chimborazo. Boussingault's pulse beat, it is true, one hundred and six times in a minute; he was thirsty, too, and felt, like Colonel Hall, a feverish excitement, in which, however, there was nothing painful.

The slight effect produced on our travellers by the atmospheric rarefaction may be explained by the degree of acclimatization they had undergone during a prolonged sojourn on the table-lands of the Andes. We are apt to believe that man may accustom himself to the rarefied mountain air when we reflect that the people of Quito live at an elevation of 9543 feet above the sea; that man dwells, without inconvenience, in South America, at altitudes as great as those of Mont Blanc and its sister-peaks; and especially when we remember the battle of Pichincha, which was fought at a level not inferior to that of the giant of the Alps.

It has been observed, and Boussingault insists upon the truth of the statement, that the conditions of elevation being equal, men experience greater inconvenience on a surface of snow than on the naked rock. The Indians, when marching on the snow, are seized with a choking attack (*akogo*), a difficulty of respiration not solely dependent on the rarefaction of the air. Boussingault, therefore, was led to conclude that the snow vitiates chemically the respirable air. Saussure had ascertained that the air extracted from snow contains less oxygen than the ordinary atmosphere. Boussingault experimented eudiometrically on the gases contained in a bottle filled with snow from the crest of Chimborazo, and arrived at the same result. This fact is indicative of a certain alteration of the atmosphere effected by the snow at great elevations.

Boussingault did not detect in the sky of Chimborazo the intense colour which

Saussure remarked in that of Mont Blanc. From Chimborazo's top the sky appeared of no deeper sapphire than at Quito. In truth, Boussingault very rarely saw the blue-black heaven of which Saussure speaks. He was convinced that the intensity of hue sometimes observed upon the glaciers is, to a great extent, the result of excessive weariness of the eyes; perhaps, also, is due in some measure to the contrast afforded by the gleam of the spotless snow. In such a case, the phenomenon will be essentially physiological.

Up to three o'clock the weather continued beautifully fine and clear, and the thermometer sunk no lower than + 8° C. But after this hour dense clouds began to accumulate at the base of the mountain, and a storm rolled and roared beneath the feet of our aerial spectators. The growl of the thunder rose towards them, but much weakened, as if it came from a distance. It was time to begin the descent, before it was rendered impracticable by snow or cold, and they had no provisions for a sojourn upon the glacier. After descending some thousand feet with exceeding difficulty, they entered the region of the clouds. Lower down, a little hail fell. Afterwards, as they continued their descent, having regained and remounted their mules, an icy rain mingled with the hail-shower. Nevertheless they arrived, safe and sound, about eight o'clock P.M., at the farm, or *hacienda*, of Chimborazo.

All the observations made by the French physicist tend to confirm Humboldt's opinion that Chimborazo is an extinct volcano. Its colossal mass is an accumulation of irregularly disposed trachytic débris. The table-lands of trachyte exhibit enormous crevasses apparently diverging from the centre, like the cracks in a sheet of glass which has been struck in the middle. Chimborazo, when upheaved, rearranged (*redressé*) the rocks, which have remained piled up around the centre of eruption.

On the 23rd of December 1831, Boussingault quitted Riobamba to continue his travels. In bidding farewell to Colonel Hall, who had so long shared his perils and fatigues, he grasped his hand warmly, and not without a sad presentiment. A presentiment unhappily verified; for, a few months afterwards, that brave and enterprising officer perished miserably in the streets of Quito by the dagger of an assassin.

A few words, before concluding this chapter, on the general elevation of the American continent.

This elevation, which is considerable, will help to explain the great altitude of the mountain-chains of America, far superior to that of the European mountains.

The primitive elevations of the low lands of North and South America are respectively computed at about 670 and 480 feet, by Humboldt; but, making due allowance for the upheaving movement (*exhaussement*) which produced the uniform redistribution of the mountain-masses over the entire superficies of the country, we obtain 1150 feet and 800 feet respectively, for the mean elevation of these continents, and 950 feet for all America.

We need not be surprised, then, at the great elevation of many places on the American mainland. Towns, indeed, exist in the New World, and men pass their lives in localities whose elevation is equal to that of the loftiest European summits. The mean elevation of the ridge of the Andes is, according to Boussingault, about 14,000 feet. But a great number of *cols* or *passes* are still loftier. That of Rumihausi is 16,160 feet above the sea; Altos de Toledo, 15,790 feet; Pacuani, 15,340 feet; Chullunquiani, 15,160 feet; Paramo d'Assäay, 15,528 feet; Vilcañota, 14,520 feet; Gualillas, 14,750 feet; and Guanacas, 14,708 feet. In all these passes isolated habitations, and even small hamlets, are found at extraordinary heights. The post-master's house at Ancomarca, frequented by travellers *en route* from Bolivia to the ports of the Pacific, is situated at 15,900 feet, equal to the altitude of Mont Blanc. The hamlets of Chullunquiani, Rio Mauro, and Huayllas, are suspended on the flanks of the Cordilleras at an absolute elevation of 15,000 feet.

[The following figures,* referring to *inhabited places*, may interest the reader :—

	FEET.		FEET.
Rumihausi, post station, Peru, ...	15,542	Oruro, city, Bolivia, ...	12,454
Ayavirini, post station, Peru, ...	14,960	La Paz, city, Bolivia, ...	12,226
Apo, post station, Peru, ...	14,376	Quito, city, Ecuador, ...	9,543
Ancochallani, farm, Peru (17° 35′ S. lat.), ...	14,683	Chuquisaca, city, Bolivia, ...	9,343
Tacora, village, Peru (17°47′S.lat.),	13,690	Bogota, city, New Granada, ...	8,730
Antisana, farm, Ecuador, ...	13,454	Arequipa, city, Peru, ...	7,852
Potosi, city, Bolivia, ...	13,330	Miquipampa, village, Peru, ...	11,870
		Puno, city, Peru, ...	12,870]

Several of these towns are capitals of provinces. Potosi, famous for its silver mines, stands at a height above the sea equal to that of the Jungfrau. The Indian village Tacora, situated at the base of an extinct volcano, has a total altitude of 14,200 feet.

In the Republic of Ecuador, the great town of Quito is 9492 feet

* [These figures are derived from Humboldt and Pentland.—*Translator.*]

above the level of the Pacific; the *hacienda*, or grazing-farm, at the foot of the volcano of Antisana, 13,500. In Central America and Mexico we find civilization flourishing at remarkable altitudes. Mexico, familiar to our boyhood as the seat of the Montezumas and the theatre of the great deeds of valour done by Cortez and his men, is 7500 feet above the sea-level; and a great number of towns on the Mexican plateau are from 6750 to 7000 feet.

Thus we find a large portion of the human race accustomed to breathe a singularly rarefied air. An atmosphere which for the European fresh from his valleys and plains is light and rarefied, is but the atmosphere at its ordinary density for the inhabitant of the table-lands of Mexico or the Andes.

[It is not the province of this volume to enlarge upon the botany and fauna of the Andes. Generally speaking, they do not exhibit that prodigal fertility of vegetation which is so characteristic of the Himalayas. Nor are they so rich in animal life. The puma wanders among their solitudes; the lammergeier and the vulture brood upon their loftier summits; their green sides and deep valleys afford shelter and nutriment to the llama, the guanaco, and the vicuña. These, however, are the principal types. The great feature of their landscapes is sublimity, but owing to the extraordinary elevation of the plateaus, and the breadth of the mountain-masses, no single peak gives so grand an idea of height or is so imposing in the eye of the spectator as Mont Blanc. Their finest aspect is when viewed by the voyager from the broad bosom of the Pacific.]

CHAPTER IV.

[MOUNTAINS OF ASIA—TABLE OF THE PRINCIPAL SUMMITS—THE CAUCASUS, THE HINDU-KUSH, THE GHAUTS, THE CHINESE AND TIBETIAN MOUNTAIN-CHAINS—THE ALTAI—THE HIMALAYAS—ASCENT OF THE IBI-GAMIN BY ADOLPHE AND ROBERT VON SCHLAGINTWEIT, IN 1855—GAURISANKAR, OR MOUNT EVEREST—KANCHINJINGA.

NATURE, on the Asiatic continent, has worked with greater magnificence than in Europe. Its table-lands rise above the mean elevation of the European mountains; its mountains soar to an altitude which we should barely equal if we imitated the old Titanic strife of mythology, and piled Pelion upon Ossa, the Pyrenees upon the Carpathians. Its deserts are of extraordinary vastness and barrenness; its dense forests and blooming valleys of no less extraordinary a fertility. Mighty are its rivers: the Volga and the Danube are but paltry streams compared with the Ganges, the Indus, or the Hoang-Ho. Nowhere else is animal life so varied and so abundant; nowhere else does it exhibit such noble and terrible types as the elephant of Ceylon, or the tiger of the jungles. Then, too, in Asia, we find, as most authorities believe, the very cradle and nursery of the human race. There, when all the world beside was shrouded in darkness, reigned a wonderful and mysterious civilization. Babylon and Nineveh had almost terminated *their* history before the annals of Greece and Rome began. While the Danube still flowed through silent solitudes, vast cities teemed with busy life on the banks of the Euphrates. Ere yet the prophets had proclaimed the will of Jehovah to the conquerors of Palestine, the priests of Brahma taught their Vedas to the dusky races of the Ganges. Of fallen empires, of vanished peoples, the gigantic monuments are still extant which witness to their skill, their industry, and their power. And here, too, the evidences remain of awful natural forces which convulsed the fair surface of our planet at epochs immeasurably anterior to the existence of man.

Before surveying the mountain-ranges of this great continent, we place before the reader

A TABLE OF THE PRINCIPAL SUMMITS.

		FEET.
IN THE HIMALAYA RANGE—		
Gaurisankar, Sikkim, ...		29,002
Kanchinjinga, Sikkim, ...		28,156
Dhwalagiri, Nepaul, ...		26,826
Juwahir, Kumaon, ...		25,670
Jumnautri, Nepaul, ...		25,500
Dhaibun, Nepaul, ...		24,740
Chumalari, Tibet, ...		23,946
Momonangli, Tibet, ...		23,500
Api Peak, Nepaul, ...		22,799
Peak, No. 12,	Between the Kali and the Ganges,	23,263
Peak, No. 13,		22,313
Peak, No. 14,		22,727
Peak, No. 15,		22,277
St. George's,	Between the Ganges and the Sutlej,	22,500
St. Patrick's,		22,638
Gungoutri,		21,219
Kohibaba, Hindu Kush, ...		17,905
Ibi-Gamin Pass, Gurhival ...		20,457
Karakorum Pass, Tibet, ...		18,600
Parang Pass, Tibet, ...		18,500
Kronbrung Pass, Tibet, ...		18,313
Doora Ghaut, Tibet, ...		17,750
Lipu Lek Pass, Tibet, ...		16,884
Niti Ghaut, Tibet, ...		16,814
Paralaha Pass, ...		16,500
Shatool Pass, ...		15,500
IN THE CAUCASUS RANGE—		
Elburz, ...		18,493
Kasbek, ...		16,530
IN PERSIA—		
Demavend, ...		14,695

	FEET.
Ararat, Armenia, ...	17,712
Argæus, Asia Minor,...	13,197
Belakha, in the Altaï, ...	11,062
IN SYRIA—	
Libanus, ...	9,517
Horeb, Arabia, ...	8,593
Sinai, Arabia, ...	7,498
IN THE URAL RANGE—	
Kamen, Asiatic Russia, ...	5,397
Termel, Asiatic Russia, ...	5,071
ASIATIC ISLANDS—	
Adam's Peak, Ceylon, ...	6,152
Slamat, Java, ...	11,930
Sumpung, Java,...	11,030
Gunong Pasama,* Sumatra, ...	13,840
ELEVATION OF PARTICULAR LOCALITIES—	
Lake Manusarowa, Tibet, ...	15,250
Lake Nainital, Kumaon, ...	6,520
Lake of Cashmir, ...	5,126
Lake Baikal, Asia, ...	1,535
Lake Van, Asia Minor, ...	54
Villages on south side of the Himalaya, in Kumaon,... ...	13.000
Ladak, Tibet, ...	9,995
Niti, village, Kumaon, ...	11,473
Darjeeling, in the Sikkim Himalayas, ...	7,165
Cabul, Afghanistan, ...	6,382
Kandahar, Afghanistan, ...	5,563
Cashmere, city of, ...	5,818

The great table-land of Central Asia is divided, between the 47th and 68th meridians of east longitude, into two parts, by a massive mountain group, in which the Hindu Kush, the Himalaya, the Tsun-lin, and the transverse ranges of the Beloot Tagh, or "Cloudy Mountains," all converge.

The table-land extends from S.W. to N.E.; and the principal

* Identified by some authorities with the ancient *Ophir*.

mountain-chains possess a similar general direction, with the exception of certain southern chains stretching from S.S.E. to N.N.W., between Cape Comorin and the Arctic Ocean. These are the Western Ghauts; the Solimaun range, bounding the Persian table-land on the east; the Beloot Tagh, which forms the western limit of the Oriental plateau; and the Ural Mountains, separating Europe from Asia. In China the Khing-han extends from north to south.

The great historic range of the Caucasus, which ages agone gave birth to the conquering Caucasian race, may be described as an offshoot of the Asiatic table-lands. It stretches for 700 miles between the Black Sea and the Caspian, throwing off lofty spurs and lateral branches on either hand, whose low-lying valleys and sheltered plains are remarkable for the fertility of their soil and the amenity of their climate. The central portion of the chain loads its massive flanks with glaciers; but the line of perpetual snow does not descend lower than 11,000 feet, and the lower slopes bloom with a vegetation which is almost tropical in exuberance.

All Asia Minor is intersected by "short chains and broken groups of mountains," inclosing quiet Arcadian hollows—the fitting nurseries of myth and legend—and declining rapidly towards the sea-coast, to terminate in bold headlands and romantic islands, which the Art of antiquity has consecrated with its beautiful memorials and monuments. Along the shore of the Mediterranean spreads a region of almost unsurpassed interest and loveliness—a region abounding in verdant plains, in broad shining rivers, in silent and fertile glens, in rich leafy groves, and steep acclivities clothed with the vine, the olive, and the myrtle. On the south rises the serrated range of the snowy Taurus, which begins in the isles of Rhodes and Cos, traverses the south-western districts of Asia Minor, and in a single lofty range edges the iron-bound coast of Karamania.

Of the lofty mountainous regions of Armenia, Kurdistan, and Azerbijan, Mrs. Somerville eloquently writes:*—

"Here the cold, treeless plains of Armenia, the earliest abode of

* Mrs. Somerville, "Physical Geography," i. 81, 82.

man, 7000 feet above the sea, bear no traces of the Garden of Eden. Mount Ararat, on which the Ark is said to have rested, stands a solitary, majestic, volcanic cone, 17,712 feet above the sea, shrouded in perpetual snow. Though high and cold, the soil of Armenia is richer than that of Anatolia, and is better cultivated. It shelves on the north, in luxuriant and beautiful declivities, to the low and undulating valley of Kara, south of the Caucasus; and, on the other hand, the broad and lofty belt of the Kurdistan mountains, rising abruptly in many parallel ranges from the plains of Mesopotamia, form its southern limit, and spread their ramifications wide over its surface. They are rent by deep ravines; and in many places are so rugged that communication between the villages is always difficult, and in winter impracticable from the depth of snow. The line of perpetual congelation is decided and even along their summit: their flanks are wooded, and the valleys populous and fertile."

The eastern division of the table-land forms a huge four-sided mass, considerably larger than the entire area of Europe, and stretching from the mountain-chain of the Hindu Kush to the Gulf of Tonquin. On the south it is bounded by the majestic range of the Himalayan—*i.e.*, the "Abode of Snow"—on whose summits and upper regions rests an eternal shroud of snow and ice. On the east lie the Chinese mountain-chains of Tun-ling and Khing-han, stretching away northward to join the range of the Shangpe-shan. The northern boundary of the table-land is formed by the metalliferous chain of the Altaï Mountains.

In Persia we meet with another mountainous region. On the north runs the great Elburz chain, culminating in the volcanic peak of Demavend, near Teheran, and throwing off numerous ridges into the volcanic table-land of Azerbijan, the ancient "fire country" of Zoroaster. Along the Persian Gulf and Indian Ocean it is bounded for 1000 miles by a mountainous belt, in some places three and in others seven-fold, having an average width of 200 miles.

Several of the Asiatic mountain-chains are unconnected with the great continental masses already spoken of. Such is the case with the Ural Mountains, the main boundary between Europe and Asia, which are easily divisible into three sections; northern, central, and southern. It is the second of these that is remarkable for apparently inexhaustible mineral treasures.

In Syria the high lands rise to an elevation of 10,000 and 11,000 feet, in the Libanus and Anti-Libanus range, which descend to the littoral of Phœnicia and Palestine in a succession of romantic and finely-wooded terraces.

The Indian peninsula is separated from the rest of Asia by the Himalayan barrier, which strikes across it on the north. Then comes a tract of low fertile plains and dense jungles, divided from the table-land of the Deccan by the Vindhya and Malwah mountain-chains. The eastern edge of this table-land is formed by the Eastern Ghauts, the western edge by the Western Ghauts; the two chains uniting at the sources of the Cauvery, in the Neilgherry, or Blue Mountains, 8760 feet in height. Suddenly sloping to a low, narrow plain, they again re-appear in the Aligherry range, and descend below the sea-level at Cape Comorin, and rise again in the bold romantic group of Adam's Peak, in the island of Ceylon.

The mountains in the islands of the Eastern Archipelago are volcanic, and links of the great volcanic chain which stretches from the Kamtschatkan peninsula on the north, to Gilolo, in the Molucca group, on the south. Another volcanic zone extends through the Sunda group of Timor, Sumbawa, Bali, Java, and Sumatra.

Of the Altaï range, the northernmost on the great continent, a few details will suffice. They are separated from the Ural by 400 miles of low marshy land and inconsiderable mountain-chains. Rising on the north bank of the Irtish, they extend in a serpentine course to the Pacific, south of the Gulf of Okhotsk, separating the high lands of Tartary and China from the wildernesses of Arctic Siberia. Under various names, their branches strike along the borders of the Gulf of Okhotsk to Behring's Strait, where they terminate at East Cape, the whole length of the range being 4000 miles. The breadth varies from 400 to 1000 miles, contracting to about 150 miles at

105° east longitude. The height is nowhere considerable; and the formation being singularly monotonous—consisting, in fact, of long flat ridges and narrow table-lands—the Altaï exhibits but rarely those majestic landscapes which are the glory of the Alps or the Himalaya. They abound, however, in mineral wealth; in silver, copper, and iron—in porphyry, syenite, serpentine, jasper, and coal. The Siberian region surpasses the Andes in the extent and value of its gold mines.

But of all the grand Asiatic ranges, the most remarkable in height, extent, and natural grandeur, is the Himalaya.

It consists of three distinct parts—the Hindu Kush, or Indian Caucasus, extending from the Paropamisan Mountains of Afghanistan to Cashmere, the "land of song and roses;" the Himalaya proper, stretching from Cashmere to Bhotan; and lastly, the Bhotan and Assam Himalayas: the three forming one magnificent and uninterrupted chain, the loftiest in the world.

The Hindu Kush, so named from a lofty peak north of the city of Cabul, spreads its offsets over the wild countries of Kafferistan, Koonduz, and Budakshan. Defining its boundaries with some degree of exactitude, we may say that it runs from the Upper Indus on the east to the Bamian Pass on the west; and lies between the 34th and 36th parallels, and the 68th and 75th east meridians. Its loftiest summit is upwards of 20,000 feet above the sea-level.

The Himalaya* extends from the 75th meridian to 95° 40′ E., a distance of nearly 1500 miles. No less than forty-five of its peaks are known to exceed 23,000 feet in height. Its passes are all above the altitude of Mont Blanc. Its southern slopes, which are the best known, consist of three distinct regions—the *Tarai*, a grassy, marshy plain; the forest belt of *Saul Wood;* and the *Dhuns,* a tract of wreck and detritus, lying immediately at the foot of the true mountains, which raise their sublime peaks far, far above, in a sky of unclouded azure.

* From Sanscrit, *hima*, "snow," and *âlaya*, "an abode,"—that is, the abode of snow.

At 6000 feet the snow falls regularly every winter.

On the Southern Himalayas, the limit of perpetual snow does not descend below 16,200 feet; on the Northern, it rises to 17,500 feet, owing to the dry atmosphere of Tibet.

Vast glaciers occur in every part of the range above the snow-line, and astound the spectator who ventures into their noiseless solitudes by a weird and truly unearthly grandeur.

Owing to the favourable climatic conditions which the great range enjoys, trees and cultivated grains flourish at the extraordinary elevation of 11,800 feet, shrubs at 15,200 feet. The tea-plant grows everywhere along the southern slope to the height of 5000 feet. Tigers ascend to 11,000 feet, and leopards to 15,000 feet. The herds find an abundant pasturage as high as 18,000 feet.

Above the rich valleys of Nepaul and Bhotan, the Himalaya still maintains its majestic supremacy, occasionally ascending to an altitude of 28,000 feet. In Bhotan it declines to the plains with sudden rapidity, the fall being equal to 1000 feet in a mile. "The valleys are crevices so deep and narrow, and the mountains that hang over them in menacing cliffs are so lofty, that these abysses are shrouded in perpetual gloom, except where the rays of a vertical sun penetrate their depths. From the steepness of the descent the rivers shoot down with the swiftness of an arrow, filling the caverns with foam and the air with mist. At the very base of this wild region lies the elevated and peaceful valley of Bhotan, vividly green, and shaded by magnificent forests. Another rapid descent of 1000 feet leads to the plain of the Ganges."

To the north of Assam the elevation of the Himalaya is still extraordinary, but the climate is mild, the valleys are fertile, and corn and fruit ripen at heights which, in other regions, even under the Equator, would be buried in perpetual snow.

The mean elevation of the range is placed by Humboldt at 15,700 feet.

The principal formation is stratified crystalline rocks, especially gneiss, with large veins of granite, and immense beds of quartz. Between 15,000 and 18,000 feet above the sea lie the Silurian strata; and the foundation of the chain is composed of granite.]

The loftiest point of the Earth which man has succeeded in attaining, the most elevated region where he has planted his adventurous foot, is the Himalayan. Here, on the 19th of August 1855, the brothers Schlagintweit, those gallant Bavarians in whom an enthusiastic scientific ardour was combined with the most heroic perseverance, ascended, on the peak of *Ibi-Gamin*, to the height of 22,000 feet.

The narrative of this remarkable enterprise cannot fail to interest the reader. We give it, in a condensed form, from the report addressed by Adolphe and Robert von Schlagintweit to the Government of British India :—

We quitted Milum on the 6th of July, accompanied by Mani and a sufficiently numerous suite, because it was necessary we should despatch our baggage to Niti by another route. After traversing the col of Outa-Dhoura, we ascended with a few attendants to the Pass of Janti, 18,500 feet above the sea-level.

We rested there three days, profiting by so excellent an opportunity of making various experiments at so great a height. From thence we went to Laptel, where the Tibetan authorities, to our great disappointment, did us the honour of providing us with an escort of nine Houniahs, who busied themselves in throwing every obstacle in our way to prevent our crossing the mountain-barrier, which still separated us from Tibet properly so called. We were compelled to submit to a delay of three days; but there, as at Janti, we made a tolerable collection of fossils from the Silurian epoch to the Jurassic period.

In the hope of deceiving the vigilance of our guard of honour, we began our journey towards Niti, and having halted on the 16th, endeavoured under cover of night to effect our escape.

Leaving behind all our camp, and taking with us only four horsemen, and four horses loaded with provisions and the most needful instruments, we marched throughout all that night and the following day. In the evening we arrived at that alluvial plain which fills up the broad valley of the Sutlej. We thought ourselves then in safety, and were on the point of choosing a small lateral valley in whose shelter to pass the night, when we descried our cavalier-guard following rapidly in our track. Mani advised us to show no feelings of apprehension. They approached with loud cries and shouts; the two who first came up made a pretence of seizing the bridles of our horses. To this we replied with some vigorous blows of our hunting-whips, which made their faces tingle, and surprised them greatly. They leaped to the ground, saluted us, and declared that they were our friends (at Laptel we had given them a few rupees), but that they had received strict orders not to lose sight of us. As the motive of these orders they alleged the war with Nepaul, and the fear of their Government that they might be called upon to answer for anything we suffered at the hand of robbers.

We sent one of our men to Daba, soliciting the Tibetan chief to come and hold parley with us ; but he despatched his chief secretary on the following day to persuade us he was absent. We were constrained to acknowledge to ourselves that it was impossible to penetrate as far as Mansarawr ; but we might make an attempt to reach Gartok in the upper valley of the Indus. After a prolonged negotiation, assisted by gifts of rupees and brandy, we obtained permission to push forward to the Sutlej, signing a treaty which limited us to a three days' sojourn on the banks of that river, and imposed a fine of 600 rupees (£52) in case we transgressed this limit.

Consequently, we resumed our march, and reached the Sutlej, near its junction with the Gyonngoul.

We remained there two days, occupied with astronomical and other scientific observations, when the Bara-Mani rejoined us, and offered his protection.

He was the richest man in Milum, and enjoyed great influence. The chief of Daba was his friend, and owed him some thousands of rupees. By dint of threats and prayers, he obtained permission for us to proceed as far as the pass of Chaco-La, which lies in that part of the chain dividing the Sutlej from the Indus. Our guards grew hourly more docile, and a few Chinese articles which we bought from them at extravagant prices, completed their good opinion of us. Permission was given us to remain five or six days at Chaco-La, the two Manis becoming guarantees for our obedience, and engaging to pay a heavy penalty in case of contravention. We were accompanied by two men only, the others preferring to remain at the foot of the mountain. On the 26th we arrived at the pass of Chaco-La, and hastened to pitch our camp.

On the morning of the 27th we resumed our march. A great number of natives were crossing the col with their flocks of sheep. To prevent any suspicions being aroused, we had left behind our tent, baggage, and one of our servants. Two horses carried our theodolite, the hypsometrical apparatus, and a supply of provisions.

We informed the passers-by that it was only our intention to ascend a neighbouring mountain to study the compass.

Having traversed the col, we plunged into a lateral valley ; but what was our surprise to behold, at the bottom of it, a hundred Houniahs armed to the teeth ! Our people were terrified ; they declared that these men had been despatched by the chief of Gartok to make us prisoners. We took refuge in a cavern, and sent one of our servants to reconnoitre. The Houniahs discovered and surrounded him. By means of our glass we could see that an extraordinary scene of agitation was being enacted beneath us ; one seized his horse, another took away his gun. Fortunately, after a short detention, he was released, having found among these men an old friend, who extricated him from his difficulty.

In the evening we descended into another little valley, situated at the limit of the shrubby vegetation. The night was unfavourable. Deprived of our tent, and with no protection against the cold but a few coverlets, we threw ourselves down as close to one another as possible. Morning revealed to us a bed of snow nearly four inches in thickness. But the sun's rays soon melted the fresh snow which had fallen during the night, and we discovered, to our satisfaction, that most of the Houniahs had departed. The weather again cleared up, and in the afternoon we found ourselves in the valley of the Indus, several thousand feet above Gartok.

A hill, rising from the left side of the valley, offered us an admirable *coup-d'œil* of this vast depression, and of the mountains bordering it to the north-east. We profited by it to make a few sketches.

On the 28th, we reached the Indus, but want of provisions compelled us to return to our camp, where we passed the night.

Next morning we made the ascent of a peak of this chain, the Gounchankar, nearly 20,000 feet high, which, owing to its isolated position, afforded an excellent station for studying the orographical configuration of the country. The prospect from the summit of this mountain is truly magical: northward rise the snowy peaks which bound the classic valley of the Indus; to the right, at our feet stretched the vast plain and the two sacred lakes of Tibet; southward, and far away in the unfathomable distance, rolled the white billowy crests of the Himalaya.

We returned, on the 30th, to the Sutlej, and from thence to Daba. Little by little we had gained the confidence of the natives; they showed us the interior of their temples, gave us books, and always expressed their astonishment at finding us so much better than rumour generally represented Europeans. Every day we received gifts of fresh milk, sheep, and other provisions.

We now struck more to the south, to the foot of the great glacier of Ibi-Gamin (such is the true Tibetan name of the Kamet). Viewed from Gounchankar, this peak surpasses all the summits of the Himalaya, and we had determined upon attempting its ascent. Provided with hatchets, ropes, and everything necessary for crossing the ice, we quitted our camp at the foot of the glacier on the 16th of August. We were surprised to find the ascent very protracted.

The Ibi-Gamin is a very beautiful and very regular glacier; it reminds one of that of the Aar, but is far more sublime. The higher we ascended, the further the summit appeared to recede from us. For three days we mounted upward, making numerous halts, and sleeping on the moraines. The third day we encamped at the very base of the Ibi-Gamin peak, at an elevation of 22,150 feet, where the valley of the glacier terminates. We were accompanied by fourteen men. Instead of wood, we were now reduced to use as fuel a species of grass which we met with on the mountain at the foot of the glacier.

The night of the 18th–19th had been cold, and a strong wind had prevailed, but the morning was beautiful, and we resolved on attempting the peak itself. Eight only of our attendants consented to accompany us; the remainder were overcome, and broke out into loud lamentations that we were going to our destruction.

We immediately began the ascent of the abrupt flank of Ibi-Gamin, traversing a bed of snow intersected by crevasses, which compelled us to make numerous détours. At the end of two hours we found it impossible to proceed; two of our people, attacked by the *mal des montagnes*, had dropped behind, and we ourselves felt fatigued and exhausted to a degree we had never before experienced. The panorama presented to our view was of no great extent; clouds incessantly enfolded us; though an occasional glimpse of light revealed to us the glacier-chains which surround the Ibi-Gamin. The highest point to which we attained was upwards of 22,200 feet; we had ascertained, by calculation, that the total elevation of the mountain was about 22,250 feet.

Towards two o'clock a strong wind began to blow from the north, and we began to think of retracing our steps. It increased in violence as we descended, and we were well pleased at arriving safe and sound at our camp in the evening. The peak of Ibi-Gamin again showed itself several times in the midst of clouds, coloured by the fires of the glowing sunset, and the reader will believe with how lively a satisfaction we surveyed our route, which the eye could clearly trace up to the highest point.

We had grown accustomed to sojourning at great elevations, especially during our travel in Tibet; but this time no one had wholly escaped suffering. We experienced severe pains in the head, and the agony in our eyes was terrible, owing greatly to the wind, which blew around us a mist of fine particles of snow. The night was again unfavourable. We had no means of kindling a fire; the wind threatened to blow down our tent; the cold was intense. All our attendants, with one exception, had lost courage, and even the faculty of thinking. Towards nine in the morning the cold decreased, and we set out for our second encampment, which was better sheltered.

That day we lost one of our servants, Dolpa, a native of Milum, and a very worthy man, who had been attacked with hæmorrhage on the preceding evening. We had caused him to be accompanied by a man in the descent; but the latter arrived shortly after us, declaring he had lost his companion in a whirlwind of snow. We sent at first two, afterwards three of our men, in search of him, but without success. Next day two men remained behind to continue the quest, but it was all in vain.

We had been three days at Mana, and had made an arrangement with the family of the poor fellow whom we supposed to be dead, when he returned to us as by a miracle. He had been lying between two great boulders of a moraine, where no one could see him; the second day he had begun slowly to descend, but did not arrive at our encampment until the two men left behind had quitted it, and thus he had remained three whole days in those frozen solitudes without food. At length, he fell in with some natives of Mana, who cordially greeted him, and brought him back. His condition was pitiable; his feet were frozen; but he slowly recovered.

In the afternoon of the 20th we were gratified by a return of fine weather. We completed our topographical surveys. Some supplies of fuel and provisions despatched by Mani from the lower station, where he waited for us, helped to re-establish everybody's strength.

The great glacier of Ibi-Gamin lies within the borders of Tibet. To reach Badrinath, we had to traverse a *col* of the glacier. We had heard of this pass (which differs materially from the ordinary Mana Pass) from one of the coolies who accompanied us. He told us that men formerly crossed it with their herds, but that it was then entirely deserted, and that no one with whom he was acquainted had ever been there. However, he had a tolerably correct idea of its position, and offered to conduct us to it.

On the 21st we recommenced ascending the western branch of this mighty glacier, and slept on its most elevated moraine. On the 22nd, the weather being clear, we continued our route, and, after some digressions, and a few mistakes, reached the pass at two o'clock. It was loftier and of more difficult access than we had supposed. It is certainly one of the highest passes in the Himalaya; its altitude cannot be less than 20,300 feet above the sea-level. We were fortunate, however, in finding any sort of pass, for otherwise we should have been forced to make a long and wearisome détour, by descending to the very foot of the glacier, and skirting the Mana-Ghat.

From the loftiest point of this col we discovered a vast glacier extending to the south-west, and before us stretched a range of mountains. The glacier was that of Soursoutti. We descended its incline, and passed the night again upon a moraine, in a place where we found a few dry herbs. To feed a fire for preparing the dinner we very sorely wanted, we were compelled to break up our staffs, and the poles of our tent. On the 23rd we arrived at Soursoutti, at the foot of the glacier, in the valley leading to Mana. We were now able to understand why the natives had abandoned the pass; it is a hundred times worse than that of the Pindari; and, moreover, it is remote from every habitation, and bare of all resources.

Next day, happily, we fell in with some persons travelling to Tibet, who gave us some of their rice. On the evening of the 24th we reached Badrinath, where our arrival had been anxiously expected.

Such is the narrative of the two Bavarian travellers. A year after this memorable ascent, one of the brothers, Adolphe Schlagintweit, traversing anew these same regions, was recognized as an European, and fell by the daggers of some murderous natives. The Tibetan Government, in 1862, struck a medal in honour of Hermann Schlagintweit. It represents the traveller in his costume as a Himalayan explorer. One word only is engraved on the medal, but it is full of meaning:—

SAKUENLUENSKI:—"He who passed the Kuen-luen."

If we remember that the elevation of Mont Blanc is 15,756 feet, we shall see, from the narrative of the preceding ascent, in which the brothers Schlagintweit attained on Ibi-Gamin the height of 22,200 feet, that the barometers had been carried 6500 feet higher than on Mont Blanc. The elevation of the mountain-chains of Asia is, moreover, very superior to that of the European mountains, and we may say, generally, that the giant of the Alps is, after all, but a dwarf, when compared to various points of the Cordilleras of America and the Himalayas of Asia. In the Tibetan chain the mean height of the cols or passes is computed, by the brothers Schlagintweit, at between 16,000 and 18,500 feet.

But if we would obtain a tolerably accurate idea of the orographic configuration of the immense Asiatic continent, we must not leave out

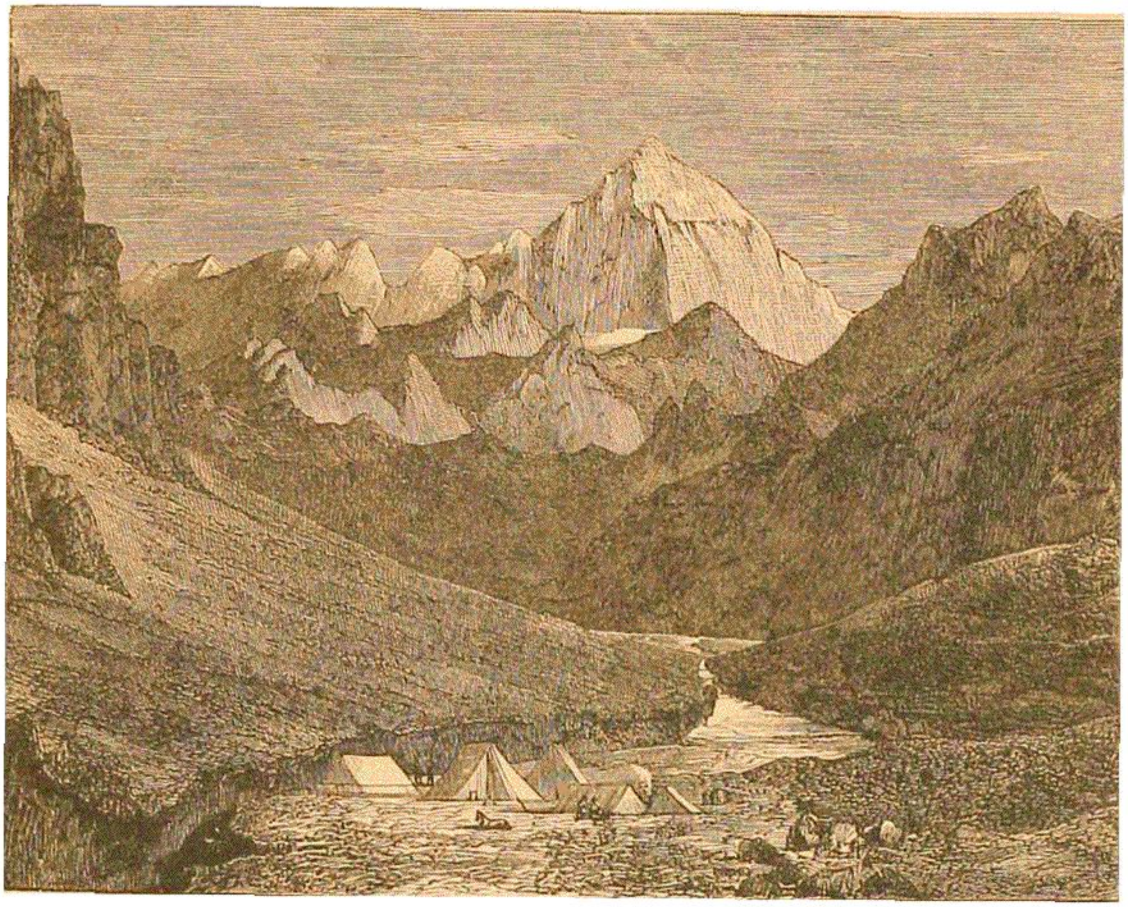

FIG. 64.—ONE OF THE NOON COON PEAKS, TIBET

of consideration the great central table-land lying between the two systems of the Himalaya and the Altaï. This vast protuberance of the soil, as Humboldt expressively calls it, stretches in the direction of S.W. and N.E. across Tibet and Mongolia. Four great chains run from west to east, in the line of the terrestrial latitudes. We have already described them, but, for the reader's convenience, repeat the enumeration here. To the north, on the frontiers of China and Siberia, rises the group of the Altaï; to the south, the majestic belt of the Karakorum and Himalayan Mountains, where we discover the loftiest summits of the world. The two intermediate chains, going from north to south, are the Thian-Shan, or "Celestial Mountains," and the Kuen-luen, which is terminated on the west by the Tsung-ling; these again, on the west, unite with the chain of Bolor-Tagh, or "Mountains of the Mist."

The Celestial Mountains seem continued, beyond the great Aralo-Caspian basin, in the Caucasus, which forms the eastern boundary of the Black Sea. Siberia is separated from European Russia by the Ural Mountains, stretching from north to south; the banks of the Indus bear the oases of the East and West Ghauts, which form in the south the plateaux of the Neilgherry, or "Blue Mountains." (See *antè*, p. 177.) Finally, Asiatic Turkey is traversed by the Caucasus and the Libanus.

The elevation of the *ligne de faite*, or the mean height of the Asiatic Passes, is, according to Messrs. Schlagintweit, as follows:—

For the Himalaya, ...	17,700	Eng. feet.
" Karakorum, ...	18,600	"
" Kuen-luen, ...	16,850	"

These figures exceed those given by Humboldt. The latter computes at about 375 feet the primitive elevation of the low lands of Asia. The Chinese plateau is 4850 feet above the sea; the plateau of Tibet has an average altitude of 5400 feet. The distribution of all the mountains, and all the lofty table-lands, over the entire surface of Asia, would raise the mean general height of that continent more than 1140 feet, which surpasses the mean elevation of America or Europe.

The western slope of the Bolor-Tagh includes the famous table-land of Pamir, which the wandering Kirghiz name "the Roof of the World." The first European traveller who described it was Marco Polo:—*

* [Marco Polo was born of a noble Dalmatian family, at Venice, about 1250. In 1275, he visited the Court of Kûblai, the Grand Khan of the Mongols, and was employed by that sovereign on various important missions. He returned to Venice in 1295, and died in 1323. The first edition of his "Travels" was published by Ramusio in his *Raccolta di Navigazioni e Viaggi* (Venice, 1559).]

"There," says the Venetian, "occurs a plain, watered by a very fine river, and covered with the most beautiful pastures, so that a lean mare would grow plump and fat in ten days. We rode onward, constantly rising higher, for twelve day's journeys, and in all that time met with no habitation, nor with any herbage except the desert. Not a bird could be seen, for the place is lofty and bleak. And I tell you that, owing to the great cold, fire burns neither so clearly nor with so much heat as elsewhere, and you cannot cook your food very thoroughly."

This plateau is the central knot, or focus, whence radiate the chains of the Tibetan mountains. In February 1838, it was visited by Captain Wood, who discovered, 15,600 feet above the sea, Lake Sir-i-Kol, a beautiful and ample expanse of water, shaped like a half-moon, which gives birth to the Amoo-Daria, or Oxus. The surrounding mountains feed several of the principal rivers of Asia, as the Yarkane and the Sin. Captain Wood describes his impressions in the following terms :—

"The appearance of the country presented the image of a winter of extreme severity. Wherever one's gaze rested, a dazzling bed of snow covered the soil like a carpet, while the sky above our heads was of a sombre and melancholy hue. A few clouds would have refreshed the eye, but none could be anywhere seen. Not a breath rippled the surface of the lake; not a living animal, not even a bird, presented itself to the view. The sound of a human voice had been harmonious music to the ear, but, at this inhospitable season of the year, no one ventured into these icy realms. Silence reigned everywhere around us; a silence so profound that it oppressed the heart."

But during the summer all this is changed; a fresh nutritious herbage springs up over the plain, and attracts the pastoral nomades, with their herds.

The general elevation of the Tibetan plateau is so considerable that villages at less than 6500 to 7500 feet above the sea are only found in its western region, the Balti.

The population, therefore, is very thinly scattered; it is chiefly gathered in the districts between 8800 and 10,500 feet in elevation. Tibet undoubtedly possesses the loftiest inhabited localities of our globe; nowhere else does man take up his abode at such prodigious altitudes. Generally, it is Buddhist monasteries which spring up in these high regions; the oldest being that of Hanlé, which is situated fully 14,400 feet above the ocean-level. There probably exist some other convents at equally lofty points in the Gnari-Korsum, on the borders of the lakes Manasarowa and Ravana-prada (lat. 31° N., long. 81° E. nearly). It should be remembered that in Europe the highest inhabited point is also a convent—namely, the Hospice of St. Bernard, in the Alps.

Tibet, like the Himalaya, has its "summer villages." But if, in the Himalaya, these habitations never exceed the elevation of 11,600 feet (Kidarnath), they rise in Tibet as high as 16,000 feet (Norbou). According to the brothers Schlagintweit, Gartok (15,000 feet) is the most important of these summer villages (which might almost remind one of the *æstiva castra* of the Romans); every year, in the month of August, a fair is held here, which attracts thousands of natives from all parts of central Asia. The summer villages of Norbou (16,000 feet) and Pouga (15,200 feet) are situated in the vicinity of rich strata of salt and borax, and sometimes afford a shelter for the shepherds. The flocks, with their owners, frequently remain for several successive months—from June to September—at an altitude of nearly 16,500 feet. In the Alps, no pasturage is found above 8500 feet (on the Fluhalpe, near Findelen).

The southern slope of the Kuen-luen is not inhabited; on the northern declivity, the summer villages lie as high as 10,100 feet; the villages inhabited throughout the year at nearly 9000 feet (Bouchia). The herds frequently climb in quest of pasture to an elevation of 13,000 feet above the sea.

Subjoined is the elevation of two Tibetan towns :—

Leh, or Ladak, ...	11,000 Eng. feet.
Lassa.	9,500 "

The old and picturesque city of Erzeroum, in Armenia, which Mr. Curzon has described so faithfully, is situated at 6200 feet; that of Ispahan at 4400 feet.

The barometrical observations of the brothers Schlagintweit ascribe the following altitudes to certain lakes in Western Tibet:—

Aksae-Ghin, ...	16,300 Eng. feet.
Tso-Kar, ...	15,600 ,,
Lake Kiouk-Kiol, ...	15,350 ,,
Manasarowa, or Tso-Mapma, ...	15,200 ,,
Ravana-prada, or Rakas-Tal, ...	15,200 ,,

In the Garval, a lake lies deeply embosomed among glaciers, at an elevation of 17,650 feet; it is the Deo-Tal. At certain intervals the icy rampart which surrounds it is cloven, and then floods of water inundate the low-lying country.

The lakes of Tibet are salter than is generally the case with fresh waters. In the Himalaya few lakes are found; that of Naintal lies 6600 feet above the sea.

The passes, or cols, of the mountains of Central Asia are distinguished, as we have already said, by an excessive mean altitude, which even exceeds the height of the loftiest Alpine summits.

But, in the Himalaya, passes exist of a far more aerial character; that of the Ibi-Gamin, which Messrs. Schlagintweit traversed *en route* from the Garval to Gnari-Korsum, is, as we have previously stated, 20,500 feet high. About 1820, some of the natives attempted to pursue this route with their flocks of sheep; but they fell into the hands of the brigands, who infest this region of the mountain, and the losses which they sustained compelled them to abandon the pass of Ibi-Gamin as a commercial channel.

The pass of Masta presents an altitude of 18,950 feet. The natives are accustomed to raise blocks of stone along these highways. These stones, and the numerous skeletons of beasts of burden abandoned on the road, are the only landmarks of these savage highways.

The Himalayan passes which rise above 15,000 feet are closed by snow during the winter—that is, from November to May, or even to June. In December 1845, a great battle was fought near Tirtapouri, in the Gnari-Korsum. The garrison of Takla-Khar escaped by one of those snowy defiles; but half of them were killed by cold, and most of the survivors suffered from frozen extremities.*

In the Karakorum the passes remain open nearly all the year, and merchants on their way from Ladak to Turkistan traverse them every winter.

FIG. 65.—VIEW OF GUARISANKAR, THE LOFTIEST MOUNTAIN IN THE WORLD (29,000 FEET).

The loftiest peak of the Himalaya and of the whole world is the *Guarisankar*,† trigonometrically measured by Major Everest in 1847. It is 29,000 feet above the sea. We delineate it in Figure 65, from a sketch in the magnificent atlas published by the brothers Schlagintweit.

Next in rank, according to elevation, comes the Dapsang, belonging to the Karakorum system, which separates Ladak from Yarkand.

* [Cunningham, *Ladak*, p. 353.]

† [Sir J. Herschel also gives it the names of Diodunga and Chingopamari. Many English geographers now name it *Mount Everest*.]

FIG. 66.—THE KANCHINJINGA MOUNTAIN.

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This summit, measured by Captain Montgomery, a staff-officer of the Indian army, is 28,650 feet above the sea-level.

The glaciers of the Himalaya, comprised between the Guarisankar, which overshadows Central Nepaul, and the Kanchinjinga of Sikkim, which holds the third place among imperial mountains (28,550 feet), present one of the sublimest panoramas which it is permitted human eyes to contemplate.

The water of these "ice-torrents" feeds the river Cosi, which flows southward to empty itself into the Ganges, whose course runs nearly parallel to this part of the Himalayan range. The Cosi traces a silver furrow across the intensely verdant plains of Bengal. Lifting your gaze from the broad argent ribbon glittering in the sun, you perceive, at 200 or 250 miles distant, the cold white outlines of those snow-shrouded peaks, sharply defined against the azure sky. At the base of this aerial chain stretches the belt of woodland known as the Teray or Taraï, from a Persian word signifying "mist." Both at the beginning and at the end of the rainy season, the forests are hung with a dense white fog, which drives from their neighbourhood every living creature. The beasts abandon their deadly shades in mid-April, and do not return until towards October.

"Tigers and elephants," we read in a recent work, "seek the mountain; apes, antelopes, and wild boars pour down upon the cultivated plains; and those human beings—as couriers and soldiers—who are occasionally compelled to traverse the forests during this terrible season, agree in asserting that not a sound, not even the voice of a bird, breaks the horrid silence of this immense solitude, given up to the sole supremacy of malaria." *

The only pass of the Himalaya practicable for tourists is the gap or ravine through which the sacred river Sutlej flings itself headlong from mountainous Tibet into the low southern plain on its passage to the Indus.

This valley sinks down to a level not 3300 feet in height. Between its black precipitous sides flows the river, scarcely 180 feet in breadth. The natives cross it by means of a rope stretched from one steep wall to the other. To the rope is slung a wooden ring, and to the ring the traveller fastens himself with all his baggage. He is rapidly drawn across; but if the cable broke, he would be precipitated into the torrent which roars and foams below.

Re-ascending the banks of the Sutlej, we meet with the fresh and fertile scenes where our Anglo-Indians take refuge in the summer-heat, and endeavour to recruit their exhausted frames.

* De Lanoye, "L'Inde Contemporaine."

One of the most picturesque portions of the colossal chain of the Himalaya is the district of Sikkim, which lies in the shadow of Kanchinjinga. In this surprising region are combined the most majestic contrasts. Glaciers roll their slowly-moving masses above the realms of snow; lower down, the roaring torrents sink, lost to sight in profound abysses; still lower, through a leafy screen of magnolias, calm lakes spread out their glassy waters in the midst of emerald-green pastures, tenanted by the small Tibetan cow, and of fertile valleys, inhabited by pastoral mountaineers. Kanchinjinga rears its crest fully 21,200 feet above the table-land of Dorjeeling, which is itself some 6800 feet above the level of the sea. In the landscape placed before the reader, in Figure 66, the Kanchinjinga rises conspicuously sublime; on the left he will notice the great torrent Rungeït, which precipitates itself into a deep gulf.

The most eloquent pen, says the eminent botanist, Dr. J. W. Hooker, the most skilful pencil, are equally powerless to place before the eye the forms and colours of these snowy mountains, or to excite in the imagination the sensations and the thoughts which such sublime phenomena at once arouse when developed in their reality. Nothing can render the precision and sharpness of their lines, and still less the marvellous effects of the hues playing on the snowy slopes, the luminous masses formed by the combinations of orange, gold, and crimson, the clouds illumined by the sunset, and finally the fantastic tint with which everything is clothed at the moment of twilight.

The most impressive characteristic of the Himalaya is the breadth of its mountain-system, the vast area which it occupies. In the Alps, the summits are disposed in narrow belts, the valleys are open as the plains; here, on the contrary, the whole chain bristles with peaks, it is an irregular and capricious labyrinth of black pinnacles, of precipitous chasms, and of glaciers which intersect each other in every direction. Sometimes we meet with summits cut horizontally like a table, or undulating crests which intercross and combine in irregular groups. The common feature of the Himalaya and of the Tibetan mountains is this methodless combination, which seems the result of the most fantastic chance.

An Asiatic mountain of all-absorbing interest is Mount Ararat, situated in Armenia, between the Black and the Caspian Seas. It is supposed that the elevation of this volcanic mass provoked the great geological catastrophe known as the *Asiatic Deluge*.

FIG. 67.—MOUNT ARARAT.

Mount Ararat was long considered inaccessible. In 1700, the eminent botanist Tournefort was compelled to abandon an attempted ascent, after having endured much useless fatigue. More recently, the Pasha of Bajazed despatched an expedition to escalade the sacred peak. These men constructed tents along their route, wherein they deposited supplies of provisions; but the cold forced them to retrace their steps without accomplishing the object of their mission. Finally, in 1829, the German traveller, Professor Parrot, succeeded in reaching the snow-shrouded summit, 17,323 feet above the sea. In 1834, his example was imitated by M. Autonomoff; he confirmed his predecessor's narrative, which had been impugned by the Armenian clergy. Some English tourists effected the ascent in 1857.

Ararat consists of two conical peaks; *the elevation of the* smaller is 13,100 feet, and the two are about 16,000 feet apart in a straight line.

The chain of the Caucasus we have already described. Its loftiest peaks are those of Elburz (18,493 feet) and Kazbek (16,530 feet).

To the south of the Caspian Sea stretches the Mazenderan chain, in which the eye is attracted by the magnificent mass of Demavend, near Teheran, the capital of Persia. Its elevation above the sea is estimated at 14,695 feet.

CHAPTER V.

MOUNTAIN SYSTEMS OF AFRICA AND OCEANIA.

IN the chart, Figure 68, we furnish a comparative view of the highest mountains of the African continent. A detailed summary is given in the subjoined Table :—

TABLE SHOWING THE ELEVATION OF THE PRINCIPAL AFRICAN MOUNTAINS.

	ENG. FEET.
[Miltoin (Atlas range), Morocco, ...	11,400
Abba Yared, Abyssinia (lat. 13° 5′ N.), ...	15,000
Buahat, Abyssinia (lat. 13° 12′ N.), ...	14,362
Kilimanjaro (lat. 4° S.), east coast, ...	21,000
Pico Grande, Cameroon Mountains, Biafra, ...	13,029
Mount Kenia (lat. 1° S.), Zanquebar, ...	18,000 ?
Sneeberg, Cape of Good Hope, ...	11,000
Clarence Peak, Fernando Po, ...	10,650
Table Mountain, Cape of Good Hope, ...	8,816
Peak of Teneriffe, Canary Islands, ...	12,236
Chahorra, Teneriffe, Canary Islands, ...	9,885
Pico de Cruz, Palma, Canary Islands, ...	7,750
Los Pexos, Great Canary Islands, ...	6,450
Alto Garaona, Gomera, Canary Islands, ...	4,400
San Antonio, Ferro, Canary Islands, ...	3,950
Asses' Ears, Fuestaventura, Canary Islands, ...	2,770
Peak of Fogo, Cape Verde Islands, ...	9,159
Pico, San Antonio, Cape Verde Islands, ...	8,815
Pico, Island of Pico, Azores, ...	7,613
Pico de Vara, St. Michael's, Azores, ...	3,570
Caldeira de Sta. Barbara, Terceira, Azores, ...	3,500
Pico de San Jorje, Azores, ...	3,498
Morro Gordo, Flores, ...	3,087
Caldeira de Corvo, Azores, ...	2,460
Ascension Island, loftiest point, ...	2,870
Ambotismena, Madagascar, ...	11,506
Peter Botte, Mauritius, ...	2,874
Piton de Neiges, Réunion, ...	10,100
Piton de la Fournaise, Réunion, ...	7,218
Pico Ruivo, Madeira, ...	6,050]

Our knowledge of the African mountains is still very incomplete. To the south the continent terminates in a rocky mass of sandstone, superimposed on schist and granite, and rising to a height of 3250 to

6500 feet. This granite formation, underlying the sandstone, is extensively developed in South Africa, where one meets with huge precipitous walls crowned by tabular blocks of sandstone. Along the east coast extends the escarpment of the great central table-land, which is traversed by a range of moderate elevation, the Mountains of the Moon, near to and almost parallel with the Equator. [This chain divides the semi-civilized States of Soudan, Bornou, and Begharmi, made familiar to us by the explorations of Dr. Barth, from the more barbarous nations on the table-land, with whom we have only lately

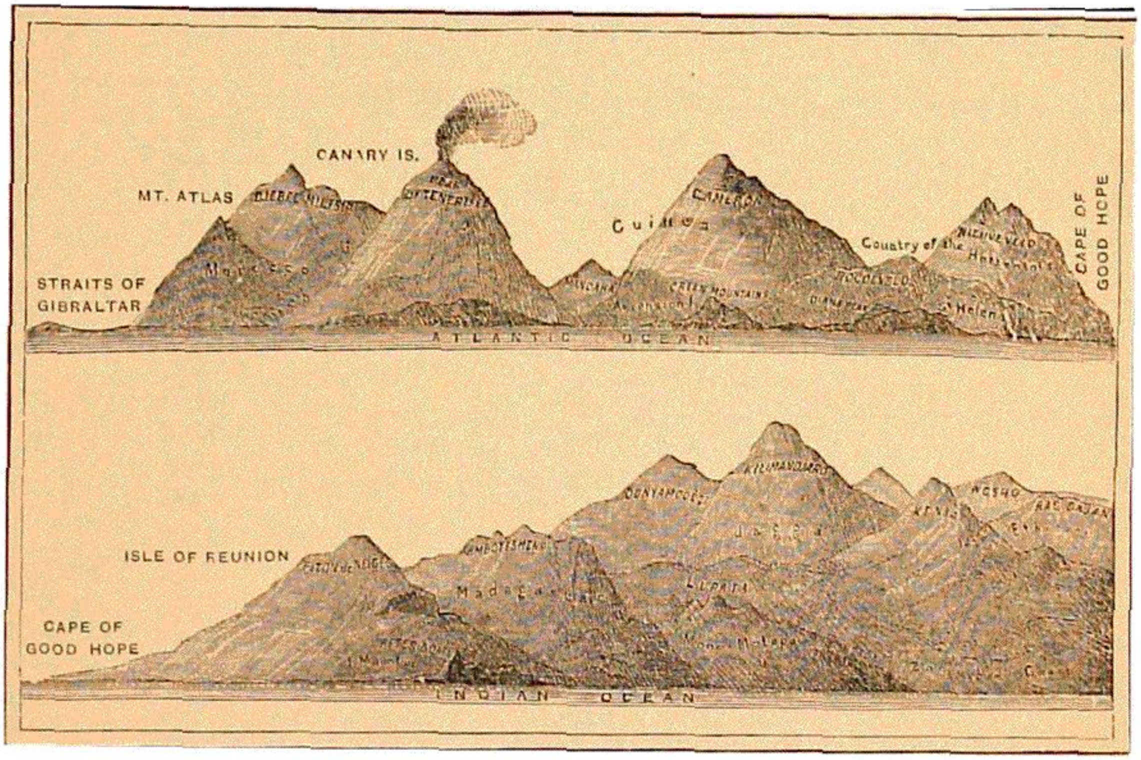

FIG. 68.—MOUNTAINS OF AFRICA.

obtained an imperfect acquaintance through the adventures of Burton, Speke, and Grant. At one end it touches the bold highlands of Abyssinia, at the other it is connected with the acclivities of Senegambia, and is prolonged by the Kong range some twelve hundred miles behind Dahomy and the Gold Coast, until it terminates in the promontory of Sierra Leone.]

On the east coast we find a rampart of mountains intervening between Lake N'yanza and the coast of the Indian Ocean. Its culminating points, nearly under the Equator, are Mounts Kenia and Kilimanjaro.

It was long believed that none of the African mountains rose above the limit of perpetual snow; but both Kilimanjaro and Kenia are exceptions to the supposed rule. The fact was obstinately disputed, until established beyond all doubt by the observations of Baron von der Decken, and the explorations of two missionaries—Mr. Rebmann and Dr. Krapf (1848). Neither of the two latter travellers attempted an ascent, but the natives informed them that, having visited Kilimanjaro, and carried away some of the white matter they discovered there, they had been surprised to see it change into water. Several of them had returned with hands and feet frost-bitten ; a misfortune which they attributed to the influence of evil spirits.

The narrative of the two travellers was at first regarded as incredible. But, in 1862, the Royal Geographical Society of London received a complete confirmation of its truth from Mr. R. Thornton, an English geologist, and the Baron von der Decken, who furnished an authentic description of the great equatorial mountain. Messrs. von der Decken and Thornton have made a sketch of their route from the coast of Mombaz to the chain of which Kilimanjaro forms the culminating point. They estimated its height at 21,000 feet, by means of a series of triangulations, but could only effect an incomplete ascent ; they were compelled to pause at an elevation of 8000 feet. At a later period M. von der Decken made a second attempt, and contrived to reach the altitude of 13,250 feet. He was surprised to encounter a heavy fall of snow.

The appearance of Kilimanjaro varies greatly, according to the point of view from which it is seen. Generally speaking, its outline is that of a cone with a very broad base. At some distance to the north-west rises another cone, that of Kenià, about 18,000 feet in height ; and seventy miles westward towers the peak of Merón, 18,500 feet. On the eastern side Kilimanjaro resembles a truncated cone ; the snow covers it like a dense cloak or pall ; a tongue of snow descends on the southern flank, and numerous "nets" (*filets*) of snow fill up the ravines and furrows. The slope, very abrupt on the southern side, prevents the snow from accumulating, and it may often be seen tumbling downwards in considerable masses. Mr. Thornton is of opinion that Kilimanjaro is the north-eastern part of an ancient volcano, whose south-western portion has sunk; he discovered the ruins in a singularly rocky mountain which is situated at a short distance from the present summit. Far away to the south-west, on a clear day, three lofty protuberances of a conical form are plainly visible, belonging probably to the central chain.

According to Dr. Livingstone, the table-land of South Africa is depressed or concave at its centre. Ethiopia, situated to the north of the Equator, is a table-land arranged in a series of terraces. The elevations on the western side are not very considerable, the mountain-groups only attaining a respectable height in the Gulf of Guinea, where the Cameroons Mountains exceed 12,000 feet. In the interior, south of Timbúktu, Dr. Barth was much impressed by the fantastic conformation of the Hombori Mountains.

The Atlas group, which, in Northern Africa, traverses Morocco and Algeria, seems connected, by its general direction and elevation, with the mountains of the Iberian peninsula. The culminating point does not rise above 13,000 feet. The flanks are richly wooded, and interspersed with romantic valleys, through whose hollows the crystal streams ripple onward to be lost in the sands of the Sahara.

The chain is continued along the Tripoli coast, where it seems to form a subordinate branch of the Apennines, the mountains of Sicily being considered as links of the same chain interrupted by the sea.

Abyssinia is entirely a mountainous region, the highlands beginning at an inconsiderable distance from the Red Sea coast, and the passes which lead into the interior being of a difficult character. The principal summits have been indicated in the Table prefixed to this chapter.

[There are several mountains, remarkable either for their height or their picturesque scenery, in the African Islands. Madagascar possesses a magnificent mountain-range, broken up by tremendous precipices, and covered with primeval forests. The Peak of Teneriffe may roughly be described as a grand cone of verdure crowned by a lesser cone of snow. In Fernando Po, which its discoverer, Fernando Gomez, very justly designated *Ilha Formosa*, the "Beautiful Island," Clarence Peak rises to the height of 10,650 feet; its summit, composed of volcanic ashes, is almost constantly enshrouded in mist. Among the Cape Verd cluster, the volcano of Fogo attains an elevation of 9159 feet. After a long interval of repose, it has suddenly given

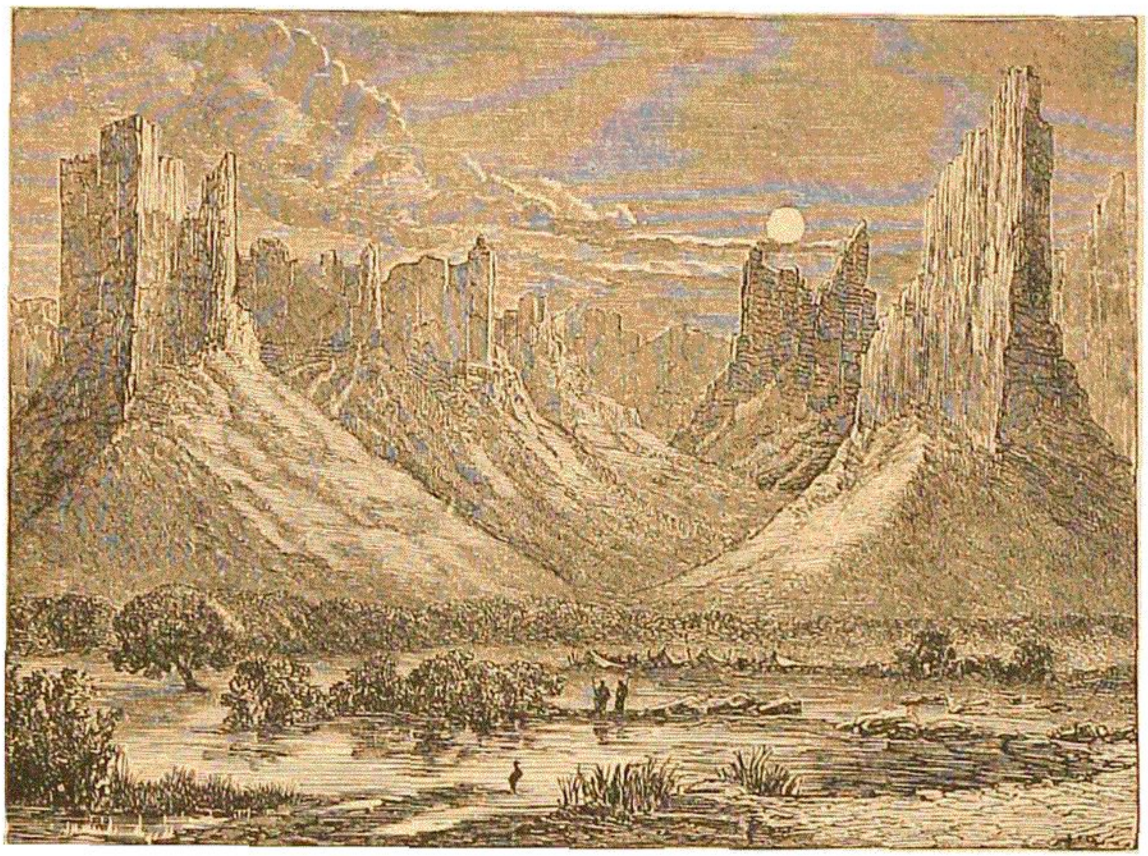

FIG. 69.—THE HOMBORI MOUNTAINS.

signs of renewed activity. The arid and gloomy mass of Ascension Island rises to 2870 feet above the sea. Diana's Peak, a dark and rugged volcanic rock in the Island of St. Helena, is 2700 feet; and Peter Botte Mountain, in the Island of Mauritius, 2874. Its shape is that of a pyramidal spire, singularly bare and precipitous, crowned by a projecting mass of rock. Bourbon, or Reúnion, consists of two groups of volcanic mountains, connected by a tongue of low land, and surrounded by a belt of rough, broken littoral. The Piton de

Neiges, 11,100 feet, is extinct; but the subterranean fires still find a vent in the Piton de la Fournaise, 7218 feet.

We now turn our attention to Australia. Along the eastern coast, at varying distances from the sea, extends a range of continuous heights, with serrated, pyramidal, and rounded summits, nearly perpendicular on the seaward side, but descending to the interior in vast downs, thinly wooded, but clothed with wild grasses and herbage, which afford abundant pasturage. In their northerly extension they are

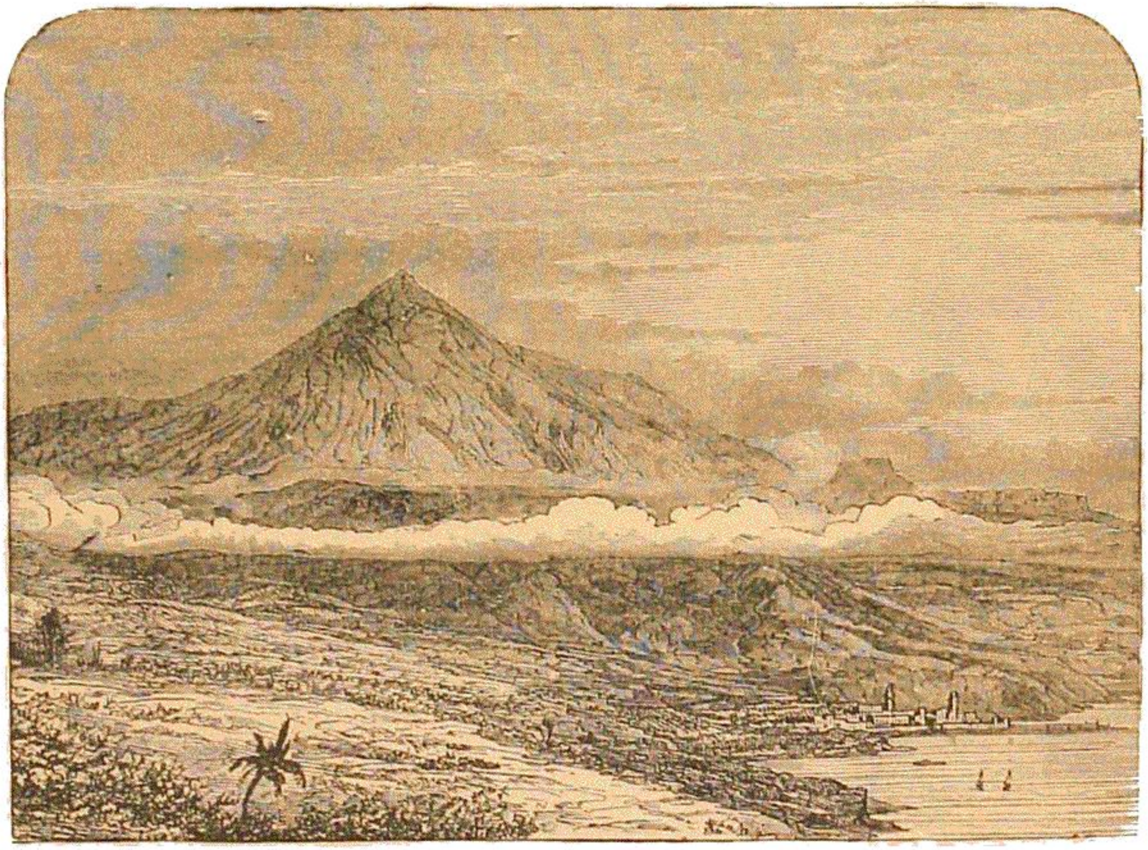

FIG. 70.—PEAK OF TENERIFFE.

known as the Liverpool range, with an average elevation of 5000 feet. In the rear of Sydney they are called the Blue Mountains, and do not exceed 3500 feet. The southerly prolongation is the Australian Alps, and distinguished by numerous lofty summits, of which Mount Kosciusko rises to the height of 6500 feet. It was ascended in 1840 by Count Strzelecki.

In South Australia the Flinders range stretches inland from the head of Spencer Gulf.

On the west coast no continuous chain has been discovered, but some isolated peaks occur. Mount Bruce, near the Fortescue river, is 4000 feet high.

A chain of mountainous islands extends across Bass's Straits to Cape Portland in Tasmania, continuing the eastern range of Australia. From Cape Portland it crosses the island in an irregular line of lofty and picturesque mountains to South Cape. Its mean height is 3750 feet, and its average distance from the sea, forty miles.

A reference to the gloriously rich islands of the Indian Archipelago must suffice us. In Papua, or New Guinea, mountains loaded with aromatic verdure rise above mountains, till in the west they tower to the height of 16,000 feet. Borneo is traversed throughout its whole length by noble mountain-ranges, their sides heavy with luxuriant forests, and their waters collecting in noble rivers. In New Zealand the English traveller meets with numerous lofty volcanic mountains, which, in the northernmost island, rise 14,000 feet above the stormy ocean, but, for fully two-thirds of their height, are buried in eternal snow and majestic glaciers.

The volcano of Tangarara pours forth deluges of boiling water, which deposit considerable quantities of silicious sinter, like the Icelandic geysers; but so vigorous is the growth of vegetation, that plants flourish nobly on the banks, and even in water too hot for the human body to endure.

The Banda archipelago forms an extensive volcanic zone; and probably no other spot on the face of the earth contains so many volcanoes as the fertile island of Java. Its central crest consists of a huge volcanic range, from 5000 to 13,000 feet high, ending eastward in a series of thirty-eight separate volcanoes with broad bases, tapering gradually into richly wooded cones. In Bali and Sumbawa the mountains do not exceed 8000 feet in height. Sumatra contains summits both of a volcanic and granitic character. To the Volcanic mountains, however, we shall hereafter recur.

The following Table will conclude our synopsis of the principal mountains of the world :—

TABLE OF MOUNTAINS IN AUSTRALIA AND POLYNESIA.

	FEET.
In *Australia:*—	
Mount Kosciusko (Australian Alps), ...	6,500
Mount Lindsay (lat. 28° 20′ S.), ...	5,700
Mount Canobolus (lat. 33° 25′ S.), ...	4,551
In *New Zealand:*—	
Mount Edgecombe, ...	9,630
Mount Egmont, ...	8,840
Mount Tangarara, ...	6,200
In *Java:*—	
Mount Slumat, ...	11,930
Sumbang, ...	11,030
Gunong Pasama, Sumatra, ...	13,840
In *Sandwich Islands:*—	
Mouna Kea, ...	13,953
Mouna Loa, ...	13,760
In the *Antarctic Region:*—	
Mount Erebus, ...	12,400
Mount Terror, ...	10,880]

CHAPTER VI.

VALLEYS, PASSES, AND MOUNTAIN-RAVINES.

THAT depression of the Earth's surface which occurs between two mountains, hills, or neighbouring plateaus, we call a Valley. In form and origin these depressions present a remarkable variety. The valleys are very narrow, and closely resemble actual gaps of the soil, if the mountains which enclose them approach one another very nearly. When they are separated by a wide interval, the valleys expand until they form plains.

If we consider their geological origin, we shall divide them into "valleys of subsidence," "valleys of upheaval," "valleys of separation," and "valleys of denudation."

The former are produced by earthquakes; that is, by the great

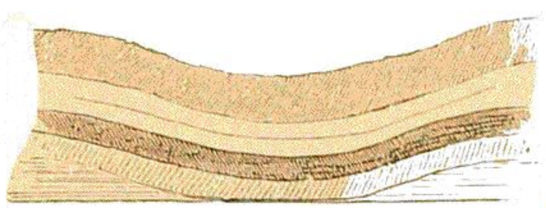

FIG. 71.—VALLEY OF SUBSIDENCE.

oscillations which in former ages convulsed the earth. Therein we see continued, with a gentle incline, the strata forming the lateral elevations.

"Valleys of upheaval" have originated in the sudden dislocation

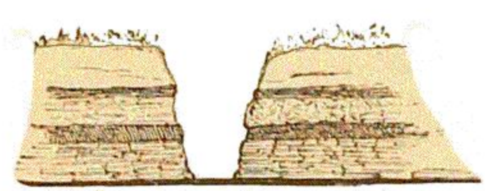

FIG. 72.—VALLEY OF UPHEAVAL.

of two or more layers of rock; a dislocation generally due to the action of an earthquake, as is shown in Figure 72.

The strata correspond, and are continued, in the two disjunct walls.

Sometimes a valley results from the upheaval of an eruptive mass between two strata; it then presents the subjoined configuration:

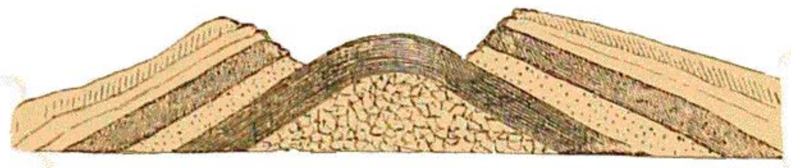

FIG. 73.—VALLEY OF UPHEAVAL.

"Valleys of separation" may also be formed by the loss or wearing away of a bed of earth formerly superimposed on other beds.

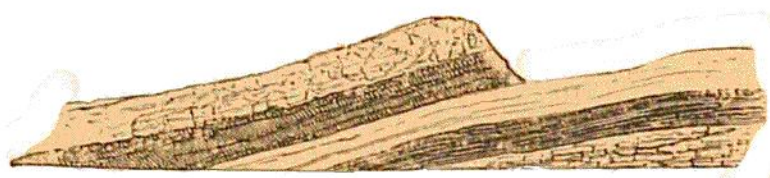

FIG. 74.—VALLEY OF SEPARATION.

This kind of valley is caused by the action of glaciers, or by surface waste.

"Valleys of denudation" exhibit the latter phenomenon on a larger scale. They owe their origin to the destructive action of the waters, which have laid bare the lower strata of the soil by carrying away the upper.

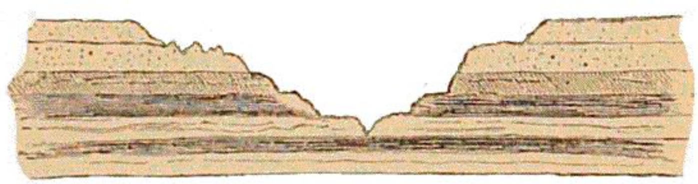

FIG. 75.—VALLEY OF DENUDATION.

Thus, then, valleys have been created by very different geological causes. The ground is lifted up in convex undulations; torn and rent by violent shocks; volcanic eruptions have broken up and dislocated the strata which were formerly continuous; currents of water gradually wearing away the earth over which they flow, have in the end excavated profound channels. It is to this concurrence of effects the surface of our planet owes its present configuration.

Among these different valleys geographers recognize yet another distinction, founded on the position which they occupy in the mountain-systems. They call them "longitudinal valleys" when they extend between two mountain-chains, because they follow the direction of the length of those chains. Such are the valleys of the Tay and the Spey in Scotland; in France, that which separates the Jura and the Alps on the east, and the mountains of the Lyonnais and the Vivarais on the west.

Valleys formed by two lateral branches of a chain are called "transversal." Such are the transversal valleys of the Doubs, the Iser, and the Durance, which open on the one side into the great longitudinal valley already spoken of, and those of the Garde and the Ardèche, which open into it on the other.

If we turn our glance towards an island, or the shores of a continent, we observe that, starting from the sea, the ground rises gradually up to a certain height, which forms the water-shed or summit-line; and that from this summit it begins to decline, thus exhibiting two opposite slopes. Each general slope subdivides into numerous secondary slopes, formed by the transversal branches which project from the summit-line, and terminate at uncertain distances. The line following the bottom of the valley formed by two neighbouring slopes is called *thalweg*, from a German word which signifies a "valley-road;" it is the route, or channel, of the waters which spring from the principal summit, and descend towards the sea or towards the plain. The *thalweg* almost always becomes the bed of a river.

The high valleys often present, at their origin, a number of small secondary valleys, whose flanks have a very gentle slope, and which are frequently called *vales*. Sometimes they start from a circular basin, or amphitheatre (*cirque*), like the Cirque of Gavarnie, in the Pyrenees. Deep and narrow valleys are termed *gorges*, or, when they are of very small dimensions, *ravines;* a ravine is usually watered by a torrent.

In mountain-chains the starting-point of two opposite branches is generally marked by a sinking of the crest, and the origin of two opposite valleys is indicated by a depression which the French call a *Col*, and the *Pyrenean* mountaineers, a *Port* or Gate.

A valley is frequently formed by a projecting angle of one of the two branches which serve as its enclosing rampart, in such wise that there remains but a narrow passage through which the traveller can penetrate; such a passage is named a *Pass* or *Defile*. We must add, however, that the words *col*, *defile*, *pass*, *passage*, are often confounded by writers, and that their exact signification is not very well established.

FIG. 76.—THE CIRQUE OF GAVARNIE (THE PYRENEES).

The aboriginal inhabitants of every country establish themselves at the outset in the low, sheltered, and fertile valleys: hence, the *cols* or *passes* which provided them with an access to the outer world have sometimes received the name of "Gates of the Nations." Let us mention, for example, the *Porta Vestphalica*, which the river Weser traverses; the Gates of the Caucasus (*Caucasiæ Pylæ*); the Pass of Issus, near the Syrian Gates, in the Taurus chain, rendered famous by the victory of Alexander the Great over Darius Codomanus;

the Pylæ Ciliciæ, which open upon Tarsus;* the Thermopylæ (or the "Hot Gates"), near Mount Œta, immortalized by the heroic devotion of Leonidas and his Three Hundred; and the Caudine Forks,† where the glory of the Roman Eagles was so pitifully humiliated. Between Sweden and Norway, near Skiaerdal, one of these gates is formed by two precipitous walls; a very similar one is found in the Dovrefeld. In the United States there exist some remarkable examples in the abrupt openings through which the Hudson has forced the mountain-barriers. Some of the "gates" in the Andes have a depth of 5000 feet.

We shall notice at more detail a few of the defiles rendered celebrated by historical associations.

The *Col de Pertus*‡ has been from all time the natural route across the eastern chain of the Pyrenees. It was traversed by Hannibal, on his way into Gallia, and by Cæsar and Pompey, before Iberia became a Roman province. Several centuries later, the Goths poured through the same defile to establish themselves in Spain on the ruins of the Roman supremacy; and when they, in the eighth century, were in their turn expelled by the Arabs, the latter forced the Col de Pertus, descended upon France, and were only arrested by the great victory which Charles Martel won over them at Tours.

The defile of the Dariel, or "Gates of the Caucasus," is thus described by Blanchard, who traversed it in 1857, on his route from Tiflis to Stavropol.

"Of all the mountain-passes which I have explored, this is the most imposing. Figure to yourself two immense walls of rock rising perpendicularly, and nearly to the limit of eternal snows, and at their foot a torrent, foaming and furious, interrupted in its course by immense boulders detached from the neighbouring mountain; a road sometimes scarcely ten feet wide, a width which has often been attained only by making it bound, in the form of a semi-vault, over the rocks of the perpendicular wall;—such is the picture. The pen cannot convey any idea of the savage grandeur which this passage exhibits; this impregnable Thermopylæ, whose master is also master of the military road penetrating from Europe into Asia."

Gorges and ravines are numerous enough in countries abounding with hills and table-lands; they invariably lead to the most open valleys. In travelling along the ridge which overhangs them, we frequently arrive upon their very brink before discovering them. Their origin is generally due to the destructive action of a violent torrent, or to crevasses produced by a sudden fracture or convulsion of the soil.

* [This is now called by the Turks *Göleh Bógház*. It was traversed by the younger Cyrus, and by Alexander the Great. Niger attempted to defend it against the Emperor Septimius Severus in A.D. 197.]

† [The pass known to the Romans as the *Furculæ Caudinæ* is supposed to have been the narrow valley of the Isclero, between Santa Agata and Moirano.]

‡ [Identical with the *Summus Pyrenaeus* of the ancients.]

The Pyrenean ravines are remarkable for their savage beauty. Dauphiny, too, is rich in this variety of mountain-landscape.

In Figure 77 we represent the curious gorge of the Rosstrappe, formed by the close approach of the mountains of the Harz.

Numerous very picturesque ravines, the haunts of wild bands of brigands, intersect the Taurus range, in Cilicia. Their flanks are clothed with cedars, oaks,

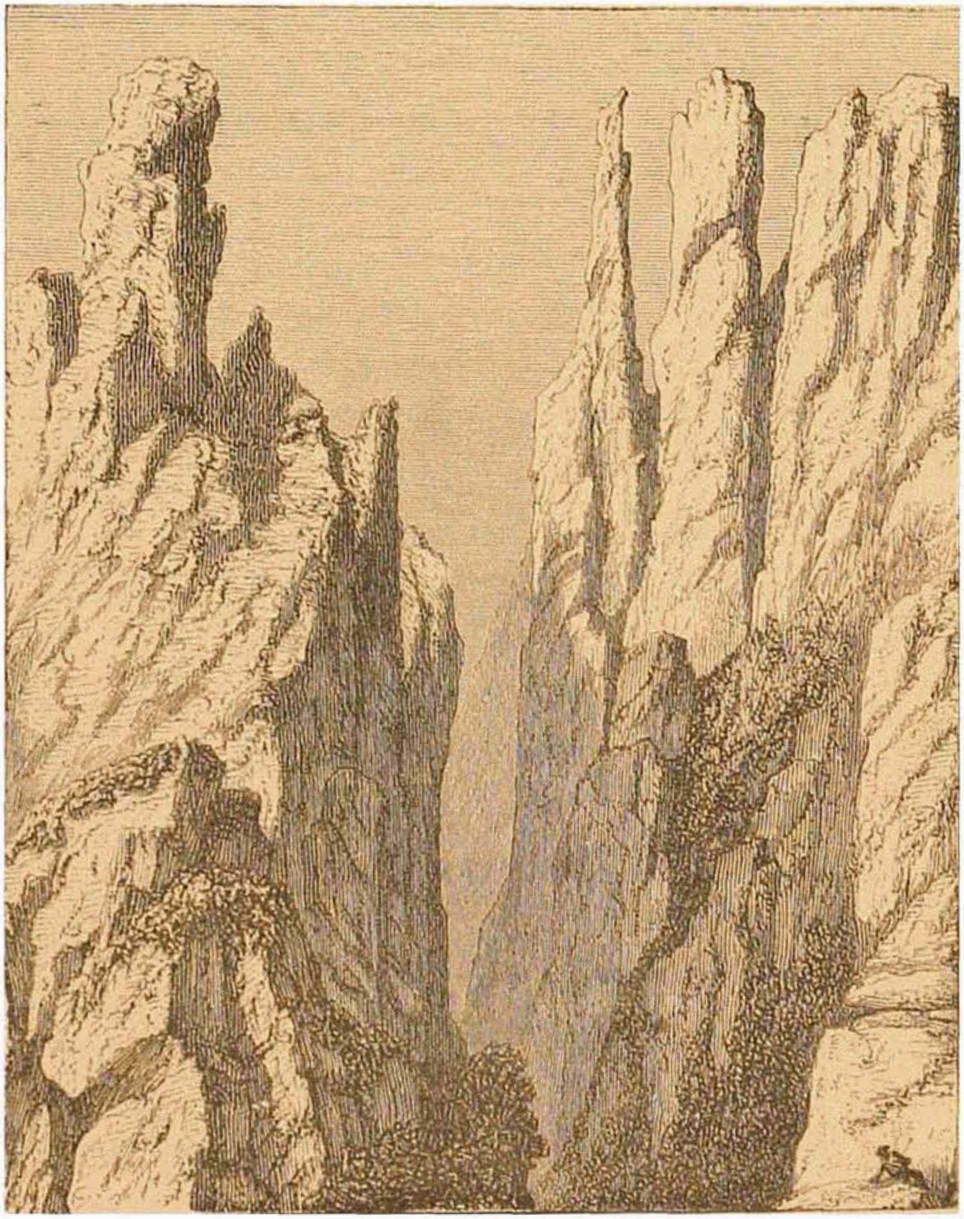

FIG. 77.—ROSSTRAPPE, A RAVINE IN THE HARZ MOUNTAINS.

planes, and resinous trees. The defile leading from Cilicia into Cappadocia has received the name of the "Gates of Cilicia." It is a strategetical point of the greatest importance. Xenophon, who traversed it, has left on record a description which very truly represents its actual condition and aspect. Such, at least, is the statement of M. Victor Langlois, who has recently explored the Taurus (Tersoos), and who adds that the Kulek is still rich in memorials of the march of the Crusaders. The natives point out to the curious traveller the tree at whose foot sat the leader of the army of the Cross, while his warriors defiled before him on their way to Antioch, and to the conquest of the Holy Land and the Sepulchre of Christ.

Ravines are formed by torrents hollowing out for themselves a channel in the mountain-side. These depressions are of great interest for the geologist, because they reveal sections of strata, and exhibit the character of the rocks composing the mountain-mass. The Pyrenees, the Alps, and especially the Andes, are furrowed in every direction by profound ravines. The loftier the mountains, the more considerable are these erosions. The Spaniards call the Andean ravines *quebradas* (or "fractures").

[The basins of great rivers are also spoken of as valleys: as the valley of the Ganges, the valley of the Rhine, the valley of the Thames. At some points, these valleys expand into plains; at others, they narrow into defiles. A remarkable example is offered by the Nile, which flows for leagues through wide, open, and level plains, to contract at Assouan between walls of savage cliff. In mountainous countries the river valleys exhibit every variety of wild and romantic scenery; in level countries they are more remarkable for fertility than grandeur or picturesqueness. Of the former, we may name as striking instances the valley of the Aar, in Switzerland; the valley of the Tay, in Scotland; the valley of the Danube, in Austria; the valley of the Indus, in Asia; of the St. Lawrence, in North America. Of the latter, the following examples will readily suggest themselves: the valley of the Thames, in England; that of the Loire, in France; that of the Meuse, in Holland; of the Po, in Italy; of the Mississippi and Ohio, in North America; of the Hoang-Ho, in China; and the Ganges, in India. In the latter the descent of the river to the plain is so gradual, that, notwithstanding its great length, it is only 1100 feet at Calcutta below the level of Saharampore, near the foot of the Himalaya. Hence, in the rainy season, Bengal lies under water for hundreds of miles in every direction, and its surface may not inaptly be compared to a slowly-moving sea.

All valleys might conveniently be classified under two great divisions: *Mountain-Valleys*, and *Valley-Plains*. To one or other of these generic classes every variety will be found to belong.]

CHAPTER VII.

ALTERATION AND DESTRUCTION OF THE ROCKS COMPOSING MOUNTAINS—CAUSES OF THE EROSION AND FALL OF MOUNTAINS.

WE cannot terminate our general study of the Mountains without speaking of the continual alterations undergone by the rocks composing them, and the avalanches, landslips, or partial falls, resulting from these alterations.

To the unreflecting observer it seems that rocks and mineral substances are absolutely indestructible; that they represent, so to speak, the very type of duration and stability.

But a very little attention will suffice to show that rocks are incessantly being destroyed, and that every mineral substance exposed to the air and the rain is, perforce, doomed to perish.

Air, by its humidity, by its carbonic acid and its oxygen, exercises upon the rocks exposed to its influence a truly extraordinary power of transformation. No rock can resist the atmospheric action: limestone and basalt, granite and porphyry, nothing is secure from the chemical operation of air and water. What poets and rhetoricians call "the hand of Time," is, in truth, this chemical agency exercised during a prolonged period. The alternations of heat and cold are powerful auxiliaries of the air in the work of destruction. Cold shatters into fragments, owing to the congelation of the water which has interpenetrated them, those stones which the atmospheric action will afterwards decompose; it is a mechanical division, preparatory to and facilitative of a chemical decomposition.*

We proceed to enumerate the most striking examples of these various transformations.

* When water has infiltrated itself into a rock, and afterwards begins to congeal, it expands—the inevitable result of its change of condition and expansion—and frequently breaks and splits up the rock.

The limestone procured from the tertiary strata, with which the houses of imperial Paris are built, undergoes a slow process of disintegration which gradually reduces it to dust. People vulgarly attribute this effect to the moon, and the popular saying runs, "The moon eats the stones." The hydraulic chemist Belidor, when he heard it repeated, made the consoling remark, that such actions being reciprocal, and the earth much larger than the moon, the former would certainly eat the larger quantity !

Marble statues exposed in the open air suffer in a singular manner from the atmospheric action.

Felspar and arkose, exposed to the air, decompose rapidly; they lose their silicate of potash, which is washed away by the rain on account of its solubility, and nothing but clay remains. Thus is formed, under our very eyes, the porcelain clay called *kaolin*.

It is for this reason that granite, composed of various silicates—as felspar, quartz, and mica—is far from becoming a guarantee for the durability of a building. The walls of the Church of Notre Dame at Limoges, built only four centuries ago, are already attacked to a depth of .275 to .314 of an inch. The Puy de Dôme, a trachytic rock, rests on a base of granite; when you approach it on the Clermont-Ferrand side, you would think you were walking on a deposit of gravel, so great has been the disintegration of the granite. In some granite quarries, where the rock has been exposed to the air, a superficial decomposition is visible, penetrating to six and seven feet in depth. It is the same cause which has given their rounded outline to certain blocks, or boulders (*boules*) of granite, which have been discovered in the Saxon Erzgebirge, and to the boulders of basalt so abundant in Auvergne, which exfoliate, and "shed" in succession the concentric layers of their crust.

Basalt thus affected is finally reduced to dust, and forms a soil of exceeding richness.

The sandstone of Fontainebleau becomes very soft, after a certain time, if subjected to atmospheric influence, and under the blow of a hammer crumbles into powder.

From these remarks the reader will understand that, in our own days and under our own eyes, the combined action of the water and the atmosphere, working upon the rocks which compose our mountain-masses, produces their avalanches and landslips; as disastrous some times, in their consequences, as the earthquake or the volcanic eruption.

Under other circumstances, dislodgments of the soil are effected by the waters of our rivers, which incessantly but silently eat into the banks and undermine them, and often produce the fall of great masses of rock. The English tourist may see remarkable examples of this fluviatile action in the valley of the Dove, in Derbyshire—in that of the Teign, in Devonshire—in that of the Esk, near Rosslyn and Hawthornden, in Edinburghshire. Localities not less interesting or curious will probably be known to every reader.

At other times, and in other places, the pluvial floods, infiltrating the ground and giving rise to subterraneous currents, carry away the foundations of the superficial strata of our hills and mountains. Two noteworthy instances of this cause and effect occur to us: the landslips of the chalky cliff of Cape de la Hève, near Havre; and the Undercliff, in the Isle of Wight.

[To every Englishman the latter district will be familiar, on account of its picturesque scenery and genial climate. In the whole circuit of the United Kingdom there is scarcely any place of equal area so distinguished by the wildness and varied beauty of its landscapes. It may roughly be described as a succession of terraces, descending to the sea from an elevation of 800 feet, overshadowed by a lofty wall of chalk, strewn with masses of detached rock, and loaded with a luxuriant vegetation. It is a scene of chaotic grandeur and sylvan loveliness: the cause, the subterranean action of land-springs on a layer of blue marl, which, gradually dissolving and gliding forward, brought down in wild confusion the strata superimposed upon it.]

Finally, at other times and in other places, by a fissure existing between the different superimposed rocks, a portion of a mountain is detached from the main mass, and, thus deprived of its support, is overthrown, or glides to the bottom of the slope.

In this way the mountains are being incessantly destroyed: the cold splits and divides the rocks, the air decomposes them, the water washes them and carries them away. It is a general process of levelling set in motion simply by the forces of nature. It will not be without interest if we furnish here an enumeration of the most remarkable catastrophes which have been produced by causes of this kind.

In 1767, the town of Newmarket was engulfed under the waters of the Adize, which had undermined the soil whereon it stood.

The town of Borge, in Norway, sunk, on the 5th of February 1702, into a subterraneous crevasse excavated by the torrent of the Glommen, which descends from the Dovrefeld mountains.

On the 25th of July 1825, about five o'clock in the evening, an awful burst of thunder resounded through the village of Barlis, in the late kingdom of Hanover (now a Prussian province). Suddenly a cloud of dust obscured the atmosphere, and the earth rolled with a great crash over an area of 130 feet in breadth, forming a deep profound chasm, whose depth may be estimated by the single fact that a pebble, it is said, was one minute in reaching the bottom.

In Ireland, numerous lakes have been created by the sinking of the peat-bogs. There, too, may be seen the extraordinary spectacle of subterranean forests; that is, of masses of trees abruptly sunk beneath the soil, but continuing to preserve their verdure on the tops of their leafy branches!

In Russia and Poland, too, many of the lakes have been formed by landslips. For an example it will be sufficient to name the lake of Arend, in the province of Brandenburg. According to Strabo, accidents of this kind frequently took place in the neighbourhood of the lake Copais, in Bœotia, which is now one great morass.*

In 1792, several houses in the town of Lons-le-Saunier disappeared, and a lake which suddenly made its appearance also swallowed up a portion of the road from Lyons to Strasbourg. The subterranean waters had undermined the soil, and it had sunk into the internal abyss.

On the 29th of January 1840, Mont Cernans, in the Jura, bodily descended into the plain which extends at its base, and a portion of the king's highway from Dijon to Pontarlier was swallowed up in a chasm 170 feet in depth, which simultaneously opened. This part of the road, known by the name of *la Rampe de Cernans*, was accordingly rendered impassable. The day following this convulsion, another mass of rock and earth was detached, which followed in the track of the

* [Colonel Mure describes it as a large yellow swamp, overgrown with sedge, reeds, and canes, through which the river Cephissus may be distinguished oozing its sluggish path for several miles.—*Tour in Greece*, i. 227.]

preceding. It is supposed that this catastrophe was due to a subterranean spring, which had dried up five-and-twenty years before, or rather had spread itself underground, where it had gradually eaten away the soil.

On the 25th of August 1618, the town of Pluno and that of Schilano, in the valley of Bregaglio, one of the fairest districts of Lombardy, were buried beneath the ruins of Mont Conto. The rocky formations of the mountain had been undermined by brooks and springs; they fell headlong upon the two unfortunate towns: 2430 persons perished; and the site of 200 houses was occupied by a lake.

In 1248, a portion of Mont Grenier, seven miles south of Chambéry, fell, and in its fall buried five parishes, comprising the town of Saint André. Mont Grenier belongs to the Jurassic formation (or Oxford clay). In the night of the 7th of December 1248, a part of this mountain detached itself from its base, and fell into the valley des Marches. The bottom of the valley, composed of a clayey subsoil, had been swept by prolonged and heavy rains. Under the enormous weight suddenly heaped upon it, it undulated and boiled like a purely liquid surface. In such wise that the plain, even to a distance very remote from the centre of convulsion, was covered with mamelons, or little mounds, intersected by ravines, which still exist.

The small town of St. André disappeared on the occasion of this frightful convulsion, as well as the hamlets, feudal castles, and numerous convents sprinkled over the country.

This gliding movement of the earths of the plain impelled by the fall of the mountain terminated in front of the Church of Our Lady of Myans, which acquired great celebrity through this reputed miracle. The Savoyards regarded as impious the suggestion that the elevation of the soil, at the point where the débris were arrested in their progress, might have proved of service in seconding the exertions of the Holy Virgin.

The devastated tract which was the theatre of this catastrophe bears to-day the name of the "Abyss of Myans" (*l'abîme de Myans*). It is almost wholly covered with vineyards, which flourish over the buried ruins of once prosperous villages.

At Adersbach, in Bohemia, a tract of seven square miles is covered with a labyrinth of blocks of sandstone, from 100 to 200 feet in height, the ruins of a shattered mountain.

The Swiss heights known as *Les Diablerets*, situated between the cantons of Berne and the Valais, had formerly four peaks. Perhaps, in the course of ages, they have lost several. On the 23rd of September 1713, one of the four remaining summits suddenly fell. It covered with its wreck an enormous extent of ground, and overwhelmed several hundred peasants' huts. The overthrow of a mass so enormous raised a thick dust, which for several hours completely darkened the air. In the middle of this terrible catastrophe, a shepherd of the village of Avon, in the Valais, disappeared; it was supposed he had perished, with too many others, on that day of gloom. Three months afterwards, on Christmas night, he returned to his native place, pale, emaciated, and covered with tatters. Immediately, a general consternation spread through the village; the door of every house was closed against him; the peasants sought for a priest to exorcise the stranger, whom they were unwilling to recognize. The supposed spectre succeeded at length in making himself known as flesh and blood, in calming their emotion, and obtaining a hearing for his story of adventure. At the moment of the catastrophe he was seated in a wooden hut; he threw himself on his knees, and engaged in prayer.

An enormous rock now fell down, leaning against the wall at whose foot his cabin was erected; thus it formed a rampart which protected the shepherd from the masses hurtling over his head. As soon as nature recovered its tranquillity, the poor man, buried alive among piles of earth and stone, set to work to free himself. He had saved from his dinner a morsel of cheese, and the water which filtered through the rocks heaped over his head, served to quench his thirst. At the end of some days—he knew not how many, for he could take no account of time—he was able to emerge from his gloomy prison, like Jonah from the whale's stomach. His eyes at first could not endure the daylight, and he only accustomed them to it by great precautions; but he lived many years after this strange event, a living witness of a miraculous Providence.

The traveller visiting the scene of the catastrophe sees all around him enormous rocks, shattered and cloven, which oppose an impassable barrier to the mountain-torrents. Sundry patches of pasturage remaining untouched, a few trunks of fir-trees half-drowned in the waters,—such are the sole memorials extant to-day of a formerly flourishing valley. A second landslip occurred in the same locality in 1749.

The Piz mountain, situated in the Trevisan territory, was corroded at its base by the waters which filtered through every fissure. In 1772, this mountain was cloven in twain; a portion was projected headlong on the plain beneath, burying three villages in its fall. The ruins stopped up the course of a streamlet, which quickly expanded into a lake. The remainder of the mountain shortly afterwards fell into this lake, which overflowed its borders, and ravaged the surrounding country with its floods.

In 1740, according to the "Mémoires de l'Académie de Stockholm," a storm of rain, which lasted eight hours, destroyed and swept away several eminences in the ancient province of Wenneland, on the frontiers of Norway. The Lidschure mountain split open and fell in; its débris were carried off by the waters.

Effects of this kind are sometimes observed in Savoy. One of the best known is that which occurred, in 1751, near Sallanches, on the Chamounix road.

The heavy snow-storms of the winter of 1751, mingling with the waters of infiltration which had long been undermining the mountain, a landslip took place, and 25,000,000 cubic yards of rock fell into the valley. An immense quantity of very fine dust, which did not clear away for three days, filled the air, and so exactly resembled smoke that it was everywhere reported that a volcano had broken forth in the midst of the Alps. The king of Piedmont immediately despatched to the place the eminent geologist Donati. He arrived in time to watch the progress of the landslip, which was accompanied by a terrible crashing sound.

Horace de Saussure has preserved the curious letter in which Donati succinctly described this remarkable occurrence.*

Landslips, or the fall of mountains, may be produced by the most singular

* De Saussure, "Voyages dans les Alpes," tome i., sect. 493.

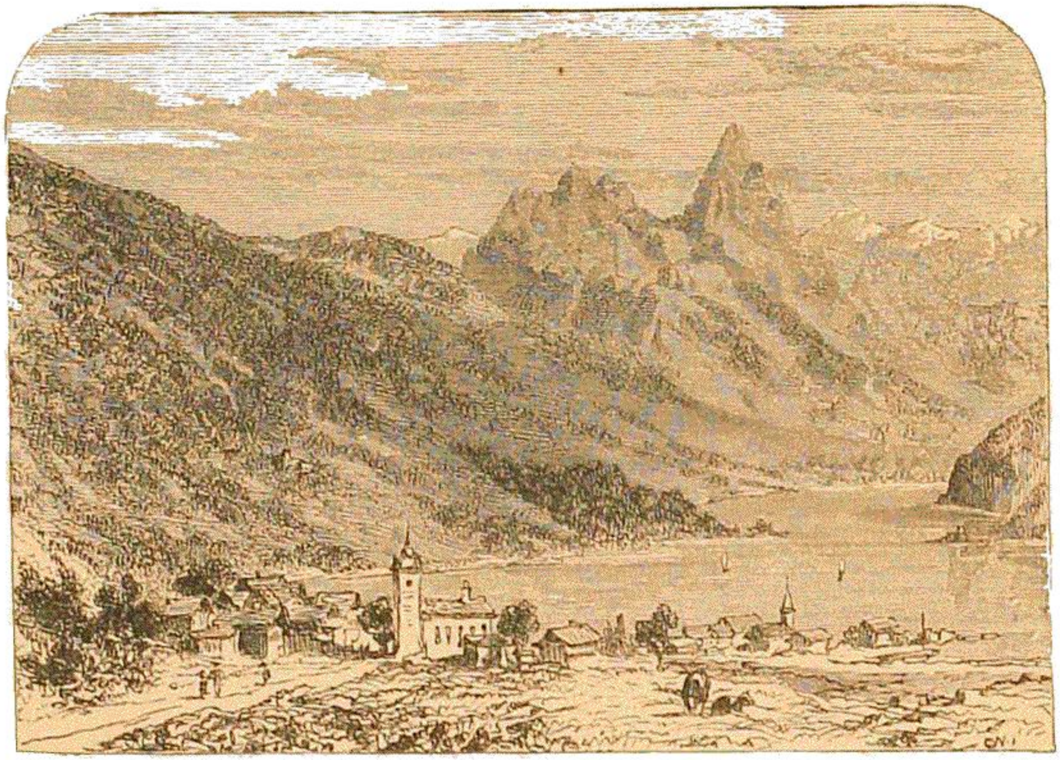

FIG. 78.—VALLEY OF GOLDAU BEFORE THE LANDSLIP.

causes ; by the simple sliding of a very extensive tract of earthy beds, which descend, without separating from one another, the mountain-side. The village of Pardines

FIG. 79.—LAKE OF LUCERNE.
(*Fluelen—Country of William Tell.*)

was built on a portion of Mont Perrier, situated near Issoire. From the 22nd to the 23rd of June 1737, the entire village glided to the foot of the mountain, dragging

FIG. 80.—VALLEY OF GOLDAU, AS IT APPEARED AFTER THE LANDSLIP OF 1806.

with it the farms, and trees, and pastures. A vineyard and a large house were transported the whole distance without being in the least affected by the motion.

Chroniclers relate that the town of Dordrecht, in Holland, was formerly removed some distance from its original site, along with the ground on which it stood. After the well-authenticated events already related, the reader will have no difficulty in crediting this fact.

About 1806, after storms of rain, the strata which cover the mountain of Solatré, near Maçon, began to glide over the beds of limestone composing its inner mass; they had already travelled some hundreds of yards, and were on the point of burying the village, when the rains ceased; with them the threatening phenomenon also paused, and the avalanche was arrested in its course.

A part of Mount Goïma, situated in the old territory of Venice, was detached in the course of a single night, descending softly along the slope of the mountain to the very bottom of the valley, with all the houses built upon it, and yet not one of them was overthrown! Their inhabitants were unaware of this extraordinary locomotion, and when they awoke, were surprised to find themselves at the mountain-foot. They thought themselves the sport of a supernatural power. But an examination of the locality soon explained to them the nature of the astounding journey which they had performed in their sleep.

But such incidents are usually attended with the most deplorable consequences. It will suffice to mention, as an example, the two catastrophes which, in 1795 and 1806, overwhelmed the villages of Waeggis and Goldau respectively.

The village of Waeggis stood on the border of the Lake of Lucerne, at the foot of the Righi. In the month of July 1795, at the close of a terrible tempest, a muddy torrent, or rather a river of mud, some three thousand feet in width, and several yards in depth, poured down from the mountain, inundated, and swept into the lake, a part of this unfortunate village. Happily the descent was not suddenly accomplished; it lasted fifteen days, and thus enabled the inhabitants to save their lives and property. At the Righi-Staffel, a memorial of this event is still visible in an enormous mass of rock placed horizontally on two others which are planted vertically, so as to form a kind of portico.

In the year 1806, when the rains, as we have already related, proved so fatal to Solatré, in France, a terrible catastrophe took place at Goldau. In the centre of Switzerland, and in the canton of Schwitz, are situated the lake of the same name, and another and a smaller lake, that of Lowerz.

Between their banks extends the fair valley of Goldau. On one side towers the Righi, famous among the Alpine heights for its picturesque outlines and its panorama of the sunrise, and 4500 feet above the level of the sea; on the other, Mont Ruffi, or Rosenberg, attains an elevation of 3700 feet. These mountains are composed of beds of sandstone pebbles and a fine-grained chalk.

On the 2nd of September, a portion of these conglomerated masses was loosened from Mont Ruffi.

Early in the morning the inhabitants of Goldau were alarmed by a frightful crash. Some hours later, the strata extending between the Spitzbuel and the Steinberger flue fell from off the mountain, and precipitated themselves, with a noise like thunder, into the valley, where their ruins accumulated in irregular heaps along the base of the Righi. These strata were nearly 4000 yards in their entire length, 100 feet high, and nearly 1000 feet in breadth. In five minutes, the valleys of Goldau and Busingen were covered with a mass of rocks 100 to 250 feet in height. The villages of Goldau, Busingen, Lowerz, Ober-Rother, and Unter-Rother, were completely buried under the débris of the mountain. Part of the Lake of Lowerz was filled up; its waters rose more than 70 feet, and devastated all the surrounding country as far as Seewen. Two churches, one hundred and eleven houses, two hundred and twenty barns and stables were crushed, together with four hundred and eighty-four inhabitants, under the gigantic wreck. A very small number escaped the disaster—only those who through some accident were at the time away from their dwellings; but they lost everything which they possessed in the world. The damage done was estimated at nearly £100,000. But who shall compute the amount of agony and regret which was the most terrible result of this astounding calamity!

In the midst of the stony solitude, now thinly clothed with grass and moss, and traversed by the great road from Arth to Schwytz, where formerly flourished busy villages, and arose the "hum of men," a chapel has been erected to preserve the memory of the landslip of 1806. Every year, on the 2nd of September, a commemorative religious service is celebrated within its walls.

CHAPTER VIII.

THE LOW LEVELS OF EARTH:—THE STEPPES, THE PLAINS, AND THE DESERTS.

WHEN the valley which intervenes between two opposite ranges of mountains is of great breadth, we call it *a Plain.*

Such valleys, forming plains of vast extent, are numerous enough in the Old Continent. In Europe, it is only necessary to recall to the reader's recollection those which occur in the north of France, in the Netherlands, in Northern Germany, and on the shores of the Baltic, and especially in the south of Russia. Their general characteristic is that of a vast inclined plane of undulating surface, sloping very gradually towards the north and south-east. In the west of Europe, the traveller often meets with wide tracts of uncultivated soil, clothed with heath, and stretching far beyond the range of human vision; such are the Landes, or Hernes, of which such remarkable examples are found in Westphalia, in the south of France, and, with some distinctive features, in the Highlands of Scotland.

[The Landes of Gascony are a strange, wild, and desolate-looking region; a waste of pine trees and fir trees, of white sand, and furze, and heather; intersected with stagnant ditches, and dotted with sombre pools. Its inhabitants are shepherds, who, mounted on stilts, stalk abroad over the shifting soil and the prickly bushes, driving their sheep or notching their trees in the wilderness. Their huts are of the most primitive construction, and their lives a constant reproach to those visionary theorists who would fain connect the happiness of man with the supposed joys of solitude. The landscape is not one, however, to stimulate thought or feed emotion; it possesses no romantic or sublime features; it seems a blending of earth and sky in one vast ocean of dreary misty verdure, on whose confines rests an eternal barrier of cloud.]

These low plains are the bottoms of very extensive and widely expanded valleys. Those of Boulogne and Saint Denis, and others in the neighbourhood of Paris, have had a similar origin. But other low plains there are which owe their formation to the alluvions thrown up by rivers at their embouchures; such are the deltas of the Rhone, the Po, the Nile, the Mississippi; such, too, the muddy swamps of Holland, and those which the Volga traverses on its way to the Caspian Sea.

The Spaniards designate by the name of *llanos*, the American

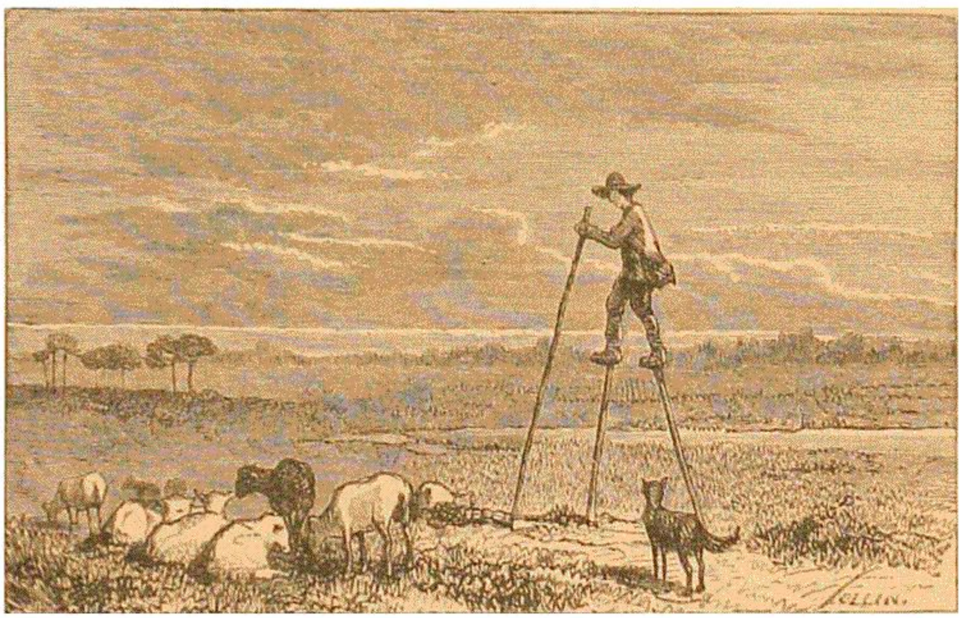

FIG. 81.—PEASANT OF THE LANDES.

Indians by the name of *prairies*, or *pampas*, and the Slaves by that of *steppes*, those immense plains which are more or less thickly clothed with grass. These words have, in fact, very nearly the same signification as *savannahs* or *landes*, but they preserve a local meaning, have certain distinctive features, and are employed as geographical designations.

THE STEPPES.

The steppes begin in Wallachia, and extend, with wearisome monotony, through the Russian provinces of Bessarabia and Kherson, beyond the Caspian Sea and Lake Aral, to the sources of the Amour and the desert of the Gobi, which the Mongolians call "the land of grasses." Between the Danube and the Don it consists of savannahs covered by a rich vegetation, supplying with abundant pasturage the numerous flocks of sheep and herds of horses which compose the personal wealth of the Cossack and the Tartar. Wide tracts, however, and especially in Lithuania, are still loaded with natural forests, where the wolf roams unchecked, and the stag finds a secure asylum from the hunter.

[Towards the eastern extremity of Europe the traveller approaches the Steppes * proper; they begin at the river Dnieper, extends along the shores of the Black Sea, occupy all the country north and east of the Caspian and of Independent Tartary, and stretch far away towards "the rising sun," to sink into the low levels of Siberia.

For hundreds of leagues you traverse a landscape which presents no striking change; a dead dull level of thin but profuse pasture; unrelieved by hill or wood, unfreshened by fountain, spring, or stream. In winter their monotony is even more apparent, for upon the entire area lies a deep shroud of snow, which the winds drive in showers of icy particles through the whistling air, while above the sky is cloudless, and the sun shines with an almost mocking brilliancy.

Not less fatal in its effects than the winter cold, which everywhere withers and smites to death the thin verdure, is the scorching heat of summer. The sun then rises and rests "like a globe of fire," drinking up every drop of moisture from the panting earth, which, for days and days, is unrelieved by any passing shower. The dust fills the air like a heavy mist, and the cattle perish in thousands. The plague of fire sweeps over the entire scene, and converts it into a charred and blackened waste.

It is evident that in such a country only the hardiest plants can thrive, but even these are wanting over the dreary region that lies along the shores of the Black and Caspian Seas. It is destitute of fresh water—well and brook and spring are all cursed with saltness. The very surface of the ground is covered with a saline efflorescence,

* [The word "steppe" is supposed to be of Tartar origin, and to mean "a level waste destitute of trees."]

like the hoar-frost that glitters on our English fields after a bleak windy night in March. Both the dew and the atmosphere are saline; the only signs of vegetable life are saline plants; the salt lakes yield considerable quantities of salt and nitre.

Turkistan, except where watered by the Oxus, the Jaxartes, and their affluents, is an ocean of moving, blinding sand; but to the north, between the river Ural and the highlands of Central Asia, Nature wears a somewhat fairer aspect. There the broad steppes of the Kirghiz are traversed by the restless Nomades and their countless

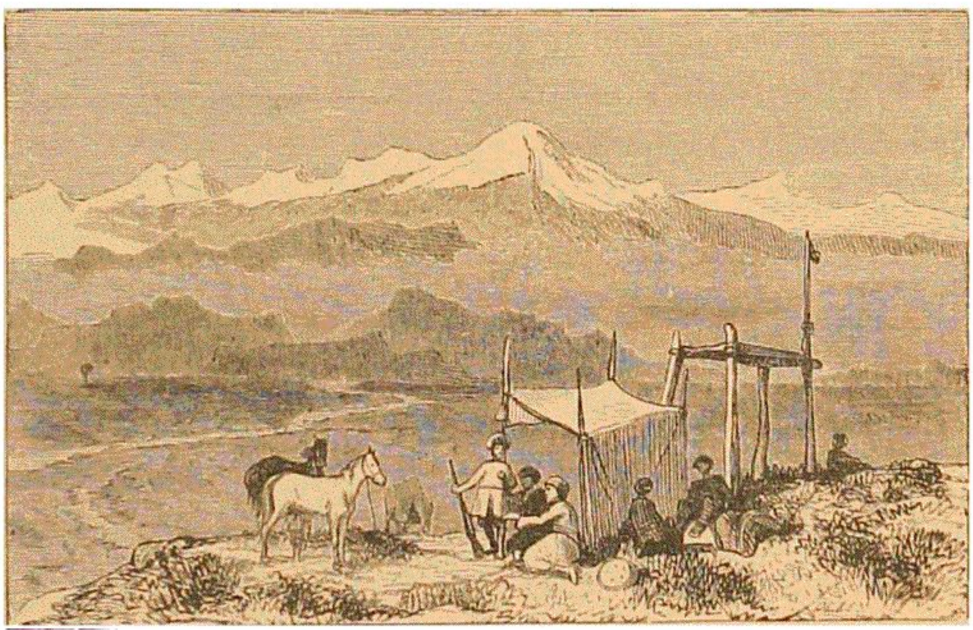

FIG. 82.—THE STEPPES OF THE CAUCASUS.

camels and cattle. To these a plentiful watercourse is a precious cynosure, which attracts every step, and from all directions their well-trodden tracks are seen converging towards it.]

The level country surrounding the Caspian, and scarcely elevated above its level, embraces a superficial area equal to about twice the extent of the British Islands.

The steppes of Russia extend westward into Hungary, where the vast grassy plains are called *puztas*. Poland and Lithuania are partly covered with a morass as large as France.

[To the north of Siberia (62° N.) extend the frozen deserts known as *Tundras;* where, says Admiral Wrangel, endless snows and ice-bound rocks bound the horizon, Nature lies shrouded in all but perpetual winter, life is an unending struggle with privation and with the terrors of cold and hunger . . . the very grave of Nature, the sepulchre of the primeval world, which occasionally reveals to the astonished gaze the forms of colossal animals long since extinct. Where the people, and even the snow, emit a constant smoke, and this evaporation is immediately changed into millions of icy needles, which make a noise in the air like the crackling of thick silk. Where the reindeer crowd together for the sake of the warmth derivable from such contiguity; and only the raven, the dark bird of winter, cleaves the sombre sky with slow-labouring wing, and marks the track of his solitary flight by a long line of thin vapour.

Often, the trunks of the thickest trees split asunder with a loud noise; masses of rock are loosened from their sites; the ground in the valley is rent with yawning fissures, from which the subterranean waters rise in a cloud of steam that immediately, on contact with the upper air, congeals into ice. Dense grows the atmosphere; the stars wane and flicker. All Nature sleeps a sleep that is most like death, and which is only interrupted in the summer by a short interval of spasmodic activity. Enough to say, that near Yakutsk the ground is perpetually frozen to the depth of more than 400 feet, of which, in the summer, only three feet are thawed.

In Southern Siberia, however, the coming of the summer is as magical in its effects as the transformation scene in a theatric spectacle. Almost as soon as the snow melts, the ground laughs with verdure, and with the bloom of flowers of many and dazzling hues.]

THE PAMPAS.

From the Old World we pass to the New.

The *Pampas* of South America are low grassy plains, shut in on the west by the terraces of the Cordilleras, but open towards the east and the south-east. They may, perhaps, be considered as ancient gulfs, which the sea would fill anew, if any extraordinary tide should have power to raise its waves to a height of some hundreds of yards. One vast green plain occupies all the southern extremity of this continent, over an area of nearly 30° of latitude.

Patagonia is a succession of horizontal platforms rising in stages to the base of the Andes, where winds the Rio Colorado. On the east it is, to use Mr. Darwin's expressive term, "a desert of shingle," diversified only by brackish streams, low spiny bushes, black masses of basalt, and glittering incrustations of salt. The temperature is subject to extreme variations, and tumultuous winds wither the arid soil.

To the north of the Rio Colorado begin the pampas of La Plata.

The red calcareous earth which composes their soil is almost destitute of water, and without tree or bush, except the indigenous ambú. The herbaceous vegetation, however, is very abundant, and renewed by heavy and continuous rains. The tufted grasses form an ocean of uniform verdure, unbroken by any "flowering isles," any picturesque oases, in the shape of broken and wooded hills.

West of Buenos Ayres the pampas* are clothed with rigid thistles of a peculiarly deep green, and with breadths of lucern not less vivid in hue, so long as the soil retains a degree of moisture. But at the beginning of the hot season the verdure fades; the thistles scatter abroad their seeds, and spring up to a height of ten or twelve feet, so as to intercept the wayfarer's view, and impede his steps with a rampart of impassable spines. Their stems are soon reduced to dust by the burning heat of summer, and the wind seizes upon it, and dissipates it afar.

During the long dry seasons of the pampas, the wild horses, tormented by an intolerable thirst, can only slake their parched lips and weary limbs in the brackish water of the brooklets, and they perish by hundreds. During the *Gran Chaco* (that is, "the great dryness"), which prevailed from 1827 to 1830, Buenos Ayres lost a million heads of cattle; a single farmer lost a herd of 20,000 oxen. Ex-

* [See Sir Edmund Head's "Ride across the Pampas," Sir Woodbine Parish's "Residence at Buenos Ayres," and Mr. M'Cann's "Argentine Provinces," for details respecting this remarkable region.]

FIG. 83.—A CONFLAGRATION IN THE PAMPAS.

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hausted with protracted thirst, the miserable animals plunged headlong into the Parana, and were drowned. Innumerable carcasses, putrid and swollen by the waters, descended to the estuary of the Plata.

Further to the west and north of Buenos Ayres spread hundreds of miles of beautiful meadows, whose long tufted exuberant grass furnish the flocks with inexhaustible pasture. The banks of the Parana present a series of extensive lawns, enriched with palms and a boundless, countless variety of tropical productions. To this succeeds a zone of swamp and marsh, lying at the very foot of the Andes; the immense lagoons bloom with aquatic plants, and, when swollen by the rains, frequently inundate the surrounding country.

If floods are the danger of the wet season, in the dry hot months of the year the pampas are liable to an even more frightful peril—the vast conflagrations which rush in flame and fire over scores of leagues, burning up every stem and branch and leaf, and swallowing up hundreds of horses and cattle.

The pampas of South America cover a most extensive superficies. They stretch far away into Upper Peru, where they form the Pampas del Sacramento. The *Punas* of Peru, where the vicũna grazes, and numerous troops of mules and asses feed, are of a very similar character.

M. Paul Marcoy, who has traversed the Pampa of Islay on his way to Arequipa, describes it in the following terms:—

"A journey across this desert is not unattended by danger. The sea-breezes which trouble its surface are incessantly renewing its aspect. From evening to morning large cavities are opened up, sand-hills erected, banks elevated, which afterwards fill up, fall over, sink, are dispersed, and again re-formed. To guide them in their march across this shifting soil, the peasants of the pampas consult the sun during the day, and during the night the stars."

THE SILVAS.

The region of forests which extends from the Cordillera of Chiquito to the mountains of Parima, including the entire basin of the Amazon, embraces a superficial area nine or ten times greater than that of the United Kingdom, more than six times the size of France. Its northern boundary, roughly speaking, is the 7th parallel of north latitude; its southern, the 18th parallel of south latitude. It is, therefore, an inter-tropical realm of luxuriant vegetation; the very storehouse and treasury of prodigal Nature.*

[In the Virgin Forest of the Amazons the soil, fattened for untold

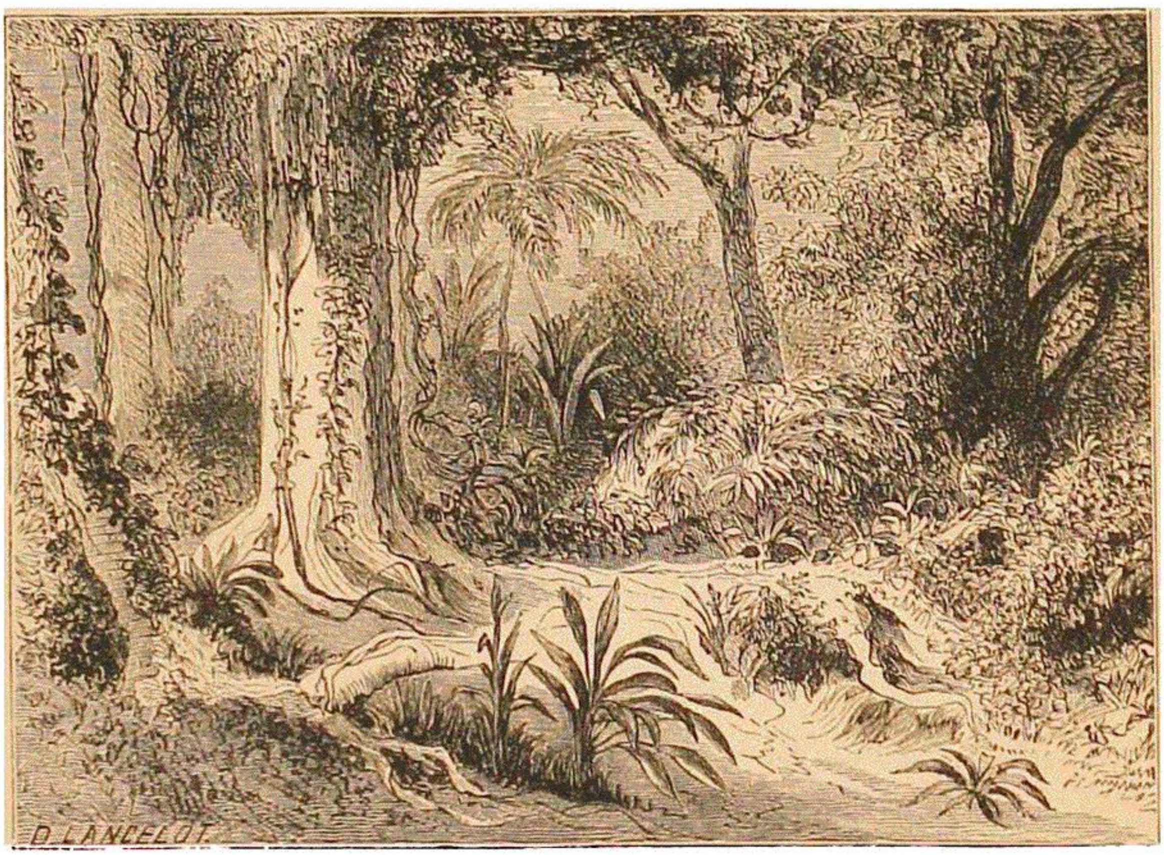


FIG. 84.—THE VIRGIN FOREST.

ages by the ruin and débris of an inexhaustible vegetation, consists of the richest mould. The trees grow to an enormous stature, frequently to 120 and 150 feet, and their girth is of equally colossal proportions. Immense ferns and brilliant orchids clothe their feet, and from bough to bough creep the rarest and most beautiful lianas,—the whole forming an almost impassable maze of creeping and climbing plants, of

* [Of late years our knowledge of this wonderful country has been largely increased by the researches of Wallace; H. W. Bates ("A Naturalist on the River Amazons"); Captain Burton ("The Highlands of the Brazils," 1869); and Agassiz ("Brazil," published by Trübner and Co., 1860).]

leaf and blossom. In the thicker depths the heat is necessarily suffocating, for the wind never makes its way through the dense overhanging canopy of foliage; and after the periodical rains, so excessive is the damp, that a blue mist rises among the huge stems of the trees, and floats suspended like a mountain cloud.

The silence that prevails in the leafy wilderness during the day is like that of the grave, but at sunset all the voices of nature seem to awake together, and bird and beast join in a farewell chorus to the departing luminary. The night is not less tranquil than the day, until the appearance of the dawn again moves the whole animal life with one common impulse. Occasionally, indeed, some nocturnal prowler will create a sudden alarm, which spreads from bough to bough and tree to tree, till all the forest rings with the discordant uproar. More dreadful is the din when the storm-wind roars abroad. Then the tops of the trees sway in the scathing, rushing blast; the darkness of midnight descends upon the scene; the brooks, swollen by the rains, crash and hurtle through the resounding glades; the vivid glare of the lightning reveals the rush of terrified animals, pouring in headlong flight through the grassy avenues, and agitated with renewed panic at every successive thunder peal.

But beautiful is the forest on a summer morning, when the warm light kindles every hue of the gorgeous blossoms, and every changing, shifting shade of the luxuriant leaves. The landscape, then, is one of indescribable charm. Strange forms of vegetation everywhere meet the traveller's eye, and around and about him flutter birds of the rarest plumage, and every blade of grass teems with insect-life of the most marvellous design. If it is on the Alps, the Andes, and the Himalaya that Nature displays her majesty; if it is in the wild, white wastes of the Polar zones that she exhibits her sublimest gloom; if it is in the Tundra and the Desert that she reveals her spirit of desolation and weariness; it is here—in the virgin forest, whose recesses are still unexplored by man—that she makes manifest her abounding and amazing wealth!

THE LLANOS.

The third region of the South American plains is that of the Llanos, which occupy 153,000 square miles between the deltas of the Orinoco and the river Coqueta: a sea of grass, unrelieved by mountain billow, and level as the flats of Essex or Lincolnshire. It is possible, we are told, to travel over these flat plains for 1000 miles from the delta of the Orinoco to the foot of the Andes of Pasto; frequently there is not an eminence a foot high in 270 square miles. They are twice as long as they are broad; and as the wind blows constantly from the east, the climate is the more ardent the farther west. The steppes, for the most part, are destitute of trees or bushes, yet in some places they are dotted with the Mauritia and other palms. Flat as these plains are, in some places two kinds of inequalities occur: one consisting of banks or shoals of grit or compact limestone, five or six feet high, perfectly level for several leagues, and imperceptible except on their edges; the other inequality can only be detected by the barometer or levelling instruments—it is called a *Mesa*, and forms an eminence rising imperceptibly to the height of some few yards. Small as the elevation is, a *mesa* forms the watershed from S.W. to N.E., between the affluents of the Orinoco and the streams flowing to the northern coast of Terra Firma. In the wet season, from April to the end of October, the tropical rains pour down in torrents, and hundreds of square miles of the llanos are inundated by the floods of the rivers. The water sometimes lies twelve feet deep in the hollows; and here so many horses and other animals perish that the ground smells of musk, an odour peculiar to several South American quadrupeds.

The mean annual temperature of the llanos is about 84° Fahrenheit; the heat is greatest during the rainy season.

THE PRAIRIES.

The immense plains of North America, lying between the Rocky Mountains, west, and the range of the Alleghany, east, and stretching northward to the frozen shore of the Polar Sea, southward to the

Gulf of Mexico, includes the basins of the Mississippi, St. Lawrence, Nelson, Churchill, Missouri, and Mackenzie rivers, and occupy a total area of 3,245,000 miles. They embrace, therefore, every variety of scenery, from the exuberance of the tropics to the sterility of the Arctic world. They expand as they proceed northward, and though nowhere so monotonously flat as the South American llanos, present no considerable elevation; the only rising ground of importance being the watershed, which throws off, on the one side, the affluents of the Mississippi, and, on the other, the tributaries of the Arctic Ocean. This watershed averages 750 feet in height, but occasionally reaches 1500 feet.

The general characteristics of this region may be rapidly summed up: a sandy desert at the base of the Rocky Mountains as high as 41° N. lat.; bare, treeless steppes in the greater part of Texas and Arkansas; a deltoid region of rank vegetation, covering 35,000 square miles, at the mouth of the Mississippi; east of that great river a magnificent undulating country, which forms the staple wealth of the American republic; gloomy pine-barriers, or vast tracts of sand covered with forests of gigantic pine-trees in Alabama and Florida; glorious woodlands, rich in azaleas, rhododendrons, tulip trees, hickory, plane, and maple, in Tennessee and Kentucky; acres of forest and fertile soil in Canada, and along the Saskatchewan and Columbia; and, finally, westward of the Mississippi, leagues upon leagues of rolling savannahs, which, covered with long rank grass and flowers of the liliaceous tribe—refreshed by numerous streams—enriched with vigorous and beautiful shrubs—occasionally shaded by groups of oak and black walnut, magnolia, tulip and cotton-trees—and traversed by immense herds of wild horses, bisons, and deer—have become famous throughout the civilized world under the name of *the Prairies*,* and as a scene of wild romance, of daring adventure, and profitable enterprise.]

* [The word is of French origin, and identical with *pré*, a meadow.—See, for fuller particulars, Lewis and Clark's "U. S. Exploring Expedition;" Colonel Fremont's "*Expedition to Oregon*;" Lord Milton and Dr. Cheadle's "North-West Passage by Land;" and Hepworth Dixon's "New America."]

CHAPTER IX.

THE PLAINS, STEPPES, AND DESERTS, CONTINUED :—DESERTS OF AFRICA AND ASIA.

WE have now to speak of the great deserts of Africa and Asia.

From the western boundary of Africa to the eastern coast of Asia stretches an immense belt of barren lowlands. To the great African deserts succeed those of Arabia Petræa, which are only separated from the former by the Red Sea and the rich Egyptian valley. Next follow the deserts of Persia, of Kandahar, of Bokhara, and, finally, that of Mongolia, generally known as the Great Desert of Gobi. The total length of this desert zone, sparsely sprinkled with oases, is estimated at 9320 miles (including Egypt). It stretches almost from Morocco to Mongolia, and therefore equals one-third of the entire circumference of the globe.

It is very probable that the aridity of these deserts results from their situation, which exposes them, for a great part of the year, to the breath of the north-east winds. In truth, those great aerial currents which sweep the earth in the direction of N.E. to S.W., and which return from the equator to the pole in the form of upper currents, find, throughout their entire circuit, no other liquid expanse than the Mediterranean, whose surface is too limited to humectate such enormous masses of air. Accordingly, the terrestrial zone traversed by these winds must receive much less moisture than the countries visited by the ocean-breezes; and this cause will explain, at least in part, the exceptionally dry climate and the sterility of the deserts of Africa and Eastern Asia.

The *Sahara*, or Great African Desert, is now well known to geographers through the explorations of recent travellers, and since the conquest of Algeria by the French. This vast plain, whose superficies has been valued by Humboldt at upwards of 6,000,000,000 square yards—and, more accurately, by other geographers, at about 760,000 square miles, including its oases—is subdivided into several basins. As these distinctions have been established after the names of the nomadic tribes inhabiting the different regions of the Sahara, they appear somewhat uncertain, and we shall refrain from adopting

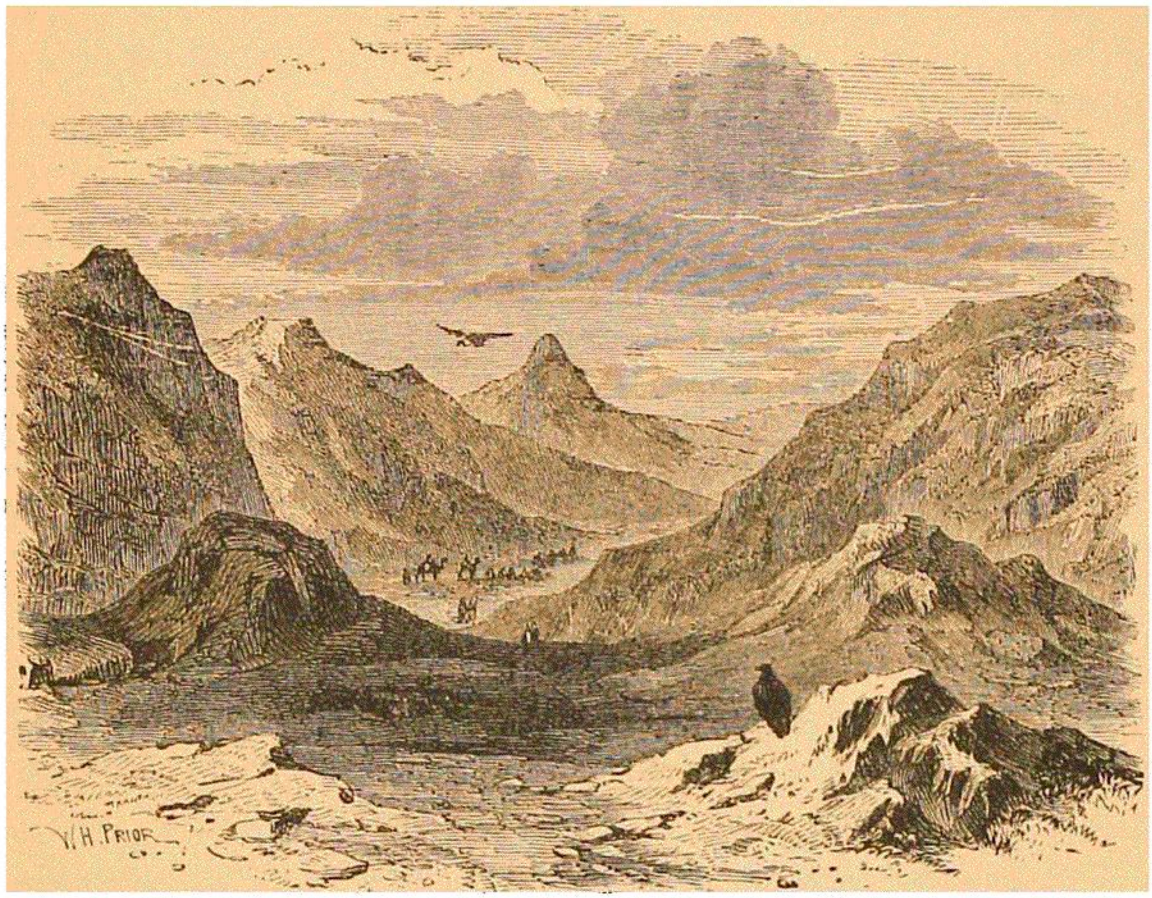


FIG. 85.—A GORGE IN THE DESERT.

them. The eastern district of the Sahara, lying beyond Fezzan, is called the *Libyan Desert*.

The level of the Sahara is very irregular: owing to this circumstance the mean altitude attributed to it varies, according to the different authorities, from 150 up to 1300 feet. Fournel represents the elevation of the interior at about 480 feet. In the vicinity of Biskra it does not exceed 200 to 220 feet; while, in the north, several tracks occur whose level is actually below that of the Mediterranean.

The soil of the Sahara is singularly broken up. For centuries this great desert was pictured as one immense sandy plain, whose uniformity was scarcely relieved by some slight undulations of the surface. Such is not the case. The central desert rises in a succession of terraces. It is a broken or indented table-land, interspersed with hills, and even more or less elevated mountains. Dr. Barth records that, in his travels, he met with mountains 5000 feet in height; their flanks ploughed by wild and precipitous ravines, bare of all vegetation, and generally composed of black, gloomy rocks. Hills, or dunes, of indurated sand bristle against the horizon with sharp ridges and pyramidal summits. As these are of fixed position, and perfectly stable, they serve as points of reconnoitring, and as landmarks to indicate the traveller's road. The soil of the Sahara, alternately stony or sandy, only merges into immense plains at its two extremities, on the east and on the west.

Among the rocks which are here and there exposed may be distinguished the *primitive* (granite, gneiss, and syenite); *eruptive* (trachyte, dolomite, basalt, and lavas); rocks of transition, and the metamorphic; and, finally, the sandstones and shelly limestone.

Upon the geological character of the Sahara we can put forward no positive opinion, on account of its immense extent and the deficiency of scientific exploration.

An eminent geographer, M. Marcou, in his "Carte Géologique de la Terre," leaves this whole extent a blank, with the exception of one of the central districts of the Sahara, which he refers to the primitive formation.

It is probable that there, as in Europe, the nature of the crust varies considerably, and that different regions belong to different geological formations.

On the north, in the districts bordering upon Algeria, the Sahara, from the observations of Messrs. Laurent and Degousée, appears to be a quaternary formation, and to exhibit traces of the *diluvium*, for rolled pebbles are abundant; the same formation also crops up in districts lying more to the south. Nevertheless, the presence of the transition saliferous earths may not be doubted, for rock salt occurs profusely in the shallower soils of many parts of the African desert. The working of the salt-beds is the staple of an active commerce between the deserts of the Sahara and those of the Soudan. In the southern belt of the wilderness the beds of rock salt are so thick that the natives use it for materials for constructing their houses. The region of the *natron lakes*, in Lower Egypt, and the oasis of Siwah, are equally celebrated in this respect.

In the northern Sahara, on the confines of the Atlas, various geological peculiarities tend to prove that it was anciently overflowed by a sea, which has been dispersed by a comparatively recent movement of elevation. The clayey and gypseous soil, the presence of sea salt and salts of magnesia, the abundant remains of shells of molluscs, whose congeners are now living in the Mediterranean—such, for instance, as the *cardium edule*—all demonstrate that the northern Sahara is the bed of an ancient sea, which, at one time, was part and parcel of the Mediterranean.

In the desert occur some considerable hollows, or depressions, which are filled with water some months in the year; these periodical lakes lie in the northern Sahara, and the Arabs designate them *Shotts.**

The shifting sands which cover a great portion of the Sahara attain, in some places, to such a degree of thickness that no bottom has been found at 300 feet.

But how are these sands formed? How is the soil reduced into atoms not less minute than those which cover our sea-shores? To these questions different answers have been given.

It is probable that these masses of sand are the result of the spontaneous disintegration of the superficial rocks, and especially of the quartzose rocks. The soil is divided, under the action of the burning sun, into particles which become finer and yet finer, and the

* [See Rev. H. B. Tristram's "Great Sahara;" M. Charles Martins, "De Spitzberg au Sahara;" and General E. Daumas, "Le Grand Désert."]

winds which beat upon them help to reduce them eventually into dust. This very phenomenon is now being repeated in Upper Egypt. There, at the foot of the sandstone hills, the accumulating grains of quartz are built up into dunes, which sometimes rise to a sufficient height to mask completely the other hills. Only here and there a few points of harder and more stable rock may be seen, which have resisted decomposition, and emerge like islands from the sea of sand, formed, so to speak, under our very eyes.

FIG. 86.—DESERT OF THE SAHARA.

The winds and hurricanes which rage unchecked over the immense surface of the desert, transport to great distances veritable mountains of sand and dust, and pile them up to a prodigious elevation. One of these heights, formed by the action of the winds on masses of sand brought from other points of the wilderness, extends from Morocco as far as Tunis; it bears the name of the *Arègue*.

Every day we hear the Great African Desert compared to a Sea of Sand, and in many respects the poetical analogy is strikingly justified. The wind creates vast powdery billows, which surge, and roll, and sink, like the waves of ocean. This fine mineral dust is, indeed, as mobile as any liquid; it responds to the least breath of air.

The sea and the Sahara may be compared with one another in their apparently boundless immensity, in their solitude and silence—a solitude and silence only disturbed by the tempests which occasionally sweep across their surface.

The Sahara, like the Ocean, has its isles of verdure, its reefs, its

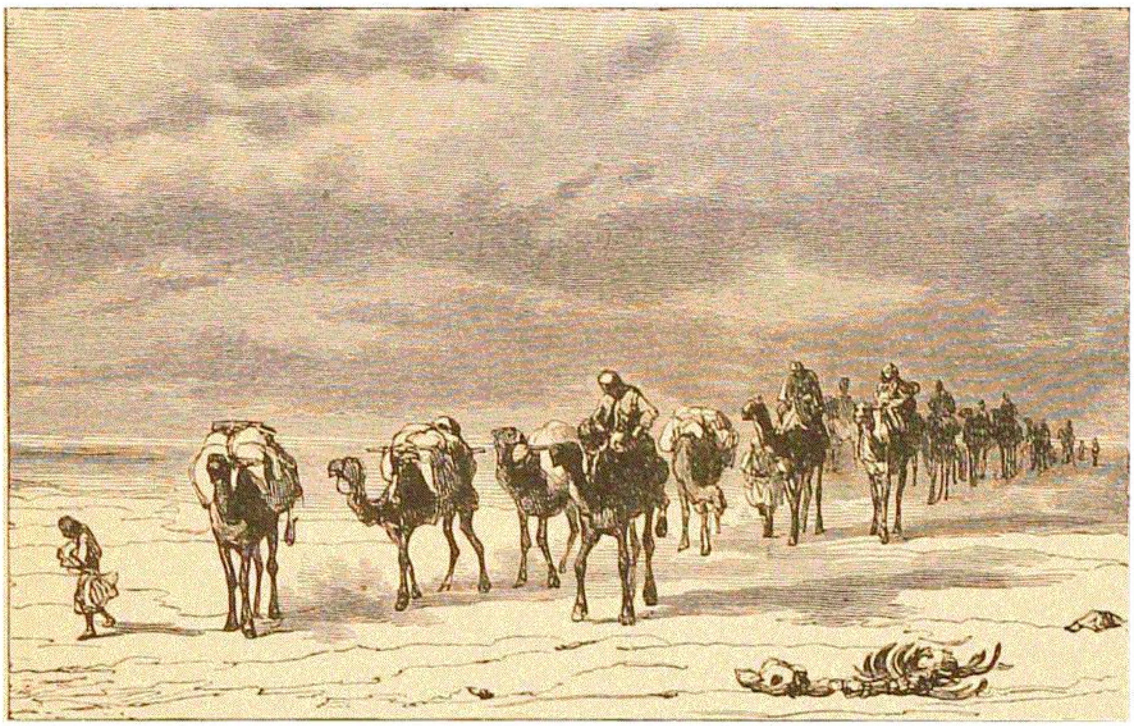


FIG. 87.—THE CARAVAN IN THE DESERT:—THE COMING STORM.

shores, on which it is always encroaching. Seen by the moon's pale lustre, in the stillness of night, the undulating masses of sand, which by day present a brown shadow or a dazzling whiteness, seem to give forth strange phosphorescent gleams, like the waters of the Equatorial ocean.

The modern Arab, and the ancient Eastern legends, term the camel "the ship of the Desert." Perched on this patient and docile animal's back, the traveller, like the mariner in the open sea, has no other means of guiding his course than the compass and the stars.

Finally, the Sahara has its pilots, its corsairs, and even its wrecks, like that liquid desert which we call the Ocean.

At all epochs the Sahara has been traversed by numerous caravans, trafficking with the tribes encamped upon its confines. These grand convoys of men and camels often number a thousand heads. Nothing can be imagined more picturesque than the long line of wayfarers defiling across the immense plain, or than the camp improvised by the caravan at its halting-places, which are generally chosen

FIG. 83.—A SCENE IN THE SAHARA:—THE FLIGHT OF VULTURES.

near some brackish well, under the shade of a few palms, or—happiness incredible! —on the bank of a flowing stream.

Except for chance encounters with other caravans, they march sometimes for whole days without seeing a single being, or even a tree, or blade of grass, or the least trace of organic life. All around, as far as his wistful glance can reach, the *traveller discovers sand—sand—or barren rocks.* The deadly silence which weighs upon nature, weighs, too, upon his spirit, like the nightmare of solitude; it inspires him with the gloomiest forebodings, which, moreover, are too often justified by the event. The burning sun of the Tropics, which deluges with his fires this denudated soil, warms the atmosphere to an incredible intensity. Under the influence of an incessant radiation, the rock and the sand acquire a temperature of 70° C. (158° F.); and then they blister the wayfarer's feet, at the same time that the reverberation of the sun heats the air up to 50° C. (122° F.), and even beyond.

The dry air of the atmosphere is nearly always filled with a reddish fog, which produces on the horizon the effect of volcanic fires. In the morning the sun rises abruptly without twilight, like a glowing orb of flame. As he mounts higher in the heavens, and darts his rays direct upon the inflamed soil, the air, growing thoroughly heated, begins to vibrate so strongly that every object on the horizon seems agitated by incessant tremblings. This is the effect of the irregular refractions and reflections of the luminous rays which traverse the unequally warmed strata of the air.

Another phenomenon, whose cause must likewise be referred to anomalous atmospheric refractions, is the *Mirage*, or, as it is called by the Arabs, the "Lake of the Gazelles" (*Bahr-el-Gazal*).

Many voyagers have left on record their more or less marvellous descriptions of this optical delusion. They assert that in the heart of the desert they have seen laughing landscapes, verdurous islands, rivers flowing between fertile banks, the spires and domes of apparently opulent towns, and a crowd of other objects which an excited imagination painted for them in the picture unrolled on the distant horizon. Sometimes, say they, the caravans imagine they can discover afar a sheet of glittering water mirroring clumps of graceful palms, and groups of drinking camels. The prospect sustains the courage of the exhausted travellers; they make a last effort to reach the oasis which invites them to repose. But the further they advance, the quicker recedes the deceptive image. Too frequently the inexperienced traveller, exhausting his energies in the vain pursuit of an illusion, misses the track, and perishes of fatigue.

Such are the stories which we find in the works of too many travellers, both ancient and modern. But put aside the exaggeration, not unnatural in the disposition of mind of a traveller, spent with fatigue, tormented by thirst, and blinded by the gleam of the burning sand everywhere around him, and we shall see to what moderate limits must really be reduced the mirage as it is seen in the Desert.

In the first place, for an object to be rendered visible by the mirage, it is necessary that it should actually exist and be within range of sight—that is to say, at such a distance that refraction may weaken the image until it becomes scarcely recognizable.

Thus, all the effects of the mirage are more or less disfigured reproductions of some natural object near at hand, and most often of the celestial vault itself.

In the latter case, the atmospheric strata, unevenly warmed and lying near the soil, which reflect the tint of the sky, resemble in themselves a liquid expanse. Nevertheless, the outlines of the "Lake of the Gazelles" are, in general, far less distinct, far less sharply defined than would be those of an actual sheet of water; moreover, these outlines of the aerial mirror nearly always possess a certain mobility, produced by the tremulousness of the heated atmosphere. When the reflecting expanse appears isolated on a plain of sand, it produces, as we have said, the effect of a distant lake. But sometimes the phenomenon of a mirage occurs near the horizon, the sheet of water only touching the lower limit of the sky at a few points, in such wise that when the spectator stoops and again stands upright, the boundaries of the sky and of his reflected image first mingle and then abruptly separate. The points where contact has *not* taken place next appear as dark spots, whose forms, more or less fantastic, originate all kinds of illusions. To one person they seem like

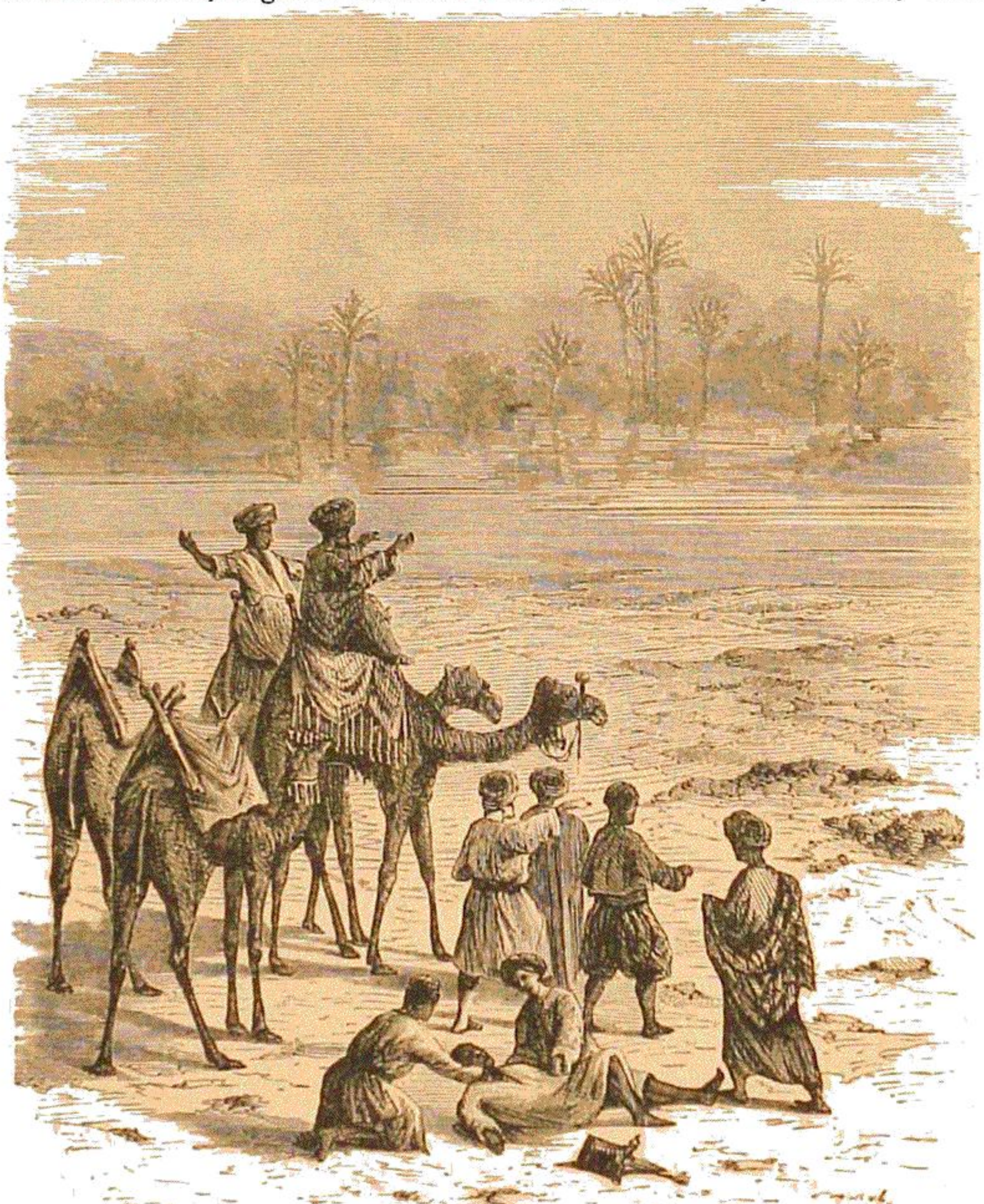


FIG. 89.—THE MIRAGE OF THE DESERT.

rocks, to another like trees—like islands, camels, ships at anchor—in fact, whatever figure an excited imagination may suggest.

To resume: the effects of the mirage can only be produced by real objects; and only when these real objects are within a moderate distance from the spectator. Sometimes a reflection of the sky is simultaneously visible; and the traveller fancies he sees, for example, a caravan wading through the water, and mirrored in the liquid surface.

Let us add that the production of this curious phenomenon is favoured by the existence of cavities, or depressions of the soil, which permit the rays of light to describe a very bold arc before they reach the spectator's eye.

Towards the equinoxes, the storms of the Desert assume a terrible character. Everybody has heard tell of that awful word, the Simoun,* and can recall to mind the statements recorded by travellers of its deleterious effects.

This formidable wind blows also in Egypt, where it is called *Khamsin* ("fifty"), because it prevails during a period of fifty days; that is, from the end of April to the middle of June. On the western border of the Sahara, in Senegambia, it is called *harmattan*. It is also identified, though not altogether satisfactorily, with the *Sirocco* of Italy, the *Solano* of Spain, and the *Foehn* of Switzerland.

The approach of the simoun is announced, in the Desert, by a black point—the "small black cloud"—which rises on the horizon, and which rapidly enlarges. A gloomy veil overspreads the sky; the sun, shorn of its beams, assumes a violet tint. Thick whirlwinds of dust rise in the air, which loses all its transparency, just as the pulverulent matters ejected by Vesuvius obscured the atmosphere when they buried beneath their accumulations the cities of Herculaneum and Pompeii.

If a caravan be surprised by the simoun, they make haste to arrange the camels in a ring, their heads turned towards the centre, and the travellers take shelter in the midst of their beasts, covering their faces, that they may not breathe the burning air. Sometimes they find an asylum in a well, if one lies within easy reach. But, despite these precautions, many of the sufferers perish, suffocated by the burning dust with which the atmosphere is loaded.

It was the terrible simoun which destroyed, according to the historians, the entire army of the Persian king Cambyses, when he rashly directed its advance into the open desert. In 1855 the simoun, it is said, destroyed, and buried in the sands, an entire caravan, composed of two thousand persons and of eighteen camels. More than once the Algerian generals, and, among others, General Desvaux,

* From an Arabic word signifying "poison."

have had serious alarms respecting the fate of their soldiers compelled to penetrate into the Desert, and surprised on their march by this terrible wind.

The impalpable dust which drifts through the air in dense clouds penetrates into the nostrils, the eyes, the mouth, and the lungs, and induces asphyxia. When this fatal result is happily avoided, the rapid evaporation which takes place on the surface of the body dries up the skin, inflames the throat, quickens the breathing, and causes a burning thirst. The terrible breath of the simoun dries up, in its course, the sap of the trees, and, by the rapid evaporation which it produces, the water-bags of the camel-drivers. The caravan then becomes the prey of an inextinguishable thirst which fires the blood. It is thus that more than one caravan, since the expedition of Cambyses, has perished in these same dreary solitudes. Hence the routes customarily travelled by the caravans are marked by the skeletons of men and animals, whitened by time and the sun; these are the ominous landmarks of the fatal highway!

Nevertheless, we must include among popular scientific fables the stories of pestiferous winds, whose very contact will cause death. The fatal effects of the simoun are easily explicable by the excessive heat which accompanies it, and by the fine powdery dust with which it loads the air. The traveller Burckhardt was the first to furnish us with positive details in relation to the winds of the desert; and he proved the falsehood of the fantastic narratives which the Bedouins love to impose upon credulous travellers to secure a larger recompense for their services.

"In June 1813," says Mr. Burckhardt, "I was surprised by the simoun on my route from Siout to Esneh. When the wind rose I was alone, mounted on a dromedary, far from every tree and every habitation. I hastened to protect my face by wrapping it in a handkerchief. Meanwhile, the dromedary, into whose eyes the wind forced the dust, became restless, begun to gallop, and made me lose the reins. I remained seated on the ground, never stirring from my place, for I could not see more than thirty feet beyond me, and wrapped myself in my clothes until the wind abated. Then I went in search of my dromedary, which I found at a considerable distance off, lying under a bush, which protected his head from the sand carried by the wind."

Other travellers who have traversed the Persian and African deserts agree with Burckhardt on this point; namely, that the simoun is only fatal through a concurrence of unfortunate circumstances.

Sometimes, too, one sees the sand-spouts rise, revolving upon their axis, moving forward at unequal rates of speed, and overthrowing every obstacle which lies in their path. Impelled by the winds, they invade the shores and islands of the vast waterless sea of the desert. In Egypt, whole cities have been buried under billows of dust ; and modern researches have revealed the existence of well-preserved monuments under the beds of sand which to-day fill up certain valleys that were formerly inhabited.*

Rain is known only in the mountainous regions of the Desert. There the heights arrest the clouds suspended in the atmosphere. From the month of July to that of November, incessant torrents, it is true, inundate the high grounds ; but the wild waters quickly disappear without descending to the plain ; they lose themselves in the arid sand, or are rapidly evaporated by the sun's fiery rays.

For this reason, water-courses are of rare occurrence in the Desert. From the southern slope of the Atlas, some few streams find their way into the plain, but they are dried up in the hot season. The same is the case with the small rivers which feed the lakes of the great Oasis lying south of Algeria ; these lakes, too, are almost dry during the summer. The western border of the Sahara is watered by the river Ouêd-Draa, which descends from the Atlas chain in Morocco ; and by the Sagniel, which comes from the south. Both are reputed to be of considerable length, but they disappear during the great heats, and very little of their course is accurately known.

The rains absorbed by the desert sands very probably accumulate underground in immense tracts of water, at no considerable depth. This circumstance is well known to the Arabs, who, from time immemorial, have availed themselves of these subterraneous waters by digging a species of Artesian well. For them, the Sahara is an island which floats upon a subterranean sea (*bahar toht el erd*). When they are in want of water, they bore through the sand until they arrive at the aqueous strata.

On this subject, we may quote the remarks of the traveller Shaw :—

"The Wady-Reag is a cluster of villages situated far in advance in the Sahara. . . . These villages have neither springs nor fountains.

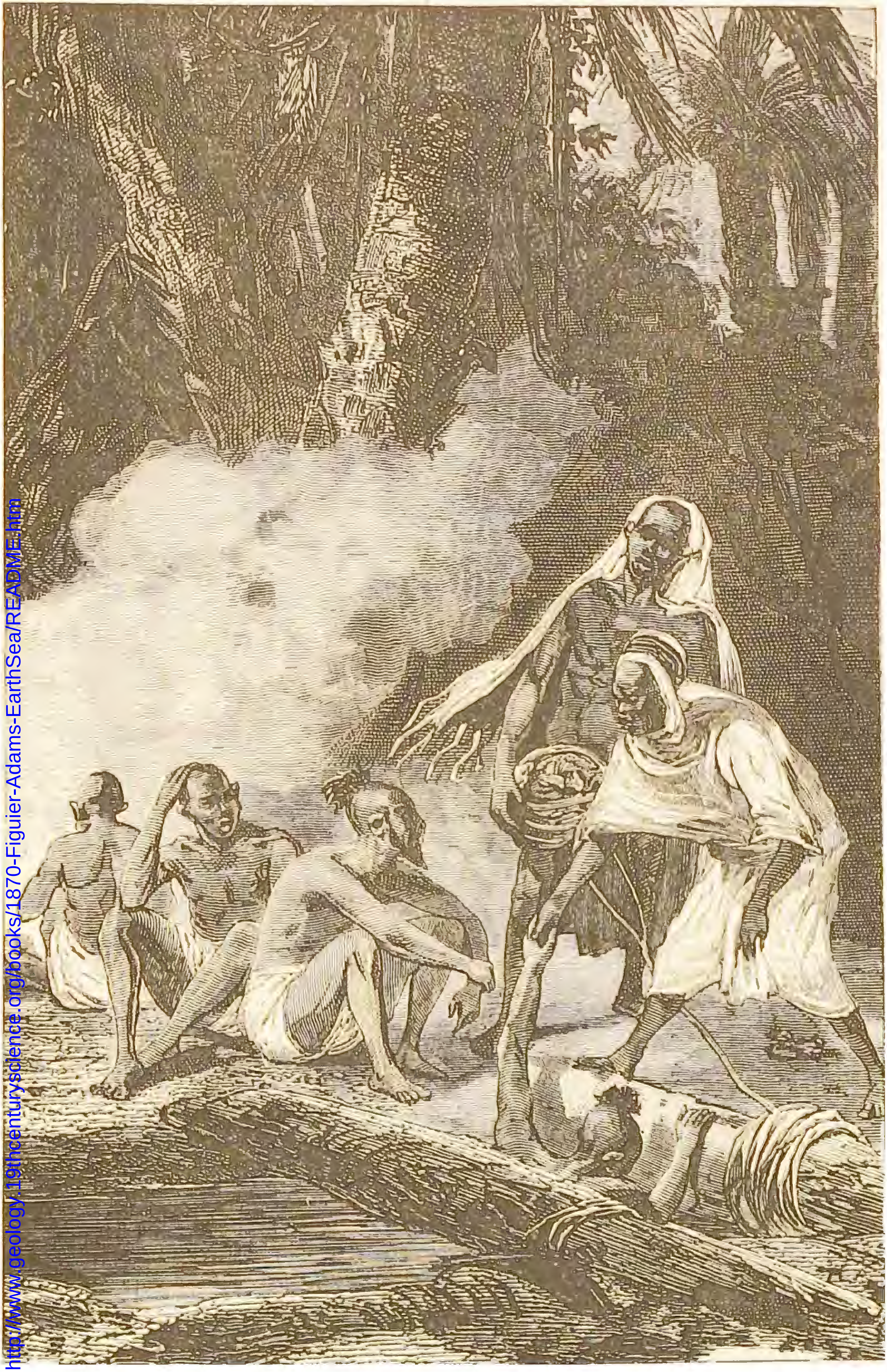
* [Rev. A. C. Smith, "Banks of the Nile;" Sir Gardner Wilkinson, "Thebes and Ancient Egypt," etc.]

The inhabitants procure water in a very singular manner. They dig wells at a hundred, sometimes at two hundred fathoms deep, and never fail to find water in great abundance. They remove, for this purpose, various layers of sand and gravel, until they come to a kind of stone resembling slate, which they know is next above that which they call *Bahar toht el erd*, or 'the sea beneath the earth,' a name which they give to the abyss in general. This stone is easily pierced, whereupon the water rises so quickly, and in such abundance, that those who descend to carry out the operation are sometimes surprised and suffocated, although their companions draw them up with all possible speed."*

The old geographer, Ptolemæus, has compared the surface of the Sahara to a panther's skin; the tawny hide represents the sandy plains, the black spots are the oases sprinkled over this immense solitude. The existence of the oasis, and of all the villages grouped around this centre of isolated vegetation, depends on one beneficent tree, the Date Palm. But to live, the Date, like its congener, the Doum Palm, must have, according to an Arab expression, "its feet in the water, and its head in the fire." To find the water which is so indispensable to the life of the palm, the Arab has, from a remote antiquity, excavated wells by removing the bed of sand, and perforating the stratum of gypsum which lies upon the aquiferous strata.

Among the Arabs of the Oued-Rir, the well-sinkers (*R' tuss*) form a particular guild, or corporation, which enjoys a remarkable amount of consideration. The means which they employ are, however, of the rudest description. As they do not know how to carry off the waters of infiltration, they frequently work under water, sometimes under columns 150 feet in height; many perish of suffocation, others die, at the expiry of a few years, of pulmonary phthisis. Each diver remains but two or three minutes below the surface, and then returns to the surface, his basket filled with débris; the reader will, therefore, understand with how much slowness the sinking of a well will proceed under such conditions.

* [Shaw, "Travels in Several Provinces of Barbary" (ed. 1743), vol. i., p. 125. The French are now sinking Artesian wells at various points of the Algerine Sahara.]



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Moreover, the wells excavated with so much difficulty have but an ephemeral duration; a gust of wind, or the simoun, will pile up within it the sands, which resume possession of their domain; and the oasis disappears along with the spring which fertilized it.

Since 1856, the French Algerines have successfully bored about forty-six Artesian wells on the northern frontier of the Sahara, whose geological constitution had been previously explored by M. Charles Laurent. Thirty-three wells, of ancient construction, have been recovered, and excavated anew. The sheet of water divides itself into two superimposed strata, in such wise that when penetrated it jets forth in springs at different depths. The subterranean source swarms with fish, named cynodontes which do not live, as some have said, in these subterranean rivers, but were introduced into neighbouring wells to cleanse them.

The first abundant Artesian well was obtained, in 1806, at Tamerna, in the Oued-Rir; it caused a great manifestation of joy among the Arabs. Their Marabout, after having blessed and consecrated it, named it the "Fountain of Peace." The Artesian well which was afterwards sunk in the locality of Sidi-Rached, restored life to that ancient oasis ruined by the barren dryness to which these solitudes seem eternally condemned.

The subterranean waters spread on the surface of the African soil excite a salutary vegetation, which attracts the clouds and precipitates the atmospheric vapours. Each spring then becomes a centre, around which huts and cultivated fields soon gather; it is, so to speak, the soul of the oasis; the inhabitants, therefore, watch over it with the greatest anxiety. The aperture of the well is covered with a skin, which protects it against the encroachment of the sands; its water is conveyed into the gardens in small channels, and refreshes the vegetables which flourish under the palm trees. Without water, life becomes impossible in the desert; when a spring dries up, the sand recovers its mastery of its ancient realm. Deprived of water, the date and the doum palm perish, and their disappearance ensures that of the plants whose cultivation is only possible under their shadow.

The ruins scattered over the Sahara attest the former existence of important villages, whose ruin has entirely arisen in the accidental stoppage of a beneficent spring. In this case the Arabs say that the spring *dies*. The oasis of Tébaïch disappeared under similar circumstances some years ago. The tops of its date trees, stripped of their foliage, may now be seen emerging above the sands, like the masts of a foundered ship.

A very inaccurate idea is popularly entertained of the oases, both with respect to their extent and the character of their soil. The least

FIG. 91.—ENCAMPING ROUND AN OASIS.

considerable will not be of less area than several days' journey in one direction or another; that is, their superficies will consist of 200,000 to 300,000 square yards; an extent which only seems insignificant when compared with the immensity of the desert. The great oases are, however, more numerous than the little, because they can the most effectually resist the invasion of the shifting sands. The oasis of the Oued-Folesseles is 170 miles long by 60 broad. That of Thebes measures 60 miles by 9. The great oasis of Asben or Aïr occupies, from north to south, and from east to west, an extent of three degrees, or about 180 miles—according to Dr. Barth, who visited it in 1850.

Composed of table-lands, whose average elevation is 2000 feet, and of mountains which attain an altitude of 6600 feet, it might justly

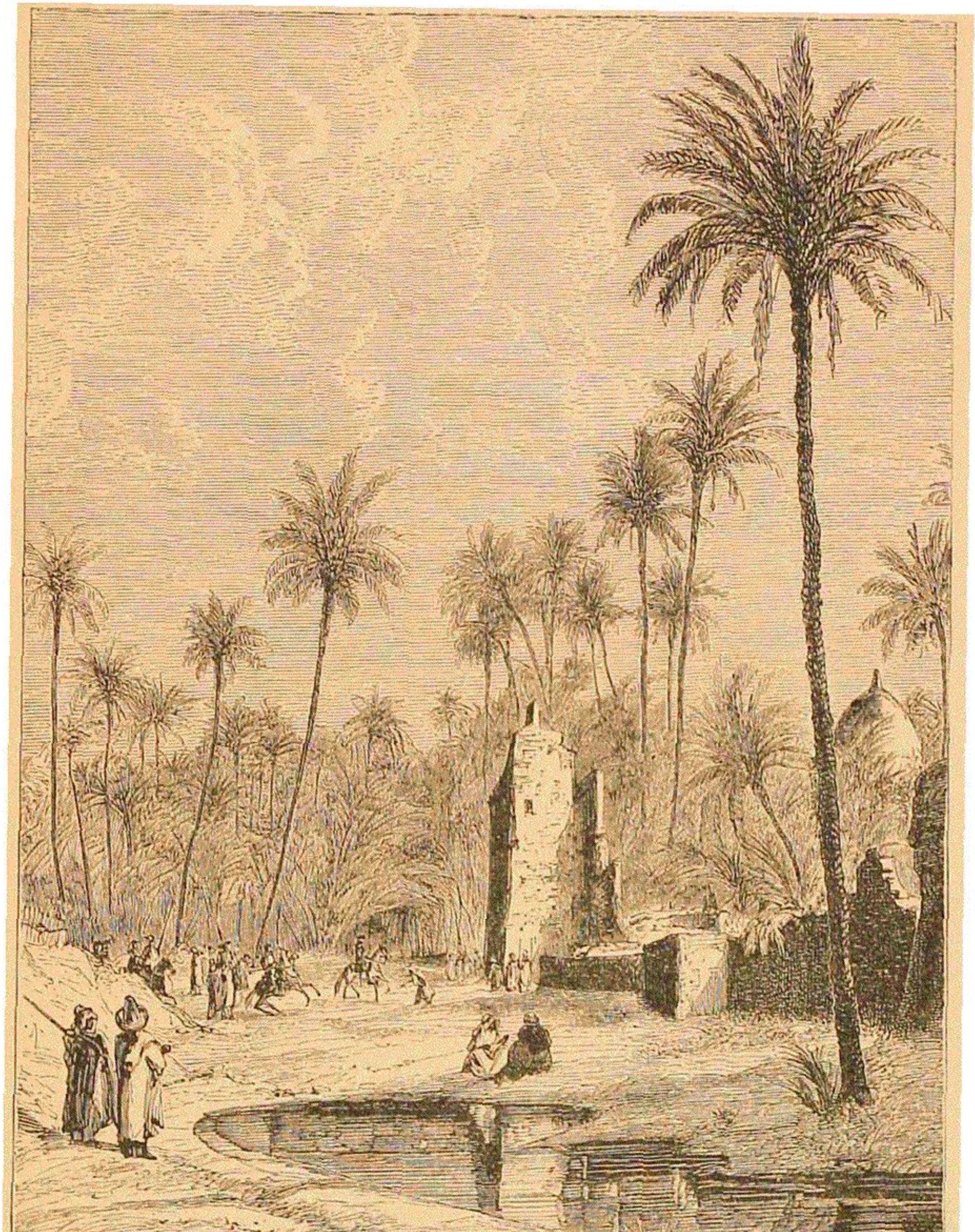

Fig. 92.—An Oasis of the Sahara.

be called the "Switzerland of the Desert." The air there is very pure, healthy, and comparatively fresh. Barley is cultivated, and especially millet and *dourra*. The animals which frequent it are the maneless lion, the leopard, the hyæna, the jackal, the ape, the antelope, the ostrich, the pigeons, the pintads. The capital of this oasis, the town of Aghades, was formerly very prosperous, and rivalled Timbuktu.

Entire kingdoms, in the Desert, occupy each but a single oasis. Thus we may regard as great oases, in the north, Fezzan, a mountainous country, with fertile valleys; and, in the south, Darfour, situated to the west of Cordofan. Egypt itself is only, as we have said, a great oasis.

It is the palm tree forests which especially constitute the oasis. The Arab says that God created the palm tree at the same time as man, to make it minister to the sustenance of human life; this is the same beneficial mission which the banana discharges in the tropical regions. The palm prospers in the African oasis, because that hardy tree can accommodate itself to, and even thrives well upon, the brackish water, which is all the Desert can furnish. The palm and the date are the commonest trees of the oasis. The female palms are especially abundant; male palms are rare. The Arabs artificially fecundate, in the spring, the female palms, by shaking upon them the pollen of the male flowers.

The Arab knows how to create, under some conditions, an artificial oasis with a few palm trees. For this purpose, he digs a hole about thirty feet in depth, and in this hole he plants a palm tree. The far-reaching roots pierce the soil, and penetrate to the watery subterranean strata; thenceforward it can dispense with artificial irrigation, and under its shadow other vegetables can be cultivated. It sometimes happens that the winds fill up these palm tree holes; the Arab then courageously recommences the fatiguing task of clearing them to a depth of thirty feet of the encroaching sands.

Besides palms and dates, numerous shrubs, vegetables, and cereals are cultivated in the oases. Barley is also grown; that truly cosmopolitan cereal which flourishes all over the world, from the icy wastes of Lapland to the burning sands of the Sahara.

Nowhere in the Desert, except in the forests of its oases, does the traveller meet with beasts of prey. The fancy of the poet has crowned the lion "king of the desert." A little reflection, however, would have suggested to them that this animal would necessarily perish of thirst in the sandy plain. The lion of the desert is a pure creature of the imagination. The African lion does not quit the mountains, where he finds both water and his prey. If you question the Arabs in reference to the presence of the "king of animals" in the desert, they reply, "Are there, then, lions in your country, which drink air, and eat sand? With us, the lion has need of fresh water and living flesh."

The ostrich alone, thanks to his sobriety, can venture with impunity into the sandy wilderness, which is also permanently inhabited by a large lizard, with glittering scales, the *shob*, or salamander of the desert.

The domestic animal of the Sahara is the camel, as the reindeer is that of the Arctic steppes. These two species of animals thrive admirably in the zone of the deserts; they seem predestined to facilitate and render practicable man's abode in these desolate regions. The camel carries within him a natural reservoir of water, which enables him to remain whole weeks without drinking, and which, after his own death, may save the life of his driver. The instinct of the animal divines at a great distance the oases, and the springs, or basins, of water; moreover, he foresees, like other animals, the advent of the tempest, and, especially, of the simoun. The *mahari*, the most valuable species of camel, is of incredible vigour and swiftness. It is said that in a day of twenty-four hours he will accomplish the journey from Tripoli to Rh̨'adames (upwards of one hundred leagues), but he succumbs on arriving at the goal. His ordinary day's march is thirty to forty leagues. That of the common camel is much shorter.

The caravans which, on the back of this patient animal, traverse the great desert, are accustomed to direct their route by piles of stones, called *kerkours*, which indicate the neighbourhood of the springs and guide the travellers. Each passer-by throws a stone upon the heap, and thus contributes to the maintenance of those monuments, which remind us of the *cairns* of the Polar expeditions. When a caravan in want of provisions meets another which is better supplied, the latter shares with the former its stock of water, dates, butter, and barley bread ; this is a custom to which even the Touaregs, the brigands of the Desert, conform.

The ever-increasing progress of modern industry will, perhaps, eventually create in the African Desert a number of oases, which will render a residence therein less dangerous and less painful, and will powerfully influence the nomadic habits of its population.

The Artesian works already executed in the Algerian Sahara have induced a remarkable revolution in the constitution of Arab society, by deciding several nomadic tribes to fix themselves definitively in the irrigated districts, and become cultivators. It is probable that if the Artesian wells be considerably multiplied, the oases will not be long in springing up, under the favouring influence of the waters so fortunately raised from the bowels of the earth. The interior of Africa will then wear a new aspect; man will have conquered to himself an immense domain ; and there will remain but few of the gloomy details in the picture we have just painted of the "waterless sea."

The Desert of Gobi (Fig. 93) stretches from west to east, from Turkistan to Manchooria, for a length of about 1250 miles ; it forms a great portion of Mongolia. The Chinese call its western part *Chamo*, or the "Sandy Sea ;" its eastern part, *Chachin*.

The Gobi desert does not everywhere present the same aspect. In its eastern districts the shifting sand nearly everywhere covers the soil, which is diversified with sandy hills and projections of granite. In the west, the sandy plains are intersected by marshes. A few oases sprinkle this region of the desert ; the principal is that of *Kami*. There the brooks keep alive an abundance of green pasture, with numerous fine trees and a rich vegetation. Beyond their limits the maps indicate only salt lakes of small extent, nearly always dry, wells, springs, and stations for caravans and the Chinese posts.

The vegetation of this part of the Gobi is poor and scanty. Some small tracts are covered with herbage, above which rise a few stunted bushes, wild apricots, and

FIG. 93.—THE GREAT DESERT OF GOBI.

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pseudo-acacias. "In spring and summer," says Malte Brun, "when there is no rain, the vegetables wither, and the burnt soil inspires the traveller with sentiments of horror and melancholy; the heat there is of short duration, the winter long and cold. The wild animals met with are the camel, the horse, the ass, the *djightaï*, and troops of antelopes."

The southern region, extending almost to the Great Wall of China, no longer deserves the name of "desert," in the sense which we attribute to that word. The soil is fertile; it abounds in pasturage, and supports myriads of herds, under the superintendence of millions of Chinese and Mongol shepherds, who call it the "land of grasses." The country is watered by numerous streams, and covered with forests, where walnut trees flourish, elms, aspens, and hazels. All the cereals do well, and a great number of vegetables and fruits; so that many of the Chinese and Mongols devote themselves wholly to the cultivation of their gardens.

The great Asiatic Desert has exercised a fatal influence on the destinies of the human race; it has arrested the extension of Shemitic civilization. The primitive peoples of India and Tibet were early civilized; but the immense wilderness which separated them put an impassable barrier between them and the barbarous tribes of northern Asia. More than the Himalaya, more than the snow-crowned mountains of Sirinagur and Gorkha, these unknown and desert steppes have prevented all communication, all fusion between the inhabitants of the north and those of the south of Asia; and it is thus that India and Tibet have remained the only regions of this part of the world which have enjoyed the benefits of civilization, of the refinement of manners, and the genius of the arts.

The barbarians who, towards the last agony of the Roman Empire, invaded and convulsed Europe, issued from the steppes and table-lands of Mongolia. It is to this fact Humboldt refers in the following paragraph:—*

"If intellectual culture has directed its course from the east to the west, like the vivifying light of the sun, barbarism at a later period followed the same route, when it threatened to plunge Europe again in darkness. A tawny race of shepherds, of *thon-khiu*—that is to say, Turkish origin—the Hioungnou, inhabited under sheepskin tents the elevated table-land of Gobi. Long formidable to the Chinese power, a portion of the Hioungnou were driven south in Central Asia. The impulse thus given uninterruptedly propagated itself to the primitive country of the Fins, on the banks of the Oural, whence irrupted a torrent of Huns, Avars, Chasars, and divers mixtures of Asiatic races. The armies of the Huns first appeared on the banks of the Volga, then in Pannonia, finally on the borders of the Marne and of the Po, ravaging the beautiful plains where, from the time of Antenor, the genius of man had accumulated monuments upon monuments. Thus blew from the Mongolian deserts a pestilential wind which blighted even in the Cisalpine plains the delicate flower of Art, the object of cares so tender and so constant."

* Humboldt, "Tableaux de la Nature," i. 8.

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BOOK IV.

THE TEMPERATURE OF THE GLOBE.

The day is Thine, the night also is Thine: Thou hast prepared the light and the sun. Thou hast set all the borders of the earth: Thou hast made summer and winter.—The Psalms of David.

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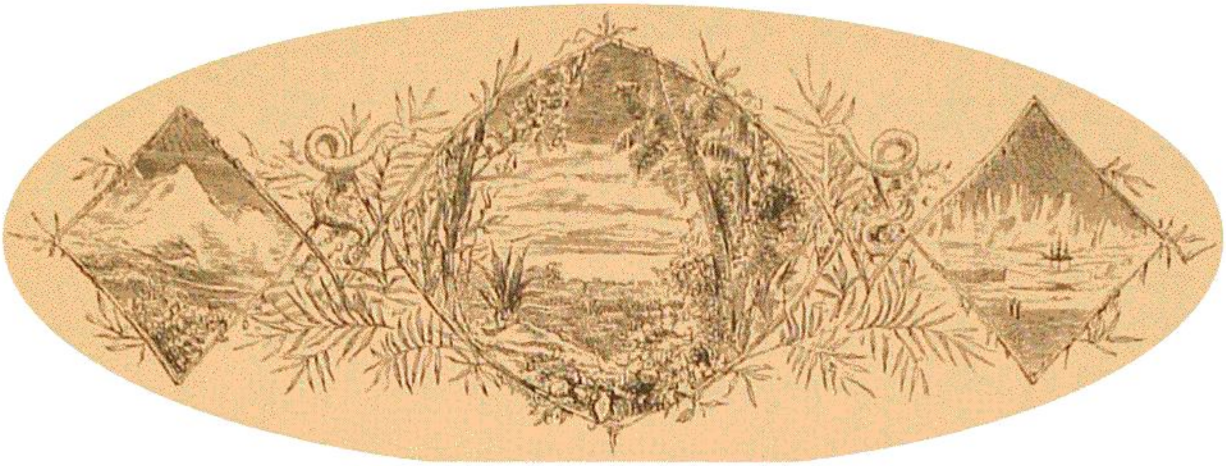

BOOK IV.

THE TEMPERATURE OF THE GLOBE.

CHAPTER I.

TEMPERATURE OF THE TERRESTRIAL GLOBE—SUPERFICIAL AND INTERNAL TEMPERATURE—THE CLIMATE—ISOTHERMAL LINES—MEAN TEMPERATURE OF DIFFERENT REGIONS OF THE GLOBE—EXTREME TEMPERATURES OBSERVED IN DIFFERENT PLACES.

LET us now proceed to the general study of the temperature of the globe.

We shall premise here a great distinction, which will enable us to divide into two groups the various subjects we are called upon to investigate.

The heat of our globe has two very different origins: on the one hand, it proceeds from the sun; it comes, on the other, from the liquid incandescent nucleus hidden in its depths, and whose caloric transmits itself partially to its very surface. This latter cause of its heat, which operated exclusively in the early ages of our planet, is to-day scarcely perceptible, on account of the density which the consolidated crust of the earth has acquired. So that in our own time the solar heat is almost the sole source which warms the surface of our planet. Nevertheless, the furnace which burns in its womb reveals its existence by the most terrible and most imposing phenomena of nature;

that is, by earthquake and volcano. For this reason, it deserves to receive in our pages the most serious consideration.

We shall, therefore, divide into two sections our study of the temperature of the terrestrial globe, and consider, successively,—

First, The Effects of the Solar Heat; and,
Second, The Effects of the Central Fire.

To the first section will be referred the study of the temperatures of the earth's surface, that is to say, its *climates;* to the second, the exposition of the phenomena of volcanoes and earthquakes.

First, The expression "climate," in its most general sense, comprehends the total or aggregate of those atmospheric variations by which our organs are effected in a sensible manner; that is, temperature, humidity, the barometric pressure, atmospheric calm, the winds and storms, the electric tension, the purity of the air or the presence of miasma, and, finally, the relative degree of the transparency and serenity of the sky. All these questions are connected, as we shall see, with the condition of the atmosphere; in other words, they belong to Meteorology—a science which it is not the object of this book to expound. It is nevertheless our duty to put before the reader some considerations on the distribution of heat over the globe's surface, and on the division of climates.

The principal source of heat—the superficial heat of our planet—is, as we have said, the Sun. The duration of his presence above the horizon and his elevation are the same for all places situated on the same degree of latitude. If, then, the terrestrial surface were composed of one homogeneous substance, presenting everywhere the same colour, the same density, the same absorbent and emissive power for the radiating heat, the mean temperature ought always to be the same on the same parallel of latitude, so that the parallels would also be *isothermal lines*, *isotheral*, and *isocheimal lines*—that is, lines of equal *annual temperature, summer* and *winter temperature.** But this primitive condition, which, in its simplicity, would lend itself admirably to a mathematical theory, to an exact science of climatology, is largely modified by the unequal distribution of land and water over the surface of the terrestrial globe, by the capricious relief of the solid crust above and below the seas, and by the varying chemical constitution of the masses which compose that mineral crust. The interposition of the waters also effects a considerable variation in the atmospheric temperature. The water is much cooler at its surface than the earth, because the quantity of caloric necessary to raise a bed of water only one degree of temperature is much more considerable than that which suffices to raise to an equal amount a similar mass of earthy matter. In the water the heat evolved from the sun penetrates to a great depth, instead of being concentrated on

* Let us explain what is meant by the *mean temperature* of a place. If we observe the thermometer regularly every day, at longer or shorter intervals, and then take the mean of those observations—that is, the sum of the figures observed divided by the number of observations—we shall obtain the mean daily temperature. If the thermometer, observed at London, for example, at six o'clock A.M., should give 55°; at nine A.M., 60°; at three P.M., 65°; and at midnight, 50°; the mean of the daily temperatures will be—

$$\frac{55^\circ+60^\circ+65^\circ+50^\circ}{4} = 57^\circ\ 75$$

If, at the end of several years of observation, we add together the means of temperature of a given day, say May 5th, we shall obtain the mean general temperature for that day of the year. In the same manner we can ascertain the mean temperature of every month; and, finally, by summing up the temperatures of the twelve months, and taking their mean, we shall gain the *mean temperature* of the place of observation.

Take, for example, the station of Paris. After observations extending over a period of fifty years, and by taking the monthly measurements of the maximum, minimum, and mean temperatures, we procure the results shown in the following table:—

MONTHS.	MAXIMUM.	MINIMUM.	MEAN.
January,	+ 5° 0	— 0° 9	+ 2° 1
February,	7° 3	+ 0° 7	4° 0
March,	10° 0	3° 1	6° 6
April,	13° 1	6° 5	9° 8
May,	18° 4	10° 7	14° 5
June,	21° 1	13° 6	17° 3
July,	22° 7	15° 4	19° 0
August,	22° 4	14° 6	18° 5
September,	18° 9	12° 1	15° 5
October,	14° 6	7° 3	11° 0
November,	9° 7	3° 9	6° 8
December,	6° 0	0° 3	3° 6
Annual Mean,	14° 2	7° 3	10° 7

These figures refer to the Centigrade thermometer. + signifies above, and — below freezing-point.

the surface, as is the case with the solid and opaque soil. On the other hand, the continual evaporation of the water cools that liquid considerably.

As a result of these different causes, the water during summer is colder than the land. In the winter, on the contrary, the surface of the sea preserves more heat than the terrestrial surface, because the warmer liquid molecules incessantly ascend from the lower strata whither the summer had penetrated, and thus brings the caloric to the surface. The sea, then, only follows very closely the variations of the atmospheric temperature produced by the solar radiation. The enormous mass of its waters serves to equalize the temperature of our globe; it mitigates the rigour of the winters and the ardour of the summers. Thence arises a marked difference between the marine climate (or that of the islands and coasts) and the continental climate. The former is characterized by the uniformity of the temperatures, which vary but little from summer to winter; the latter presents excessive variations, severe winters followed by burning summers.

Thus, on the Atlantic Ocean, the temperature never descends below 50° F. under the latitude of Bordeaux, while at Bordeaux itself the mean winter temperature is only 42° 48′ F. Under the latitude of Brussels, the mean temperature of ocean remains always above 48° 15′ F., a temperature much higher than that of Brussels.

Points similarly situated north and south of the Equator do not possess the same mean temperature; at the Falkland Islands, for example, the climate is colder than it is under the same latitude (51°) in England, on account of the immense expanse of waters surrounding that island-group.

Analogous considerations explain the difference which exists between the climate on the eastern and on the western coast of the same continent. The trade winds, or east winds of the Tropical zone, determine in the atmosphere certain counter-currents, which cause the west or south-west winds to predominate in the Temperate zones. Land-winds prevail on the eastern, and sea-winds on the western coasts.

The winds exercise a powerful influence upon the climates of the regions which they visit, because they carry thither the temperature of the countries they have just quitted. The south-west wind which arrives at Boston and Quebec has already traversed the entire extent of North America, and has assumed its temperature, hot in summer, cold in winter; therefore, it can neither lower the summer temperature, nor raise the winter, on the east coast of America. But, on the contrary, when it reaches the west coast of Europe, it will carry with it the moderate temperatures of the Atlantic Ocean, and its effect will be to temper on our shores the summer heats and the severity of the winters. It is for this reason that the climates of the western coast of the Old World are less extreme than those of the eastern coast of the New, though the two represent the two borders of the Atlantic Ocean. Western America, exposed to the winds of the Pacific, possesses a far less rigorous climate than Eastern.

These different causes—the configuration of the continents, and the distribution of waters around those continents; exposure to the ruling winds; the presence of mountains serving as ramparts against those winds; the elevation of a locality above the sea-level; the distribution of the lakes, marshes, and forests, which act upon the soil as refrigerants, and a host of other circumstances more or less effective—enormously modify the course of the *isothermal* lines*, or *lines of equal heat*, by local perturbations very difficult to define. It results that the track of the isothermal lines which we obtain by describing a series of curves through the various points possessing a similar degree of mean temperature, must exhibit the most capricious sinuosities and inflections. Between the Tropics they do not wander so far from the parallels of latitude as in the regions of the North, where the causes of variation are more numerous.

The chart, Figure 94, represents the most generally admitted isothermal lines, according to the researches of Humboldt, somewhat modified by recent observations.

* From ἴσος, equal, and θέρμος, heat.

The line of maximum heat, or the isothermal equator, cuts the terrestrial equator under the meridians of Tahiti and Singapore, and traverses the Pacific to the south and the Atlantic to the north of the Equinoctial line. The mean temperature of this line of maximum heat is about 84° F.: more specifically, it represents:—

In Asia, ...	82° 40′ F.
In Africa, ...	80° 45′ F.
In America, ...	84° 10′ F.

Thus, in Africa and America we find its two extremes. The Pacific

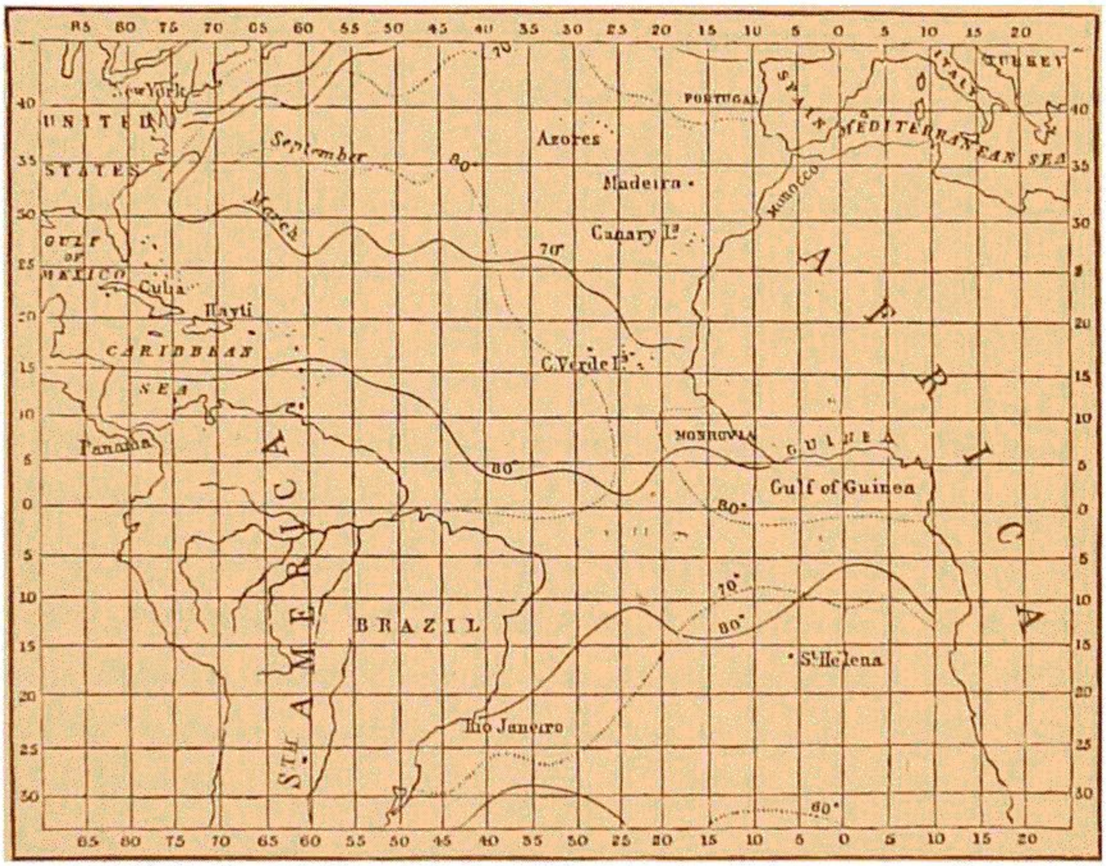

FIG. 94.—CHART OF ISOTHERMAL LINES, ACCORDING TO HUMBOLDT.

Ocean is about one degree warmer under the thermal equator than the Atlantic. The southern hemisphere is, in general, much cooler than the northern, owing to the greater predominance of great basins of water in that division of the globe.

The two poles do not appear to be the coldest points of the earth; those which are named the "poles of cold"—that is, the extreme points of the *minimum* terrestrial temperature—are not as yet very exactly determined. It would seem, according to Sir David Brewster, that both lie in the north, one in Siberia, the other in America; but this hypothesis is controverted by the great German meteorologist Dove. The mean temperature of the north pole of the globe is probably very near 46° F.; it is not impossible, therefore, that an open and iceless sea exists in its vicinity, as Dr. Kane asserts.

If we consider separately the summer and winter temperatures in the different regions of the earth, we can trace the lines on which those temperatures will be always the same: that is,—

The *Isotheral*, or lines of equal summer temperature; and

The *Isocheimal*, or lines of equal winter temperature.

These are fully as irregular as the general isothermal curves. Between the tropics, however, they do not differ much from those of the parallels. There the seasons occur with tolerable regularity, and they are but two—a dry season, and a wet or winter season. The former lasts four or five months; the latter seven to eight, with occasional breaks of fair weather.

When we lay down the isothermal curves, it is necessary we should, as far as possible, choose places of equal elevation above the sea, for the simple elevation of any locality is of itself sufficient to lower the temperature. This remark leads us to consider the important question of the decrease of the atmospheric temperature when we mount above the surface of our globe.

The extent to which we must rise in the air to secure a decrease amounting to one degree, varies greatly according to the locality, the season of the year, and the hour of the day. Under the torrid zone, Humboldt ascertained that the elevation requisite was 650 feet for each degree; in Switzerland, 450 feet seems to have been the mean result obtained from a great number of observations.

These figures, however, cannot be generalized. According to an English meteorologist, Mr. Glaisher, who made, in 1862 and 1863, some bold aerostatic ascents with the view of determining the law of the decrease of atmospheric temperature in the ratio of elevation of level, the thermometer sinks at first one degree to every 2000 feet (when we have reached the absolute altitude of 11,000 feet). The correction by which our physicists reduce the mean temperatures at the level of the sea is, therefore, exceedingly vague. The variability of the thermometric decrease with the absolute elevation, is particularly conspicuous in the limit of perpetual snow, of which we shall speak hereafter.

It will not be uninteresting to the reader if we particularize in this place a few of the extreme temperatures which have been observed on the globe.

Let us speak at first of extreme heat.

Between the tropics, Humboldt has frequently found the temperature of the surface, when exposed to the solar rays, to exceed 124° F.; and Arago, one day, observed 127° 25′ F. in the sand of the gardens of the Paris Observatory. Marès, while studying, in 1854, the action of sulphur upon vines attacked by the *oidium*, ascertained that the temperature of the arable soil, in the plain of Launac, near Gigean (department of Hérault), was between 123° 45′ and 131° F. The white quartzose sand near the Orinoco, which teems with a rich vegetation, has shown a temperature of 140° F. Finally, Nouet has marked 153° F. in the sands of Philæ, in Egypt.

In the shade, and in the open air, the following temperatures have been recorded by different observers:—

Place.	Temperature.	According to
At Paramatta, Australia, ...	105° 45′	Lord Brisbane.
Cape of Good Hope, ...	109° 25′ to 111°	Lacaille.
Pondicherry,...	110° to 113°	Le Gentil.
Madagascar, ...	113° to 114° 45′	Le Gentil.
Esneh, in Egypt, ...	114° 45′ to 116° 30′	Burckhardt.
Mourzook, in Fezzan, ...	132° 48′	Ritchie.

Proceed we now to note a few facts respecting extreme degrees of cold. The lowest temperature observed at Paris was 12° 10′ F., on the 25th of January 1795. At Yakutsk, in Siberia, the thermometer has been known to sink in January to 0° 15′ F. Sir John Franklin observed 5° 45′ F. of cold at Fort Enterprize, in 64° 5′ N. lat. Black, in North America, endured a degree of cold represented by—1° 50′ F. The mean temperature of Melville Island, according to Parry, is 10° 5′ F.; the *maximum* and *minimum*, respectively, 26° 10′ and 8° 25′ F. But the eminent explorer, Sir Roderick MacClure, observed 2° F., in January 1853, a month whose mean temperature is estimated at 9° 20′ F.

Between the two extremes of 132° 48′ F. observed in Fezzan, and 0° 15′ F. observed at Yakutsk, the range is 132° 33′ F.! Such are the surprising variations of temperature which man and animals can endure.

CHAPTER II.

THE LIMIT OF PERPETUAL SNOW:—AVALANCHES.

THE *isothermal*, *isotheral*, and *isocheimal* lines have taught us to comprehend the influence of geographical latitude upon terrestrial climates; but we have already seen that climate also depends, to a very important extent, on the elevation of any particular locality above the level of the sea. In proportion as we ascend in the atmosphere, the temperature decreases with rapidity, but this decrease varies according to the latitude, and even according to the season. It may, however, be put forward as a general rule, that the temperature sinks in the same ratio that we rise above the sea-level. In the Andes, M. Boussingault has found a mean diminution to obtain of 1° temperature to every 550 feet of elevation—a figure which does but slightly differ from the result secured in the region of the Alps.

The decrease of temperature with the elevation of places has an interesting consequence: namely, that as we gradually ascend a lofty mountain, we meet with the organic productions of every country arranged upon different levels or terraces, and we pass in succession from one climate to another still more rigorous. If we stand upon the heights of Switzerland, we embrace at a single glance the panorama of the Alps; and, as in an open page of the book of Nature, we may read in the picture before us the rules and the laws which science has established concerning the distribution of living beings at different latitudes. We perceive, with sufficient distinctness, six zones or belts raised one above another, and clearly distinguished in their outlines by the difference of vegetation and the appearance of the soil. Lowest of all extends the fertile plain, intersected by lakes, great highways, rivers, and forests, besprinkled with farms and villages : this is the abode of man. Above this verdant carpet rise, in admired disorder, green swelling hills, sometimes naked, sometimes covered with wood and shadow. Higher still, the eye rests upon rocky ridges, crowned with groups of firs. Among these rocks we still discover the slope smiling with rich pasturage ; but soon the character of the landscape abruptly changes : death succeeds to life, verdure gives place to the gray monotonous tints of the naked rocks. The mountain then borrows its attractiveness or its grandeur from other aspects, from the wild fantastic forms of the rocks which constitute its majestic mass. And finally, highest of all, the Alps enfold themselves in a dazzling canopy of snow, through which a few peaks, whose steep inclines are unable to retain the drifting flakes at the moment of their fall, with difficulty project themselves.

These six regions have received, according to the characteristics of their vegetation, the following denominations :—

	ELEVATION IN FEET.
1st, or *Sub-montane* region, or that of the walnuts, ...	2700
2nd, or *Montane*, or that of the beeches, ...	2700 to 4500
3rd, *Sub-Alpine*, or that of the fir-trees, ...	4500 to 5700
4th, the *Alpine* region, or that of the shrubs, ...	5700 to 7000
5th, *Sub-Niveal*, or that of the grasses, ...	7000 to 9000
6th, the *Niveal* (snowy) region, or that of the perpetual snows, ...	above 9000

The figures in the foregoing table are those generally accepted as correct, so far as the Alps are concerned ; in other localities they vary according to the distance from the Equator, and the mean temperature of the country.

Of all the natural regions which thus ascend in due graduation the mountain-sides, not one has so marked and specific a character as that of the *Perpetual Snows ;* so named, with justice, because they resist the summer heats, or renew themselves immediately a partial liquefaction in spring or summer has diminished their glittering mass. All the other regions are to some extent confused and intermingled, and encroach slightly upon each other's boundary ; but the lower limit of the snows which withstand the sun of summer appears in the distance like a line of demarcation traced by an unwavering hand :

it separates from the cultivated regions the black and inhospitable world of the lofty crests. Below, life is astir; the soil changes its aspect with the changing seasons; all kinds of organisms are developed by the solar rays; and even upon the very border of the snow-line a space of a few yards suffices to transform a snowy plain into a field of smiling verdure. But beyond this limit reigns winter, with all its horrors: the landscape is enfolded in a vast and frozen shroud; the silence of the desert is unbroken except by the fury of the liberated elements.

The reader will easily understand that the *line of perpetual snow* is always found at a greater elevation in proportion to the greater warmth prevailing at the sea-level; in other words, the hotter the climate the higher is the snow-line. In the North Polar and Antarctic regions, where reigns an unbroken cold, the snow-line ought to be found on the same level as the sea; but, on the contrary, in all hot equatorial countries it will be situated at a very high elevation. According to Rénou, this boundary is the altitude where the mean temperature of the warmer half of the year (May to October) is zero.

In the subjoined Table we give the limit of perpetual snow on the principal mountain-ranges of the world, and indicate the latitude to which the estimate applies:—

	LATITUDE.	HEIGHT OF SNOW-LINE IN ENGLISH FEET.
Spitzbergen,	79° N.	0
Mageroe (Norway),	71°	2,350
Norway, interior of,	70° to 60°	3,500 to 5,100
Iceland,	65°	3,050
Unalashta (W. America)	54°	3,510
The Altaï Mountains,	50°	7,034
The Alps, northern side,	45°	8,885
" southern side,	45°	9,150
The Caucasus,	43°	11,063
The Pyrenees,	43°	9,000
Mount Ararat,	40°	14,150
Karakorum, northern side,	36°	17,500
" southern side,	36°	19,300
Kuen-luen, northern side,	36°	15,000
" southern side,	35°	15,680
Himalaya, northern side,	29°	19,560
" southern side,	28°	15,500
The Mexican Cordilleras,	17°	14,650

	LATITUDE.	HEIGHT OF SNOW-LINE IN ENGLISH FEET.
Ethiopia, ...	13°	14,075
The Andes of Quito, ...	1° S.	15,680
The Andes of Bolivia, east, ...	16°	15,800
" " west, ...	18°	18,400
The Andes of Chili, ...	33°	14,600
The Andes of Patagonia, ...	43°	6,300
Strait of Magellan,...	54°	3,700

We must guard the reader, however, against accepting these figures as absolutely accurate; for, in truth, the phenomenon of the perpetual snow-line is very complicated. It is influenced by the temperature, by the hygrometrical condition of the atmosphere,* the configuration of the mountains, the direction of the prevailing winds and their contact either with the land or the sea, the total elevation of the heights and the comparative precipitousness of their declivities: finally, by the extent and absolute elevation of the table-lands on which these mountains are situated.

All these causes combined affect, in a considerable degree, the elevation of the snow-line. On the springing peaks of the Swiss Alps, the snow begins at an elevation of 9000 feet, and a few scanty lichens barely colour the rocks which here and there emerge from their icy shroud; while on Chimborazo, in South America, M. Boussingault found saxifrages clinging to the crags at a height of 15,600 feet above the sea—that being the limit of perpetual snows on the mountain in question. On the flanks of the Eastern Cordilleras of Upper Peru, Pentland has observed that the lower limit of the snows rarely descends below 16,900 feet; while in the Andes of Quito, which are much nearer the Equator, it sinks as low as 15,000 feet.

On visiting these immense fields and wastes of snow, we are surprised to discover among them some faint traces of organic life. Even on the loftiest summits, the rocks which pierce through their heavy and perpetual pall are overspread with broad tracts of lichens and other plants of an inferior character. Messieurs Agassiz and Dessors have found these signs of nature's activity on the summit of the Jungfrau and the Schreckhorn.

* That is, the relative humidity or dryness of the atmosphere.

Herr Schlagintweit has given a list of forty-five vegetable species collected on the Alpine crests, between 10,500 and 15,500 feet above the sea; that is, at ice-stricken points of elevation, where we would have thought all life impossible.

The same order of phenomena furnishes us with an explanation of the *red spots* sometimes remarked on the snowy sheet of the Alps, and which have always excited the curiosity of tourist or traveller.

This red snow, as it has been erroneously called, is especially abundant during the months of July and August, at elevations not exceeding 9000 feet. Let us briefly describe the manner in which it appears and disappears.

The snow begins to blush with "rosy gleams," which tint it to a depth of some few inches. Gradually, these spots spread farther and farther, and assume a deeper hue. But, towards the month of September, the colouring matter decomposes, and nothing is visible on the broad white glittering surface but a black powder.

The microscopical researches of Vogt and Shuttleworth have shown that this singular substance is composed of infusoria (such as the *Astasia nivalis*, and *Gygas sanguineus*), and of the spores of a lichen called the *Protococcus nivalis*;* in allusion to the curious primitive simplicity of its organization, and the peculiar nature of its habitat.

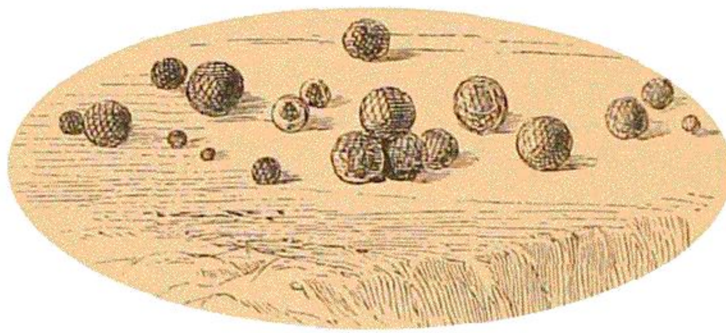

FIG. 95.—PROTOCOCCUS NIVALIS.

[If we place a small quantity of snow coloured with this plant upon a piece of white paper, and allow it to melt and evaporate, the result is a residuum of granules sufficient to communicate a very faint crimson tinge to the paper. Examine these granules with a microscope, and they resolve themselves into small spherical cells, *from the $\frac{1}{1000}$th to the $\frac{1}{3000}$th part of an inch in diameter.* Each cell has an *opening*, surrounded by indented lines, whose smallest diameter measures only the $\frac{1}{6000}$th part of an inch. When perfect, the plant may aptly be likened to a red-currant berry; as it decays, the red colouring matter passes into a deep orange, and finally into a brownish-black. The thickness of the wall of the cell does not exceed the $\frac{1}{30000}$th part of an inch.

Each one of the cells, says Mr. Macmillan,† may be regarded as a distinct individual plant, since it is entirely independent of others with which it may be aggregated, and performs for and by itself all the functions of growth and reproduction, having a containing membrane which absorbs liquids and gases from the surrounding matrix or elements, a contained fluid of peculiar character formed out of these

* [The *palmella nivalis* of Sir William Hooker.]

† [Rev. Hugh Macmillan, "Foot-notes from the Page of Nature."]

materials, and a number of excessively minute granules equivalent to spores, or, as some would say, to cellular buds, which are to become the germs of new plants. There is something extremely mysterious in the performance of these widely different functions, by an organism which appears so excessively simple. That one and the same primitive cell should thus minister equally to absorption, nutrition, and reproduction, is an extraordinary illustration of the fact, that the smallest and simplest organized object is in itself, and, for the part it was created to perform in the operations of nature, as admirably adapted as the largest and most complicated.

This so-called red snow appears to have been first observed by the celebrated Alpine traveller, De Saussure, in 1760, who found large patches of it near the icy summit of Mont Breven, in Switzerland ; afterwards, on the Pennine Alps ; and on the Col du Géant, during his ascent of Mont Blanc. Captain Ross also remarked it extending in considerable quantities over a range of cliffs on the shore of Baffin's Bay for eight miles, and tinting the snow in some places to a depth of 12 feet. In March 1808, storms of red or rose-coloured snow fell in the Tyrol and on the Carinthian mountains—to such an extent, indeed, that the hills were covered with it to a depth of six feet. It is also recorded that, ten years later, enormous quantities overspread, "like a bloody pall," the Apennines and the other Italian hills, terrifying the credulous inhabitants of the surrounding districts, who regarded it as an augury of imminent misfortune, and flocked to the chapels and shrines of the saints in superstitious devotion.

Mr. Macmillan remarks, however, that this phenomenon is by no means peculiar to the Arctic regions, or the highly elevated mountains of the globe. It has been discovered spreading over decayed leaves and mosses on the borders of small lakes, and in water-tanks in hot-houses ; and in greater perfection on limestone rocks washed by the spray of the Atlantic in Lismore, an island off the Argyleshire coast. Mr. Harvey, an eminent Irish botanist, has found small patches on micaceous schist near Miltoun Malbay, on calcareous rocks at Limerick, and on granite in the vicinity of Dublin, where the supply of moisture is only occasional. Mr. Macmillan has detected specimens on the large masses of unmelted snow which cover the summits of Ben Nevis and Ben Lawers, even in the warm days of July and August.

To conclude this digression : The fact, says an authority, that the red snow is capable of growing in such spots as those in which it has chiefly been found in Britain —namely, on rocks, leaves, and mosses, exposed to occasional or frequent inundations of water—seems to prove that the ice-plains of the Arctic regions, and the snow-crowned sides and summits of the European mountains, are not its natural situations. When, however, its germs have once been deposited in these barren and cheerless localities, the simplicity of its organization, and the consequent strong persistency of the vital principle in it, enable it effectually to resist the cold ; and with that extraordinary power of rapid development which characterizes in a greater or less degree all the members of the family to which it belongs, it forms in a few years, when nourished by the moisture produced by the melting of the icy snow during summer, vast and dense masses, sometimes twelve feet in depth, and extending many miles in length, which afford by their strange contrast to the painful uniformity of the pure and dazzling whiteness all around, a sight more surprising to the Arctic or the Alpine traveller than would be the realization of all the fabled wonders of the Arabian tales.]

In addition to these inferior organisms, a black insect, known as the Glacier-Louse (*Desoria glacialis*), is also met with on the icy surface of the Alps, lurking in the shelter of crag and stone.

We cannot leave our present subject, the mountain-snows, without some remarks on the terrible natural phenomenon of the *lavanges;** or

AVALANCHES.

What is an Avalanche?

A mass of snow or ice which descends the declivity of lofty mountains, and crashes headlong into the valleys with a roar like that of thunder; overthrowing everything which chances to lie in its path, and dragging down in its tremendous course houses, and forests, and entire villages, so that the scene which previously bloomed like a fairy landscape is suddenly converted into a desolate and silent wilderness. In its disastrous consequences it is frequently second only to an earthquake or volcanic eruption; and of the violence with which nature's hidden forces act, when momentarily released from their normal condition of subjection, it is an extraordinary and a fearful example.

The most formidable avalanches occur in the Alps; a fact which is due to their altitude and configuration, inasmuch as they abound in narrow and confined valleys. There, in their descent, they will often traverse the mountain-side for several thousand yards—a torrent of earth, and rock, and snow, and wood; and falling into the depths of the ravines, they bury everything beneath their ruins, or, blocking up the waters of some stream, provoke an inundation of the lower lands.

The German naturalists, who have carefully studied this formidable phenomenon, distinguish five kinds of avalanches:—

1st, *Snow* or *Mountain Avalanches* (*Schrund-lavinen*), masses of snow which the infiltration of the rain-water or the melting of the snows has loosened from the

* [In German, *Lavinen* or *Lauesinen*.]

ground, by operating underneath them. This kind is observed particularly towards the beginning of summer. It is the least dangerous; because those places in the Alps are known where the snows periodically detach themselves, and the circumstances which retard or accelerate their fall.

2nd, *Creeping Avalanches* (*Avalanches rampantes; Schleich-lavinen*), which occur on the gentler slopes, covered with snow, and nearly always on the southern exposure of the mountains. They descend slowly, increased by the snows they accumulate on their route, and gathering up behind them the obstacles they encounter until the latter yield to their increasing pressure or the mass divides into two parts, each of which then takes a separate downward course.

FIG. 96. – AN AVALANCHE IN AN ALPINE VALLEY.

3rd, *Earth Avalanches* (*Schlag-lavinen**), which are the most dangerous, on account of the rapidity of their fall; and occur in those parts of the mountains where a gentle incline terminates suddenly at the edge of a precipitous wall. The accumulated snow-masses glide gradually to the limit of the inclined plane, and remain for a while poised on the brink of the tremendous cliff, like an eagle prepared to spring, until either pressure, or some slight disturbance of the air—a gust of wind — a shout — the report of a gun or pistol—impels them forward. Then they sweep over the precipice with a horrible crash and collision which no words can describe; carrying destruction and death along their terrible path. As, frequently, they fall from very considerable elevations, they produce a concussion of the air violent enough to sweep away the peasant and his hut to a remarkable distance from the theatre of the catastrophe. Certain Alpine passes, such as the Schoellen, on the Saint

* *Schlag*, literally, a stroke, a blow.

Gothard route—the valley of Tremola—and the Grimsel, are infested by these most unwelcome visitors; and wooden crosses, planted along the traveller's road, invite him to utter a prayer for their victims.

4th, *Summer Avalanches*, or *Glaciers* (*Sommer-lavinen*), fall only in the loftier mountain-regions. When you see from afar the rapid flow of one of these icy rivers, filling the air with a glittering dust like the dazzling foam of a cascade, you would think it was a cataract of silver storming down the rugged steep; a flood of frozen spray thrown up from the depths of some mysterious congealed ocean! During its descent, the summer-avalanche considerably increases in dimensions. This beautiful cascade of snow and ice may often be observed on the route of the Scheideck, in the Oberland. Like every other kind of avalanche, it heralds its fall by a hoarse dull sound, which warns the mountaineer of the impending danger.

5th, *Drift*, or *Dust Avalanches* (*Staub-lavinen*). When in the winter season the temperature—no rare occurrence in the Alps—rises up to 12° or 14° C. (=38° 35′ or 39° 45′ F.), the softened snow becomes pulverulent, or powdery. An avalanche formed of snow reduced to this physical condition cannot produce the tremendous effects of these dense compact masses formed of ice and solid snow. It is, in fact, nothing more than dust, which spreads abroad on the air, and can no longer operate by its own weight upon any obstacles it may encounter. Yet it is not without peril for the traveller surprised by it. The impetuous winds so common in mountain-regions lift up its incoherent particles, and complete their pulverization; at the mercy, then, of the slightest atmospheric agitation, you may see them floating, like clouds of sand, around the mountain-peak, even in apparently calm weather; and if acted upon by a sudden hurricane, they gather into formidable whirlwinds, which destroy more lives than even the headlong descent of the heavier avalanches.

Taking into consideration the etymological sense of the word *avalanche*, we must own that it is wrongly applied to these tornadoes of snow. In tracing them to their origin, we may with more justice compare them to the sand-storms of the immense deserts of Africa; the poor wretch buried beneath the snows of the Alps perishes of cold, while the dry, scorching, stifling sands of the Sahara threaten the traveller with a still more terrible fate.

Such are the peculiarities presented by the formidable phenomena of avalanches. They are most to be dreaded at the epoch of the thaw—that is, in spring; in the summer there is less cause to apprehend their occurrence, at least in the region of perpetual snow.

If you are compelled to traverse during the months of spring the defiles of the mighty Alps—sentinelled as they are by ever-watchful snow-helmed peaks—and before the annual landslips have accomplished their predestined work, you must adopt numerous imperative precautions. At such a time of the year, tourists should arrange to travel in small companies, each person at a convenient distance from the other, so that in case any accident happens some may escape, and carry succour to their less fortunate fellows. In dangerous passes, you are recommended to remove the bells from the harness of your animals; to set out at early dawn, before the sun's first rays have attacked the treacherous surface; and to move forward in the most utter silence, to *avoid waking the slumbering lion.** Frequently, the precaution is taken to discharge a pistol at the entrance of a dangerous ravine, for then the concussion of the air produced by the report of the fire-arm brings down all the avalanches on the point of falling.

Some of the Swiss towns and villages are only preserved from the ravages of these awful visitants by the forests which overhang them; and the clearing of the mountains is consequently forbidden by severe laws. In other localities, above the houses exposed to avalanches, men construct a kind of rampart or stone bastion, with an acute angle, intended to cleave and part in twain the monster which may hurl itself upon the barrier. Above some of the dangerous passes of the Splugen, and other Alpine localities, vaulted galleries have been erected for the defence of the traveller.

The reader will not be surprised, after the foregoing details, to learn that history has preserved a record of many of the more signal disasters occasioned in the Alps by the fall of avalanches. We proceed to note a few of them.

In 1478, sixty Swiss soldiers were simultaneously destroyed by an avalanche.

In 1499, four hundred Austrian soldiers were buried under a mass of snow in the Ersebirge; but help was at hand, and they were successfully extricated.

In 1500, an avalanche overwhelmed, in the pass of the Great St. Bernard, a hundred persons.

In 1624, another avalanche, descending from Mont Cassedra, swallowed up three hundred individuals.

In the month of February 1720, at Obergestlen, in the Valais, one hundred and twenty houses were destroyed, and eighty-four persons and four hundred head of cattle perished.

In 1749, an avalanche swept away a great part of the village of Ruaeras (in the canton of the Grisons), involving in the frightful whirlwind a hundred men and women, of whom, however, sixty were eventually saved. So gentle was the descent of this avalanche, that persons living in huts on the side of the mountain were not awakened by the movement; only they fancied that the night was very long, and it

* From the German word *lavine*, the common people have made *lavinne* (a lioness).

seemed as if morning would never break. It was only when they went abroad, and found themselves carried to a considerable distance from the locality they had inhabited on the previous evening, that they comprehended what had passed, and hastened to fly from the impending peril.

In the month of January 1767, an avalanche swooped down upon the valley which lies at the foot of the Dent-de-Jarnan; it overthrew numerous huge firs, swept away a dozen of thriving farms, and passing over an inn in Allières, carried off the upper story, without inflicting the slightest injury on the people collected in the ground-floor apartments.

About the same date, the village of Saint Antœnien was overwhelmed by a fall of snow, and a female, one of its inhabitants, was extricated alive from her house, after having been buried beneath the snow for a whole week.

CHAPTER III.

THE GLACIERS—THE PART THEY PLAY IN THE ECONOMY OF NATURE—THEIR ORIGIN AND MODE OF THEIR FORMATION—THEIR PROGRESSIVE MOVEMENT—MELTING OF THE GLACIERS—THEIR STRUCTURE AND PHYSICAL CHARACTERISTICS.

THE lines defining the limits of perpetual snow, which we have just studied in the preceding chapter, do not circumscribe the Realm of Ice; the sway of the frost-king stretches far below the snowy wastes. We proceed to clear up what there may be of obscurity in this proposition, and to prove that in its terms nothing contradictory exists.

On passing through those great valleys of Savoy and Switzerland which lie at the base of the lofty Alpine peaks, we are surprised, if not pre-acquainted with the fact, to find ourselves suddenly confronted by actual, veritable rivers, which seem frozen in their beds. In the midst of a thriving vegetation, among well-tilled fields and forests of dark green firs, shine enormous masses of ice, which defy the power of the hottest summers. These enchanted rivers are the Glaciers. An inexhaustible subject of admiration for the tourist—the most striking and popular phenomenon of the Alpine world—they have recently become, on the part of naturalists and geologists, the subject of incessant, and, one might almost say, impassioned study, and the discoveries which have thence resulted have guided Geology into an order of ideas of an absolutely novel character, which tend to encroach still further on its old and recognized domain. The existence of a Glacial Period in the history of our globe is not the only discovery with which Science has been enriched through the careful observations made of late years upon existing glaciers; the explanation of the Diluvial phenomena is, perhaps, likely to be advanced in no small measure by a judicious application of the same views.

What, then, is a glacier?

The fortunate spectator who could embrace with a bird's-eye view, or from the chariot of some adventurous aeronaut, the whole of the vast Alpine chain, from the shores of the Mediterranean to those of the Adriatic, would behold nearly every shining and silent peak draped in a dazzling robe of ice, which falls over the vast body of each mountain like a kingly shroud, except when broken here and there by the sharp points of rocks too precipitous to retain the descending snows.

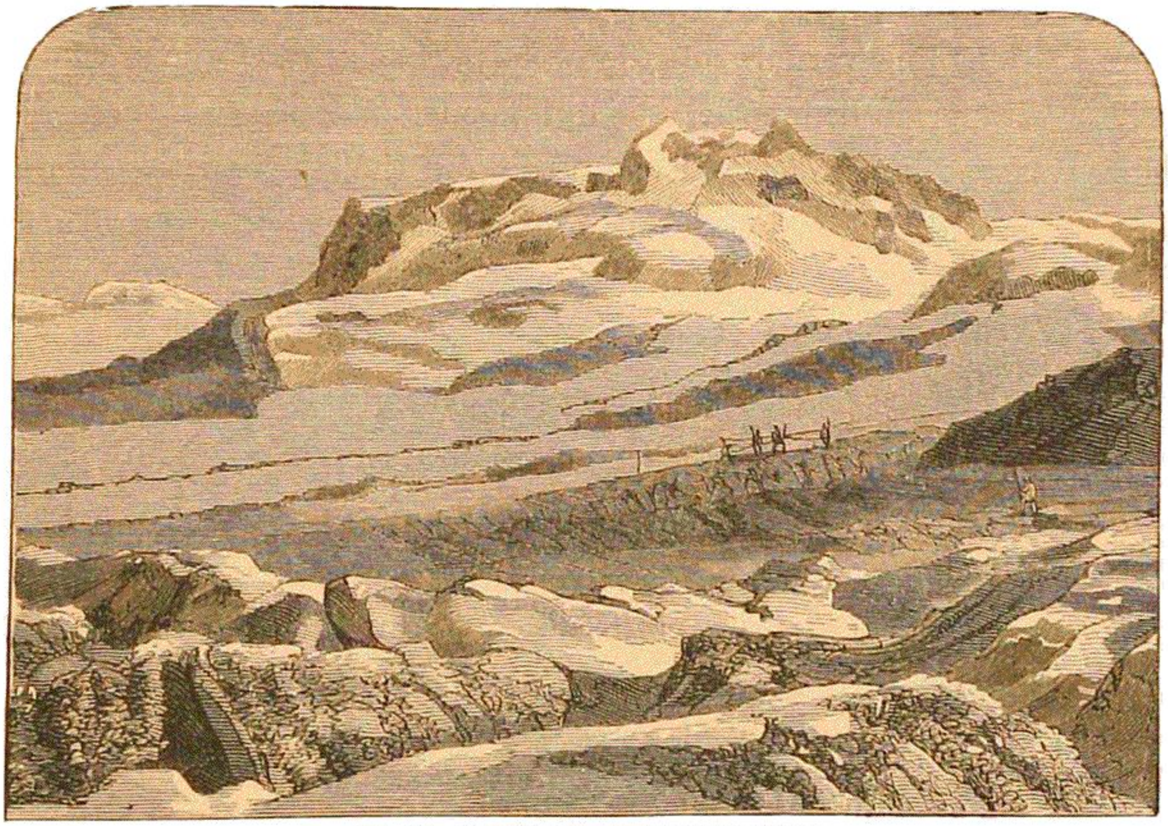

FIG. 97.—THE GLACIERS OF MONTE ROSA.

Beneath, far beneath these towering crests he would mark a labyrinth of narrow valleys, whose inner flanks are rude with furrows of ice, like the fringes or tatters of the silver mantle spread about the summit. He would perceive that these long furrows penetrate to the very heart of the fertile regions which the sons of men call their own. If he removed his gaze from the centre of the Alpine mass, secondary and less important chains, ramifying in every direction, would offer him the same spectacle on a smaller scale. And if his wandering glances descended lower still, he would observe that the ice and snows gradually disappear; that nature loses its savage and inhospitable aspect; that the contours of the soil grow rounder and more softened; and finally, that the smiling vegetation and fairy-like bloom of the plains replace the desolate monotonousness of the bleak fields of snow.

These rivers of solidified water, which, in the Alps, are found wherever the mountain-summits rise above the perpetual snow-line, and which descend into the valleys far below that boundary, perform no unimportant part in Nature's grand economy. On the awakening of spring, Nature, too, awakes; the budding trees announce and prepare the laughing verdure of the woods; everywhere the gloom of winter disappears before the genial influence of April. The glaciers alone respond not to the warm embraces of the sun, and the summer heats apparently play upon their impassive surface without producing any impression.

But when we reflect that these long, motionless, frozen rivers descend unbrokenly from the region of eternal snows, we easily divine that their origin must be sought, no less than their sustenance, in the remote recesses of the mountain-summits. The glaciers are the advanced guards despatched from the inaccessible heights where reigns Eternal Winter; they are the emissaries of those powers of frost which clothe in snow and ice the supreme elevations.

The snow which falls on the loftier mountains never melts; it preserves its condition of solidity upon all rocks whose temperature never rises above zero. The masses which are thus accumulated, year after year, would eventually, one might say, threaten the very sky; they would gather in ever-succeeding strata on the summits, and deprive the plains of the benefit of their waters, if provident nature had not guarded against so evil a result. And it guards against it by the formation of glaciers. A glacier is immovable only to the eye; in reality, it is endowed with a progressive motion. This motion is miraculously slow, and in this very slowness of progression rests the providential intention of the phenomenon. Little by little the glaciers advance into the valleys; there they undergo the influence of the mild temperature of spring and summer; they melt away at their base; and in this manner create inexhaustible springs and innumerable water-courses. Ascend the bed of an Alpine torrent; follow it up the course of the miry ravine which encloses it, and you will come upon a glacier. A glacier is, in fact, neither more nor less than a vast reservoir of congealed waters, which melt very slowly, and drag on their lingering way into the lower valleys, where they form a rapid stream or broaden into a noble river. And if we would unveil the whole series of nature's operations in this branch of her chemistry, we must add that, in the plains and the valleys, the heat of the sun, evaporating the water of brook and river, returns it to the atmosphere in the condition of *vapour;* which, after awhile, descends again to earth in the form of *snow*, to be anew converted into ice, and then into vivifying springs; accomplishing thus the most complete and marvellous circle of natural operations, a circle everlasting, which, like its Author, has neither beginning nor end.

We have said that the glaciers are gifted with a slow progressive movement, which apparently represents the final cause of their existence.

It is singular that a phenomenon so impressive should have long escaped the observation of mankind. Yet, most undoubtedly, it has only been detected within a comparatively recent period. De Saussure had remarked it, and recorded the fact in his great work; but the world of science attached no importance to it.* To an unlettered

* We quote from Saussure's Travels the following illustrative passage :—

"Another cause which efficaciously opposes the excessive accumulation of the ice and snows, is their excessive weight, which drags them with greater or less rapidity down into the low valleys, where the summer heats are sufficiently strong to melt them.

"It is the slow but continuous gliding motion of the ice on its inclined base which propels them into the lower grounds, and continually piles up masses of ice in valleys warm enough to produce great trees and even fertile harvests.

"In the bottom of the Chamounix valley, for instance, no glacier is formed; even the snows disappear there in the months of May or June; and yet the Glacier des Bossons, the Glacier des Bois, and the Glacier d'Argentière, descend into the depths of their respective valleys.

"But the lower ice of these great glaciers was not formed in the valleys; and they carry with them, as it were, a certificate of their place of birth in the fragments of rocks embedded in their bulk, which belong to the uppermost extremity of the valley of ice; these rocks being composed of strata whose like cannot be found in the mountains bordering the lower extremity of this very same valley."—DE SAUSSURE, "Voyages dans les Alps," ii. 251.

Valais guide, modern physicists are indebted for its fundamental observations.

This was in 1817. A geologist, whose glacier studies were one day to render him famous, M. de Charpentier, strayed in the course of his excursions into the hut of Jean Perraudin, a guide of the Valais, and a redoubtable chamois-hunter. A storm detained him in this cabin a whole night. Seated before a glowing cheery fire, geologist and hunter began to talk. The former explained to his companion that chance had conducted him thither; then the theories in vogue among men of science, by which they endeavoured to explain the mode of transport of *erratic blocks;* that is to say, of those boulders detached from their parent mountains which are frequently met with at great distances from their birth-place. The geologists of the first quarter of the present century referred their removal to the action of currents of water.

"Why," then said the mountaineer,—"why do you invent your deluges and torrents, and load them with rocks evidently too heavy to be carried by them? Is it not more reasonable to conclude that these stony masses were transported by the glaciers, which are every day transporting similar masses under our very eyes?" An explanation so categorical greatly surprised M. de Charpentier. It was so opposed to the theories then accepted by geologists, that he meditated upon it for eighteen years, while closely studying the characteristics of the glaciers. It was not until 1834, and before a meeting held at Lucerne by the Swiss naturalists, that he made known the results of his protracted investigations.

Already, before this date, an intrepid Alpine explorer, Hugi, of Soleure, had made a very important and decisive experiment. In the summer of 1827, he had had constructed, on the edge of the glacier of the Lower Aar, a small hut of stone; supporting it against a kind of promontory, named the *Abschwung*, and verifying at intervals its exact position. In 1830, he found that it had descended about 320 feet lower; in 1836, it had accomplished a distance of 2300 feet. In 1840, it was sought out by Messrs. Agassiz and Dessor, who discovered it at a point 4650 feet below the promontory. In a bottle hidden under some stones, they found the manuscript notes of Hugi's earlier observations. In the following year, Agassiz ascertained that a further removal of 210 feet had taken place. Thus, in a period of thirteen years, Hugi's hut had descended about 4850 feet, or at a rate of 373 feet per annum.

To study these phenomena more completely, Agassiz passed two

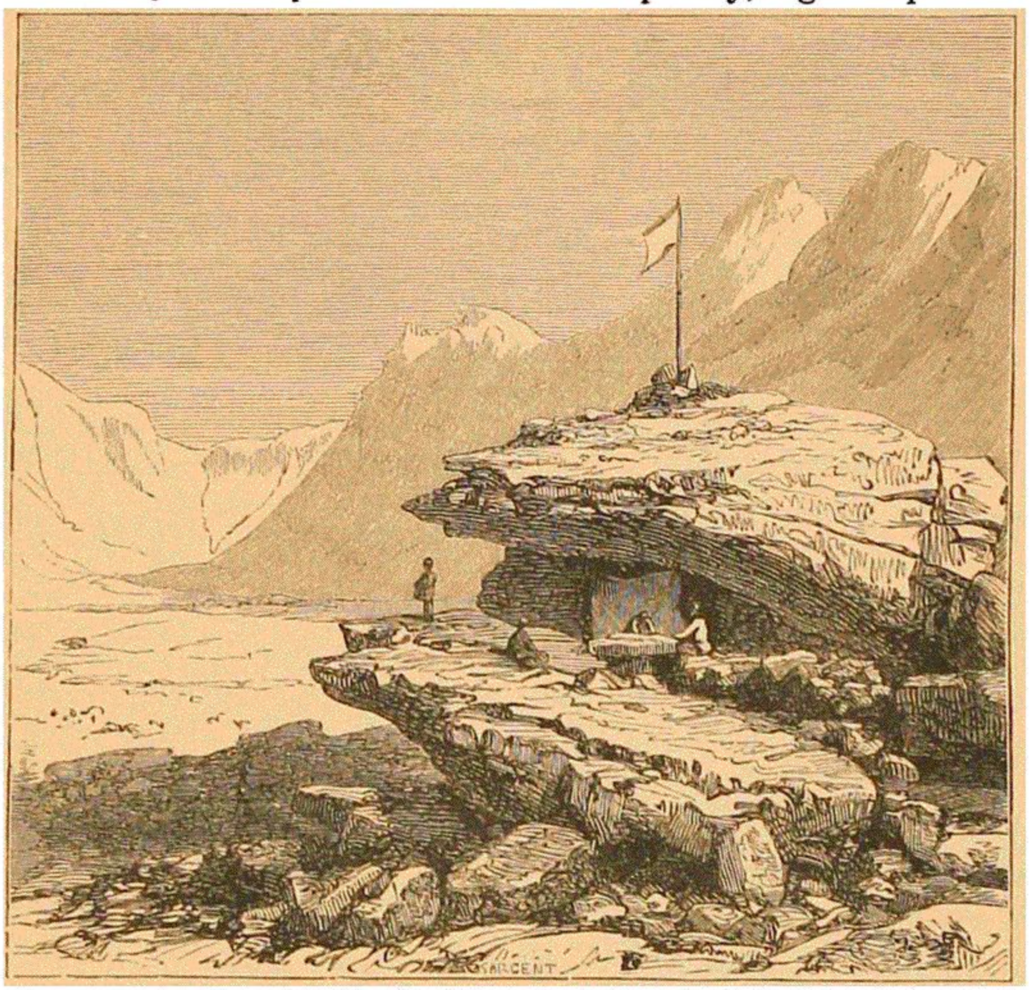

FIG. 98.—THE HOTEL DES NEUCHATELOIS.

summers in the midst of the icy regions of the Alps. He took up his abode on the glacier of the Unteraar (or Lower Aar), at a point 2120 feet above Hugi's hut, and 8850 feet above the sea-level. To shelter it, he chose, in the centre of the moraine, an enormous erratic block. Under this roof of stone M. Agassiz caused a rude dwelling to be constructed, which he designated the *Hôtel des Neuchâtelois*, and which under this name enjoyed a prolonged reputation. The kitchen was situated beneath a projecting corner of the rock; the bed-chamber was hollowed out in the ice beneath; and a bed of stones, covered with hay, served as a bed for our patient explorer. A flag-staff and a waving banner denoted the position of the *Hôtel des Neuchâtelois* to distant observers.

In this dreary solitude Agassiz endured for two summers the rudeness of an Alpine climate, that he might snatch from nature some of her secrets. On his ambulatory block he inscribed the distance to the promontory of the Abschwung in 1840, a distance of 2600 feet (797 metres): to-day it must be considerably greater, since the rate of translation of the glacier to the point where the hotel was situated, has been ascertained to be, on an average, 235 feet per annum.

At the time that Charpentier made public his views upon glacier-motion, Hugi's discovery was not known, though we can give no reason for the secrecy in which the brave explorer had concealed it. However that may be, Charpentier's hypothesis met with no very favourable reception from the scientific celebrities assembled at Lucerne, and was even loaded with ridicule by most contemporary geologists.

The truth, however, was not long in coming to light. Courageous explorers and *savants*, such as Dessor, Venetz, Martins, Leblanc, Edward Collomb, Dolfus-Ausset, and others, established themselves, for months, on the frozen plains, with the view of definitively solving what was felt to be an important problem.

The issue of their investigations and experiments was to establish as an undoubted fact the Progressive Movement of Glaciers; and, at the same time, to throw a flood of light upon their properties. In these *solid rivers* were discovered various physical characteristics of an exceedingly curious nature. In fine, from the profound knowledge which has thus been acquired of the traces impressed upon the rocks by the transit of these colossal masses, we have re-ascended in the history of the terrestrial globe, and proved that they formerly extended far beyond their present limits in the Alps, the Jura, Scotland, and the whole of northern Europe.

Thus was introduced into modern geology the idea of a glacial period; one of the definite acquisitions made by that great science, and one which every day tends to occupy in it a more important place.

After this rapid historical sketch of the scientific labours originated by the glaciers, we proceed to the analytical study of their phenomena: considering—

1st, The Mode in which they are formed;

2nd, Their Downward March; and

3rd, Their partial Liquefaction.

THE MODE OF FORMATION OF GLACIERS.

A glacier is, in fact, a *frozen river*, whose consistency is greatest at its point of termination. It begins in snow; it ends in ice, which is distinguished by the purity of its colour and the minuteness of its crystallization.

As we have already stated, the snow which falls on the mountains above the limit of perpetual congelation, never melts; it accumulates in every hollow, every depression of the soil. The water produced by its superficial fusion during the warm days of summer filtering slowly into the inner mass, and then congealing anew during the night, the snow passes into a condition known as the *névé*; a kind of intermediate substance between snow and ice, a granular mass composed of rounded and agglutinated crystals, closely compacted by the pressure of the superincumbent layers.

The density of the *névé* holds a medium between that of snow and that of ice; while a cubic yard* of snow weighs about 285 lbs., a cubic yard of compact ice weighs 1960 lbs., and a cubic yard of the *névé* varies between 660 and 1300 lbs. Thus:—

Water, cubic yard of, weighs	... ...	2,400	lbs.	
Ice, ,, ,,	.. ..	1,960	,,	
Snow, ,, ,,	... ...	285	,,	
Névé, ,, ,,	... ...	980	,,	(mean weight).

The line of demarcation between ice and the *névé* is not very well defined. According to the degree of pressure it undergoes, it passes

* More correctly, a mètre, which is equal to 39.37879 English inches.

successively through a series of phases characterized by different densities; it becomes, in the first place, *glace bulleuse* (enclosing air-bubbles, *bulles*); then *white granular* ice; and, finally, *compact blue ice*, which latter forms the substance of the glaciers.

In the Alps there falls about 60 feet of snow yearly, which is equivalent to a stratum of ice two yards thick.

In those lofty regions, the solar heat is powerless to melt such a quantity of solid water; consequently, every year a residuum or *stock* of ice is left, which composes the nucleus or kernel of the glaciers. Heaped up, one upon another, these annual layers would eventually gather into considerable mountains, had not far-seeing nature guarded against such a contingency by the progressive movement of which we have spoken, and which is nothing more than the slow, continuous

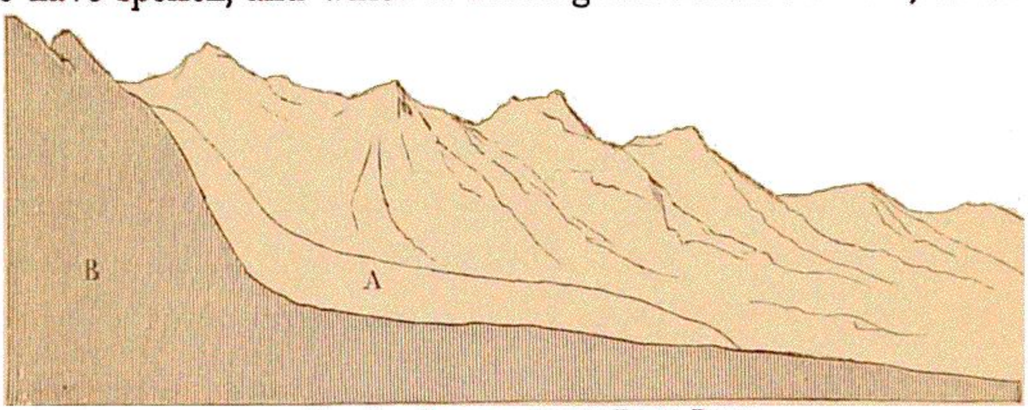

FIG. 99.—GLACIER OF THE FIRST RANK.

descent of these enormous masses on the inclined plane of the mountain. And by degrees, as they descend, they are eaten away at the base by the warm temperature of the valleys.

Saussure has divided them into *glaciers of the first* and *second rank.*

Those of the *first rank* descend from the loftiest chains, and fill up the higher valleys; their surface is sometimes nearly horizontal; and they are then named *Mers de Glace* (seas of ice). Such is the *Mer de Glace* of the Mont Blanc chain. There are some of these ice-seas 22,000 to 28,000 yards in length—larger than not a few of the Cumbrian lakes. Their base descends to an altitude of 6100 or 3900 feet.

The *glaciers of the second rank* do not descend into the valleys;

they remain suspended on the mountain-sides, and possess only on a diminished scale the characteristics of the great glaciers. In Spain no glaciers are met with but those of the inferior order.

Our illustration, Fig. 99, is an ideal section of an Alpine glacier, in which A represents the glacial mass descending from the mountain into the valley.

Figure 100 is a hypothetical section of the Glacier de la Maladetta, in the Pyrenees. A represents the glacier hanging on the mountain-acclivity; B the granitic soil of the Maladetta.

We shall here concern ourselves with *glaciers of the first rank* only.

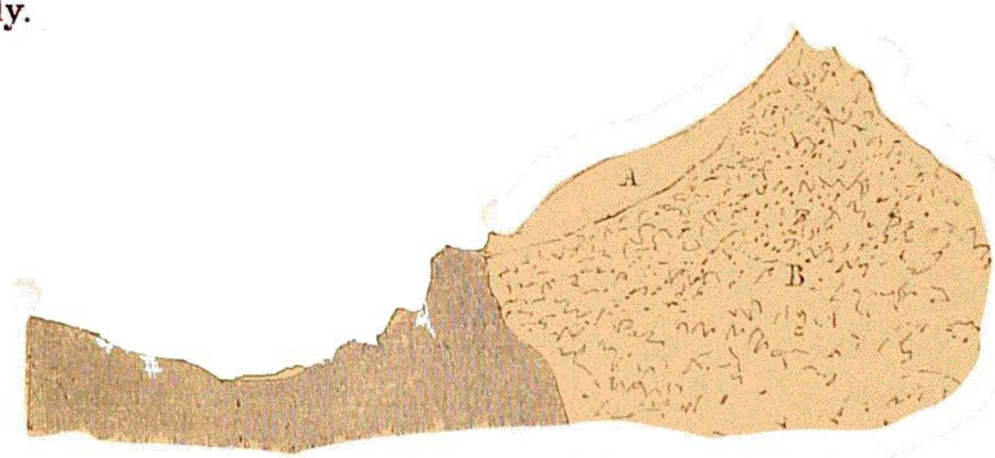

FIG. 100.—GLACIER OF THE SECOND RANK.

The orographical configuration is of great importance in the formation of glaciers. The first condition is the existence, at the upper end of a valley, of a large ravine, situated 8500 feet above the sea; for it is only at such an elevation the snows can accumulate and store themselves, when the mountain-side is swept by the winds. At a temperature of 44° F. or 50° F. above zero, the snow becomes dry, powdery, and as mobile as the desert-sand; it does not concentrate, or adhere, but is scattered abroad by every gust of wind. This is the reason why smooth and isolated mountains afford no opportunity or vantage-point for the formation of great glaciers, while the Alps, being broken up and fissured in every direction, afford all the necessary conditions for retaining and consolidating those mighty masses.

The inclination of a glacier generally depends on the inclination of the ground it traverses; it moulds itself upon all the irregularities it meets with. The plane of glaciers of the second rank is therefore necessarily steeper than that of the great glaciers which fill the valleys.

Some attempts have been made to estimate the surface and volume of a few remarkable glaciers. It has been found, for example, that the glacier of the Aar presents, on a length of 8800 yards, a superficial area of 9900 to 11,000 square yards; its maximum thickness has been computed at 1500 feet, but it decreases rapidly to about 200 feet. Assuming its average density at 820 feet, it has been calculated that the volume of this part of the glacier is equal to 2200 or 3300 cubic yards. The contents of the glacier of Aletsch are put at 26,250 cubic yards.

In Switzerland there are more than 600 glaciers: 370 in the basin of the Rhine; 137 in the basin of the Rhone; 66 in that of the Inn; 35 in the basins of the rivers which pour their tributary into the Adriatic. The naturalist Ebel has essayed to value approximately the total area of the ice-rivers of Switzerland. He has found that the Swiss portion of the Alpine chain between Mont Blanc and the rugged heights of the Tyrol contain a glacial surface of 138 square leagues. Hence we may conceive some idea of the fundamental part played by the glaciers in feeding the principal European rivers.

You must not figure to yourself, O reader, a glacier as a compact and homogeneous body; it is, on the contrary, a *felted* mass (*une masse feutrée*), composed of an infinite number of blocks or fragments of rough, hard ice, hollowed by a network of fissures and ducts in which the water may freely circulate. Hence that plasticity and softness of the glaciers which are evidenced by their assuming the outlines of the soil beneath them. This property which they possess of folding and transforming themselves, is also due to the yielding character of ice when maintained at a constant temperature of zero—the ordinary temperature of the interior of the frozen bulk. The searches of Agassiz, Dessors, and Forbes have brought us acquainted with the fact that the temperature of the glaciers seldom rises above zero, or sinks below it. The savants of the *Hôtel de Neuchâtelois* obtained this result by introducing *thermometrographs* into the sounding-holes which they had pierced in the ice.

The permanency of this temperature is partly attributable to the thick mantle of snow which covers the surface of the glaciers during the greater part of the year, and protects it from the atmospheric heat.

Another interesting phenomenon, and one which has caused considerable discussion, is the *stratification of the glaciers.* It has been a recognized fact, since the days of Saussure, that the superior *névés* are arranged in horizontal strata of about 7 to 10 feet in thickness; the existence of these strata is known through the *zones d'affleurement*—the sectional elevation—at the limit of the glaciers, and at those points where the interior of the mass is laid bare in the crevasses or fissures. Each strata corresponds to one heavy fall of snow, and several are generally formed in the course of a single winter. The fresh-fallen snow is soon glazed over with a thin layer of frost, on which the air deposits a quantity of vegetable or mineral dust. Hence the dull gray colour which, in the *névés,* indicates the separation of the strata.

But this stratified structure is not confined to the névés; it is conspicuous in every aspect of the glacier, and accompanies it in its evolutions; only the strata rise in proportion as the glacier descends, and towards the centre they become almost vertical, afterwards to incline anew, and resume the horizontal towards the terminal escarpment or *talus.* This change in the inclination of the strata lies like a bugbear in the path of the partisans of Agassiz, who assert that the primitive stratification of the *névés* is preserved when they pass into the condition of compact ice.

Agassiz attributes these differences of inclination to an actual *straightening* of the icy strata which descend the mountain-side. According to him, the strata are raised, towards the central region of the glaciers, by means of an accelerated movement of the lower beds, and are again inclined by the retardation arising from their friction against the ground. These hypotheses require proof; it seems particularly difficult to admit the acceleration of the lower strata, which M. Agassiz puts forward in explanation of the vertical direction of the strata in the heart of the glaciers. It appears to us more natural to suppose, with Forbes and Schlagintweit, that the mass of the *névés,* at the moment it is transformed into ice and commences its "facilis descensus," splits across, and easily gapes open, in such a manner as to present transversal crevasses, which promptly infiltrate the snow-water, and produce the vertical strata of blue ice alternating with the strata of white and aerated ice. As the glacier descends, these strata, by virtue of the unequal swiftness of their different parts, ridge up and swell in a downward direction, and the *zones d'affleurement,* or *stripes* then visible on the surface, assume an ogival form, whose convexity is turned towards the foot of the glacier. These ogives are composed of convexities of blue ice alternating with furrows of powdery whitish ice, where sand and dust incessantly make their deposits, and communicate the sombre tint easily recognizable at a distance. Professor Forbes calls them *dirt-bands.* They are detected with special facility in a time of thaw, and the veins of azure ice are then remarkable for their transparency.

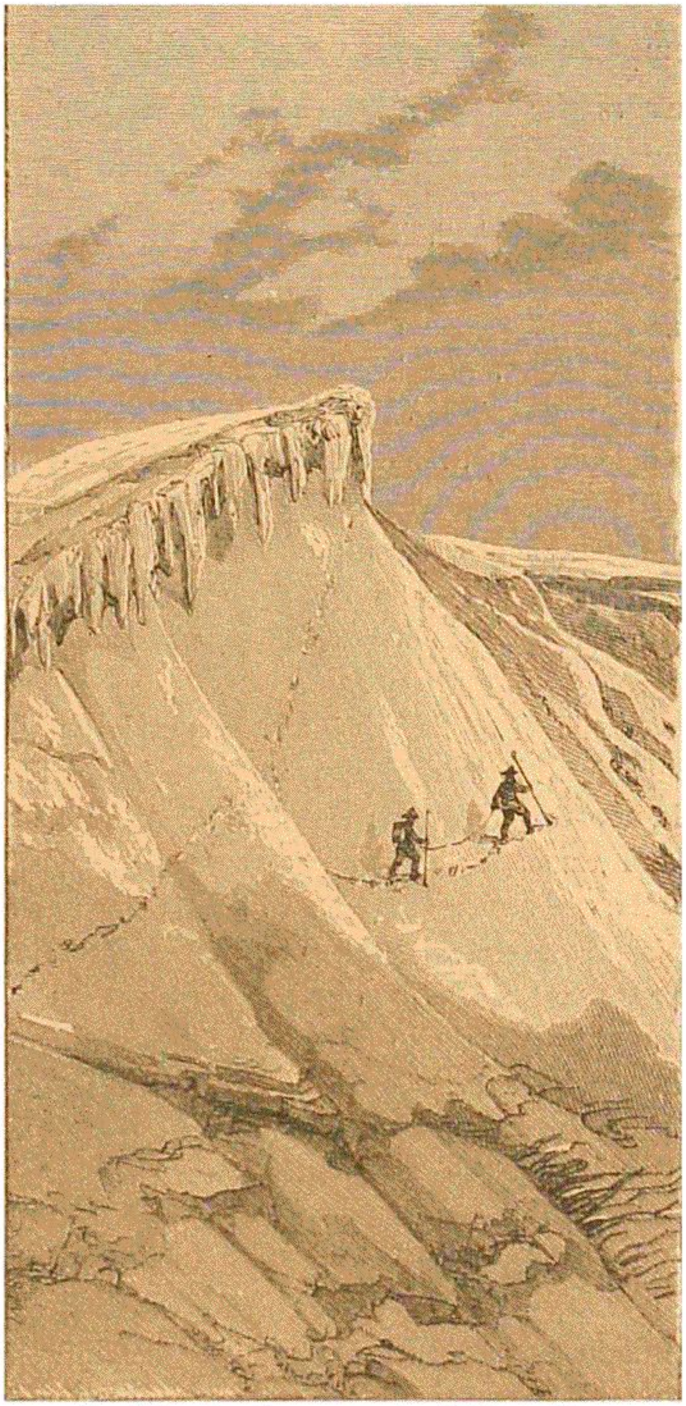

FIG. 101.—THE GLACIER OF THE SCHWARZ-THOR.

At various points of its surface a glacier is always intersected by a great number of crevasses, differing immensely in width. Generally perpendicular to the direction of the strata, they originate in the unequal movement of translation of the glacier, and in the tension thereby produced at certain points of its bulk. Consequently, they are most numerous wherever the general inclination abruptly changes, or where an angle or an escarpment occurs. They are formed suddenly, and sometimes with a noise like the report of artillery; the ice shivers, and then splits across to a considerable extent, sometimes slowly, and sometimes with a simultaneous shock. During the summer the crevasses are enlarged by the gradual melting away of their sides, until they become great yawning abysses, which surround with new perils the path of the adventurous explorer.

After a fall of snow, they are not infrequently spanned by a bridge of only a few inches in thickness, which conceals their perilous character, but is not of sufficient consistency to bear the foot-tread of a man. Over such treacherous traps the traveller must necessarily proceed with the greatest caution, constantly sounding the soil with his iron shod staff, and implicitly obeying the directions of his guide.

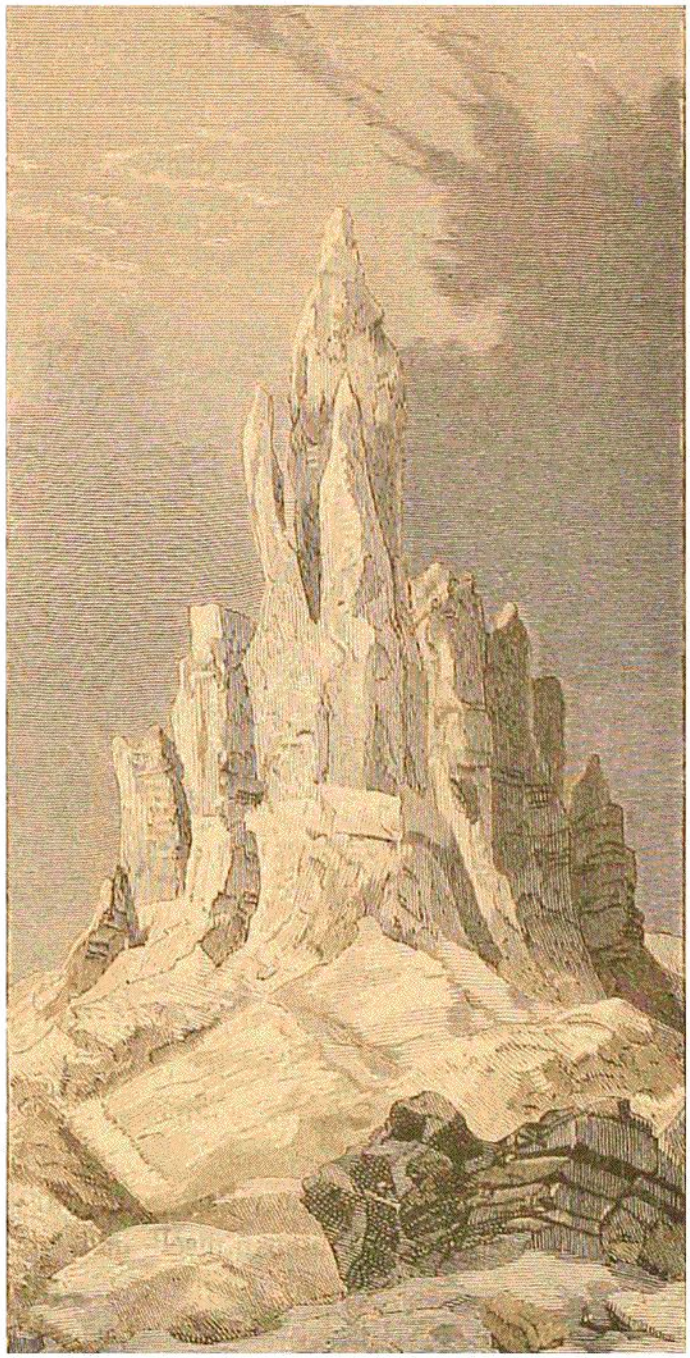

FIG. 102.—AN "AIGUILLE," OR NEEDLE OF ICE.

In a few rare cases the crevasses extend downward to the very bottom of the glaciers; they then constitute a complete rupture of the entire mass. Such may be seen, in the summer months, at the source of the Aar.

When numerous crevasses strike across one another at the same point, the ice divides into an infinity of prisms and "needles," which alternate, break up, and disappear under the destructive influence of the atmospheric agents, or melt into chaotic groups of the most fantastic outline. In Professor Tyndall's "Glaciers of the Alps"—a work of pre-eminent merit and great vigour of style—may be seen a drawing of one of these capricious formations, discovered on the Glacier des Bois, the terminal part of the Mer de Glace of Mont Blanc.*

* Tyndall, "Glaciers of the Alps," p. 316.

It is to the same cause we must attribute the formation of those "needles" (*aiguilles*) of ice, confusedly heaped together, and varying in height from 48 to 65 feet, which beset the base of the Glacier des Bossons, above the Chamounix valley, and are locally named *Pyramids.*

The names of the travellers, tourists, or guides who have perished in the crevasses of the great glaciers would form a dreary death-roll. The Alpine mountaineers preserve the memory of many of these melancholy events, of which we can here recall only a few of the best known.

During the summer of 1790, an inhabitant of the Grindelwald, one Christian Bohrer, was conducting a flock of sheep across the glacier named after that romantic village. On arriving at the border of the upper glacier, he slipped into a crevasse not less than 400 feet in depth. The horrible fall deprived him of consciousness. On recovering his senses, he found himself in a kind of twilight gloom, between two precipitous walls, and in the immediate neighbourhood of a brook fed by the melting snows. The murmur of the water revived his courage; and dragging himself along upon his knees, he commenced to ascend the stream. It was not until after several hours of painful exertion he regained the blessed light of day, and found himself at the foot of the Wetterhorn, where the brook was swallowed up in the ice. Then he discovered, for the first time, that his left arm was broken. In the evening he arrived at Grindelwald, having effected a miraculous escape from the frightful situation in which he had seemed a hundred times in face of immediate death.

On the 31st of August 1821, a Protestant pastor of Neuchâtel, named Mouron, found himself on the same Grindelwald glacier. He was leaning over a crevasse, to admire the azure gleams of its resplendent walls, supporting himself against a pole which he had fixed in the opposite side, when suddenly the pole slipped, and the poor wretch was precipitated headlong into the abyss. His guide, in an agony of terror, made haste to the village to give information of the sad event. But no other person than the guide himself had witnessed the pastor's fall. Suspicions arose; it was hinted that he had first robbed the traveller, and then flung him down the crevasse. The Grindelwald guides could not endure that one of their number should rest under so dark a cloud, and decided that they should draw lots for one of them to descend into the gulf, in search of the corpse of the unfortunate minister.

The lot fell upon Pierre Burguener, one of the most stalwart and bravest of the villagers. A rope was fastened round his waist and under his shoulders, and four men lowered him into the crevasse, with a lantern suspended to his neck, holding in one hand an iron-shod staff, and in the other a signal-bell. Twice on the point of suffocation, Burguener gave the signal for raising him; but succeeded finally in recovering the mutilated body, though at the peril of his life. He was then dragged up to the surface, with his melancholy burden.

The pastor's watch and purse were found upon his person, and the guide was cleared from all suspicion.

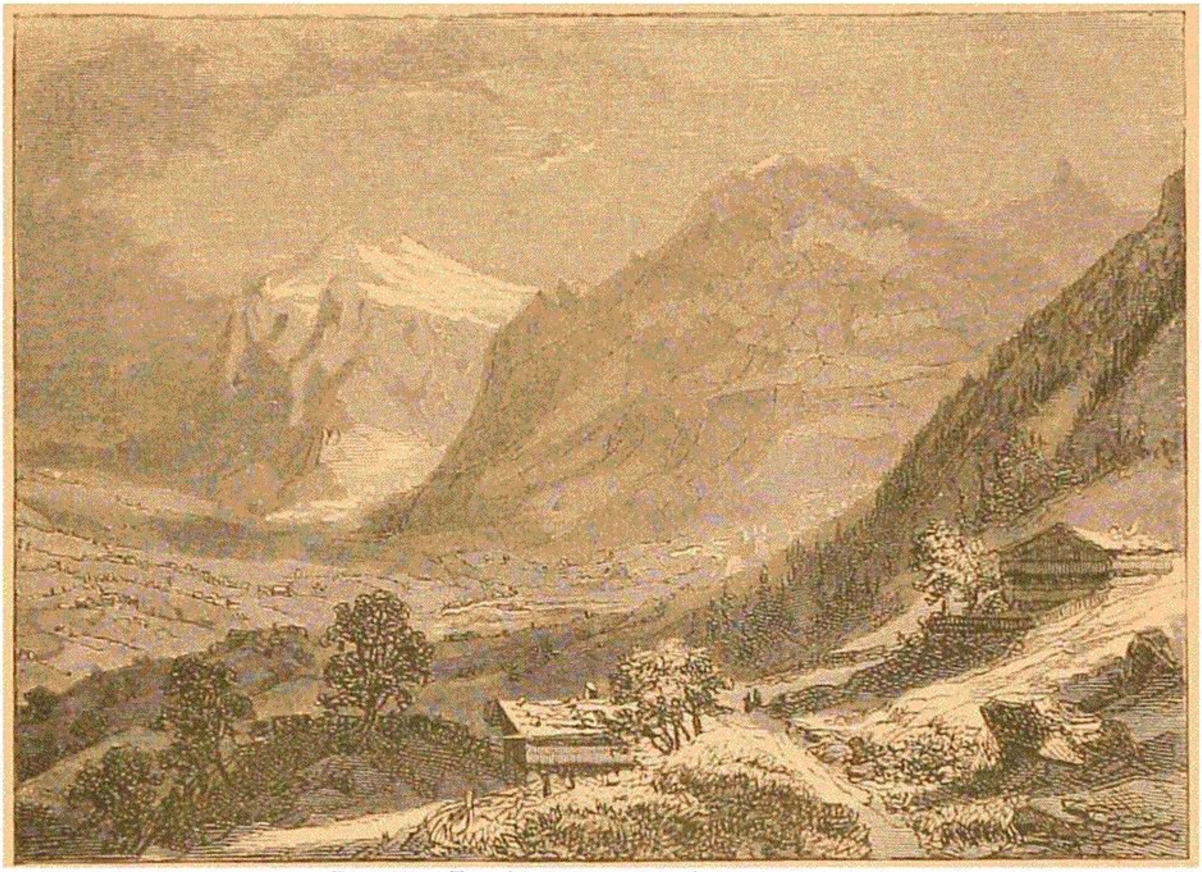

FIG. 103.—THE GLACIER OF THE GRINDELWALD.

His body was interred near the gate of the Grindelwald church, under a tombstone which records in brief phraseology the manner of his death.

In 1864 Dr. Burstenbinder, of Berlin, met with the same fate on the glacier of Oetzthal. He was alive when extricated, but died a few hours afterwards.

On the 7th of August 1800, a young Dane, the poet Esher, perished in the Glacier de Buet. Despite of the repeated warnings of his guide, he had set out, accompanied only by a friend, and keeping always a few hundred yards in advance, when suddenly he disappeared. His friend fled to Savoy in search of help. The unfortunate young man was found at the bottom of a crevasse 100 feet in depth, standing upright, his arms raised above his head, and the body completely stiffened by the twofold rigour of death and of the shroud of ice enfolding it.

In 1836, the guide Devoissous fell into a crevasse of the Glacier de Talèfre, in the Mont Blanc chain. A man of great physical energy, he succeeded in effecting his deliverance by cutting steps with his knife in the icy wall of the crevasse.

MOVEMENT OF THE GLACIERS.

We have spoken, in general terms, of the phenomena of the glacier movement, which has been measured with the most scrupulous exactitude by the Swiss and French naturalists.

The movement of translation of a glacier is not uniform throughout all its parts. Its different sections are animated by different rates of swiftness. The medial line, where the density and the incline are greatest, moves with the greatest rapidity. The minimum speed is found at the edges, that is to say, at points where the mass is thinnest, and where the greatest resistance is offered by the friction of the channel in which it moves. Agassiz and Dessors have measured with great preciseness the ratios of the movement of the different parts of the Glacier of the Aar, by planting on its surface a series of poles, whose motion they compared by referring it to objects fixed on the surrounding rocks.

A row of these poles, planted in a straight transversal line of 4400 feet in length, described in the course of a twelvemonth a curve of ever-increasing convexity. Here are the figures which express, in yards, the mean displacement of each of the poles composing the line we speak of:—

5 ... 20 ... 48 ... 55 ... 62 ... 64 ... 67 ... 69 ... 79 ... 68 ... 64 ... 54 ... 47 ... 39 ... 21 ... 11 ... 1.

The reader will observe that the central points advanced annually at the rate of about 70 yards, while the lateral made but a very inconsiderable progress.

By arranging these landmarks on the medial line of the glacier, the Swiss physicists have ascertained that the medial portion descends about 70 to 77 yards yearly, while the terminal *talus*, or base of the glacier, does not accomplish more than 30, and the upper part more than 40 yards.

Professor Forbes * has confirmed these results by his observations on the Mer de Glace and the Glacier des Bois. He ascertained that

* Professor Forbes, "Occasional Papers on the Theory of Glaciers."

a block situated on the lateral portion of the glacier descends at the rate of 185 yards per annum, which would give a progressive motion of fully 250 yards yearly for the centre.

Glaciers of the second rank move much more slowly; their annual displacement scarcely exceeds 25 yards.

Moreover, a sensible influence is exercised on this displacement by the seasons. It attains its maximum of speed in the spring, and decreases as the winter draws nearer. On the other hand, accidents of soil also modify the rate of advance. Professor Tyndall proved, in 1857, that the whole eastern side of the Mer de Glace moves more quickly than the western.

The movement of progression of the glaciers is arrested by the fusion which takes place at their base in the valleys, but is only partially arrested by this cause. It is an established fact that most existing glaciers are positively advancing at their base. Their sources of supply above counteract their destruction from below. The glaciers of Aletsch, of the Aar, of Grindelwald, descend with majestic certainty, though with stately slowness, towards the green valleys lying at their feet, and destroy by their irresistible inroads the forests of larch and fir they encounter on their path.

"The encroachments of the Alpine glaciers during the last centuries," says M. Hogard, "appear to be as incontestably demonstrated by historical documents as their recent and actual invasions are proved by the undeniable traces of their incessant destruction. Vast breadths of pasture are laid waste, forests of ancient trees invaded and demolished, and, finally, isolated châlets or groups of houses, formerly situated at considerable distances from these masses of ice, are incessantly attacked, overthrown, and devastated under our eyes. Will this progressive march one day slacken, and that in an immediate future, before new calamities shall have fallen heavily on populations already threatened or sorely tried? No one can venture to affirm it."

One would be inclined to believe that this extension of the glaciers is due to a gradual cooling of our hemisphere. And, moreover, a careful observation of the glacier-system shows that they not only advance from above to below, but also extend laterally, expanding from beneath by encroaching on their banks.

We now arrive at the consideration of one of the most characteristic features of the glaciers—that is to say, the *Moraines*.

All the glaciers carry on their surface and propel before them the débris of rocks, frequently of colossal size, detached from the mountain declivities by the action of the atmosphere, the fall of avalanches, and also by the very movement of the glacier. Composed of granite and porphyry—rocks pre-eminently liable to change—the sharp Alpine summits, exposed to the constant influence of atmospheric action, are incessantly broken up, and reduced into fragments of greater or lesser dimensions, which fall on the surface of the glacier. In their movement of progression the glaciers carry away these débris. New rocks, falling at the same point, place

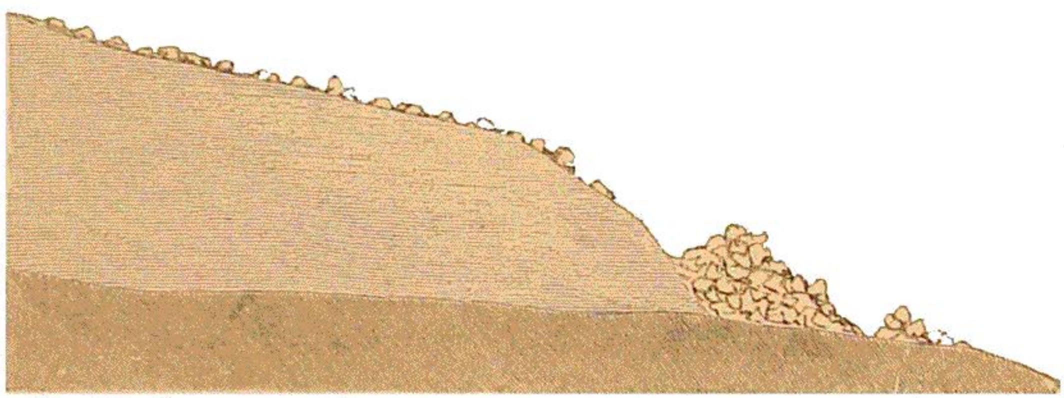

FIG. 104.—LONGITUDINAL SECTION OF A GLACIER, EXHIBITING A FRONTAL MORAINE.

themselves in the rear of the former, and march in their track. In this manner certain longitudinal ridges have been formed, which the mountaineers of Switzerland have named *moraines*. When the débris fall simultaneously from the two mountain ramparts which shut in the glacier, the moraines eventually arrange themselves in two parallel belts, which may be likened to the wheel ruts of a cart filled in with stones.

To give an example, taken from nature, of a simple and well-defined moraine, we represent in the subjoined illustration (Fig. 106) the glacier of Zermatt, in Switzerland.

The moraines conspicuous in this glacier are called *lateral.*

Another kind of moraine, the *frontal*, originates under very different conditions.

When the stones of a moraine have been carried, by the slow-moving river of ice, to its point of termination ; when, after a longer or shorter traject, the rocks thus borne onward reach that part of the valley which marks what may be called the "mouth" of the glacier, and there accumulate in frequently enormous piles and ridges, in a kind of Titanic rampart—that is, in other words, a *Frontal Moraine* (See our illustration, Fig. 104).

An example, taken from nature, is shown in the next illustration (Fig. 105)—the moraine of the glacier of the Ober-Aar—which is

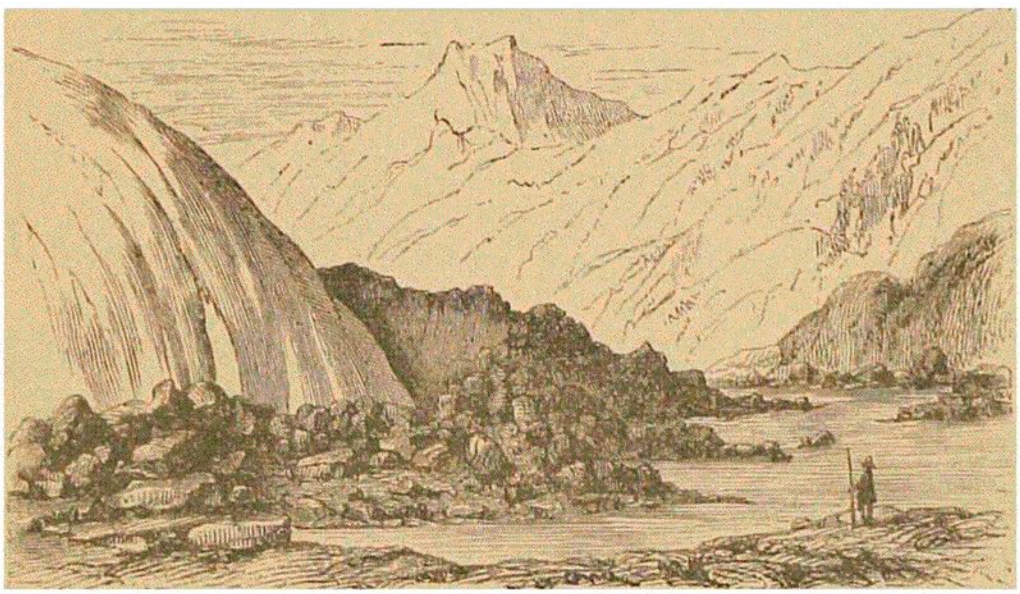

FIG. 105.—FRONTAL MORAINE OF THE GLACIER OF THE OBER-AAR.

composed of granitic detritus cast down from the Ober-Aar-Horn, the Grünhorn, and the Rothhorn.

When two glaciers meet one another in a common channel or bed, their lateral moraines unite, and blend in a single ridge—a *Medial Moraine*—which runs straight in the centre of the mass produced by the fusion of the two separate currents of ice.

A fine example of these medial moraines may be seen in the central portion of the glacier of the Aar. Here the explorer observes the re-union of the glaciers of the Finsteraar and Lauteraar in a single bed, into which also descend the glaciers of the Thierberg and the Finsterberg, like the tributaries of a noble river. The medial moraine of the glacier of the Unteraar is formed by the fusion of the lateral moraines of the two former glaciers, at the foot of the promontory of the *Abschwung*, to which we have already referred.

As an example of the medial moraines, and a view at the same time of one of the most magnificent mountains in the whole world, we represent, in Figure 107, the glaciers which rise at the foot of Monte Rosa—the famous peak on the southern slope of the Alps, only 350 feet inferior in elevation to Mont Blanc itself.

In concluding our examination of the details connected with the

FIG. 106.—GLACIER OF ZERMATT. (*From a photograph by Ferrier.*)

movement of the glaciers, we have to speak of the physical traces they leave upon their passage—that is, of *striated pebbles* and *roches moutonnées.*

One easily understands that the glaciers, by virtue of their enormous weight and continuous movement, must exercise upon the rocks supporting or inclosing them a very considerable friction, and imprint the lasting marks of their powerful action. But ice alone would not produce all the effects we observe. These effects are due, before all, to a layer of pebbles, sand, and mud, which ordinarily separates the ice from the underlying soil, and which acts like emery-powder under the polishing-iron. Thanks to this stratum of detritus, the glacier levels the asperities of the rocks, rounds and polishes them as if they had passed under the hand of the marble-cutter. At the same time the fragments of hard stones which the ice and mud drift along engrave more or less superficial streaks, and even profound furrows, on the rock over which the immense slow-moving roller glides.

The pebbles, blocks, and fragments of stone, found embedded beneath the glacier, and forming there interior moraines, are pressed,

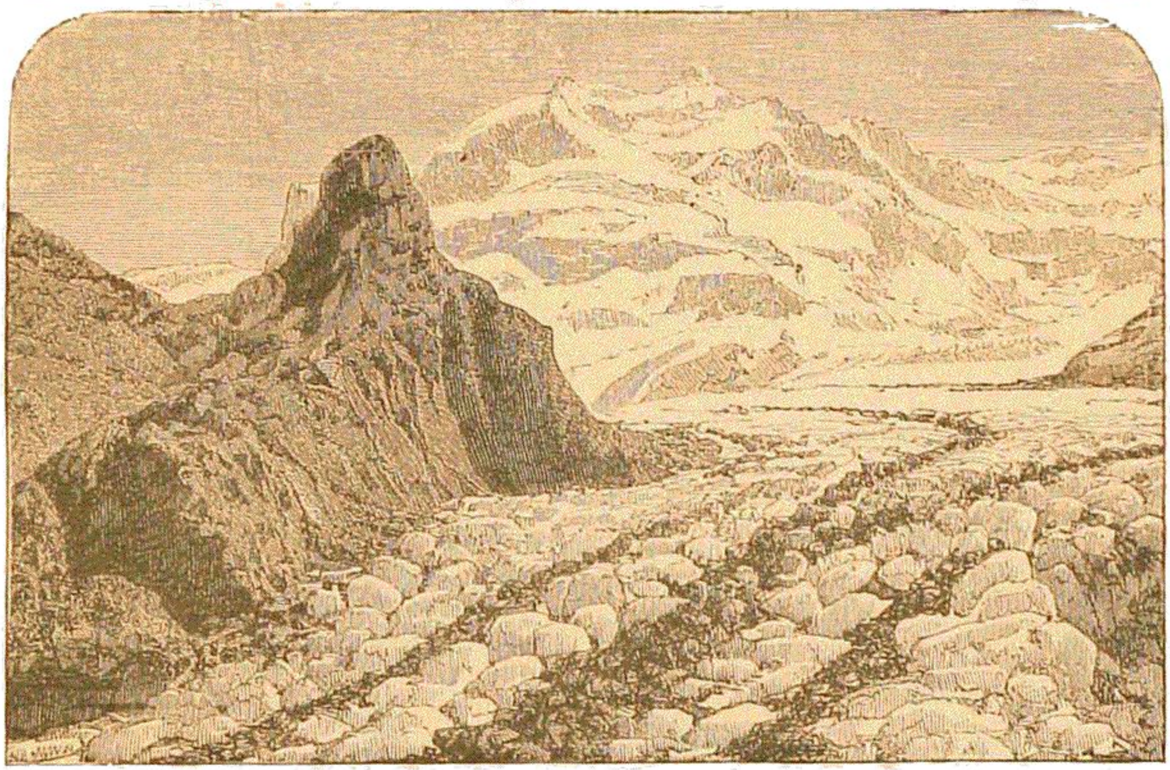

FIG. 107.—MONTE ROSA AND ITS GLACIERS, WITH THE MEDIAL MORAINE.
(From a photograph by Ferrier.)

triturated, and crushed by its weight and progressive movement; are ground down into sand, silt, and mud. Those which escape destruction are, at all events, striated, and worn superficially. M. Agassiz, therefore, calls them *striated pebbles*, whose presence invariably points out the passage of an ancient glacier in the valley wherein they are discovered. For water, when it carries down pebbles, does not scratch, but, on the contrary, rounds and polishes them.

The striations observed on stones which have been dragged under the glacier seem to have been produced by fragments of quartz embedded in the ice; these fragments having acted like a burin or graving-tool on the pebbles rolled underneath them. The stones being movable in the moraines, are scratched in every direction; while the fixed rocks over which a glacier has glided present a series of parallel and rectilineal streaks in the direction of the glacier's movement.

The environs of glaciers are literally sown with rounded rocks, polished and striated like those which have been found underneath the "frozen rivers," whenever explorers have succeeded in penetrating thither. De Saussure called them *roches moutonnées*, on account of their rude resemblance to a flock of sheep. Ebel compares them to haycocks scattered over a meadow.

The finest examples of rocks wrought by glaciers are found in Scandinavia and the Alps, and in the neighbourhood of the glaciers of the Aar, of Zermatt, and Rosenlauï. Where the Aar pours forth its flashing waters in the bright cascade of the Handeck, all the rocks dominating over the gulf are rounded domes, bare, and so highly polished that one cannot cross them without a shudder. They are the most beautiful *roches moutonnées* in Switzerland.

When the ice in its movement of progression, encountering an obstacle, cannot surmount all the ruggednesses of the soil, it turns aside, and attacks them in flank. You can then distinguish in the furrows of the rock which side the ice has touched. The preserved side retains, in effect, its natural surface, while the side assailed by the ice is worn and channelled. Thus it is that at the promontory of Pavillon, on the glacier of the Aar, the upper surfaces are polished and striated, while below the rocks are wholly unaltered.

The nature of the modifications undergone by the rocks depends upon the mineralogical constitution of the soil. The limestones of Rosenlauï and Grindelwald are covered with fine deep furrows by the action of the fragments of gneiss and granite flung down from the higher amphitheatres; but they are only polished very imperfectly. When a glacier-bed is formed of argillaceous, soft, or friable rocks, their surface is triturated and levelled, but presents neither the channels nor the polish observable on the harder rock. And, finally, when the glacier descends over a bed of granite and porphyry, the friction produces a polish as brilliant as a looking-glass. Nowhere is this phenomenon more strikingly visible than in the neighbourhood of the Aar, at the place called the *Roche-Miroir* (or "Rock-Mirror"). It is an immense surface of granite, of such exceeding smoothness, and

FIG. 108.—STRIATED ROCKS AND ROCHES MOUTONNÉES, EXHIBITING THE ACTION OF ANCIENT GLACIERS. (*From the Atlas to M. Agassiz' work upon "The Glaciers."*)

so uniform and slippery, that men are compelled to cut notches in it before they can venture to cross it. And opposite, on the other side of the valley, a perpendicular wall may be observed, polished as the rock itself, and interrupted only at intervals by colossal grooves or gutters—indelible memorials of the powerful agents which in times gone by have wrought upon these stones.

In Figure 108 we furnish the reader with an illustration of striated rocks and *roche moutonnées*. Our view hypothetically unites the two kinds of effects exercised upon the rocks by the passage of ancient glaciers.

The *roches moutonnées*, striated stones, and terminal moraines, by preserving their various positions after the recession and disappearance of a glacier, enable us to recognize the ancient existence of glaciers in countries where no one would have suspected it but for these physical signs and this tangible evidence brought to light by modern science. We are constrained, by proofs so incontestable, to admit that glaciers in the primitive age must have extended over a wide area of the world.

We owe to the industry of Venet a list of thirty-four observations, by which he has established in Switzerland the existence of ancient moraines, isolated, and situated at a great distance from the glaciers which, after building them up, have abandoned them. For example, the moraine of Kandersteg is now some thousands of yards from the glacier of Oeschinen. The villages of Ried, Bodmen, and Halten, in the Valais, are built upon an old moraine of the mighty glacier of Viesch, which is now a league distant from that village.

But it is not only in the valleys radiating from the foot of the Alps that we discover—thanks to the existence of erratic blocks, moraines, and striated pebbles—the infallible traces of the existence of ancient glaciers. We meet with them in the north of Europe, extending even into the central districts—into Sweden, Russia, and even Prussia. Eloquent witnesses are they to the existence, in the ancient history of our globe, of a *Glacial Period*, during which a part of our continent was infolded in a mantle of ice and snow: they are, so to speak, the milestones placed at intervals along the extent of those vast frozen wildernesses which for an unknown time invaded Europe and annihilated organic life.

MELTING OF THE GLACIERS.

The melting of the glaciers takes place at their extremity, either in the valleys, or in those parts of the mountains which are below the limit of perpetual snow. It necessarily varies according to the temperature of the air, and is less sensible at great elevations than in the lower regions. M. Agassiz, by fixing a series of standards or measuring-poles in a glacier, contrived to estimate the amount by which its level was annually lowered through thawing. In the central part of the glacier of the Aar he found the annual thaw averaged from 9 feet 10 inches to 10 feet 6 inches. In the month of August alone 39 inches of ice melted; but in winter, of course, no liquefaction occurred. M. Charles Martins has ascertained that on the glacier of Faulhorn the average deliquescence of the snow rose to about an inch and a quarter daily in the month of August, which would give nearly 39 inches for the month—and that of the ice to about an inch and a third, or upwards of 41 inches in the same time.

The waters which are produced on the surface of the glacier infiltrate through its crevasses, and through the innumerable very minute fissures which its substance contains. M. Agassiz compares a glacier to an immense sponge, which alternately absorbs and distils, according to the quantity of water it receives.

The liquid originating in the liquefaction of the glaciers accumulates under the ice, and eventually issues forth in torrents at the terminal slope (*talus*). The colour of these glacier-torrents is characteristic; it is not limpid like spring-water, but loaded with sediments which indicate the nature of the rocks encountered by the torrent. Granite rocks are known by a milky tinge, as may be observed in the sources of the Arve and the Rhone, each of which issues from an Alpine glacier. A greenish tint denotes a bed of serpentine; blackish, a bed of black schists. All these torrents carry down with them the silt proceeding from the various rocks which the friction of the glacier, in its movement of progression, has reduced into powder.

The soil subjacent beneath the glaciers does not possess sufficient warmth in itself to assist in melting them; but the springs which escape from the soil with a somewhat higher temperature than rain-water, and those originating in the thaw of the glacial surface during the hottest month of the year,—finally, the waters of the brooks which pour down the declivities of the valleys and are absorbed in the fissures of the glaciers, eat into it from below, and sometimes hollow out considerable cavities, in which continual currents of air are produced through the difference of temperature between the atmosphere without and the air within the excavations.

Thus, underneath the glacier, gusts of air are created of a temperature of from 43° to 45° F.; this air plays on the lower sides, and powerfully assists in enlarging the caverns and conduits originally formed by the water alone. M. de Schlagintweit contrived to penetrate under a vault in the glacier of Marcel for upwards of 250 yards. Hugi has explored a hollow nearly one league square under the glaciers of Uraz, at the foot of the Titlis, and has shown that these immense arched roofs are supported on the ground by rows of massive pillars. An analogous phenomenon had previously been observed by Altmann in 1751 beneath the glacier of the Grindelwald.

The caverns existing beneath a glacier generally open at the foot of the terminal declivity. Sometimes the mouth is of considerable area, and the light playing upon its walls of ice produces in the interior the most magical effects. Shades of rose and azure, the glitter of innumerable prisms, the play of countless rainbows, convert these ice-caves into a spectacle of the most beautiful and fantastic character, which seems to realize the brightest dreams of Faeryland ever conceived by impassioned poet.

> "It was a miracle of rare device,
> A sunny pleasure-dome with caves of ice!"

In Figure 109 we represent the ice-grotto situated under the *Glacier des Bois* of Mont Blanc, and forming the source of the Arveiron.* Its height varies greatly at different seasons; so great a change as from 100 feet to 30 feet having been remarked. It is not always safe to enter the interior, from the blocks of ice which are constantly falling. In 1797 three persons were crushed to death. But it is a

* [The river originally flowed from the cavern, but has recently made its exit from the side of the glacier at a point some way higher up, where it forms a waterfall conspicuous from Chamounix.]

scene, once beheld, never to be forgotten. All its concomitants are calculated to impress the mind: the intense darkness, like that of night, which fills up, so to speak, the inner vault—the huge boulders and crags, flung down from the mountains above, which oppose unsuccessfully the forward march of the torrent—the iris-like gleams and flashes which play about those parts of the ice affected by the

FIG. 109.—SOURCE OF THE ARVEIRON. *(From a photograph by Ferrier.)*

light—and the sombre masses of pine-wood which stretch like a rampart on either hand.

As already hinted, the yearly fall of blocks of ice from the cavern-roof, produced by the gathering heats of the interior, are continually modifying its configuration, and frequently bar the egress of the subterranean streams, which thereupon accumulate in a mass of waters, whose pressure forces a way through the crevasses in the surface of the glacier.

Numerous brooks meander around the glaciers, formed by the thaw of the ice during the summer season. They flow only by day; at night they dry up, and their tinkling sounds cease to be heard. They engulf themselves in vertical shafts, commonly named *puits* or *moulins;* and frequently these *puits* are of a very considerable depth.

What are named in the Alps *meridian holes* are depressions produced by the presence of a foreign body, such as black sand or an erratic block. Heated by the sun's rays, this block thaws the ice beneath and immediately around it, sinking in the cavity thus created, whose depth increases continually through the incessant action of the warm water which descends from the surface exposed to the sun.

A wholly opposite effect is produced when erratic blocks or great heaps of white gravel, resting on the surface of a part of the glacier, protect that point from the solar radiation. Accordingly, it is only around that point the ice can melt; and when this phenomenon occurs with any degree of intensity, the block or pile of gravel will remain upright, suspended upon a conical pedestal or column of ice, whose height sometimes exceeds three or four feet. The block thus suspended is designated a *Glacier Table*, numerous specimens of which may be seen on the glacier of the Aar. According to the amount of influence exercised by the solar rays, these gigantic *mushrooms* assume a more or less decided inclination towards the south, so that they indicate with some degree of accuracy the direction of the *meridian*. It is even certain that their slope varies at different hours of the day, according to the sun's position; but this oscillatory movement, which would seem to convert the glacier tables into a new kind of sun-dial, is in reality scarcely perceptible.

Eventually the sun eats away the ice-pedestal on its southern side; the stone table supported by it then glides from its horizontal position and falls upon the ice beneath, where it sometimes carves out for itself another prop.

We must now direct the reader's attention to a final phenomenon connected with the Glaciers.

When the water originated by the melting of the ice cannot flow off for want of an issue, it excavates for itself a bed upon the basin of the glacier, and gathers into a veritable lake. One of the largest lakes thus formed is that of the *Märjelen Sea*, situated on the left bank or border of the Aletsch glacier (Fig. 111).

[The Aletsch glacier is supposed, by some authorities, to be the largest—it is assuredly the most remarkable—ice-river in the Alps, or, perhaps, in the world. It has its source in the great basin of ice and snow enclosed by the white peaks of the Jungfrau, the Aletschhorn, the Mönch, the Trugberg, and the Walliser Vieschhörner. From the Mönch to the source of the Massa, at its base, it flows over a bed fully twenty miles in length, with an average breadth of from one to nearly four miles. It is separated from another, but less magnificent, glacier, the Vietsch, by a

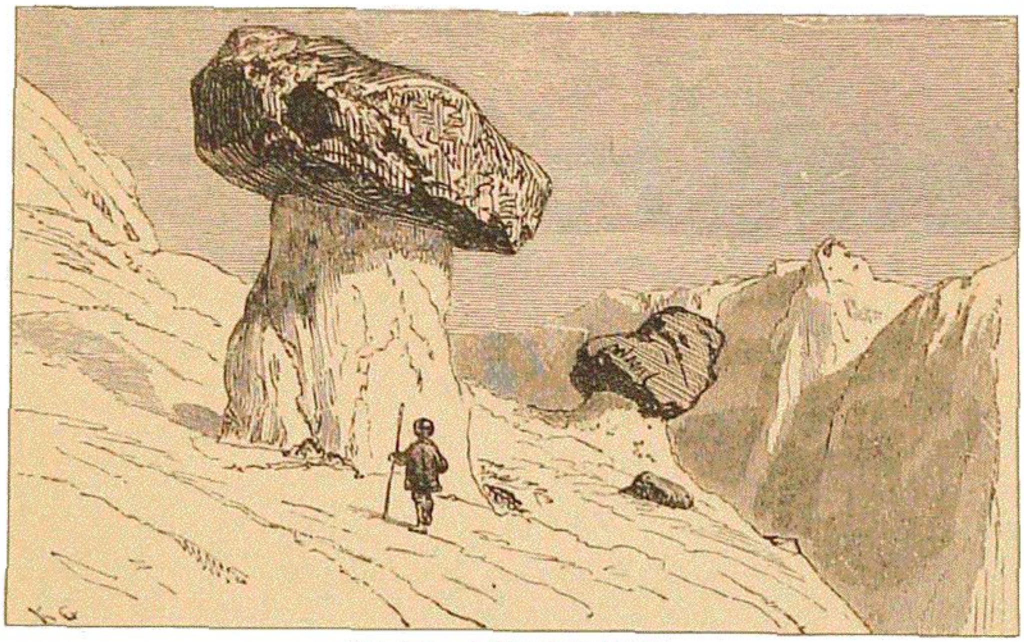

FIG. 110.—A GLACIER TABLE.

mountain-ridge, which, however, as it descends, is depressed into a flat table-land, two or three miles long and about half a mile wide, and bordered on one side by the radiant ice-cliffs of the Aletsch glacier. The waters are thus brimmed up into a small and singularly romantic lake, on whose surface float the blocks of ice that fall away from the cliffs, like icebergs; so that the scene represents on a miniature scale many of the phenomena of the Arctic Ocean. To prevent the lake from invading the adjacent pastures a channel has been dug, which carries the surplus in an opposite direction to swell the torrent from the Vietsch glacier. At times the never-ceasing progression of the Aletsch opens up some subterranean or rather sub-glacial channel, by which a great body of the lake-waters escapes beneath the ice, having stranded on the icy shores a small armada of icebergs.]

This lake is 1600 yards in length, 450 in width, and 8 to 10 yards in depth.

"It presents in its economy," says M. E. Collomb,* "a remarkable phenomenon;

* Collomb, "Mémoire sur les Glaciers Actuels," Paris, 1857.

it is intermittent; it alternately empties and fills its basin in the course of a few years. The glacier of Aletsch, on its western shore, fences it in with a vertical barrier of ice, about 33 feet high. At intervals huge blocks are detached, which float (as already stated) on the surface of the lake, and present the characteristic form of a mushroom, like that of the icebergs of Bell Sound, in Spitzbergen. When the pressure of the water prevails over the resistance offered by the icy cliffs, the lake suddenly empties itself and finds a passage underneath the glacier, producing a disastrous inundation in the Valley of the Rhone, whose effects are particularly felt

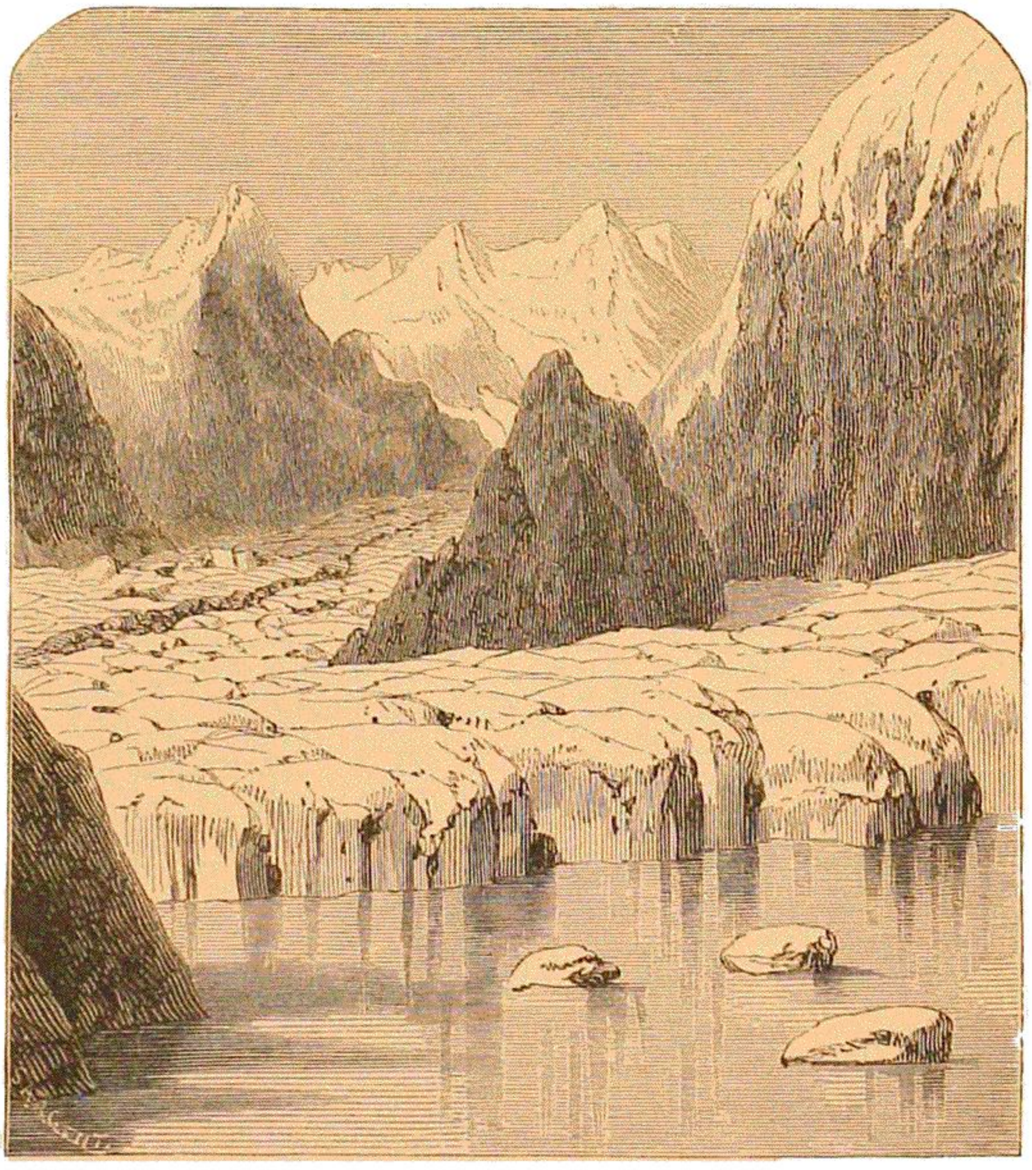

FIG. 111.—THE MARJELEN SEA, BELOW THE GLACIER OF ALETSCH (SWITZERLAND).

in the neighbourhood of Vierge. Three millions, and upwards, of cubic yards suddenly added to the waters of the Rhone, render its vicinity peculiarly dangerous. When I visited this lake, on the 28th of August 1848, it was covered with floating icebergs; on the 18th of August in the year following, it had just run dry; the blocks of ice stranded on the banks were not yet completely melted."

The *Gouille de Vassu*, another ice lake, formed between two branches of the Valsorei glacier, empties itself yearly, according to Saussure. We may also refer to

Lake Rofner, at the foot of the glacier of Vernagt; Lake Combal,* in the Allée-Blanche; and Lake Tacul, in the Mer de Glace.

As an interesting example of lakes formed by glacial waters, we subjoin an illustration of the miniature basin which sleeps in the shadow of the Hospice of Mont St. Bernard, and in a terrible solitude, animated and vivified by charity and devotion.

[Strictly speaking, there is no mountain actually bearing the name of St. Bernard; which, as in the case of St. Gothard, is really given to the Pass.

The Hospice, a massive stone building on the very summit of the Pass, is 8200 feet above the sea-level. It is open to the fierce storms of the north-east and south-

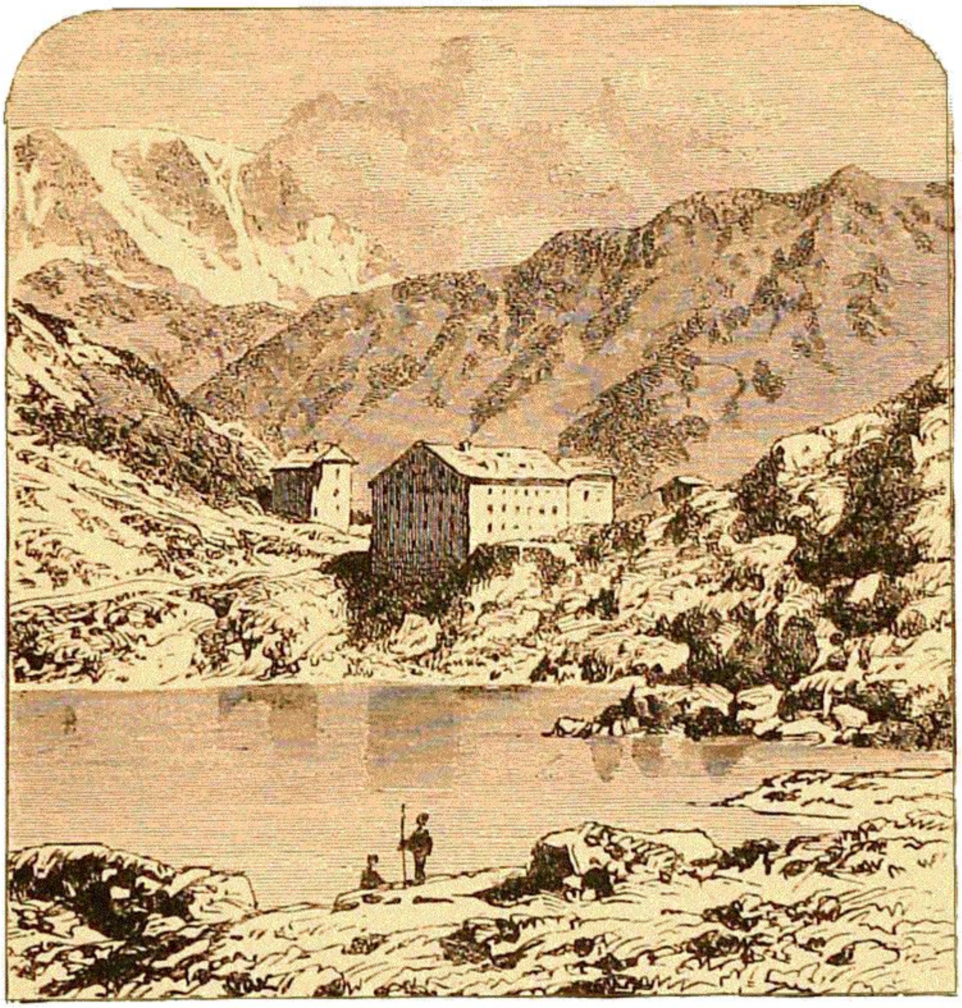

FIG. 112.—LAKE OF MONT ST. BERNARD. (*From a Photograph by Ferrier.*)

west; but on the north-west is protected by the Mont Chenellettaz, and to the south by the Mont Mort. Its establishment consists of twelve brethren of the Augustine order, and several assistant lay brethren, named *marroniers*, who devote their lives to the relief of the travellers journeying through the Alpine wastes of ice and snow. As many as 19,000 cross the St. Bernard in the course of a year, and numerous lives would be lost but for the opportune aid afforded by these heroic messengers of charity.

* [The Allée-Blanche is a vast glacier on the Italian side of Mont Blanc. From the Combal lake issues one of the sources of the river Dovia Baltia.]

The present Hospice was founded in 962, by Bernard, who was born, of a noble Savoyard family, at the Chateau of Menthorn, on the lake of Annecy. At an early age he resolved to devote himself to an ecclesiastical life, and for this purpose he repaired to Aosta, of which city in due time he became archdeacon. While residing there, his frequent intercourse with pilgrims and travellers probably inspired him with the idea of founding an asylum for their reception, which he governed for upwards of 60 years, dying in 1008.]

CHAPTER IV.

[GLACIERS OF THE ALPS, PYRENEES, AND SPITZBERGEN (EUROPE)—GLACIERS OF THE HIMALAYA (ASIA)—GLACIERS OF THE CORDILLERAS (AMERICA).

WERE it possible for the reader to transfer himself, by some enchanted scarf or carpet, such as one reads of in the Arabian Nights' Entertainments, from the "cheery ingle" or the garden-bower—wherever he may be perusing these pages—to the frozen landscapes of the Alps, how vast and how singular a panorama would he see revealed before his gaze! He would stand silent and astonished, as a German writer remarks, before that Titanic mass of mountain architecture, built up by powers whose origin and action can indeed be described, and whose relation to other powers can be elucidated according to the laws deduced by science from the observation of natural phenomena, but whose extension and boundaries in the universe human knowledge can only dimly apprehend. Far away in the clear, cold, sapphire sky—in that wondrous azure never obscured by cloud or vapour, that living and ever-present symbol of the Infinite—roll, like billows suddenly frozen and stiffened into rest, mountain upon mountain, folded in a robe of eternal snow, like a dead giant in his shroud! Below, the huge lammergeier plies the labouring wing, and the startled chamois flings his shadow from crag to pinnacle, and the silence is but partly broken by the low murmur of the remote cascade; and lower still, the mountain-flanks are hung with masses of deep forest-growth made musical by the song of birds;—but where he stands, on the lofty peak, no life shares with him the awe of the solitude or the intensity of the silence; he looks above, and the heavens are still; he looks around, and from the Alpine heights comes no welcome voice; not a flower, not a leaf, not a blade reminds him of the sweet sylvan landscapes and the happy meadows;

the sunlight falls upon glittering snow and shimmering ice as upon a vast sea of glass; and he feels as if surrounded by the unseen hosts of heaven—as if he stood in the immediate presence of the Divine Power!

Less sublime, but not less singular the scene, if the traveller should content himself with making his way across one of the precipitous passes which afford an opening into the mountain-region. Around, in a majesty which has something of the wild and savage in it, rise hundreds of icy pinnacles and white cold peaks, which are scarcely ever reached by human foot—scarcely even by the mountain goat. No philosopher has hitherto comprehended the laws of their confused and irregular accumulation; little is known of their fragments of a vegetable and animal world; but along their grim gaunt sides winds the noisy caravan of commerce. The braying post-horn echoes among their heights, blending its sounds with the ringing bells of the mules and the voices of men speaking in many tongues. But by all this stir and tumult the Alpine giants are unmoved. With the glittering crown of eternity on their anointed heads, they continue their long, long sleep—dreaming, mayhap, of the primeval ocean-billows that once roared against them—of the throes and tumult which marked their upheaval from the great central fire—of the radiant molluscs and fishes that in the times of old disported in their winding creeks and deep recesses;—then, how the waters slowly ebbed away; how the luxuriant blossoms and tapering palms of a rich new world began to flourish on their summits, or how the chestnut and the lime hung their slopes with fresh green foliage; and, again, how all life eventually sank down into the mysterious depths—how the storms swept away their outer stratum of soil—how cold blasts prevailed instead of warm winds, and angry clouds instead of laughing skies—how the winters grew longer, and the brief summers stinted the much-needed supply of sunshine; until rain and vapour congealed into snow—into snow which yearly clung closer to their sides, crept down to the very edge of the valleys, and mantled them in a mail of impenetrable brightness—while the spirit of the Winter reigned everlastingly upon the haughty crests which had formerly rejoiced in the glory of a tropical vegetation! Perhaps, too, these silent giants—these mute warders of an inaccessible world—may be reflecting on the ruins of a more beautiful primeval state, which were converted into stone lest they should be lost; on the veins of glittering gold that run deep within their bosom, the beds of crystal that lie there unseen, and the concealed treasures of their flashing gems. But to the eye of man how dead they seem—yon mighty Alps! and every century buries them deeper in snow-drift and glacier, and crumbles away their mighty ribs.*]

Of the glaciers, which form, perhaps, the most remarkable feature of these snow-shrouded, ice-burdened mountains, we have related the more interesting details of what may be called their physical history. We proceed to indicate the principal regions of the two hemispheres where are found in their greatest development those immense and picturesque rivers of ice which, descending from the mountain summits, remain suspended half-way on their flanks.

From what the reader has previously gathered, he will understand that several important conditions must unite in a chain of mountains before their snows can be transformed into permanent glaciers; and in no part of Europe are those conditions found existing together in the same degree as in the Alps of Savoy and Switzerland. There, in truth, we discover an almost unbroken *relievo* rising above the limit of perpetual snows, whose base, broken up by a multitude of valleys, stretches down into a region with a moist and temperate climate, adapted to facilitate the *glacification* of the snows. And, therefore, nowhere in Europe do we meet with such vast and magnificent glaciers as in the Alps. To some of the most important of these we have already referred. [That which has been most completely explored and investigated by physicists is the great glacier of the Unter-Aar, in the Oberland, measuring about fourteen miles in length,

* [See Berlepsch, "Der Alpen;" Von Tschudi, "Nature among the Alps;" Professor Tyndall, "Glaciers of the Alps;" "Peaks, Passes, and Glaciers;" Wills, "The Eagle's Nest;" and Professor Forbes, "Travels in the Alps of Switzerland and Savoy."]

and between one and two miles in breadth. About the centre it divides into two branches, the Lauter Aar and the Finster Aar; the two being separated, like the double current of a stream, by a rocky promontory called the *Abschwang*, which is the base of a huge ridge, the Mettenberg, that rises far above Grindelwald into a summit of sublime elevation. We may also name the glaciers of the Grindelwald, which are rendered unusually picturesque by their contiguity to the green pastures and fir groves of the rich Grindelwald valley. In the descent of these two vast streams of ice into the luxuriance of a thriving pastoral and agricultural district, there is something peculiarly impressive. They issue from the bosom of the Eiger ("the giant") and Wetter-horn ("the tempest-peak"), and are divided into two channels by the lofty Mettenberg (or "middle mountain").

Even Lord Macaulay's school-boy knows by name the famous MER DE GLACE, or *Eis-see*, of the Chamounix valley, whose colossal bed is formed by the union of the *Glacier du Géant* (S.W.), the *Glacier de Lechaud* (S.), and the *Glacier du Talèfre* (S.E.) We know that words, when wielded by a master-spirit, are powerful to move the hearts and agitate the minds of men; to realize the highest dreams of the poet's fancy and embody the airiest creations of the romancist's art; but, assuredly, no words can convey even the feeblest idea of the wonders of this vast frozen sea—girdled, as it is, by a giant range of frozen mountains—lit up by a myriad fantastic and ever-shifting rainbow-hues, and rendered awful by its intense solitude and silence!

> "All that expands the spirit, yet appalls,
> Gather around;"

and nowhere does man feel more terribly dwarfed and humbled by a sublimity which he is wholly unable to comprehend!

The most striking portion of the Mer de Glace is the Glacier de Talèfre, where a solitary rock, about seven acres in extent, and nowhere less than 9000 feet above the sea, is clothed with beautiful herbage, and, in August, dressed out in flowers—an oasis of poetry

FIG 113.—THE MER DE GLACE (MONT BLANC). (*From a Photograph by Messrs. Bisson.*)

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in the midst of the most awful desolation—a Calypso's island set in a sphere of azure ice—the *Jardin*, or Garden, as it is appropriately called, of a palace of Titans!

The magnificent *Glacier of the Rhone* has been described by the poet Longfellow* as "a frozen cataract, more than two thousand feet in height, and many miles broad at its base. It fills the whole valley between two mountains, running back to their summits. At the base, it is arched like a dome; and above, jagged and rough, it resembles a mass of gigantic crystals of a pale emerald tint, mingled with white. A snowy crust covers its surface; but at every rent and crevice the pale green ice shines clear in the sun. Its shape is that of a glove lying with the palm downwards, and the fingers crooked and close together. It is a gauntlet of ice which, centuries ago, Winter threw down in defiance to the Sun; and year by year the Sun shines in vain to lift it from the ground on the point of his glittering spear."

The *Glacier of Rosenlaui*, near Meyringen, is not remarkable for its magnitude, but, nevertheless, has an interest of its own, from the singular purity of its glittering white surface, and the bright limpid azure of its icebergs. It has no medial moraine. Its bed being a flat rock, the advance and occasional retrocession of the glacier—in fact, all its phenomena of motion—may here be observed with facility. The torrent issuing from it has furrowed a deep chasm in the mountain-side, and from the frail bridge which spans it you may look down into a caldron, 200 feet in depth, where the wails boil and seethe, as if vexed by some witch's spell.]

In the Pyrenees few glaciers occur; the conditions requisite for the glacification of the snows being only imperfectly united. Their main ridge does not soar above the snow-line; only a few isolated peaks wear the "crown of eternity." It is therefore difficult for glaciers to accumulate in their valleys.

Those worth noting in the Pyrenean chain are the Maladetta, the

* [H. W. Longfellow, "Outre Mer," Prose Works, American edition, 1854.]

Crabioules, the Vignemale, and that of the Brèche-de-Roland.* The Maladetta glacier is represented in Figure 114.

In the Sierras of Spain there are no glaciers worthy of being so called.

In the Caucasus range, in Asia, the traveller Kolenati discovered some fields of *névé*, and some secondary glaciers; such as those of

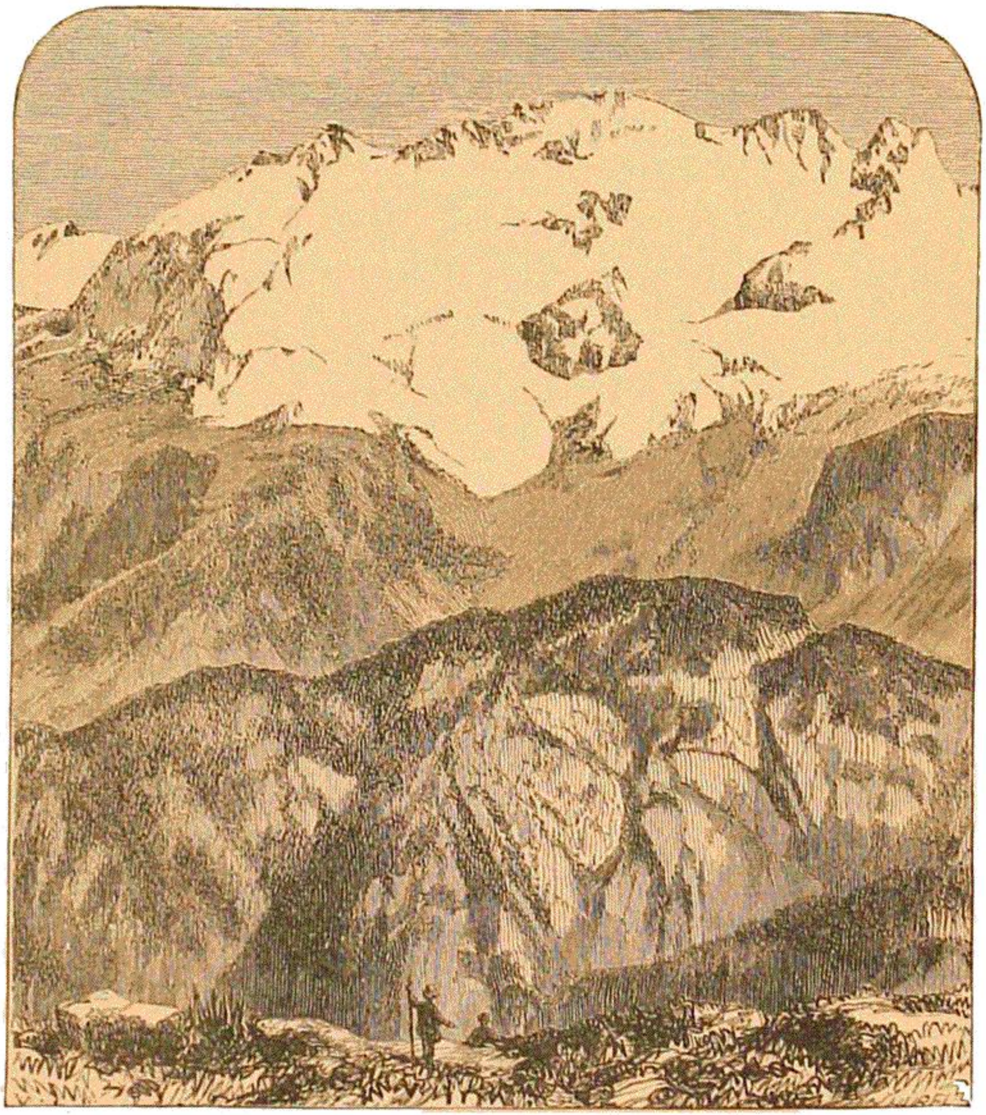

FIG. 114.—GLACIER OF THE MALADETTA (PYRENEES). (*From a Photograph by Ferrier.*)

Tchobari, Zminda, and Desdaroki, which lie embedded between the summits of the Kazbek.

In the chain of the Himalaya, the brothers Schlagintweit observed some magnificent glaciers, at an elevation of 10,000 feet. In our Illus-

* [The Pass or Valley of the *Brèche-de-Roland* derives its name from a tradition that the great Frank hero, Roland, when dying, overpowered by his enemies, flung away his sword lest it should fall into their possession. It clove a deep gash in the mountain, which remains to this day.]

trations 117 and 118 we represent two of these, from the sketches of those celebrated explorers; namely, the glacier of Kothsada, and that of Nubin (in Tibet). They are distinguished by lateral moraines like those of the Alps.

The glaciers of Kouphinia and Pindour descend to an absolute altitude of 11,000 and 12,000 feet; that is to say, about 3000 feet below the line of congelation, which, in the Himalaya, is found, according to Captain Strachey, at an elevation of 15,000 feet. In the Himalayan glaciers the same progressive movement has been remarked as in the Alpine "rivers of ice"—as well as moraines, crevasses, striated rocks—in a word, all the phenomena we have described as characteristic of the European glaciers.

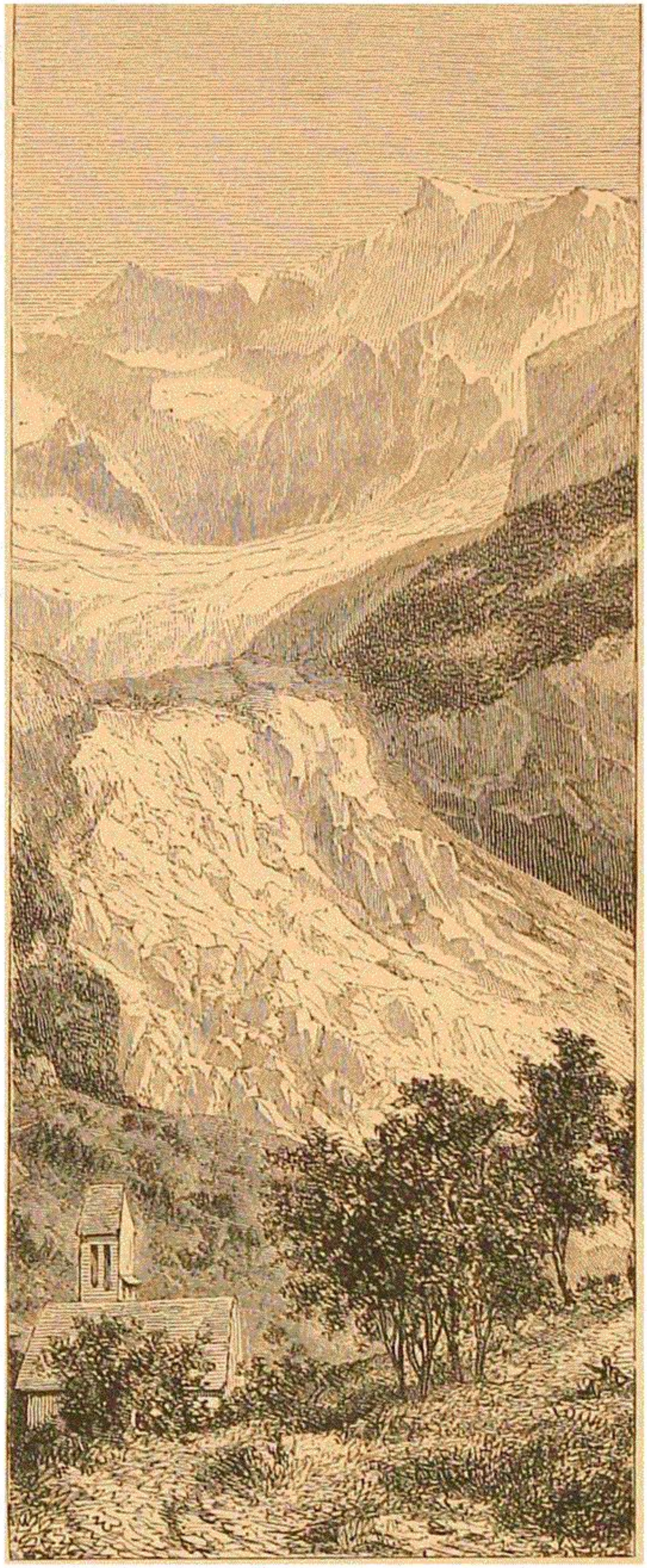
FIG. 115.—LOWER GLACIER OF GRINDELWALD.
(*From a photograph by Ferrier.*)

In the Andes of Central America, the formation of glaciers encounters insuperable obstacles through the isolated position of those peaks which tower above the perpetual snow-line, and in no less important a degree through the uniformity of the tropical climate, which offers none of those alternations of humid heat and intense cold necessary for the transformation of the *névé* into compact ice. It was long believed that not a single glacier could be found throughout the entire extent of the Cordilleras; however, M. Acosta has discovered one in the Nevada de Santa-Marta, under the 11th degree of north latitude. Moraines, erratic blocks,

FIG. 116.—GLACIER OF THE CERRO DA TOLOZA (CHILI).

crevasses, and other distinctive glacial features are combined in it. The ice descends below the snow-line, which is here placed at 15,250 feet.

A German painter, Rugendas, has explored and sketched the glaciers of the Cerro da Toloza, which occupy the loftiest points of the Chilian Cordillera, between Santiago and Mendoza. Situated under the 34th parallel of south latitude, and at an elevation of nearly 13,000 feet above the sea, they fill up the broad and deep ravines which furrow the summits of phonolite. Composed of white ice—bluish in the escarpments—and dragging onward in their triumphal course the huge blocks which have fallen from the overhanging peaks, these glaciers in every respect resemble the *secondary* Alpine glaciers, which, suspended on the flanks of the Wetterhorn and the Schreckhorn, do not descend into the inferior valleys.

The few isolated glaciers of South America are the last vestiges of the immense icy shroud or curtain which covered a great portion of the continent during the Quaternary epoch. And, indeed, numerous erratic blocks which have been detached from the Cordilleras, and drifted as far as the Equator, bear witness to the existence of immense glaciers in the New World long before the days of man had a beginning.

No glaciers are known to exist in the Rocky Mountains of North America; but they are found among the wonders of the Arctic region. Dr. Kane, the intrepid American explorer, discovered that Europe was united, as it were, to North America by a colossal glacier, which, after the illustrious author of "Kosmos," he named the Humboldt Glacier. The chasm between the Old World and the New is thus bridged over by the Almighty Hand, forming a scene of such awful grandeur that the most indifferent could not gaze upon it without emotion. The Humboldt Glacier is, probably, the largest in the world, and forms an impregnable barrier to Arctic explorations in that direction. It is situated in about lat. 79° 30′ N.]

The glaciers of Norway do not derive their origin from those grand amphitheatres in which the snow accumulates on the flank of the Alps. They issue from immense plains or *fields of snow*, in the sub-polar regions, and extend over an area of several square leagues, covering the rugged and unequal soil with a thick white pall, through which, here and there, a mass of black rock protrudes.

The glaciers, or *bræer* of Justedal, under the 61st parallel of north latitude, begin at an elevation of 1150 feet above the sea. The physical description given by Naumann proves that the Norwegian glaciers are also gifted with a progressive movement of trans-

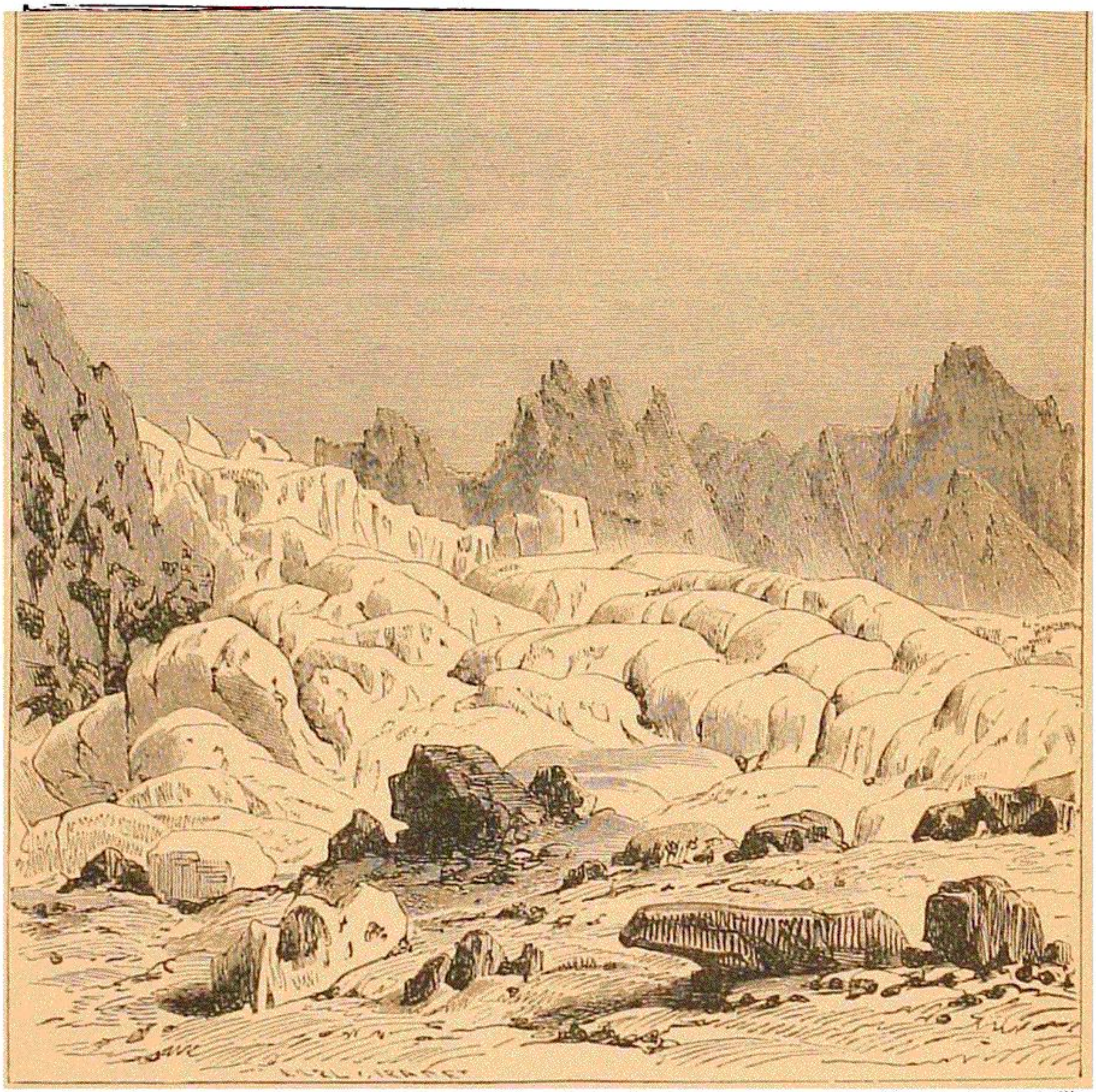

FIG. 117.—GLACIER OF KOTHSADA HIMALAYA). (*From Schlagintweit's Atlas, in the "Voyage en Asie."*)

lation. The *Soulitelma*, which is 5600 feet above the sea, detaches numerous glaciers into the lower valleys.

In Iceland the loftiest portions are completely hidden by an uninterrupted shroud of dense and compact snow. This immense field of *névé* extends over 40 square miles: from its borders descend a great number of true glaciers (*jokuls*), displaying all the various phenomena we have described in our preceding chapter. Here, under the double influence of an extremely rigorous climate and of mountains of considerable elevation, the glaciers descend to the very margin of ocean. Nevertheless, they do not advance directly into its waters, and between the wave and the glacier invariably stretches a belt of open shore.

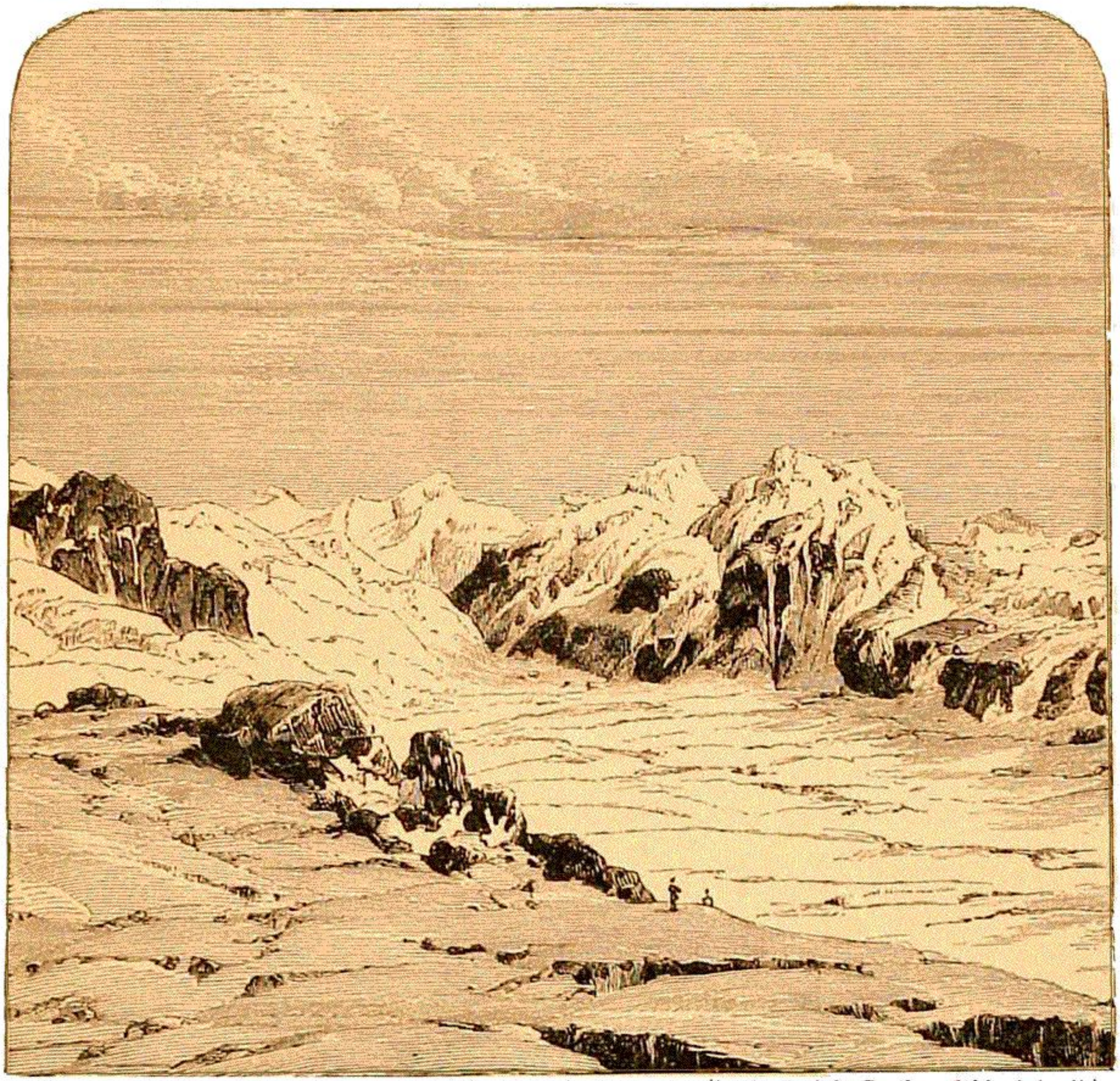

FIG. 118.—PEAKS AND GLACIERS OF NUBIN (TIBET). (*From the "Atlas" of the Brothers Schlagintweit.*)

But the glaciers of a region still nearer the pole do actually strike into the very sea. That of Bell Sound (Figure 119) is about 13 miles in length by 3 in breadth.

The enormous power of these huge masses, and the continuous severity of an Arctic temperature, preserve them to a great extent from the crevasses and fractures so common in the ice-rivers of the Alps. But, according to M. Charles Martins, who resided for a time in Spitzbergen, these glaciers are, in truth, simple *névés*, resembling in every respect the upper portion of the Swiss glaciers; they are fields of snow, modified by the alternations of frost and thaw; they transform themselves into ice, but into *névé*, and not *glacier-ice*. This incomplete development is caused by the uniformity of the cold in these parts, for the formation of a glacier is not possible without marked alternations of temperature.

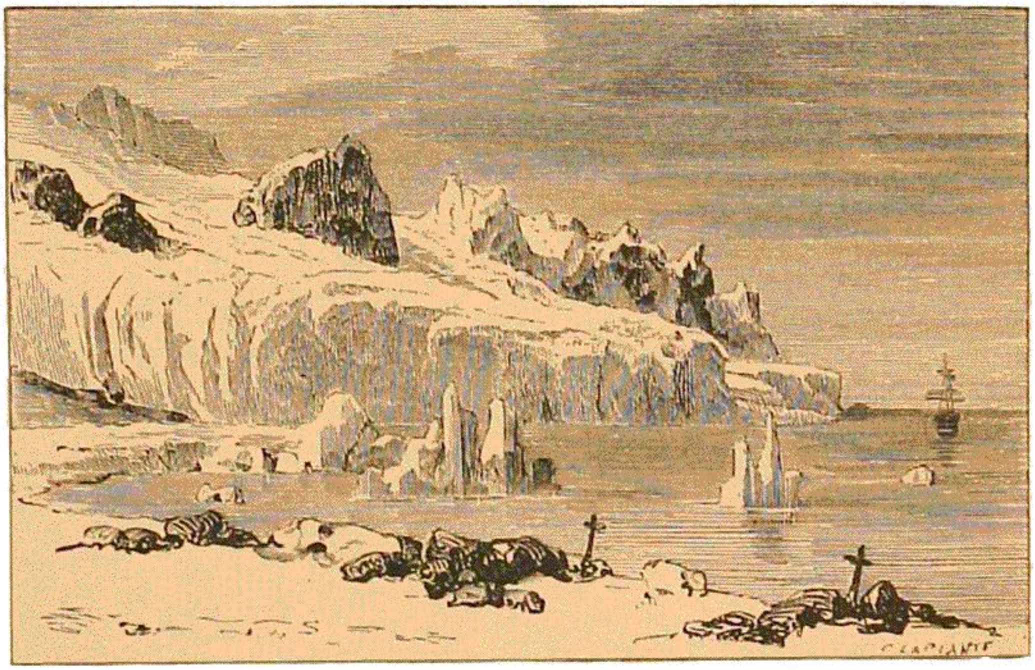

FIG. 110.—GLACIER OF BELL SOUND (SPITZBERGEN).

Like the Alpine glaciers, the Polar glaciers are endowed with a progressive motion; discharging slowly the burdens of snow and rock piled upon them by the protracted winters. But to these we shall hereafter have occasion to return, when speaking, in the later pages of our work, of the Arctic and Antarctic Seas.

CHAPTER V.

THE PROPER TEMPERATURE OF THE GLOBE—ON THE LAW WHICH REGULATES THE INCREASE OF HEAT IN ITS DEPTHS—DIRECT OBSERVATIONS UPON THE INCREASED TEMPERATURE IN THE INTERIOR OF MINES AND ARTESIAN WELLS—TEMPERATURE OF THERMAL WATERS AND VOLCANIC LAVAS.

TO prove the existence of an incandescent nucleus in the centre of the terrestrial mass is now-a-days unnecessary, because it is the accepted foundation of all modern geology. Disputed at the close of the last century by Werner—the great chief of the Neptunian school—it has been established in the clearest possible manner by two of Werner's own pupils—Leopold von Buch and Alexander von Humboldt.* What we have, then, to discuss in our

* [*Werner.—Von Buch.—Humboldt.—Abraham Gottlieb Werner* was born at Wehlau, in Upper Lusace, on the 25th of September 1750; and died at Dresden, on the 30th of June 1817. His treatise on the stratification of rocks appeared in 1787. He argued in it that the formation of the rocks composing the earth's crust was owing to chemical precipitation from water. The Neptunian system, as it was called, found many warm supporters, but eventually it was opposed, and, to a certain extent, confuted, by Hutton and his followers, the partisans of the Plutonian system. The truth appears to lie between the two extremes: fire was a powerful agent in the stratification of the rocks, but their present appearance is also largely owing to the action of water, especially in the shape of ice.

Leopold von Buch, one of the most eminent of modern geologists, was born at Uckermark, on the bank of the Oder, in 1774; died in 1853. His attention was early directed to geological studies, in which he was destined to effect a remarkable revolution. He began as the pupil and disciple of Werner; he ended by completely overthrowing the Neptunian system, and giving due prominence to the remarkable results of igneous action. He was a great traveller, and his exploration of the principal volcanic regions of Europe led him to important conclusions, which are now accepted among the fundamental principles of geological science.

We owe to Von Buch the doctrine of the elevation by igneous force of mountains and continents; clear and definite views upon the mechanism of the formation of volcanoes; the theory of the shifting of the beds of oceans in accordance with the upheaval of mountains; and the all-important truth of the unconformity of strata.

Friedrich Heinrich Alexander, Baron von Humboldt, was of noble birth and ancient lineage, and born at Berlin on the 14th of September 1769. After a careful preliminary education he was sent, at the age of seventeen, to the university of Frankfort-on-the-Oder, whence he repaired, in 1788, to Göttingen, studying under Heyne, Blumenbach, and Eichhorn. In 1790 he accompanied the naturalist Forster in a tour through Germany, Holland, and England. Shortly afterwards he was appointed director-general of the mines of Anspach and Bayreuth, in which capacity he wrote and published his "Specimen Flora Freibergensis."

present chapter, is not the fact of the existence of an igneous fluid in the world's interior, but only the law which regulates the increase of temperature in proportion as we descend into its depths.

It is generally admitted that the temperature of the earth rises *one degree* for every 110 feet in depth. But these figures are only the *mean* result of a great number of observations; and local circumstances—especially the comparative facility with which the rocks conduct caloric—vary, according to place, this uniform rate of progression. It will be useful, therefore, to dwell upon the different observations which have induced our physicists to adopt the above-named average.

The learned Jesuit, Kircher, who wrote in the middle of the seventeenth century, speaks of the increase of temperature noticeable in the Hungarian mines. The first measurements of the heat of mines were not made, however, until 1740, when Gensanne, in the lead-mines of Giromagny (in the Vosges), discovered an increase of 1° for 61 feet.*

Towards the close of the eighteenth century, Saussure remarked that the Alpine glaciers melted away at their base every season. He attributed this fusion to the natural heat of the earth, and was thus induced to make, in various localities, such experiments as might reveal the law of the progression of temperature in the globe's interior. From his observations in the salt-mines of Bex, he found himself able

In 1797 he travelled in Switzerland and Italy, exploring their volcanic districts; and two years later embarked on a voyage to Equatorial America, where he collected a mass of facts in reference to its natural history, antiquities, inhabitants, and physical phenomena. After a sojourn of five years, Humboldt, and his friend Bonpland, the naturalist, sailed for Cuba; returned to Carthagena; ascended the Amazon river; visited Chili; ascended Chimborazo; traversed Peru, Mexico, and the United States; and returned to Europe in August 1804.

Several years were then spent in scientific research, and in the collation and reduction of his multifarious observations. His appetite for travel kindling anew, he undertook, in his sixty-third year, a journey to Central Asia, at the expense of the Russian emperor. He left Petersburg in May and returned in November 1829, having accomplished in six months a distance of 2320 geographical miles.

His greatest work, "Kosmos: a Physical Description of the World," was written when its author was in his seventy-third year, and remains an extraordinary monument of his genius, patience, learning, and remarkable powers of analysis and combination. Only inferior to this in value are his "Asie Centrale," and his "Voyage aux Regions Equinoctiales du Nouveau Continent."

Humboldt died at Potsdam, on the 6th of May 1859, within a few months of his ninetieth year.]

* Mairan, "Dissertation sur la Glace," Paris, 1749, p. 60.

to fix at 1° for every 125 feet of depth the regular increase of the terrestrial temperature.

In one of the ablest and most lucid contributions which ever enriched the literature of science, and which has inaugurated a new era for geology, Cordier,* revising the conclusions of his predecessors, and endeavouring to avoid the errors into which circumstances had led them, has established certain important and unalterable principles. He has proved the local variations of the temperature of the terrestrial interior, but that the fact of the regular augmentation of that temperature is beyond all doubt. He found an increase of 1° for 120 feet in the mines of Carmeaux (department of the Tarn), for 64 feet in those of Hittry (Calvados), and for 50 feet only at Decize (Nièvre). He concluded, therefore, that the mean of increase might be fixed at 1° for 80 feet.

In the mines of Cornwall, a new mode of measuring the temperature has recently been adopted. This consists in ascertaining the temperature of the waters pumped out of the shafts. Seventy thousand tons of water were daily brought to the surface, and the exact depth of the mine was ascertained; the temperature of the waters, therefore, accurately represented that of the reservoir whence they were exhausted. The experiments thus made led to the same result as that determined upon by Saussure—namely, 1° for every 125 feet.

[We may remark, however, that in the Dolcoath copper-mine, a thermometer buried three feet in the rock, at a depth below the surface of 1377 feet, indicated a temperature of 75.5° F., while that of the country was 50°; showing a rate of increase of heat of 1° for every 54 feet.

In the coal-mine of Killingworth, made famous by its connection with George Stephenson, the annual mean temperature at the surface is 48° F.; at about 900 feet in depth, 70°; and at 1200 feet, 77°.]

In the mines of the Erzgebirge, in Saxony, an extensive series of observations was carried on for a period of ten years, with the view of determining the temperature of the rocks by thermometers sealed

* Cordier, "Essai sur la Temperature du Globe" (Annales du Muséum, &c.), 1828.

up in the stone. These were all arranged on the same vertical line. The experiments were made in twenty mines, extending over a surface of about 25 square miles. The instruments were examined several times monthly, and the mean of these observations taken for each month, and, afterwards, for each year. The result was, that between 1821 and 1831 more than four hundred observations were taken, at levels varying between 65 feet and 1100 feet; and M. Reich concluded from them that the increase of temperature was represented by 1° for about 140 feet.

Similar experiments made in the mines of the Ural in Siberia have conducted M. Kupffer to a result superior by nearly one-half, as to the rapid augmentation of heat—namely, 1° for 65 feet. On the other hand, in some of the Scotch mines, the same experiments have shown an increase of 1° for 205 feet. And, finally, it has been ascertained in England that the temperature increases much more rapidly in coal than in metallic mines.

The diversity of the results which we have thus recapitulated proves, that observation of the temperature in the interior of mines does not afford a perfectly reliable basis for calculations.

The Artesian wells,* now established so generally over Europe, furnish us with a far more exact method than the preceding of work-

* [Artesian wells are so named from Artesia, now *Artois*, in France, where they are of frequent occurrence. It is supposed that the Chinese have been long acquainted with them, and for centuries they have existed in Austria, though the boring for them was there conducted in a very rude and empirical manner. Nor was it possible, until geology assumed a definite position as a science, for the engineer to decide with any degree of certainty whether a supply of water could or could not be obtained by this means in any particular district.

The principle of the Artesian well is simple; namely, to bore through the upper and non-retentive soil to strata containing water which has percolated from a higher level, and which is again forced up to that level through the boring-tube by hydrostatic pressure.

The wells supplying the fountains in Trafalgar Square, London, are bored through the upper clay into the chalk strata to a depth of 393 feet. At Grenelle, in the neighbourhood of Paris, the water is brought from the gault, at a depth of 1798 feet. The supply amounts to 516½ gallons of water in a minute, and it rises with such force as to be propelled 82 feet above the surface. For such an effort as this a pressure is required which has been calculated to exceed fifty atmospheres at the bottom of the bore.

Since the French occupation of Algeria, Artesian wells have been successfully introduced into the Desert of Sahara, creating gardens in the midst of dreary wastes, and literally making the wilderness to blossom like a rose. These artificial oases invariably become the nuclei of large and prosperous Arab settlements, and their effect on the habits and manners of a nomadic race promises to be as beneficial as it is extraordinary.]

ing out the desired law or principle. The depth of a well thus excavated being accurately known, the temperature of the water which rises to the surface of the earth through the Artesian tube ought to indicate, without the possibility of error, the temperature of the point of earth whence it has risen, inasmuch as it has not time to cool to any perceptible extent. That which is obtained from the Artesian well of Grenelle, for instance—1798 feet in depth—has a temperature of 81° 7′ F. The mean temperature of Paris being 53° F., we see that this water extracts from the "bowels of the earth" no less than 28° 7′ F. of heat, or about 1° for every 65 feet. The Artesian well of Passy gives a very similar result, = 82° 25′ F. at 1860 feet.

M. Walferdin has introduced into the abductor tube of various Artesian wells certain thermometers so arranged as to resist the pressure of the water, and to give, with much exactness, their true temperature. By means of his *thermomètres à déversement*, Walferdin has ascertained in the Artesian well of the *Ecole Militaire*, at Paris, in that of Saint-André (department of the Eure), and in that of Grenelle, an increase of 1° for every 100 feet. His experiment in the first well was made at a depth of 565 feet, in the second at 825 feet, and in the third at 1300 and 1650 feet.*

We may add that an Artesian well of 725 feet depth having been bored at Pregny, M. de la Rive, of Geneva, was able to introduce thermometers at various depths, obtaining as the result a rate of increase amounting to 1° for 165 feet.

The deepest borings have been executed at Mondorf, in the Grand Duchy of Luxembourg, and at Neusalzwerck, near Minden (Prussia). The former has been carried to a depth of 2380 feet, the latter to a depth of 2270 feet.

By comparing these various results, we arrive at the mean which is now generally accepted, of 1° for every 110 feet in depth; observing, nevertheless, that this will vary a third, and even a half, in some localities.

* [Some experiments recently made at Creuzot, by Walferdin, resulted in a rise of 1° for every 55 feet down to 1800 feet, and of 1° for every 44 feet beyond that depth.]

The depth to which observations of this kind can be carried is never very great, for no Artesian wells have hitherto exceeded 2280 feet, and our deepest mines do not descend below 6600 feet. Experiments in reference to the heat of the earth, pushed to the furthest limits of human adventure, could not, therefore, arrive at a greater temperature than 176° at the utmost. But this temperature has never been observed with any instruments referred to the depth we speak of. Yet a peculiar geological phenomenon enables us to establish the existence of far higher temperatures in the interior of the earth.

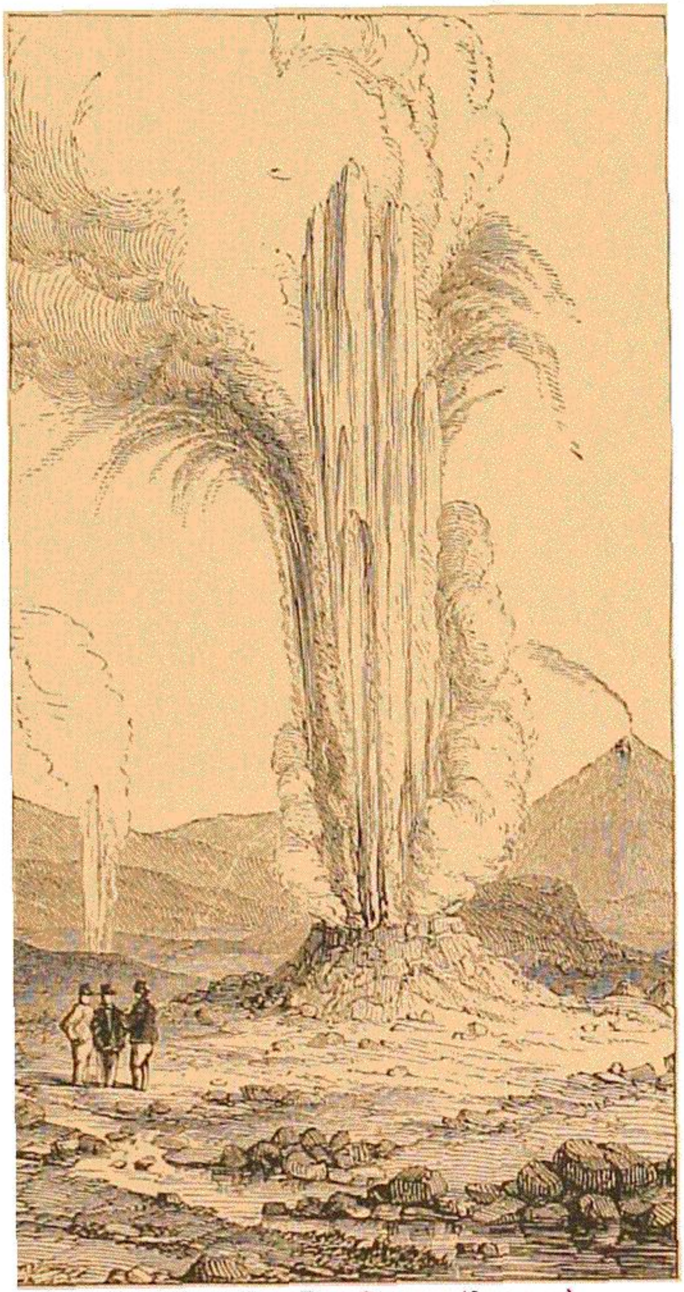

FIG. 120.—THE GEYSERS (ICELAND).

Certain mineral springs rise to the surface of the soil with a temperature of even 158° F.*

These immense sheaves of water loaded with silica, which escape from the soil of Iceland, and are named *Geysers*,† exceed a temperature of 212° F. at the point of emergence, and in their subterranean channel, at a few yards deep, the temperature is 256° F. This heat is obviously due to the depth in the earth of their great reservoir.

[The eruptions, or explosions, of the geysers, is thus accounted for by Professor Bunsen. "He points to the fact that water, after being long subjected to heat, loses much of the air contained in it, has the cohesion of its molecules much increased, and requires a higher temperature to bring it to boil; at which moment the production of vapour becomes so great, and so instantaneous, as to

* [We append a list of some remarkable thermal springs, with their ascertained temperature:—

Matlock (Derbyshire)....	68° F.	Ursprung (Baden), ...	153° 30′ F.
Buxton (Derbyshire), ...	82° F.	St. Gervaise....	98° F.
Stoney Middleton (Derbyshire),	70° F.	Aix-les-Bains, ...	117° F.
At Bath:—		Montiers, ...	101° F.
Cross Bath, ...	109° F.	Vichy, ...	104° F.
King's Bath, ...	114° F.	Barèges,...	120° F.
Hot Bath	167° F.	Carlsbad, ...	165° F.]

† [From the Icelandic *geysa*, to burst forth furiously.]

cause explosion. The bursting of furnace boilers is often attributable to this cause. Now, the water at the bottom of the well of the Great Geyser is found to be of constantly increasing temperature up to the moment of an eruption, when on one occasion it was as high as 261°. Professor Bunsen's idea is, that on reaching some unknown point above that temperature, ebullition takes place, vapour is suddenly generated in enormous quantity, and an eruption of the superior column of water is the consequence." *]

Another, and still more important geological phenomenon, proves, beyond the possibility of confutation, the existence, in the globe's interior, of a temperature which cannot be less than 2732° F. Numerous observations, made during the eruptions of Vesuvius, have proved that the lavas ejected from its mighty crater, and distributed over its declivities, possess an almost incredible amount of heat. Cast into the lava, as it flows, some pieces of glass, or of still harder substances, such as basalt or granite, and you will find that they fuse immediately on coming into contact with it. Frequently, in the interesting excavations which have been carried on at Pompeii, bars and fragments of iron, curtain-rings, and the like, as well as gold and silver coins, have been found half melted, having been liquefied by the mere action of the volcanic ashes. The fusing-point of iron being about 2032° F., this fact demonstrates that the temperature of the interior of our earth is certainly not *less*. We repeat these latter details in reply to an objection sometimes offered, that direct experiments made in the terrestrial depths have never shown a higher temperature than 86° to 104° F.

We have proved, then, that the temperature of the interior of our globe increases in proportion to the depth; and that the result of numerous careful observations fixes that increase at the rate of 1° to every 110 feet.

Admitting that this progression continues regularly to the centre of the earth, an hypothesis equally difficult to reject or defend, it would result that the temperature of the terrestrial nucleus must be estimated at 383,000° F.; that at a depth of one-fiftieth of the terrestrial nucleus, the heat would be 14,254° F. (or 100° by Wedge-

* [Lord Dufferin, "Letters from High Latitudes," p. 92.]

wood's pyrometer), a temperature capable of melting all the lavas and a great portion of the known rocks; finally, that a temperature of 212° F.—in other words, boiling-water heat—would prevail at a depth below the surface of 8100 feet.

Hence it appears, that if the art of boring Artesian wells should one day be so developed as to carry their soundings to a depth of 8100 feet, and if at that depth any basins of water exist, we might draw from the interior of our earth real rivers of boiling water, imitate artificially the imposing phenomenon of the geysers, and endow human industry with incalculable treasures, by placing at its disposal, without cost or danger, the mechanical force of the vapour of water —steam—that universal motor, and regenerator of the world!

But, to quit the allurements of hypothesis and return to the domain of fact, we conclude, from the particulars now set forth, that the central mass of the earth is constantly in a state of liquefaction produced by heat; and with this fundamental datum to guide us, we proceed to an investigation of the two great phenomena of Earthquakes and Volcanoes, which, at all epochs, have been a continual subject of terror for the vulgar, of astonishment for the philosopher, and of study for the man of science.

CHAPTER VI.

EARTHQUAKES—THEIR GENERAL PHENOMENA.

EARTHQUAKES and Volcanoes are two successive or concomitant effects of one and the same general cause.

Since the interior of our planet, at a depth of probably not more than twelve leagues from its surface, is occupied by a liquid incandescent mass—by fused matter—we may figure to ourselves its solid crust as a kind of raft floating, with no other support than its own cohesion, upon an ocean of fire, the *Phlégéton* of the Greek.

This thin crust must necessarily be susceptible to the various impressions communicated by the tumultuous movements of the liquid mass which supports it.

A French savant, M. Perrey,* has given to this idea an eminently scientific form. He has endeavoured to establish, from the calculation and comparison of an immense number of observations, that the lunar and solar attraction, which produces on the surface of our globe the flux and reflux of the seas, acts in like manner on the inner sea concealed in the depths of our earth; to the potent influence of our satellite he refers those convulsions which we call earthquakes, and which would be, as it were, the periodical result of the tides of the internal lava-ocean. We are not here called upon to examine closely this remarkable and strikingly original hypothesis. We only allude to it to establish the general cause of earthquakes, and to demonstrate the indissoluble connection of their phenomena with those of the volcanoes.

When the incandescent floods of the inner sea of fire dash against the interior surface of the terrestrial crust, an earthquake occurs over

* [See his elaborate and comprehensive "Histoire des Tremblements de Terre."]

an area of variable extent. When the pressure exercised by the subjacent lavas is sufficiently powerful to break *through* the terrestrial crust, and by the fracture so produced to effect a direct communication between the interior of the globe and its surface, the lavas—that is, the billows of the central ocean—will one day leap into the light, and form *a volcano.* If this opening, this communication accidentally established at one point between the interior and exterior of the earth, remain permanent, and if the eruption of lavas be continuous, as at Stromboli, or recurring at longer or shorter intervals, as at Vesuvius and Etna, the volcano will be *active.*

If the communication should after awhile be closed up again, we call it an *extinct volcano;* and of extinct volcanoes great numbers exist in various parts of the world, as in the Andes of South America, or in Central France. The occurrence of eruptive masses, such as trachytes and basalts, and of ancient craters, whose form resembles that of existing craters, enable the geologist to affirm without hesitation the past existence of violent igneous action.*

A German physicist, Herr Emile Kluge, has sought to prove that the frequency of volcanic eruptions follows the same cycle of eleven years which has been established in reference to the solar spots, the Aurora Borealis, and the variations of the magnetic needle. He adds that the secular period of the eruptions of Vesuvius, Etna, and other volcanoes—a period whose existence has already been ascertained—comprehends nine of these periods of eleven years. This is not the place, however, to discuss the bearings of such a law, even if we admit that its existence can be proved.

Let us first examine the characteristic phenomena of earthquakes; after which we will pass to a consideration of those of volcanoes.

* [Volcanic action, says Sir C. Lyell, may be defined to be "the influence exerted by the heated interior of the earth on its external covering." If we adopt this definition, without connecting it, as Humboldt has done, with the theory of secular refrigeration, or the cooling down of an original heated and fluid nucleus, we may then class under a general head all the subterranean phenomena, whether of volcanoes or earthquakes, and those insensible movements of the land by which large districts may be depressed or elevated without convulsions.—"Principles of Geology," i. 577.]

From the earliest ages of human society, earthquakes have justly been a subject of dread and horror. A mere spasm of the terrestrial crust, which, so far as concerns the natural history of our globe, is but an insignificant accident, proves to be a source of frightful misfortunes for civilized man; who, in an interval of a few seconds, may witness the spread of utter desolation over an immense extent of country—opulent cities and blooming fields converted into a mass of unsightly ruin—villas, churches, palaces, orchards, gardens, all overthrown and destroyed—and hundreds of his fellow-creatures either buried beneath their own shattered roof-trees and sanctuaries, or swallowed up in the abysses of the yawning death!

[The truth is, that there is something peculiarly appalling to our humanity—something which confounds, as it were, the very evidence of our senses, and cuts away from beneath us the support on which we have been glad to lean—in the occurrence of these phenomena. We feel no astonishment at the perils of the ocean. There is an instability in water, and a want of fixity, which appears consistent with violent and premature changes. We hear of shipwrecks, not without pity, but without astonishment; if men go down to the deep in ships, we reason with ourselves that such catastrophes are but the natural consequences of their hazard, just as a man who dashes into the tumult of battle must naturally count upon wounds, capture, or death; but earth to the untutored eye seems so firm, so solid, so impregnable, that we are not wont to associate with it any ideas of sudden panic or overwhelming disaster. This round world, we say, cannot be moved. If caught in a storm on the breast of ocean, we long for "land;" we yearn after the safety of the quiet valley, the security offered by the deep forest shades. We speak in loving and confident tones of our dear mother earth—our unshaken *terra firma*—where, if we can but plant our feet, we feel ourselves delivered from every danger. And yet, alas! no ocean calamity can equal in extent the ruin inflicted by a single shock of earthquake!]

Before presenting an historical narrative of some of the more remarkable of these awful events, of some which have impressed the minds of men with the saddest memories, we think it will be useful for us to trace the general features of an earthquake from a scientific view-point. We proceed, therefore, to examine in succession:—

1st, The signs and precursors of an earthquake;
2nd, Its superficial extent;
3rd, The duration and direction of its shocks;
4th, Its effects on the configuration of the soil;
5th, The nature of the disasters which it produces; and,
6th, The moral impression which it exercises upon man.

THE SIGNS AND PRECURSORS OF AN EARTHQUAKE.

It is generally imagined that an earthquake is always preceded, heralded, and, so to speak, prepared by some unusual atmospheric agitation, by a violent storm, a hot stifling wind, or an anomalous state of the magnetic needle. This is not the case. Nor should the absence of precursory symptoms surprise us, when we know that the cause of earthquakes is entirely internal, and, consequently, in no way connected with the conditions of the atmosphere. Frequently, the sun is shining with its most dazzling lustre, and in the air prevails the profoundest calm, when those catastrophes suddenly occur which convert the smiling plain, and towns echoing with the "busy hum of men," into a scene of death and ruin, and in the twinkling of an eye hurry thousands of our fellow-creatures into an unexpected and most awful grave. The terrible earthquake of Lisbon surprised the Portuguese capital on a day of festival, at nine o'clock in the morning—one of the loveliest mornings of that glorious climate—at the moment when its inhabitants were thronging to the churches. Earthquakes occur under a serene sky as frequently as during a storm of rain; when the wind blows freshly and gently, as when the hurricane is raging abroad. Humboldt had never seen the needle agitated in any one of the numerous earthquakes which he observed during his five years' sojourn in Equatorial America; and another traveller, Adolph Ermann, made the same observation in the temperate zone, on the occasion of an earthquake which occurred at Irkutsk, near Lake Baikal, on the 8th of March 1829. The earthquake of Rio-Bamba, February 4th, 1797—one of the most terrible calamities recorded in the physical history of our globe, and in reference to which Alexander von Humboldt collected many important details—was not preceded by any atmospheric symptom.

It frequently happens that a terrible noise precedes, accompanies, or follows the catastrophe. But this noise does not originate in the atmosphere; its source is in the bowels of the earth, and is produced by the crashing of the rocks as they yield, over an immense extent, to the pressure of the burning lavas which shatter them. An awful subterranean roar preceded, by a few minutes, the disaster of Lisbon. But the great shock at Rio-Bamba, in February 1797, was not ushered in by any sound. A formidable detonation was heard under the soil of Quito and Ibarsa, two towns at a considerable distance from Rio-Bamba, but not until twenty minutes after the calamity. A quarter of an hour after the earthquake had destroyed the opulent city of Lima—October 28, 1746—a gust of subterranean thunder re-echoed at Truxillo. In like manner, it was not until long after the great earthquake in New Grenada, on the 16th of November 1827, which M. Boussingault has described, that subterranean reports were heard in the valley of Cauca.

[The subterranean noises accompanying or following earthquakes vary greatly. Sometimes they may be likened to the rumbling of a railway train through a tunnel, or of a series of waggons over the arches of a viaduct. Sometimes they resemble the echoes of thunder among the mountains; sometimes the explosion of a mine. Occasionally, they remind the hearer of the roll of a thousand drums; or the clinking of glass and porcelain, as if masses of vitrified rock had suddenly split asunder in the terrestrial cavities. They have also been compared to the sound of a mighty wind rushing through subterranean corridors; to the clanking of chains and the ringing of bells. In point of intensity, they seem to vary from a comparatively subdued muttering or grinding, to the awful battle-roar of two vast contending armies. In the latter case, it is probable an explosion actually occurs at a great depth below the surface; in the other instances, the sounds may be supposed to originate in the rending and splitting of the strata displaced by the "earth-wave."]

Physical science teaches us that solid bodies are admirable conductors of sound; the sonorous undulations are much more quickly transmitted through wood, metals, and rocks, than by the air or gases. Of this fact the reader may convince himself by placing a watch at one extremity of a beam, and applying his ear to the other extremity.

The movement of its balance-spring, which could not be heard through the air at that distance, may be perceived with the greatest facility through the inter-medium of the pole or beam. Thus, then, the noises produced in the earth's womb by the crackling rupture and dislocation of solid mineral masses transmit themselves to very great distances, and make themselves heard at a remote point from their place of origin.

According to Humboldt, at Caracas—in the plains of Calabozo—on the banks of the Rio-Apure, one of the affluents of the Orinoco—that is to say, over an area of 15,000,000 square acres—a frightful subterranean report was heard at the very moment, as was afterwards ascertained, that a torrent of lava burst from the volcano of Saint Vincent, in the West Indies, distant 720 miles. To assist the reader in forming a conception of this rapidity of progression, we may remind him that it was just as if the discharges of Vesuvius were simultaneously heard at Dover.

During the great eruption of Cotopaxi, in 1744, the report of the subterrene detonations was transmitted to Honda, a distance of about 500 miles; these two points, moreover, present a difference of level equal to 17,700 feet, and are separated from one another by colossal mountains. During the earthquake of New Grenada, in February 1835, subterranean noises were heard in the Caracas, at Haïti, in Jamaica, and on the banks of the lake of Nicaragua.

But these subterranean noises not unfrequently occur without the terrible accompaniment of any visible signs of internal disturbance. On the 9th of January 1784, a sound like remote thunder (*bramido y truenos subterraneos* *) was heard at Guanaxuato, the chief town of the Mexican province of the same name, and lasted for upwards of a month, broken at intervals by violent detonations. From the 13th to the 16th of January, they resembled a tempest; brief sharp reports, like the vollied lightning, alternating with the reverberations of distant thunder. Though Guanaxuato is not situated in the volcanic region of Mexico, its inhabitants were stricken with terror, and deserted their homes *en masse*.

Great quantities of silver in "bars" were then stored up at Guanaxuato, and a few individuals, whom the bait of so splendid a prize enabled to resist the general infection, broke open the houses and enriched themselves at will. Gradually, however, the population took heart, and began to re-enter the town; and a company of

* Literally, "roarings and subterranean thunders."

the local militia hastened to recover the treasure which had been plundered under such singular circumstances. To prevent a resumption of the emigration, the magistrates levied a severe fine from every rich family which attempted to quit the town, and punished the poor with imprisonment. But the gradual cessation of the subterranean turmoil proved still more effective in checking the emigrating tendencies of the population.

No shock or convulsion had accompanied these alarming sounds ; nor was any movement felt, either on the surface of the soil or in the neighbouring mines, at a depth of 1598 feet. But a proof that they proceeded from the earth's interior was the fact, that in the mines they were infinitely louder than above ground.

Nothing of a similar kind has since occurred at Guanaxuato.* But at Meleda, one of the islands of the Adriatic, situated off the Dalmatian coast, subterranean noises were prolonged over a period of four years ; from March 1822 to September 1826. They succeeded one another so frequently, that more than a hundred subterranean explosions were heard in one night (the 2nd to 3rd of September 1823). And so exactly did they resemble discharges of artillery, that they were at first attributed to some naval battle ; but, still continuing, were supposed to be forewarnings of an impending earthquake, which, however, did not occur. Only a slight shock was felt, which did no injury to the houses, but detached a fragment of rock from a neighbouring mountain.

The inhabitants of the island, alarmed by this accident, and dreading a volcanic outburst, demanded permission from the Austrian Government to transfer themselves in a body to the mainland. The Viennese authorities despatched on a preliminary mission of inquiry two naturalists, Franz Riepel and Paul Partsch, who succeeded in relieving the popular mind from its apprehensions of danger.

At Nakous, on the Red Sea coast, underground noises, like the tinkling of a bell, are heard at frequent intervals.

SUPERFICIAL EXTENT OF EARTHQUAKES.

An earthquake, being in reality an oscillation or progressive movement of the terrestrial crust, cannot be confined to a single point on the globe's surface, but must necessarily spread over a considerable space. There are numerous instances of its effects extending to an almost incredible distance.

Thus : the earthquake of Lisbon propagated itself over nearly a whole hemisphere ; and it has been computed that its shocks were perceptible over an extent of country four times as large as the European continent.† On the same day the ground was agitated,

* [Full details of this remarkable event are given by Alexander von Humboldt in his "Kosmos."]

† [The area disturbed was estimated at 3300 miles in length and 2700 in breadth, or nearly 9,000,000 square miles.]

not only in the Iberian peninsula, not only in the north and west of Europe, but in northern Africa and even in America.

The town of St. Ubes, or Setubal, twenty leagues to the north of Lisbon, was engulfed.

At Cadiz, on the Spanish coast, the sea rose upwards of one hundred and five feet.

At Kinsale, in Ireland, several vessels were lifted by the tide into the very market-place.

In England and Scotland the lakes, rivers, and springs were extraordinarily perturbed.

Light oscillations were felt in Sweden, Norway, Holland, France, Germany, Switzerland, Italy, and Corsica.

The thermal springs of Tœplitz suddenly ceased to flow; then returned in a ferruginous coloured torrent, which inundated the town.

A mineral spring at Néris rose four feet.

In the north of Africa the oscillation of the earth was very violent. At Algiers and Fez about ten thousand victims were counted. At Tangiers the sea was extraordinarily agitated, and, ten times running, the waves overpassed their ordinary limit.

In the island of Madeira the sea rose more than sixty feet above its usual high-water mark.

Fez and Mequinez, two thriving towns in Morocco, were shattered to the ground.

Finally, in the Lesser Antilles, where the rise of the tide does not usually exceed two or three feet, the waves, black as ink, rose to the height of twenty-two feet.

Thus, then, the Lisbon earthquake—that terrible calamity, which sank so deeply in the minds of our forefathers—was felt from Portugal to Lapland in one direction; to the West Indies in another; and yet again, in a third, from Africa to Greenland.

The Calabrian earthquakes of 1783 and 1784 propagated their shocks in all directions, over a radius of about 72 miles, and both by sea and land. The shocks rolled onward in a straight line; and their effects seemed to move from point to point, so that they had terminated in Calabria before the first houses were overthrown in Sicily, and the inhabitants of Messina saw the glittering villas on the sea-shore flung down before the oscillations had reached their own habitations, which fell into ruins a few moments after.

The earthquakes of Chili (July 1794), which ravaged 300 leagues of the American coast, were felt 170 leagues out at sea, so that the convulsion spread over a superficial area of upwards of 50,000 square leagues.

On the 8th of September 1601, men felt at Lima a shock of earthquake which extended over nearly the whole of Europe, and even into Asia.

The convulsion which overwhelmed Caracas, the 12th of May 1812, propagated itself to a distance of 180 leagues.

The earthquake in New Granada, on the 17th of June 1826, exercised its fatal influence over an area of many square miles.

Earthquake shocks in Martinico are felt over the West Indies, in Florida, along the Gulf of Mexico, and over a portion of South America; in other words, over an area of 375,000 square leagues.

[It happens at times that the *length* of the area convulsed greatly exceeds the breadth, as if the undulations were confined within a comparatively narrow channel. Thus, in the Chilian earthquake of 1835 the extent of ground affected was as 2 to 1 in length compared with breadth; and in the Syrian earthquake of 1837, as 5 or 6 to 1.

The terrible earthquake which devastated Peru and Ecuador on the 13th of August 1868, extended along the coast of the Pacific for 1200 miles—from 8° S. to 42° S. lat.—and was felt at numerous remote points in the West Indies and Mexico.]

The comparison of these and other similar occurrences fully establishes the fact of the propagation of the earth-wave over very considerable spaces. The oscillation seems spread at times over a great circle more or less inclined towards the equator.

It is unnecessary to say that these terrible manifestations of the hidden forces of Nature are not confined to continents. The bottom of the ocean may be shaken by the commotion of the earth, and a violent movement in this manner communicated to the great mass of waters. Out at sea vessels have frequently experienced shocks of this description. In 1660 Captain Oxmann was navigating the Southern Ocean, when suddenly his ship experienced a rocking which occasioned the crew a paroxysm of terror. They thought she had run aground, but, after casting anchor, quickly discovered that they were far distant from reef or sandbank. A similar accident befel the navigator Lemaire in the strait which bears his name.

The violence of these earthquakes has frequently dismasted "tall barques," and caused them to spring dangerous leaks; but the equilibrium natural to a ship renders this species of accident of no very serious character. The tumult of waters produced by earthquakes is only formidable upon the shore, where it is not unfrequently the cause of melancholy catastrophes.

During the disaster of Lisbon the upheaval of the ocean added its ravages to those of falling houses and shattered churches. The waves rose to a height of fifty feet above the highest tides. This mountain of seething, and boiling, and foaming water broke with resistless fury on the ruined city, overwhelming whatever the earthquake had spared, and inundating the whole line of coast. Thrice did the pitiless sea return to the assault, dragging back with it in its hasty retrocession everything that it had encountered in its furious march.

During the earthquake at Lima, October the 28th, 1746, the sea, swelling suddenly to an elevation of eighty feet, dashed against the unfortunate city of Callao, and wholly ingulfed it. A new irruption carried away the very soil on which Callao had once stood. All the ships in harbour were wrecked or foundered, and the raging waves were covered with masts, and spars, and timbers. The smaller craft were submerged where they rode at anchor; the large ships broke their cables and drifted ashore. Four of these were transported by the rolling wave for a league and a half beyond the walls of the city. All these vessels perished, with their crews and cargoes. Of the whole population of Callao—who had gone forth in the morning to work or make merry, to love or hate, addressing themselves to the pleasures or duties of life without any presentiment of the coming doom—of all this population only fifteen persons succeeded in effecting their escape to Lima. When the inhabitants of the latter city had so far mastered their terror and recovered their composure that they could bethink themselves of the misfortunes of others, they found, under the pile of wreck which had once been well-equipped barques, nothing but putrefying corpses, or a few poor, mutilated wretches dying of hunger for want of strength to drag their crippled limbs to the abundant stores of food that lay almost within their reach.

During the earthquake which, in 1692, shook the coasts of Jamaica, the sea rose to a prodigious height. An English frigate was hurled by the waves over the houses and spires of the town of Port-Royal, and deposited, it is said, on one of the furthest buildings, whose roof it crushed in, remaining suspended between the walls.

DURATION AND DIRECTION OF THE EARTHQUAKE SHOCKS.

The duration of an earthquake is very variable. In some countries the spasms, so to speak, are protracted for weeks and even for whole months: at Peru the tremulous motion has continued for several consecutive years. In certain regions these convulsions are periodical. At Jamaica, for instance, a shock is expected once a year. In other regions they are felt for six months or a year consecutively; and then centuries pass away without a renewal of the agitation. In some the phenomenon does not last above a day, an hour, perhaps a second. Nothing, then, varies more than the duration of an earthquake.*

* [It may here be noted that the greater number of earthquakes occur in the first, or winter, and the last, or autumnal, quarters of the year; that is, when the earth is nearest to the sun. More earthquakes take place at new and full moon than at the quadratures, and more when she is in perigee, nearest the earth, than when she is in apogee, or at her greatest distance. The igneous action, in its effort to free itself, is evidently assisted by the comparative proximity of the moon and sun to the earth, and by the concurrence of the two luminaries in a line passing through our globe.]

But whatever may be the number and frequency of the shocks composing an earthquake, the shock itself is almost instantaneous. The earthquake, like the storm, may endure for a period; but the shock, like the lightning, is the work of a few seconds.

The convulsion which, in 1693, devastated the fair city of Messina, and fifty hamlets and villages in Sicily, causing the death of 60,000 individuals, lasted only five seconds—only the twelfth part of a minute! That which, in 1812, destroyed Caraccas, and converted that town into a heap of ruins, was of still briefer duration: in three seconds the terrible doom was accomplished! The first shock toppled down the spires and towers of the churches; the second unroofed the houses and public buildings; and before the timid populace could look around and estimate the amount of their misfortune, a last shock shattered the town into ruins, under which the inhabitants were crushed and buried.

The shocks which, from April the 2nd to May the 17th, 1808—that is, for seven weeks—did not cease to disturb the province of Pignerol, and were repeated four or five times daily, never lasted more than a few seconds each.

The direction of these movements of the soil is not always easy to define; for it is very rare, on the occurrence of so awful a catastrophe, an observer can be found with a mind sufficiently stoical to observe, with philosophical calmness and scientific accuracy, the course of the terrible convulsions which threaten himself with an immediate and a frightful death. Aristotle, who had been able to study in Greece and on the coast of Asia Minor some of these phenomena, was the first to establish three distinct categories in the course and direction of the shocks. We may say, then, with the illustrious Stagyrite, that they are sometimes *undulatory* or *horizontal*; sometimes *vertical*—that is, resulting from a rapid succession of upheavals and depressions of the soil; and, thirdly, sometimes *rotatory*.

Vertical and horizontal shocks are frequently simultaneous. According to Humboldt, a vertical shock directed from below to above, in the earthquake of Rio-Bamba (1797), produced all the effects of the explosion of a mine: the dead bodies of a number of individuals were hurled as far as an opposite hill, more than four hundred and eighty feet in height. When the three kinds of shocks occur at the same time, nothing can escape the devastation. Such undoubtedly was the case in 1783, when all Sicily and Calabria were ravaged. So violent and so complex were the movements, that the tops of the tallest trees were bowed to the ground. According to Dolomieu and Sir William Hamilton—both conscientious observers—houses were lifted off the ground, and then returned to their former sites; and one saw even the summits of the Apennines balancing in the air:—

"Insolitis tremuerunt montibus Alpes."—(*Virgil.*)

It has frequently been pretended that the great mountain-chains—especially when, like the Apennines, they are granitic, or, in other words, composed of primary rocks, and thrusting their roots, so to speak, down into the very depths of the terrestrial crust—arrest the propagation of the earth-wave, which seems to die away at their feet. But this assertion is controverted by undeniable facts.

EFFECTS OF THE CONFIGURATION OF THE SOIL.

The effects of earthquakes are not limited to the ruin of entire cities and the destruction of the work of men's hands: the surface of the earth also undergoes more or less extensive modifications. It may be upheaved, as was the case in the terrible Chilian earthquake of 1822, when the American coast was raised above its former level throughout an extent of three hundred leagues. New mountains may thus make their appearance; while often, on the other hand, the ancient hills—so erroneously called "everlasting"—crumble away in a mass, filling up the valleys with their débris. Sometimes the ground yawns wide, leaving after the catastrophe—as if to keep men's minds in constant remembrance of it—enormous crevasses of several leagues in length. When referring, in a former chapter, to the Calabrian earthquakes, we gave illustrations of several of the fissures formed by the convulsion of the strata. These are not always permanent: opening when the shock occurs, they sometimes close as suddenly, crushing between their sides the houses which they swallow up. Individuals have been seen to disappear between their yawning jaws, whose bodies, a few moments afterwards, were launched in the midst of a deluge of water from the very chasm that had so recently ingulfed them.*

An alteration in the level of the soil, resulting from the upheaval or sinking of a more or less considerable extent of the earth's crust, is one of the commonest effects of earthquakes. In India, in 1819, a hill or ridge, some twenty leagues in length by six in width, rose in the middle of a flat and level country. Further to the south, but parallel in the same direction, the land yielded, carrying with it the villages and the fort of Sindré, which remained surrounded with water. The changes spread in India over this immense extent are invariably displayed, over more confined spaces, in every earthquake. The primitive level of the soil is destroyed, and an abbreviation in the course of rivers and brooks is the usual result.

From the clefts thus opened in the soil, eruptions of various matters frequently take place—as of water, vapour, and even flames. At Catania, in 1818, jets of hot water were seen to leap from the earth's depths; in 1812, near New Madrid, in the valley of the Mississippi, currents of steam; at Messina, in 1812, streams of mud and black clouds of smoke. During the Lisbon earthquake, in 1755, flames and smoke were observed arising from a crevasse near the town, which had opened in the rocks of Alsidras: the louder grew the subterranean detonations, the intenser grew the smoke and fire. During the earthquake of New Granada, November the 16th, 1827, immense effluvia of carbonic acid gas, issuing from the clefts in the

* [It is but right to warn the reader against the exaggeration of these statements. Mr. Mallet—than whom there is no better authority—refuses credence to all such highly-coloured narratives of "yawning chasms" and "profound abysses." They seem to have originated in a few cases of extraordinary landslips and the production of circular pits.]

earth, suffocated a multitude of cave-dwelling animals, such as rats and serpents.

The waters which thus escape from the earth are frequently mingled with sand; and even eruptions of dry sand occur, producing small circular openings in the soil, of which we shall see some examples when we describe in detail the great Calabrian earthquakes.

The gaseous exhalations are not easily recognized on the earth, because the gases dissipate in the atmosphere without anything indicating their passage or their presence. Their emission is, in fact, only appreciable when it takes place under a liquid stratum. Sometimes in the course of an earthquake the sea boils, and enormous bubbles rise to the surface—a phenomenon which renders visible and distinct the subterranean escape of gas. Some savants have thought it possible to detect a certain coincidence between the escape of the gases which rise from the bottom of the Lake of Geneva, and certain shocks of earthquake which make themselves felt throughout the vast chain of the Alps.

NATURE OF THE DISASTERS PRODUCED BY EARTHQUAKES.

The narratives of earthquakes observed in all quarters of the world, and recorded in the annals of every nation, bring before us the scattered details of the general picture we shall attempt to trace. Everywhere we read of crevasses and fractures of the terrestrial crust—of chasms suddenly created, in which the superficial strata are swallowed up, with houses and churches, fields, gardens, orchards, and cornfields. Everywhere we read of enormous masses of water or clouds of vapour issuing through the gaps in the earth's surface—sometimes even of flames, which are produced by the action of the atmospheric oxygen on combustible gases. Sometimes huge hills are suddenly thrown up in the midst of plains, or rocks and sandbanks rise above the waves of ocean. Sometimes the mountains are shattered from summit to base, and undulating districts are rolled flat, and replaced by lakes of water. Rivers are swallowed up in subterranean recesses or directed into new channels; while, on the other hand, abundant springs well forth in localities that were formerly dry and barren, or the ancient fountains are silenced, and the thermal waters cooled.

The very various effects of earthquakes tend to invest with an air of probability certain events recorded in the chronicles of the ancient world. Who would now dare to contradict the assertion of Pliny—following the older historians—that Sicily was sundered from Italy by an earthquake? Is there not, indeed, every reason to believe that such an event actually took place? Who would contradict the same author—credulous as he often shows himself—when he adds that the blooming island of Cyprus was separated from Syria by the same cause, and Negropont (the ancient Eubœa) from Bœotia? Are we in a position to deny positively the former existence of the famous Atlantis, which, according to Egyptian traditions, has disappeared beneath the waves, when we shall have to refer to contemporary facts of an analogous character? The events now transpiring under our eyes explain what has occurred in past times.

The relations embodied in modern works do but reproduce the very catastrophes whose story has been transmitted to us either by the poets or chroniclers of antiquity. If the poet who wrote under the name of Homer is silent—a circumstance sufficiently remarkable—in reference to earthquakes and volcanic eruptions, though in his era Greece and Asia Minor were undoubtedly ravaged by the subterranean fires, Virgil describes in detail the paroxysms of Etna.

["Ætna, with her voice of fear,
In weltering chaos thunders near.
Now pitchy clouds she belches forth
Of cinders red and vapours swarth,
And from her caverns lifts on high
Live balls of flame that lick the sky;
Now with more dire convulsion flings
Disploded rocks, her heart's rent strings,
And lava torrents hurls to-day,
A burning gulf of fiery spray."*

Pindar, long before the time of Virgil, recorded the volcanic phenomena with equal spirit and accuracy; the streams of flame that poured forth from the bowels of the mountain, and the lava-rivers, that in the daytime emitted only clouds of smoke, but at night glowed like sheets of fire rushing towards the sea.† In the

* [Virgil, "Æneid," iii. 570–577, Professor Conington's translation.]
† [Pindar "Pyth.," i. 40.]

"Prometheus Vinctus" of Æschylus we likewise read of "rivers of fire that with ravenous jaws devoured the smooth fields of blooming Sicily." Eruptions are also noticed, with careful details, by Thucydides and Diodorus.]

Ovid, Lucretius, Lucian, Seneca, Ammian Marcellinus, and all the ancient historians, describe events which are the faithful image, and, as it were, the exact anticipation, of events in our days. Lucian remarks that the earthquake completed the destruction of those pillars of Palmyra and Baalbec which time and the fury of barbarians had spared :—

"Etiam periêre ruinæ" (The very ruins have perished).

It is certain that no destructive force of a more terrible character exists, or one which, in a brief moment of time, can involve a greater number of men in death and ruin than an earthquake. The towns of Syria, and those "isles of Greece," so dear to poesy and legend,

"Where burning Sappho loved and sung,"

were almost annihilated, with their inhabitants, in the first centuries of the Christian era. Under Tiberius and Justinian, about the years 19 and 526 A.D., nearly 200,000 persons perished in Syria and Asia Minor. The mediæval chroniclers refer to catastrophes not less terrible which occurred in the following centuries. Sixty thousand men lost their lives in the earthquake of Sicily in 1693; in 1793—less than a century afterwards—80,000 were swept away in the same ill-fated island. The earthquake of 1755, which destroyed Lisbon, and shook the coasts of Spain and Northern Africa, counted 60,000 victims; in that of Rio-Bamba, in 1797, 40,000 perished. It would be a too easy task to prolong this gloomy death-roll.

[A popular belief has long prevailed that England is exempt from these awe-inspiring convulsions. Such is not the case: the British Islands have been visited by frequent shocks, even in historic times, though happily unattended by any very serious catastrophes.

It is true that Camden speaks of the town of Kenchester as having been swallowed up by an earthquake; and that Reginald of Durham asserts that at Mungedene Hill, near Norham-on-Tweed, the earth yawned and ingulfed many thousand Scots who were sacrilegiously ravaging St. Cuthbert's lands. But these are probably the sombre imaginations of popular superstition. As far as authentic records go, English earthquakes have had no more serious consequences than a crumbling wall or two or a shattered spire.

An earthquake which shook all England occurred, according to Roger Wendover, in 974. Others, in 1076, 1081, 1089, 1099, are described as attended with or preceded by "heavy bellowing." The "Saxon Chronicle" reports that in 1089 there was "a mickle earth-stirring over all England;" and Florence of Worcester that, in 1110, "a very great earthquake" was felt at Shrewsbury. "The river Trent was dried up at Nottingham from morning to the third hour of the day, so that men walked dry-shod through its channel." In 1119, 1133, 1142, 1158, many parts of England were shaken. In 1165 "there was an earthquake," says Matthew Paris, "in Ely, Norfolk, and Suffolk, so that it threw down men who were standing, and rang the bells." Another took place in 1179, when the ground was raised up at Oxenhall, near Darlington, to a prodigious height, and after a few hours suddenly let sink again; another in 1185; others in 1199, 1246, and one especially in 1247, which did much damage on the banks of the Thames, and was distinguished by a supernatural—or preternatural—tranquillity of the seas on our English coast. In the following year the west of England was visited; a cupola on the tower of Wells Cathedral was dashed down upon the roof. In 1250 we read of a shock in Buckinghamshire; in 1275, of one which shook almost all England, and injured many churches; and, passing over 1298 and 1318, of an earthquake in Kent and elsewhere in 1382, which a contemporary poet made the theme of his muse:—

> "Forsooth! this was a Lord to dread,
> So suddenly made men aghast!
> Of gold and silver they took no heed,
> But out of their houses full soon they past.
> Chambers, chimneys, all to burst,
> Churches and castles foul 'gan fare;
> Pinnacles, steeples to ground it cast,
> And all was for warriors to be ware."

John Harding, in his metrical "Chronicle" for 1361, describes—

> "On St. Mary's Day
> The great wind and earthquake mervellous,
> That greatly gan the people all affraye;
> So dreadful was it then, and perilous."

The same chronicler speaks of the one in 1382, already recorded:—

> "The earthquake was, that time I saw,
> That castles, walls, towers, and steeples fyll,
> Houses and trees, and crags from the hill."

In 1426 all "Great Britain" was shaken by an earthquake; and in 1551, on the 25th of May, various parts of Surrey were visited. On the 17th of February 1571, an earthquake took place near Kynaston, in Herefordshire:—"A hill, called Marcle Hill, with a rock under it, made at first a mighty, bellowing noise, which was heard afar off, and then lifted up itself a great height and began to travel, carrying along with it the trees that grew upon it, the sheepfolds, and flocks of sheep abiding thereon at the same time. In the place from whence it removed, it left a gaping distance 40 feet wide, and 80 ells long;—the whole field was almost 20 acres." In 1574, on the 26th of February, York, Worcester, Gloucester, Bristol, and some other towns, were affrighted out of their propriety by a severe shock; and on April the 6th, 1580, London was so grievously visited, and, indeed, nearly all the country, that Queen Elizabeth judged it needful to issue a form of prayer for the use of all heads of families before they retired to bed. In 1666 Oxfordshire was afflicted; in 1677 and 1688, Staffordshire; in 1683, Oxfordshire again; in 1690, Bedford; and in 1692, September the 8th, most of the metropolitan counties were alarmed by an earthquake, which Evelyn has described, and which suggested numerous predictions of the approaching end of the world. In 1703 Yorkshire and Lincolnshire, in 1712 Shropshire, in 1726 Dorsetshire, and in 1727 Kent, were considerably disturbed.* But that of 1750, which repeated its shocks in February, March, April, May, July, August, and September, disturbing nearly the whole of England south of the Mersey, is better known, owing to the lively accounts left on record by Horace Walpole.† Describing what he himself experienced, he says :—"I had been awake, and had scarce dozed again—on a sudden I felt my bolster lift my head. I thought somebody was getting from under my bed, but soon found it was a strong earthquake, that lasted nearly half a minute, with a violent vibration and great roaring. I got up, and found people running into the streets, but saw no mischief done. There has been some ; two old houses flung down, several chimneys, and much earthenware." ‡

Several slight earthquakes have been noticed of late years, especially in 1852 and 1863. Mrs. Somerville, writing in 1858, states that 255 are recorded *in toto* as having occurred in the British Islands, but this is undoubtedly far below the truth. At Comrie, in Perthshire, a shock occurs once or twice every year ; in the winter of 1839–1840, one hundred and forty shocks, or nearly one a day, were experienced. These, however, are assigned to a district of very small extent, which seems to be situated at a point where the earth-wave expends its lingering force, and are productive of little damage.§

On Friday, October 30, 1868, a considerable portion of England was visited by an earthquake, which appears to have been most severe in Wales and the western counties, and occurred between ten and eleven at night. In some places two distinct shocks, each lasting about six seconds, were experienced. Their effects were, happily, of no great importance ; no lives were lost, no buildings thrown down, no disturbance of the earth's surface was produced ; but beds rocked, and bells suddenly jangled, and window-frames rattled, accompanied, in a few localities, by a low, rumbling sound, like that of a subterranean explosion, and which may very probably have been due to some explosion of the gases in the carboniferous strata. ||

Mr. Plant, the meteorologist, remarks :—"The earthquake of November 9, 1852, occurred early in the morning. Both the barometer and thermometer were high. The former rose half an inch. The earthquake of October 6, 1863, was at four in the morning. After the earthquake the temperature rose considerably. The earthquake of Friday, October 30, 1868, was at 10.40 P.M. Both barometer and thermometer were high ; the latter rose remarkably."

A shock of earthquake was felt in the Midland counties in the early part of the present year (1869).]

* ["Quarterly Review," No. ccli., p. 84. There were also shocks at various places in 1731, 1732, 1736, 1738, and 1748.]

† ["Letters of Horace Walpole," to Sir Horace Mann, Bentley's edition.]

‡ [An earthquake occurred in 1775, which produced so much impression as to suggest to the Rev. John Newton one of his popular Olney Hymns.—See Book ii., No. 68.]

§ [Upon this subject the reader may consult Mr. Mallet's "Report on Earthquakes to the British Association" (1850–58) ; Burton's "General History of Earthquakes ;" and Sir Charles Lyell's "Principles of Geology," tenth edition.]

|| [In this connection we may record that a shock of earthquake was felt at Cologne, at a quarter past four P.M., Nov. 17, 1868, simultaneously with the eruption of Vesuvius described in a succeeding chapter.]

After considering these details, the reader will not be surprised if we add that nothing so grievously terrifies man — nothing fills his soul with so unconquerable an anxiety—nothing, in fact, so utterly demoralizes him—as the earthquake. Humboldt has described, with his usual force, the profound impression, the wholly peculiar and distinct effect which it produces on the human mind :—

"That impression," observes the illustrious physicist, "does not proceed from the images which the awful catastrophes whose memory history has preserved, then crowd upon the brain. What really moves us is, that we suddenly lose our innate confidence in the stability of the soil. From our infancy we have been accustomed to contrast the shifting nature of water with the immobility of earth. Our security has been strengthened by all the evidences of our senses. But the ground trembles, and that moment suffices to destroy the experience of a life. An unknown power is suddenly revealed, the calm of nature being but an illusion, and we feel ourselves thrown back violently upon a chaos of destructive forces. Then every sound, every breath of air excites the attention; we grow mistrustful of the very ground on which we walk. Animals, too, and especially dogs and swine, experience this anguish; the crocodiles of the Orinoco, generally as mute as our own little lizards, fly from the shattered bed of the river, and take refuge, roaring, in the forest." *

[A recent writer has very justly observed that the first physical effect of an earthquake seems to be to strip men of all their sense of moral relation to the universe altogether, to reduce them to the sickness of absolute isolation, and this even before the shock has worked its destructive effects. A gentleman who witnessed one of the worst earthquakes at Copiapo, remarked, "Before we hear the sound, or at least are fully conscious of hearing it, we are made sensible, I know not how, that something uncommon is going to happen; everything seems to change colour; our thoughts are chained immovably down; the whole world appears to be in disorder; all nature looks different from what it was wont to do; and we feel quite subdued and over-

* [Humboldt, "Kosmos," i. 243.]

whelmed by some invisible power beyond human control or comprehension."*]

No catastrophe, in fact, alarms the human soul with such justifiable terrors. When we are told that 30,000 or 40,000 persons have perished by an earthquake, this simple fact, significant as it is, can give us no exact idea of the misfortunes directly and consecutively provoked by such a catastrophe.† Those who have escaped it alone can tell us under what various and terrible forms death is presented to their gaze; they alone can tell us what frightful tortures the human victims, buried alive, have experienced; how they perish of rage, despair, or hunger—giving utterance to their agony in heart-rending groans—and with none to help them in their supreme distress! It must be left for eye-witnesses to paint the situation of the poor unfortunates who, wounded or half-dead, have miraculously been rescued from the disaster, but are exposed to the horrors of cold and famine—in want of bread, and provisions, and clothing—their household gods shattered, and their possessions all destroyed. It is for them to speak of fortunes destroyed in the twinkling of an eye, of the rich reduced to beggary, of entire families deprived of all their resources; as also of states half-ruined by such enormous losses; the progress of civilization and the national welfare retarded by catastrophes which overthrow towns, block up harbours, devastate cultivated fields, render roads impracticable, and transform fertile valleys into lakes, or fill them with the piled-up ruins of the neighbouring hills.

* [The *Spectator*, vol. for 1868, p. 1307.]

† [Seneca has traced a comparison full of truth between the dangers of earthquakes and those with which we are menaced by other physical phenomena:—

"A tempestate nos vindicant portus; nimborum vim effusam et sine fine cadentes aquas, tectus propellunt: fugientes non sequitur incendium; adversus tonitrua et minas cœli, subterraneæ domus, et defossi in altum specus, remedia, sunt. In pestilentia mutare sedes licet. Nullum malum sine effugio est. Hoc malum latissime patet, inevitabile, avidum, publice noxium. Non enim domos solum, aut familias, aut urbes singulas haurit, sed gentes totas, regiones que subvertit."—*Quiæst. Nat.*

(Harbours shelter us from the tempests, roofs defend us from the violence of the storms and from incessant rains; fire does not pursue the fugitives; caves and deep caverns are a refuge from thunder and the arrows of heaven; we can save ourselves from the plague by changing our place of abode. But the scourge of the earthquake extends afar—is inexorable and inevitable—an universal calamity. Not only does it swallow up houses, districts, and towns, but it convulses nations and desolates entire countries.)]

We must not, then, be surprised to hear it said that the man who has once been witness of an earthquake is he who most dreads its return. In such a fear there is nothing imaginary; one feels one's-self in the hands of an Almighty Power. The first shock is frequently the most terrible; and in two or three seconds those busy hives which men call towns are crumbled into indistinguishable ruin. And nothing prognosticates the imminence of the peril: the tranquillity of night, the calm of day, cannot reassure you against this horrible eventuality; no human precaution can ward it off. When once the shock has occurred, neither prudence, nor courage, nor skill can save a single life. Men rush into the tottering streets, or fly towards the country or into the open places, to avoid the falling ruins, and lo, the earth gapes apart, and swallows them up in its unfathomable abysses!* Mistrusting the earth, they take refuge upon the waters; they crowd the boats or ships; and the depths of the sea may suddenly disappear in a yawning gulf, or the tumult of the waves hurl and dash their frail asylum, a wreck, upon the shore!

Thus, in an earthquake, a just and insurmountable sentiment of fear is added to all the other fatal causes, swelling the terrible list of victims. In this circumstance may be found the justification of the Oriental apologue. A dervish in the neighbourhood of Cairo saw a phantom stalking towards the city.

"Who art thou?" said he to the phantom.

"The plague."

"Whither goest thou?"

"To Cairo, to slay there 15,000 men."

"Is there no means of staying thy progress?"

"No; is it not written?"

"Go then, but do not thou kill a single man above thy number."

A few days afterwards, the dervish encountered the same phantom on his way back from the stricken city.

* [Here again we must remind the reader that there is no authentic proof of any such catastrophe having occurred. The loss of life in earthquakes is due to the falling of houses and churches, and to the desolation caused by the sudden inroads of the sea-wave.]

"Thou comest from Cairo," said the dervish; "what hast thou done there?"

"I have killed 15,000 men."

"Thou liest, for 30,000 have perished."

"*I* killed but 15,000 of them; the others died of fear."

[The writer in the *Spectator*, already quoted, makes some judicious remarks on the change which would probably be effected in our solid English character if earthquakes were as frequent and destructive in these islands as in tropical regions. "We suspect," he says, "that a deep physical distrust of nature would operate on Englishmen very much like their recent deep moral distrust of commercial enterprise—that it would simply paralyze and narrow their active powers, but in no way contribute to enlarge their spiritual life." In the presence of constantly recurring catastrophes which no skill or audacity could prevent or control, the Englishman would probably fold his hands, and sink into a blind fatalism or a degrading superstition.]

CHAPTER VII.

DESCRIPTIONS OF CERTAIN SIGNAL CALAMITIES:—THE EARTHQUAKE OF LISBON (1755) —THE EARTHQUAKE OF CALABRIA (1783)—THE EARTHQUAKE OF RIO-BAMBA (1797)—THE EARTHQUAKE OF ECUADOR AND PERU (1868).

LISBON, 1755.

ON the 1st of November 1755, at fifteen minutes to ten A.M., the sky being clear and cloudless, the thermometer standing at 64° 25′ F., a report like that of thunder suddenly echoed under the city of Lisbon.

This awful roar was followed by three shocks.

The first was hardly perceptible; but about thirty seconds afterwards, the ground experienced an oscillation which lasted from thirty to forty seconds, and proved to be of such violence that most of the houses of the city began to totter. The dust raised by their downfall was so dense as completely to obscure the sun. In about a couple of minutes this dust settled to some slight extent, and enough light was afforded to enable the startled inhabitants to look about them and reconnoitre the amount of injury effected, when a third shock convulsed everything anew. The houses which had previously escaped toppled headlong with a frightful roar; the sky grew dark; it was the image of chaos. The oscillations of the earth, which still continued to shake—the dim twilight of the day—the groans of the dying and the wounded—the frantic shrieks of alarm from those who had been saved, but every moment apprehended a terrible fate—and the howls of the terrified animals—increased the horror and confusion of the catastrophe. But in about ten or twelve minutes the movements of the soil ceased.

[It was then found that Lisbon had ceased to exist. The calamity had occurred on All Saints' Day, one of the great festivals of the Roman Church. Eager crowds had accordingly thronged to the sacred edifices, where lamps were blazing, and incense was ascending in fragrant clouds of odour, and robed priests and acolytes moving to and fro in solemn procession, while the sounds of noble music pealed over the heads of kneeling worshippers. And in the midst of their devotions, on priest and votary alike, had fallen the sudden doom; swifter and more terrible even than the appalling fate which seventeen centuries before had smitten the bright cities in the shadow of Vesuvius. The incense no longer spread in perfumed waves upon the air; the chant was lost in an awful hush and silence, followed almost immediately by a storm of cries and groans which all the organs of Lisbon had vainly attempted to drown. Out from aisle and nave streamed the startled crowds: they rushed into the streets, but the houses were bending like aspens before the wind, and in a moment fell to the ground, a hideous mass of ruin. Everywhere might be seen the dead and dying, the wounded and mutilated; and so frightful was the prospect, so heart-rending were the shrieks, that the minds of the bravest were paralysed into a dull, hopeless, stolid inaction, and many minutes elapsed before the few who had escaped could bethink themselves of the thousands that had perished.]

FIG. 121.—EARTHQUAKE AT LISBON, NOVEMBER 1, 1755.

Forty thousand persons at least were buried, dead or dying, under the chaos which, a few minutes before, men had known as Lisbon. At the first shock the sea had retired, as if in alarm; at the second it suddenly returned, with a leap like that of a tiger on his prey, and rising full fifty feet above its ordinary level, furiously flung itself upon the shattered city. Then again, it receded with an equally rapid movement; otherwise the whole town must have been submerged. The mountains of Arrabida, Estrella, Julio, Marvan, and Cintra, which are included among the most elevated points of Portugal, were violently shaken; a few were rent open to their very summit, which was cleft and broken in a most singular fashion; enormous masses of rock, loosened from their crumbling sides, rolled down into the valleys;

and it was said that flame and smoke issued from their fissures, irradiated by electric flashes.

But words can convey no accurate idea of the spectacle presented by the ruined city, of the corpses piled under its débris, of the dying half-buried under the rent houses and fallen churches. So great was the panic that the most resolute durst not pause a moment even to remove the heavy stones which were choking the life out of the beings they loved most dearly, and whom a helpful hand might still have saved; the cowardly sentiment of self-preservation alone prevailed at this terrible hour. The only means of safety seemed to be an immediate flight to the open country,

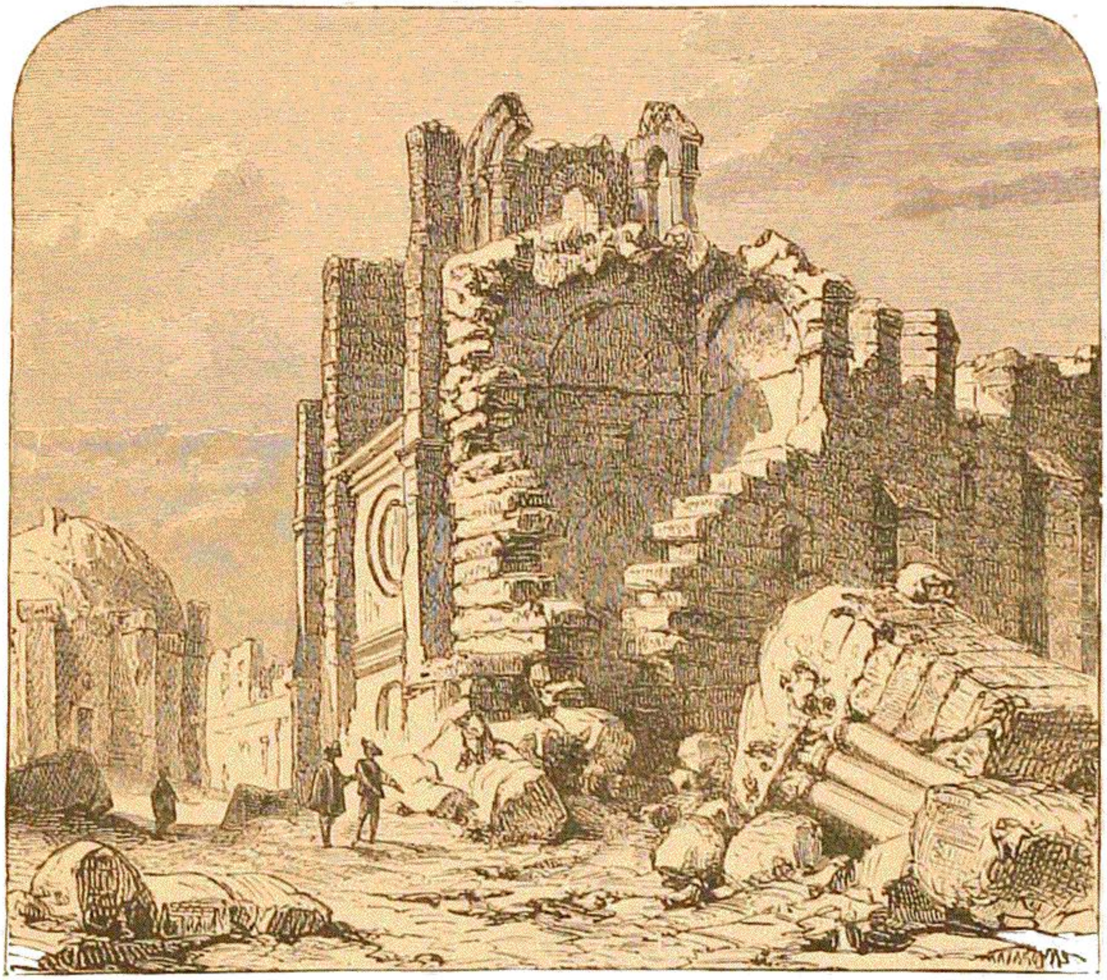

FIG. 122.—RUINS OF THE CATHEDRAL AT LISBON.

whither, with tottering but rapid steps, hastened crowds of weeping and wailing fugitives.

Those who inhabited the upper stories of the houses were more fortunate than those who had rushed out of doors into the crumbling streets. Persons on foot suffered more severely than those in carriages. But nowhere was the number of the dead, for reasons already stated, so appalling as among the ruins of the churches. At the first shock, moreover, hundreds had hastened, out of a not unnatural instinct of devotion, to take refuge in the sacred buildings, where they all perished, crushed by the fall of spire, and tower, and vaulted roof.

About two hours after the catastrophe, fire broke out at three points of the city;

burning cinders and ashes having been brought into contact with all kinds of combustible material. To increase the misfortune, a strong breeze, which succeeded the morning's calm, so stirred up the flames, and so carried them in every direction, that the conflagration soon became universal.

Thus, earth, and water, and fire seemed to have combined their forces to consummate the destruction of this most unfortunate city. From the chaotic depths of the ruins, by every way of egress—every lane or street still left standing—there might you have seen men and women emerging, spectre-like, pale, disfigured, half paralyzed with terror, some carrying with them a valued heirloom or darling child, others scarcely able to drag along their wounded limbs ; nearly all, with voices half-strangled by despair and terror, calling upon the dear ones whom they loved, but should see no more. A father, a mother, sought distractedly for their children ; a wife vainly appealed for help to her missing husband ; the weeping child invoked in vain its parent's succour. The aged and the infirm were suffocated in their beds, or consumed by the flames ; some mad with despair, and lost to all consciousness of the scene around them, lay stretched upon the earth, motionless and almost dead. Others, kneeling, implored the mercy of an angered and avenging God.

On the occurrence of the first convulsion, many persons, in the expectation of finding a secure asylum on the waters, had made towards the harbour, to precipitate themselves on board its boats and vessels ; but the great ocean-wave of which we have spoken hurled ships and boats upon the shore, and drove them one against another in wild confusion. The ebb and flow lasted with great violence throughout the night, apparently rushing with intense force at intervals of five minutes.

The harbour was embanked with a splendid quay of white marble, recently constructed at a very great expense. Here a multitude of individuals took refuge, hoping to be safe from the falling ruins. But the whole quay sank suddenly ; it disappeared under the waters, and so completely, that not a single one of the victims who were carried down with it ever rose to the surface. A great number of boats, and some small craft which were moored to the quay, disappeared in the same abyss, and not a fragment of their wreck was ever seen. We must suppose, to explain this extraordinary event, that a certain extent of soil sank into a chasm which opened suddenly, and almost immediately closed. The fact has been attested by the direct evidence of an eye-witness who escaped the disaster.*

Although the convulsion was universal, it was much severer at some points than at others. All the old, or Moorish town, was completely overthrown, and in the new town about seventy of the principal streets. Earthquake and fire together destroyed the cathedral church, eighteen parish churches, nearly all the convents, the palace of the Inquisition, and the most splendid public buildings—such as the royal palace, which was the first to fall, and that of Braganza, the Treasury, the mansions of the Dukes of Cadoval, of Lafoens, and of others. The loss experienced by English commerce from this disaster amounted to several millions sterling. The docks, all the warehouses full of merchandise, and the public grain stores were consumed.

The conflagration lasted for four days, and at last died out from want of aliment.

* [Quoted by Sir Charles Lyell, "Principles of Geology," 10th ed., bk. ii., c. 11.]

It prevented, perhaps, the scourge of a general pestilence, by its incremation of the forty thousand corpses whose deleterious emanations would otherwise have corrupted the air.

The inhabitants, wandering among the ruins, were menaced with the horrors of famine, for all the supplies of corn were destroyed, and the sacks of flour which had been preserved could not be converted into bread for want of the necessary implements. Let us add, moreover, that a company of wretches, who had escaped from the prisons, traversed the smoking ruins, groping among the débris, breaking open the houses still standing, pillaging, stealing, and slaying.

FIG. 123.—RUINS OF THE CHURCH OF ST. PAUL.

When the disaster occurred, the Portuguese court was not at Lisbon, but residing in the castle of Belem, in the environs of the city. The castle was uninjured, but the king thought it prudent to spend the night of the 1st and 2nd of November in a carriage. He remained four-and-twenty hours without any attendant, and almost without food. The next morning he repaired to his ruined capital to organize the first measures of relief.

The numbers of wounded were immense. The king had them tended under his own eyes. The queen, the infanta, and the ladies of the court, worked with their own hands, preparing lint and making bandages. As a portion of the royal kitchen remained upstanding, provisions were distributed to as many as needed them ; and among these poor wretches might be seen persons of rank and wealth, rejoicing yesterday in their prosperity, but reduced in the twinkling of an eye to the most frightful destitution. For some days after the catastrophe, a pound of bread was worth an ounce of gold! All the corn which could be collected in the environs of Lisbon was purchased by the government, and sold at reasonable rates to those who could pay for it, distributed gratuitously to those who were penniless.

Provision had also to be made for the lodgment of the numerous individuals so suddenly deprived of a home, and still afraid to seek an asylum in the shattered

FIG. 124.—RUINS OF THE CHURCH OF ST. NICHOLAS.

houses. For this purpose wooden barracks were hastily constructed. Tents were also pitched in the open fields, and hay and straw distributed to serve as mattresses, that the inhabitants might not be compelled to lie upon the ground.

Finally, efforts were made to rescue the poor unfortunates buried underneath the ruins ; and a great number were saved, who though they had passed many days in so frightful a situation, were nevertheless restored to life. It has been estimated that, in all, 40,000 persons perished through the immediate effects of the earthquake, and that 20,000 afterwards succumbed to their wounds or were killed by want and hunger. Twelve hundred lost their lives in the public hospital alone, and 800 in the civil prison. In many convents, which each contained 400 inmates, not one escaped.

This awful convulsion was followed by several others, so that not less than thirty shocks, of which some were very violent, occurred in the space of one month.

Hence, at first, men were unwilling to engage in rebuilding a city which seemed doomed to destruction, or to fix their homes on a soil which was liable to such terrible disasters. But after awhile their minds grew more calm ; and as there appeared no reason to expect a return of the scourge, the government addressed itself to the task of reconstructing or repairing the houses, the churches, and the palaces. For a long time, however, the city showed only an unsightly mass of ruins, through which a few practicable passages had been opened up by the simple process of piling up the stones and rubbish on either hand. As none dared to erect any substantial

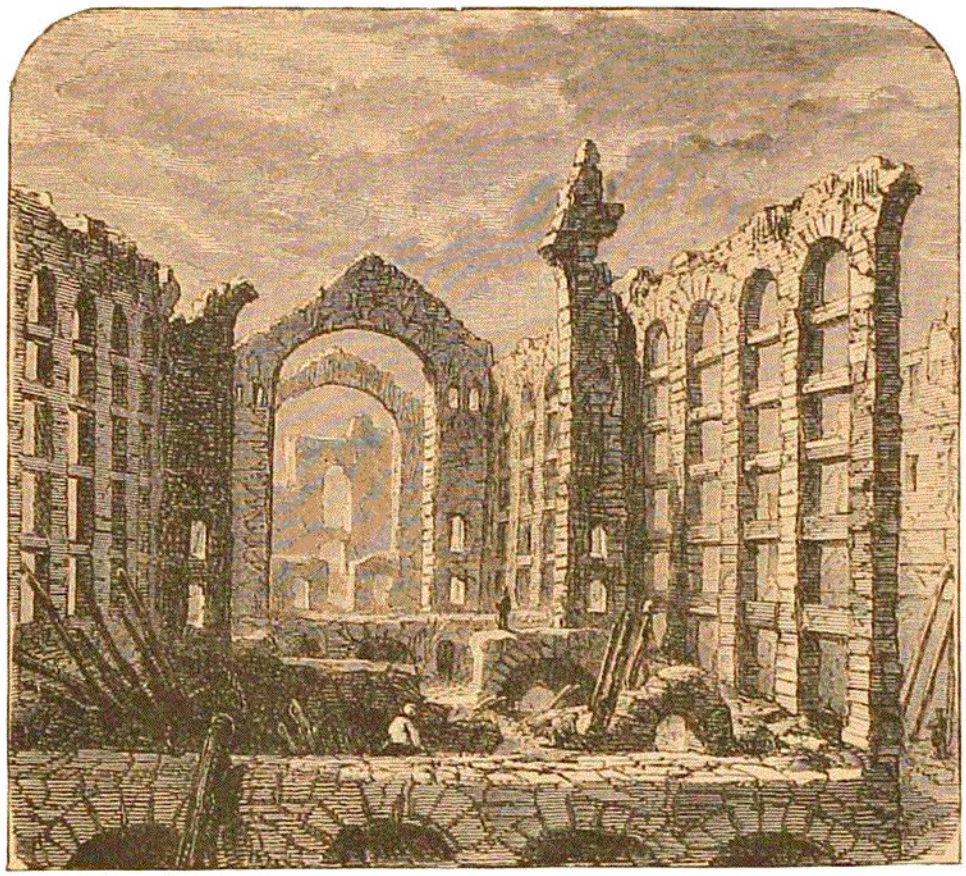

FIG. 125.—RUINS OF THE OPERA.

edifices, the first buildings were mere huts and barracks of timber. These were got ready in Holland ; were shipped in pieces on board the vessels engaged to transport them, and put together on arriving at their destination ; a coat of plaster being laid over them as a protection against atmospheric influences.

At the end of about twelve years, however, the city was entirely rebuilt, and became, as it now is, one of the handsomest capitals in Europe. Nor, since 1755, has it been visited by any similar affliction.

In our preceding chapter, when treating of the general phenomena of these convulsions, we remarked that the Lisbon catastrophe was far from being a local event, and that the earth-wave which produced it propagated its influence over a very extensive area.* Without repeating details already given, we shall furnish the reader with a few particulars in reference to the more violent shocks experienced at no very remote distance from Lisbon.

They were felt most severely in Spain, Portugal, and the north of Africa. Saint Ubes, or Sétubal, situated seven leagues south of the capital, was completely washed by the great sea-wave, and all its houses inundated.

The agitation of the soil at Algiers and Fez was terrible. An oasis, eight leagues from Morocco, composed of several villages, was swallowed up, with all its inhabitants, in a gulf which opened and shut immediately. Eight to ten thousand Arabs, their flocks and herds, were thus engulfed.

The undulatory movement of the soil along the Spanish coasts provoked the recession of the sea, followed almost immediately by the influx of an enormous wave, which, at Cadiz, rose to a height of sixty feet, and for a moment filled the inhabitants with apprehension of a fate similar to that which had befallen Sétubal. The waters swept away the face of a long wall, which they bore into the interior of the city, and thus penetrated within its defences. Happily, the breach was made on the lowest side of the city, and a few houses only were inundated. But outside Cadiz, the disaster was very great. The mighty billow, rushing furiously along the tongue of land which leads from Cadiz to the island, carried off two hundred persons, who, with the exception of two or three, miraculously preserved, perished in a moment.

Among the victims of this inundation was the grandson of Racine, the son of the author of the poem *La Religion.*

The young heir of so illustrious a name had entered upon a commercial career, and was residing at Cadiz. On the 1st of November 1755, he had set out in a post-chaise, with a young man, one of his friends, to spend a few days in rest and recreation at the latter's house, on the island, three leagues from Cadiz. They drove their vehicle themselves, with a servant in a seat behind them. When about half-way along the isthmus that stretches between two seas, they felt the shock which, a few minutes before, had convulsed Cadiz, and they quickened their horse's pace ; but the sea, rising all on a sudden, poured headlong over their road, and upset the carriage. The servant, carried away by the flood, caught hold of a neighbouring bush, and clung there until its fury was spent. He saw his master and his master's friend perish before his eyes, and returned to Cadiz to make known the melancholy tidings. The two bodies were removed to Cadiz, where young Racine was buried in the principal church, in the midst of a great concourse of his countrymen. He was only twenty-one years old.

* [According to Milne Home, this earth-wave propagated itself with a velocity of 13.5 geographical miles in a minute. It extended its ravages over an area of 4000 miles in diameter.]

CALABRIA, 1783.

Alas for Sicily! rude fragments now
Lie scattered where the shapely column stood.
Her palaces are dust. In all her streets
The voice of singing and the sprightly chord
Are silent. Revelry and dance and show
Suffer a syncope and solemn pause,
While God performs upon the trembling stage
Of his own works his dreadful part alone.
. . . . From the extremest point
Of elevation down into the abyss,
His wrath is busy and his frown is felt.
The rocks fall headlong and the valleys rise,
The rivers die into offensive pools,
And, charged with putrid verdure, breathe a gross
And mortal nuisance into all the air.
What solid was, by transformation strange
Grows fluid, and the fixed and rooted earth,
Tormented into billows, heaves and swells,
Or with vortiginous and hideous whirl
Sucks down its prey insatiable. Immense
The tumult and the overthrow, the pangs
And agonies of human and of brute
Multitudes, fugitive on every side,
And fugitive in vain. The sylvan scene
Migrates uplifted, and with all its soil
Alighting in far distant fields, finds out
A new possessor, and survives the change.

COWPER, *The Task*.*

Calabria is that country so justly famous in ancient history—that *Magna Græcia*—where Pythagoras, surrounded by his disciples, cultivated the arts and sciences; and which, at a later period, becoming the battle-field of the heroic Spartacus, saw the great servile insurrection of 71 B.C., after long menacing the safety of the Roman government, crushed by the vigorous exertions of Crassus.

Calabria is at too short a distance from the volcano of Etna not to have been exposed in all ages to shocks from earthquakes. In 1693, it was visited by a severe disaster. According to a medal struck in memory of the event, the number of victims on this occasion amounted to one hundred thousand.

The convulsions which, less than a century afterwards—in 1783—shattered Calabria and the eastern districts of Sicily, proved scarcely less fatal, since out of 365 or 370 villages then flourishing in Upper Calabria, 192 were entirely ruined, and 92 more or less gravely damaged.†

* [Cowper published his *Task* in 1785, about two years after the occurrence of the catastrophe which he has so powerfully depicted in the passage quoted above.]

† "Description historique et géographique de la ville de Messine, et détails météorologiques du désastre que cette ville vient d'éprouver (le 5 février 1783) par le tremblement de terre, avec des notes curieuses et intéressantes sur la Calabre altérieure, la Sicile, et les îles de Lipari" (ed. 4to, Paris, 1783), p. 18. [As a corrective of the highly-coloured statements of this treatise, the reader should turn to Mr. Mallet's "Neapolitan Earthquake of 1857" (edit. London, 1862), where some of them are incidentally examined.]

The area devastated by the earthquake embraced about sixty square leagues. Its theatre was the region situated between the 38th and 39th parallels of latitude.

If taking for our centre the town of Oppido, in Upper Calabria, we trace around it a circle with a radius of twenty-two miles, the space so enclosed comprehends the surface of country whose every town and village were destroyed. The shock of the 5th of February 1783, overthrew in a few minutes the majority of the houses, towns, and villages comprised between the Apennines and Messina, in Sicily—revolutionizing the country, changing its level, and producing, so to speak, an universal *shudder* of the superficial soil. A second convulsion,* which occurred on the 28th of

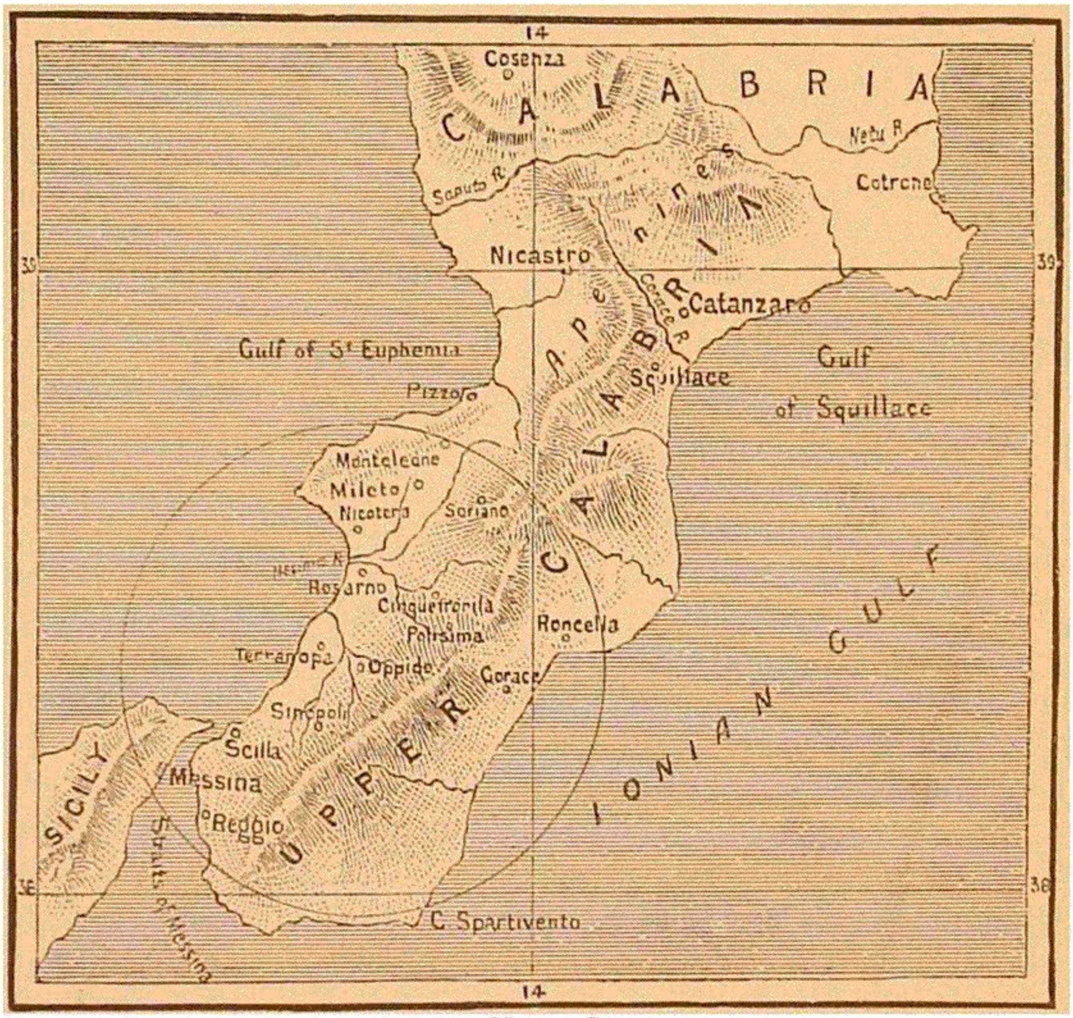

Fig. 126.—Map of Calabria.

March, was fully as violent as the former; it shattered and rent the chain of the Apennines, and if it did not overthrow any towns and villages, that was because the work of destruction had so far been completed by the shocks of the 5th of February.

The Calabrian earthquake is the most terrible, and yet, at the same time, the most easily described of all similar calamities which have occurred in modern times, because its site has been frequently visited and explored by scientific men and geologists of deserved reputation. The French naturalist, Déodat de Dolomieu, who at the time was travelling in the south of Italy, hastened to Calabria at the first tidings of the disaster, and has left on record a narrative of the phenomena, accom-

* [Minor shocks took place on the 6th and 7th of February, and on the 1st of March.]

panied by an admirable geological exposition. The Academy of Naples despatched to the scene a scientific commission, which devoted itself to a description of the various changes effected in the configuration of the surface, to counting and measuring the depressions, upheavals, fissures, and crevasses. The British ambassador, Sir William Hamilton, to whom we owe a standard work on the eruptions of Vesuvius, traversed the whole country; sailing along the coast in a *speronare*, and landing at intervals to explore, not without personal danger, the inland regions still in a condition of turmoil and unrest. It is from these various authorities we have gathered the particulars we shall now attempt to combine in one comprehensive picture of the principal effects of this melancholy and remarkable event.

More than one hundred and ninety towns and villages were razed to the ground, as we have already said, in Upper Calabria and Sicily by the earthquake of February 5, 1783. Unable here to enter into any minute details, we shall cast a rapid glance at the leading events which occurred in a certain number of these localities.

The disastrous day, so fatally marked in the annals of Calabria, was the 5th of February; the time three quarters past noon. The shock lasted only two minutes; this brief interval sufficed for the destruction or devastation of Calabria. The ground was agitated in every direction; it undulated like the waves of the sea, and to such an extent that not a few persons experienced all the effects of sea-sickness. Dolomieu, whose well-weighed evidence merits every consideration, assures us, on the faith of several eye-witnesses, that the trees were so curved and bent as to touch the earth with their loftiest boughs. At the same time, violent vertical movements occurred, acting from below to above. In fact, the earth seemed seized with a sudden dizziness, and rolled like a child's top which has nearly ceased to spin.

"I cannot better describe the effect," says Dolomieu, "than by supposing several cubes of sand, cut and kneaded into shape by the hand, placed at a short distance from one another. Then, by striking repeated blows under the table, and shaking it at the same time horizontally and violently at one corner, you will gain an idea of the different and furious movements by which the earth was for a time disturbed."

No structure raised upon the earth's surface could possibly resist so complex an agitation. The towns, the hamlets, the isolated farmsteads, were all thrown to the ground at the same moment. The foundations of the houses seemed vomited out of the earth. The stones were pounded, crushed, and violently triturated against each other.

In the rapid description we are thus drawing, we halt for a moment at Messina. Two minutes sufficed to shatter into a heap of ruins that bright and beautiful Sicilian city, the seat and centre of the commerce of all Southern Italy. We shall not attempt to describe the horrors of its downfall, or the terror of its wild, shrieking, distracted inhabitants. The art of Timanthes failed him when he would have painted the grief of Antigone's father; words are unable to cope with some of the weightier and more awful manifestations of the secret forces of nature.

The damage caused by the earthquake would not have been so extensive at Messina—which was not, after all, the town most heavily afflicted—but for the conflagration which broke out after the fall of the houses, and was provoked by the chimney-fires lighted everywhere at the hour of dinner. The large stores of oil laid up in the warehouses of Messina helped to feed the flames, which spread from point to point with incredible rapidity, carrying with them ruin and desolation on the wings of the wind. Who can picture to himself the horror of such a scene, when the unbridled fury of all the elements seemed let loose against unhappy man; when the fugitive who sought a temporary refuge under some broken arch, or amidst the ruins of some shattered town, was pitilessly driven thence by the devouring flames and wreathing, stifling smoke, yet trembled to advance a step, lest the treacherous earth should suddenly give way before his feet!

We shall give a summary of the disasters that on this occasion befell the capital of Sicily, from the official report addressed by its Senate to the King of Naples. This simple but affecting narrative well merits preservation:—

"Sire,—The frightful condition to which Messina has been reduced by the effects of the earthquake that commenced half an hour after noon on the 5th of the month, and still continues, induces the Senate to believe you will pardon them for addressing directly to yourself the report of the calamity, instead of transmitting it to your Majesty, according to custom, through the hands of his excellency the Viceroy.

"We do not doubt that your Majesty's feeling heart would experience the deepest grief at the most painful spectacle of a magnificent city suddenly converted into a mass of ruins by a terrible and hitherto unexampled event. The shocks, which succeeded one another at intervals of a quarter of an hour with inconceivable violence, have shattered, from roof to basement, every edifice, public or private. The royal palace, that of the archbishop, the whole pile of the Maritime Theatre, the Monts-de-Piété,* the great hospital, the cathedral, the monasteries for both sexes—nothing has escaped destruction. And, accordingly, you might see the distracted nuns traversing all the city in search, if possible, of a place of refuge and security, with the small number of persons who, like themselves, had miraculously escaped the convulsion.

"This spectacle is frightful, undoubtedly; but there is one still more terrible—namely, that of the majority of our citizens dead and dying, buried under the ruins of their habitations, while we are unable to rescue from the débris the unfortunates who are still alive, for want of workmen to render assistance in such circumstances.

"The moans, the cries, the shrieks, the wailings, all the accents of grief are everywhere audible; and our powerlessness to save from death these miserable victims renders still more heartrending the expression of the despair which demands in vain the assistance of humanity.

"To all these calamities a new scourge is added, which increases their horrors. Above the ruins of the shattered and prostrated buildings, suddenly rises the devour-

* [These are the great pawnbroking establishments managed by the State. Advances are made to the poor at very low rates of interest.]

ing fire! Unfortunately, the first shock occurred about the dinner hour, and the fire then lighted in the kitchens was communicated to the different combustible materials found among the débris of the demolished houses. The king's lieutenant and his troop immediately hastened to the spot; but the total want of workmen and necessary implements rendered all attempts at assistance useless; and it was impossible, not only to extinguish the conflagration, but even to offer any effectual resistance to the progress of the flames, which continue to devour the melancholy remains of a city formerly the glory of its sovereigns, and the most flourishing in the kingdom.

"To these numerous disasters, all occurring simultaneously, must be added a thousand others, whose horror outstrips description. The magazines of grain being destroyed, bread, that most important article of food, fails us. The Senate have hastened immediately to remedy this misfortune, by laying an embargo on the vessels in port loaded with corn; but how is it possible to make bread when the bakehouses and baking utensils are buried under the ruins, and the bakers have perished or taken flight? The water-courses having been diverted, the public fountains have run dry, and the mills can no longer grind the grain.

"This crowning disaster has nearly reduced to despair the surviving inhabitants, who ask with loud cries for bread to sustain them. Some mourn the loss of all their property; others of their relatives and friends. Despite the zeal and activity of the magistrates in the prevention of robbery, individuals have been found so devoid of humanity and religion, so regardless of the Divine anger which everything should have recalled to their minds, as to plunder not only the houses of private individuals but also the public buildings and the Monts-de-Piété. It is, then, only the powerful protection of your Majesty that can remedy the numerous misfortunes which have followed so rapidly one upon another, and endow with a new life this city, which needs to be re-established.

"The Senate implores your Majesty to send with all speed the necessary assistance in men and money, so that the roads and highways, now covered with ruins, may be rendered passable. The Senate likewise beseeches your Majesty to send supplies of all kinds of provisions for the sustenance of the inhabitants dispersed in the plains, and who, for want of food, will be reduced to take flight, to the considerable detriment of your royal treasury."*

Let us pass in review the principal localities of Calabria which suffered simultaneously with Messina from these formidable attacks; dwelling particularly upon the physical modifications which were effected in the surface and continuity of the ground.

The town of Rosarno, situated on a hill of sand, at a short distance from the river Metramo, was almost entirely razed to the ground. The prince's château, the churches, and the houses were reduced to a heap of ruins. The Metramo for a moment ceased to flow.

* "Nouveaux détails historiques et météorologiques des tremblements de terre arrivés depuis le 5 février 1783, dans la Sicile et la Calabre ultérieure, &c.; avec une idée générale de la ville de Messine, de son administration, de son commerce et de ce qui s'y voyait de plus remarquable avant sa destruction," &c. &c.

A strange phenomenon, which occurred in many parts of Calabria, was especially noticed, according to the report of the Academy of Naples, in the outskirts of Rosarno. Across the whole extent of the surrounding plain opened numerous circular cavities (Figs. 127, 128), of about the size of a carriage-wheel. Some of these cavities—

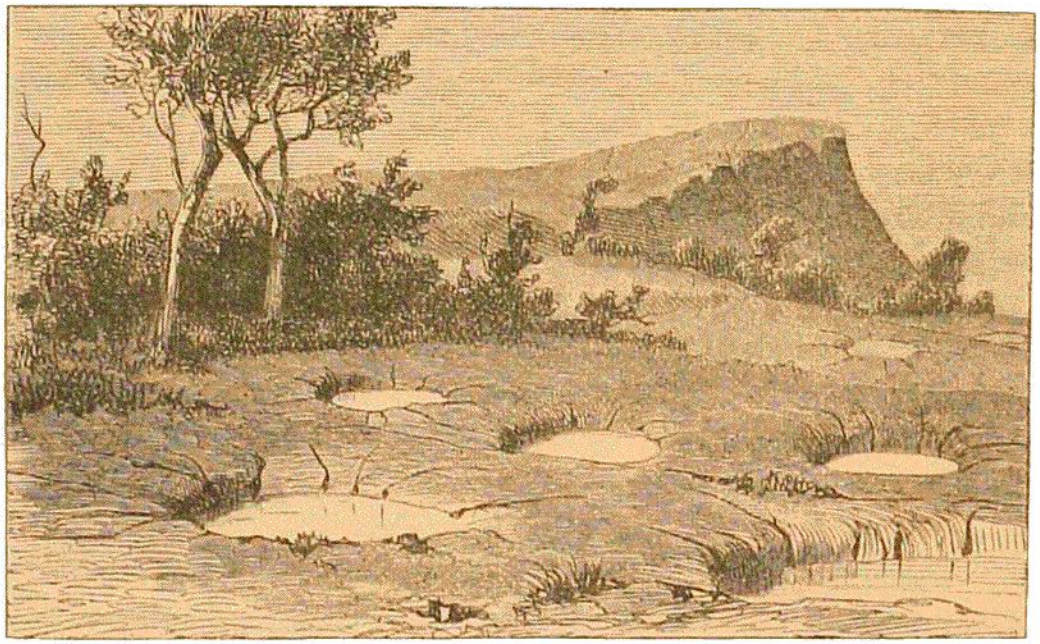

FIG. 127.—CIRCULAR CAVITIES AT ROSARNO (CALABRIA).

which strikingly resembled wells in appearance—were filled with water to about ten or twenty feet from the surface; but more generally they contained dry sand. Afterwards, when the ground around them was excavated, it was discovered that they were shaped like a funnel with its mouth upwards.

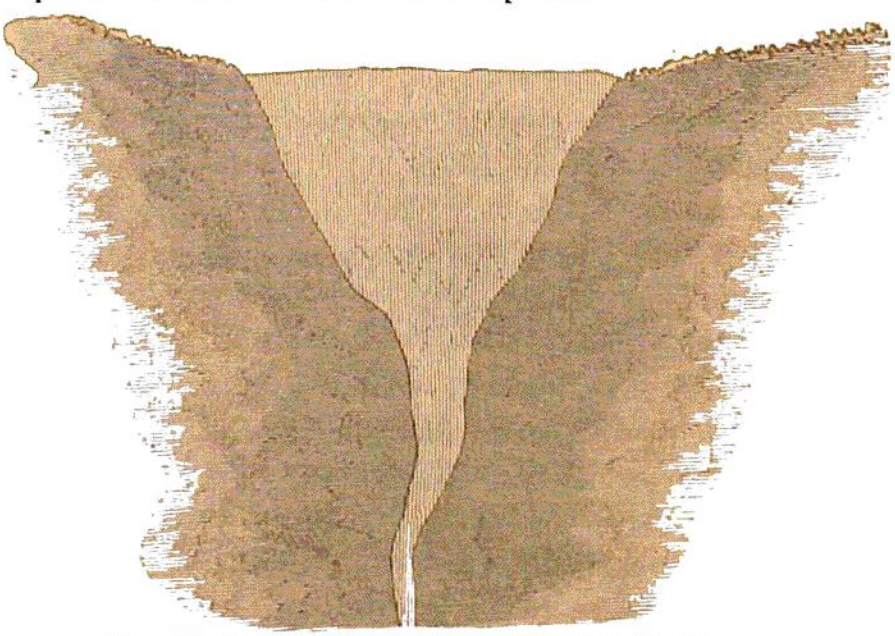

FIG. 128.—INTERIOR SECTION OF A CIRCULAR CAVITY.

The populous and thriving town of Polistena, built upon two declivities on either side of a small river, was wholly destroyed. Not a house, not a foot of wall, was left standing. The ground gave way on the river-bank, dragging down with it the houses. Half the inhabitants perished beneath the ruins: the survivors hastened to take refuge in wooden sheds and barracks, which were run up outside the shattered walls of the ill-fated town.

Dolomieu thus describes the painful impression produced on his mind by the sight of the ruined Polistena :—

"I had seen," says the French geologist, "Messina and Reggio ; I had lamented the fate of those two cities : in neither had I found an inhabitable house, nor one which did not require rebuilding from its foundations. But, after all, the skeleton, the framework, of these two cities still exists ; most of their walls are standing. You can see what they have been. Messina still presents, at a certain distance, an imperfect image of its whilom splendour. Every person can recognize either his house or its former site. I had seen Tropæa and Nicotera, where but few houses have not been seriously injured, and many have been entirely demolished. My

FIG. 129.—FISSURE NEAR POLISTENA (CALABRIA).

imagination could conceive of nothing more terrible than the fate which had befallen these towns. But when from the high ground I surveyed the ruins of Polistena, the first town in the plain which met my gaze—when I contemplated those shapeless heaps of ruin which cannot even give the slightest idea of what it formerly was—when I saw that nothing had escaped destruction, and that every building had been levelled to the earth — I experienced a sentiment of terror, pity, and affright, which for some moments suspended all my faculties. The spectacle, nevertheless, was but a prelude to that which developed itself before me at every stage of my journey."

The fissures frequently produced in the soil when an earthquake occurs were nowhere more numerous than in the neighbourhood of Polistena. In Figure 129

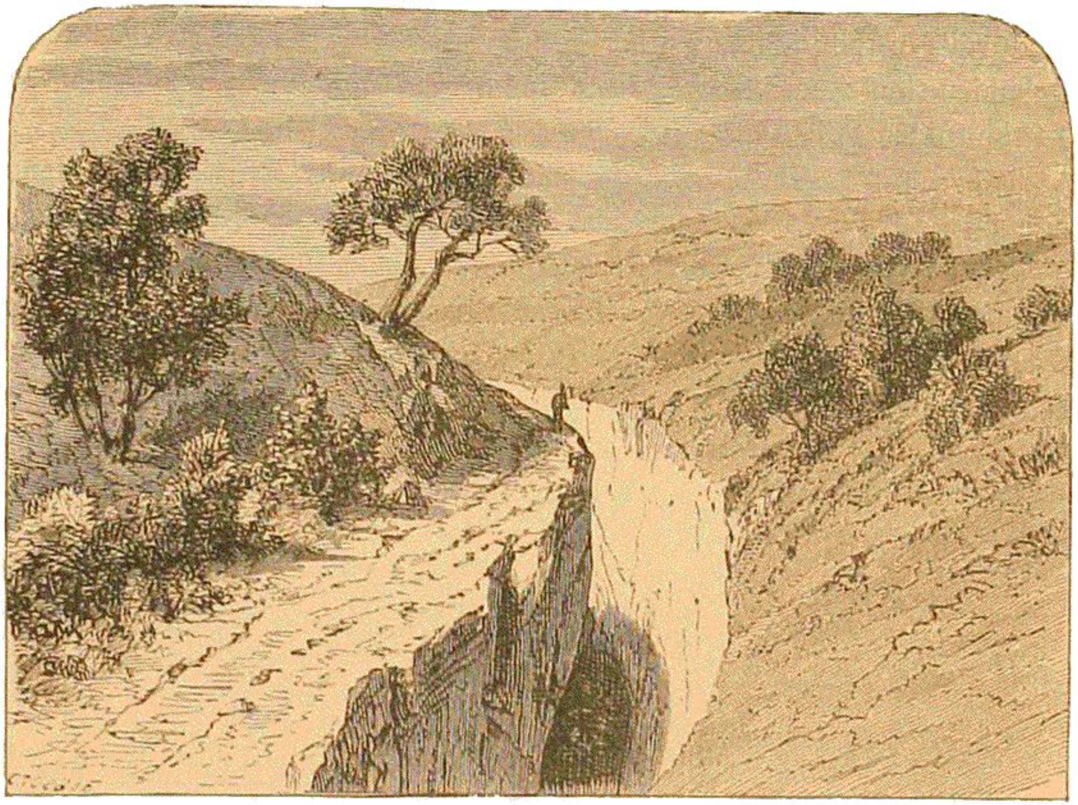

FIG. 130.—CREVASSE NEAR SORIANO (CALABRIA).

we delineate a deep chasm, which remained open after the convulsions had ended.

As an example of an analogous fissure in the ground, we shall here depict a great crescent-shaped crevasse, which extended about five hundred and fifty yards in

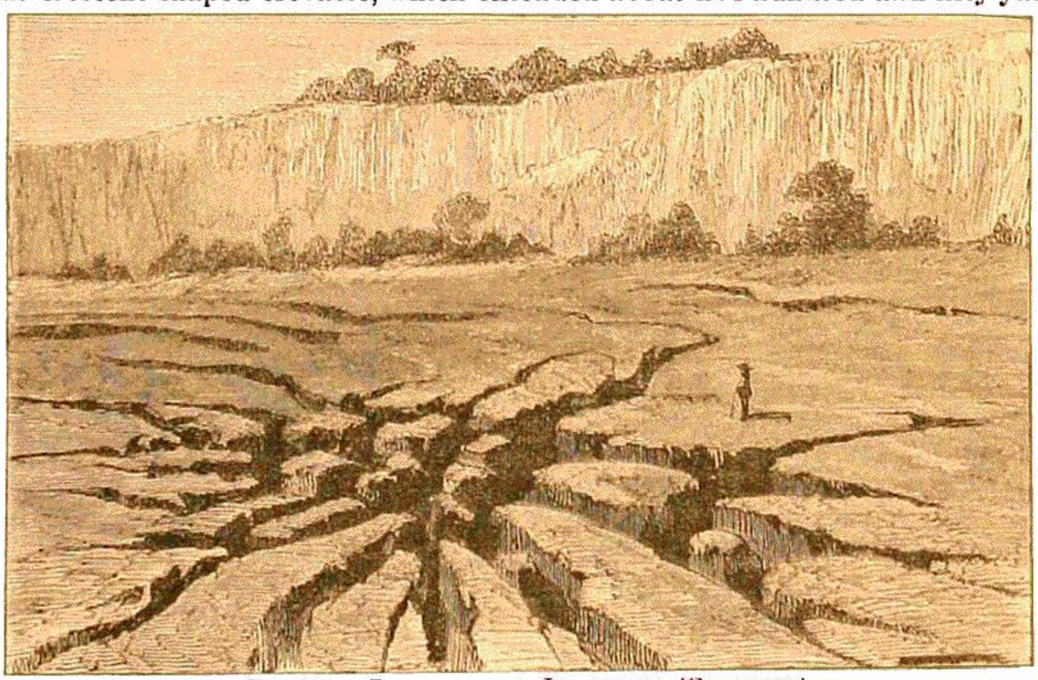

FIG. 131.—FISSURE NEAR JEROCARNA (CALABRIA).

length, and was fully three feet and a quarter broad, in the hill of St. Angelo, situated near Soriano, and not far from the little river Messima.

At Jerocarna the fissures presented a very remarkable arrangement. They extended in every direction, like the cracks in a pane of broken glass (Fig. 131).

Cinque-Frondi, a village situated about half a league from Polistena, was demolished. In its centre rose a square tower, which was occupied by its lord as his castle. It was an ancient monument, belonging to Saracenic days, and seemed of unassailable solidity, as much through the great thickness of its walls as through the nature of the mortar, which had cemented the whole into a mass as hard and firm as a rock. This tower was toppled headlong, and in falling split up into great blocks of astounding magnitude, one of them containing a complete staircase.

Casalnuovo was a pretty town, situated at the foot of a mountain, in a broad and agreeable plain. With its regular streets, and its low houses, each decorated by a tree, and a trellis-work of vines which afforded a pleasant shadow, and transformed the highways into blooming garden-walks, its aspect was enchantingly picturesque. From apprehensions of a possible earthquake, all reasonable precautions had long been

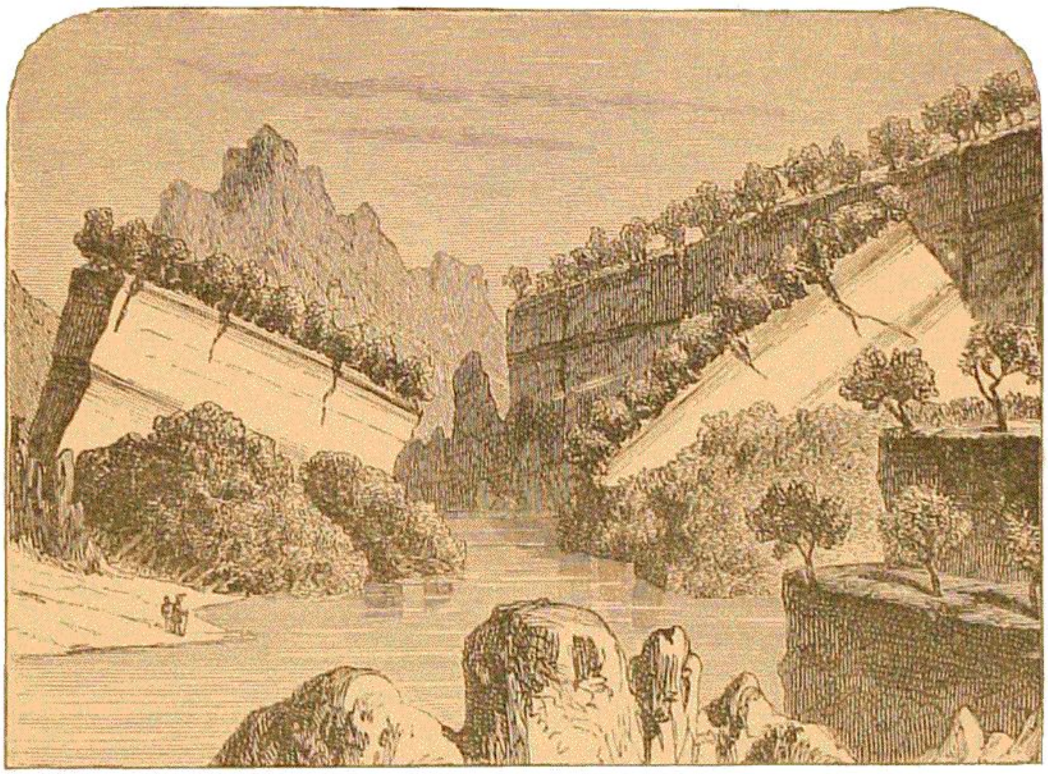

FIG. 132.—LANDSLIPS AT CASALNUOVO (CALABRIA).

taken ; the houses were built very low, and the streets were of unusual width. But all was overthrown ; all levelled to the ground. The Marquis de Gerace, a wealthy Calabrese noble, revered throughout all southern Italy, was crushed, with his family and household, under the ruins of his villa. The entire plain around Casalnuovo was considerably depressed ; the slopes stretching up towards the mountain glided lower down, leaving, between the shifting soil and the parts which remained immovable, large fissures from 16,000 to 18,000 yards in length, and upwards of three feet wide. In thus descending, some portions of soil were carried from the mountain into the plain, and deposited on far distant fields. Of this phenomenon we give a representation in Figure 132.

From Casalnuovo to Santa Cristina, a space of six leagues, the ground was so extraordinarily disturbed that it was impossible to move a step without encountering chinks and crevices, or larger and more considerable depressions, producing a miniature labyrinth of gorges, ravines, and little valleys.

But never was any town more completely devastated than the unfortunate Terranova; never was ruin accomplished under more singular and varied circumstances. Terranova was built above three deep gorges, at the extremity of a plain, and in the immediate shadow of a high mountain. This position explains the conditions of its destruction. In the earthquake of the 5th of February, a part of the site of the town gave way, and gliding down the declivity of one of the gorges, dragged with it the houses it supported; the débris of stones and timbers, mingled with the displaced soil, filled up a portion of the valley.

Elsewhere in the town the earth was cloven into a perpendicular gap; a part of the soil thus divided fell away, and descended in a mass into the ravine which yawned beneath. The houses were flung headlong into a gulf 320 feet deep, which was almost filled up with their wreck.* Out of a population of 2000, 1400 persons were crushed beneath or buried among the ruins. They did not all perish; for, owing to the difference of weight, the materials falling along with human beings, the latter were precipitated *upon* the débris; some fell on their feet, and were able to make their way immediately into a place of safety; others, buried only up to the thighs or the chest, released themselves with a little assistance.

Such are the singular details of the demolition of Terranova, which was literally turned topsy-turvey (*sens dessus dessous*). In the three valleys half-filled by the landslips, and the ruins which they brought down, all was overthrown; it was impossible to recognize the site of a single house; the high places were brought low. the low levels were raised, owing to the depression of the surrounding parts. The masonry of a well in one of the convents was made to resemble, through this circumstance, a tower of 70 to 90 feet in height, somewhat diverging from the perpendicular.

The falling-in of the town and hills, by closing up the channel of a small stream, and that of a copious spring which welled out at the bottom of the gorge, formed a couple of lakes, whose stagnant waters, loaded with carcasses and organic deposits of every description, disseminated infection through the whole country, and destroyed, with putrid fevers, those of the population who had escaped the disasters of the earthquake. Considerable landslips occurred in the neighbourhood, on the border of the valleys; the entire plain which lay in front of the town was hollowed with gaps and crevasses; in certain parts there was not an inch of soil which could be regarded as firm and solid ground.

The village of Moluquello, situated opposite Terranova, and on the same level, upon a small platform hemmed in by two rivers which flowed between the two valleys, met with the same fate as Terranova. One part of the village fell into the right-hand valley, the other into that on the left-hand; so that of the former site of Moluquello there remained only a ridge, like an ass's backbone, which was so narrow that you could not walk along it.

* [Surely this statement requires to be taken *cum grano salis*.]

Oppido, a considerable town, was built on the summit of an isolated mountain, whose escarpments were very steep, and its declivities exceedingly rapid. The town was completely demolished by the earthquake ; not a hand's-breadth of wall was left standing. However, the soil of the mountain did not yield ; only a kind of citadel or stronghold, which commanded the valley, fell into the lower gorge.

If the soil of the mountain on which Oppido was built resisted the violence of the shocks, such was not the case with the opposite hills. There, immense land-slips took place, filling up the valleys with their wreck, and blocking the course of the springs, which accumulated in lakes all around the town. Similar effects were produced in the other valleys adjacent to Oppido.

A vast gulf opened on the declivity of a hill near that town ; to some extent its ravenous jaws were filled with masses of earth and a great number of olive-trees and vines which were precipitated into it. Yet the chasm, after all, remained 200 feet in depth, and 500 feet in width.

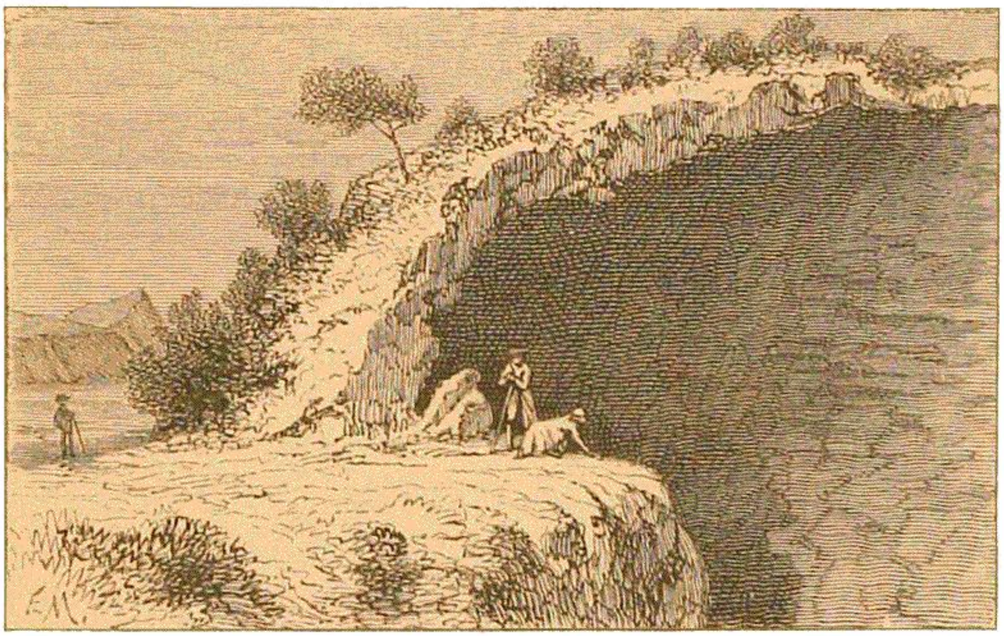

FIG. 133.—CHASM NEAR OPPIDO (CALABRIA).

About a league below Oppido stood the little village of Castellaccio, on the edge of an escarpment, which suddenly gave way, and fell into the depths of the valley ; the ruins of a few houses remaining on the mountain-crest were the only indications of its former site and existence. The village of Corsoletto underwent an almost similar fate.

We turn to the town of Santa-Cristina, situated nearly at the foot of the great mountain of Aspromonte,* and placed on a precipitous sandy elevation, surrounded by ravines and deep valleys. Its position closely resembling that of Terranova, the same doom befel it. The houses, and a portion of the mountain, were flung down

* [Rendered historically famous—we had almost said infamous—by the collision which took place there, August 29, 1862, between the troops of Victor-Emanuel and the volunteers of Garibaldi. The Italian revolutionist was severely wounded in the ankle, and made prisoner.]

headlong; innumerable chinks and crevasses traversed the bulk of the mountain, and penetrated it from side to side, so as to alarm men's minds with the idea that the entire mass would sink into chaos; the whole surface of the soil was changed in configuration. The territory of Santa-Cristina, intersected likewise by a great number of gorges and valleys, with steep declivities, experienced the same accidents as that of Oppido.

It was in the territories of Terranova, Oppido, and Santa-Cristina, the earthquake-shocks achieved the most destructive ravages, and produced the most extraordinary effects; whence we may infer that the focus of the shocks of the 5th of February was seated beneath this portion of the great Calabrian plain.

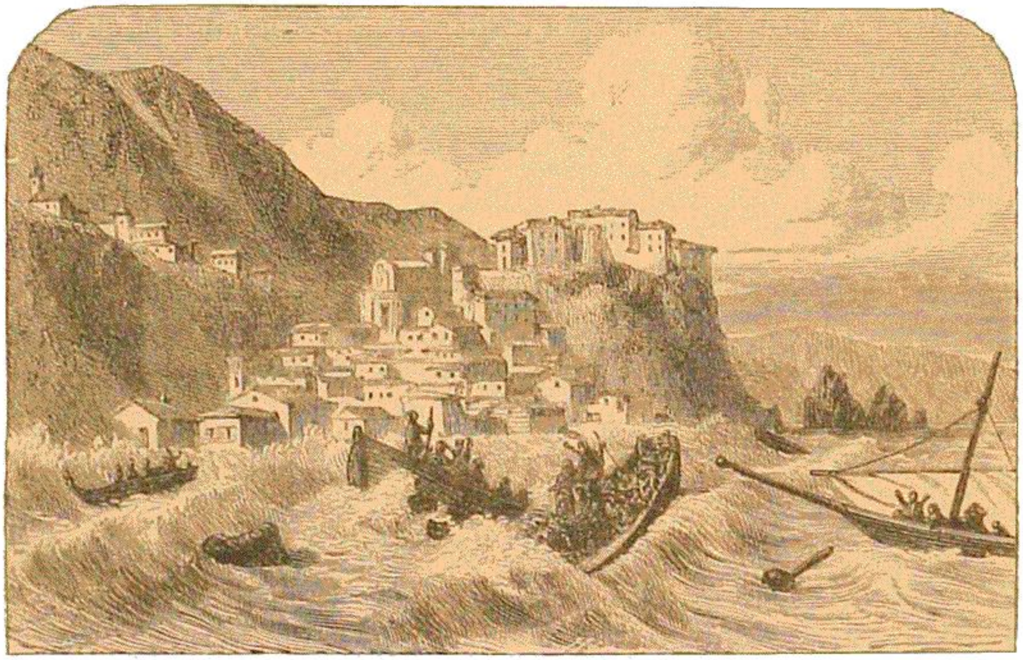

FIG. 134.—WRECK OFF THE COAST OF SCYLLA, IN THE STRAIT OF MESSINA (FEBRUARY 5, 1783).

Who has not heard of the famous rock of Scylla, situated on the coast of the Strait of Messina, and the object of so much exaggerated dread and so many fabulous traditions in the ancient world?

[Virgil's picturesque description will be familiar to our readers:—

"Dextra Scyllam latus, lævum implacata Charybdis
Obsidet, atque imo barathri ter gurgite vastos
Sorbet in abruptum fluctus, rursusque sub auras
Erigit alternos, et sidera verberat unda.
At Scyllam cæcis cohibet spelunca latebris,
Ora exsertantem et naves in saxa trahentem.
Prima hominis facies, et pulchro pectore virgo
Pube tenus; postrema immani corpore pistrix,
Delphinum caudas utero commissa luporum."

Aeneid, iii. 420, *et sqq.*

We subjoin Professor Conington's version:—

"There Scylla guards the right-hand coast:
The left is fell Charybdis' post;
Thrice from the lowest gulf she draws
The water down her giant jaws,

Thrice sends it foaming back to day,
And deluges the heaven with spray.
But Scylla crouches in the gloom
Deep in a cavern's monstrous womb;
Thence darts her ravening mouth, and drags
The helpless vessels on the crags.
Above she shows a human face,
And breasts resembling maiden grace:
Below, 'tis all a hideous whale,
Wolf's belly linked to fish's tail."

The rock, or promontory, invested with so many imaginary horrors, juts out boldly into the sea nearly at the entrance of the Sicilian Strait, which is here 6047 yards in width.* It is united to the mainland by a narrow isthmus, and thus forms on either side a small but sheltered bay.]

From this famous rock the convulsions of 1783 tore away enormous masses, which crushed in their downfall numerous villas and gardens.

After the shock of the 5th of February, the prince of Scylla had persuaded a great number of his vassals to quit the shore, and take refuge on board the fishing-boats, to escape a new disaster. The prince himself embarked in one of them. Towards midnight, while the weary landsmen lay asleep at the bottom of the boats, a second shock, agitating the ground, detached a cliff from the neighbouring mountain. Immediately afterwards the sea suddenly rose—one might almost say, leaped—a height of twenty feet, rushed headlong upon the beach, and swept everything before it. Then it retired, to return again, after a pause, with even greater violence. All the fishing-boats went to the bottom, or were wrecked upon the shore; many were carried a considerable distance inland. The aged prince of Scylla perished, with 1430 Calabrese.

We need not extend any further this painful enumeration, but shall content ourselves with remarking that, throughout an area of ten leagues in length by six in breadth comprised between the river Metramo, the sea, and the Apennines, there remained not a single edifice entire, nor a rood of land which had not changed its configuration or position, or suffered considerable damage.

A few feebler shocks followed the great convulsion of the 5th of February. On the 28th of March, a formidable tremor shattered anew the ill fated Calabria. The centre of this last disturbance was removed towards the north; it appeared to be seated under the Apennines. Upper Calabria and the provinces of the Neapolitan kingdom experienced the recoil. On both sides of the Apennines the country was devastated. This later earthquake was preceded by a subterranean noise like a clap of thunder, which was repeated at each shock. The movements of the soil were very complicated; rotations and undulations took place, as on the 5th of February, interrupted by violent effects from above to below.

We shall not enumerate all the towns and hamlets which were demolished or

* [Rear-Admiral Smyth, "Sicily," p. 108.]

rendered uninhabitable by this new calamity. Its destructive effects, moreover, were not so widely spread as those of the 5th of February. Even the towns which suffered most—such as Nicotera, Tropea, Monteleone, Squillace, Nicastro, Catanzaro, San Severino and Cotrona—were not wholly destroyed. The shocks, however, augmented the disorders of Messina, and increased the damage done to Reggio.

Earth-movements continued throughout the year 1783. Several were even felt in the months of February and March 1784. But none of them could be compared in violence or fatality to those of the 5th of February and 28th of March in the preceding year.

Sir William Hamilton, the English ambassador, who carefully explored this region soon after the occurrence of its calamities, estimated the number of persons who perished at about 40,000; fully 20,000 others succumbed to the contagious fevers and epidemics occasioned by the spread of pestiferous vapours, want of food and of shelter against the inclemencies of the weather.

The majority of the victims were buried beneath the ruins of the houses and other buildings. Many, and especially the peasants who fled into the country, were swallowed up in the fissures which opened under their feet. It is probable that their skeletons are interred in the bowels of the earth at a depth of several hundred yards.*

Numbers perished in the conflagration which followed the downfall of the houses, and which raged with awful fury in towns, like Oppido, containing vast stores of oil.

A great many victims might have been saved had assistance been at hand. Unfortunately, in catastrophes so terrible and sudden, each person, occupied with his own misfortunes or those of his family, seldom thinks of extending any help to his neighbour. And, moreover, the small number of survivors precludes all attempts at comprehensive and really efficacious succour. We shall quote a few traits of devotion inspired by maternal love, conjugal tenderness, or friendship; but by the side of these isolated instances how many atrocious deeds of cruelty has not humanity to blush for!

When the earthquake took place at Messina, the Marchioness of Spadara, a Frenchwoman, and the daughter of a Provençal gentleman, fainted, and in this condition was carried by her husband as far as the port. On recovering her senses she perceived that she was not accompanied by her son. At a moment when her husband was too much occupied to watch over her, she contrived to escape; made her way back to her house, which was still standing, and snatched her child from his cradle. But the staircase crumbled away before her feet, and blocked up her only means of retreat.

She fled from room to room—followed, as it were, by successive crashes—and, at length, as a last hope of safety, took refuge in the balcony. Showing her infant in her arms, she implored assistance from the few witnesses of this pathetic scene. But on occasions of public disaster we can place little reliance on the pity of our neighbours. Ere long the conflagration reached the ruins of her house; the unfor-

* [The reader will be on his guard against these sensational exaggerations.]

tunate lady fell a victim to the flames, still clasping to her bosom the object of her tenderness and the cause of her sorrowful fate.

The lower orders of Calabria manifested, amidst all the horrors of this awful catastrophe, the very excess of depravity. On the tottering walls, and among the smoking ruins, men might be seen who braved an ever-present danger, and trod under their feet the half-buried victims, vainly imploring their assistance, in search of gold or jewellery or plate—breaking open and plundering the houses that still stood erect. They stripped, while yet warm with life, the bodies of their unfortunate fellow-creatures, who would have rewarded them lavishly for timely help. At Polistena, a gentleman of rank had béen buried under the ruins of his house, with his head downwards; only his legs could be seen, which protruded into the air. His servant ran up to him—but it was only to tear away the silver buckles of his shoes, and then to take flight immediately, in spite of the entreaties of his master, who contrived, however, to effect his deliverance by his own exertions. The greater number of the Calabrian peasants who chanced to be in the open fields on the fatal 5th of February, poured headlong into the towns, still enveloped in clouds of dust; hastening thither, says Dolomieu,* not to carry help and encouragement—no feeling of humanity awoke in their bosoms in these terrible circumstances—but to rob and plunder.

Frequently, as we have said, the survivors were so few that they could render no effectual assistance to the buried persons. A mother, with dishevelled hair, and covered with blood,—a father half-mad with grief,—heard from beneath the earth the moans and cries of their dearest and best-beloved; they recognized their voices, and knew the exact place where they were slowly dying, yet were utterly unable to give them any help. The want of strong arms and stout hearts, the enormous mass of débris which required to be removed, paralyzed all the efforts of those who sought to deliver them, and who found themselves compelled to listen in despairing inaction to the complaints of the victims, and to the groans extorted from them by their supreme agony. These appalling sounds were sometimes heard for several days consecutively.

In the town of Terranova, four Augustinian monks having taken refuge in the sacristy of their convent, were saved from immediate death by the solidity of its vaulted roof, which sustained unshaken the pressure of the superjacent ruins. But how could any succour reach them? Out of more than a hundred brethren whom the monastery had contained, only one had effected his escape, his extraordinary bodily strength enabling him to struggle through the earth, timber, and masonry under which his comrades lay crushed. Wandering to and fro, solitary and despairing, he heard, for four days, the cries of the poor wretches shut up in the vaulted sacristy; their voices gradually grew fainter, and when, at last, the ruins were cleared away, they were found with their arms interlaced in death.

* Déodat de Dolomieu, "Mémoire sur les tremblements de terre de la Calabre, pendant l'année 1783" (in 4to), p. 12.

"I have spoken," says Dolomieu, "to many persons who were extricated from the ruins in the different towns I visited; they all agreed in the statement that they thought only their own houses had been overthrown, that they had no idea the destruction was general, and could not conceive why assistance was so long in coming. A woman of Cinque-Frondi was found alive on the seventh day. Two children lying near her, however, were dead, and their bodies had already begun to putrefy. One of them, resting on his mother's thigh, had occasioned there a similar condition of putrefaction. Many other persons had remained in this living death for three, four, and five days; I have seen them, spoken to them, and heard them describe their experiences of those fatal moments. Of all their physical sufferings the severest was thirst. The first want manifested by the animals which were rescued from the ruins, after a fast protracted in some instances for upwards of fifty days (?), was to drink; and they seemed wholly unable to satisfy themselves. Several persons, buried alive, supported their misfortunes with unexampled firmness, of which I could hardly believe human nature to have been capable without an almost total collapse of the intellectual faculties. A pretty maiden of Oppido, about nineteen years old, was, at this time, near the end of her pregnancy; she remained under the ruins for upwards of thirty hours; was rescued by her husband, and delivered, a few hours afterwards, as fortunately as if she had experienced no suffering. I was received on board her boat, and among numerous questions which I addressed to her, I asked of what she had thought during her fearful suspense. She answered: 'I waited.'"

This melancholy picture of the disasters of Calabria we shall terminate by a remark of a different character, which, however, is not without interest. That animals forebode the approach of an earthquake is a fact which has frequently been demonstrated. When no sign announces to unthinking man the coming Terror, these creatures indicate it by their agitation and their cries. Every animal without exception feels this singular presentiment, but it has been more particularly observed among the geese, ducks, and denizens of the poultry-yard. "During the shocks of the 5th of February," says Dolomieu, "the dogs howled so distressingly that orders were issued for their destruction." A similar restlessness is shown by oxen and horses in the open country.

Humboldt relates that, in the earthquakes so frequent in South America, oxen and other domestic animals stand with their legs placed wide apart, as if they hoped by this device to lessen the danger of being precipitated into a crevasse which might suddenly open under their feet. It is for this reason that men, in the same regions, are recommended, on the occurrence of an earthquake, to extend their arms from their bodies in the shape of a cross. The precaution is one which experience and tradition have impressed on the inhabitants of the New World. But who has endowed the patient steer, or the humble domestic fowl, with so extraordinary a presentiment? Is not this a powerful argument, among a thousand, to enforce upon naturalists who do not hesitate to deny the intelligence of the animal creation?

EARTHQUAKE AT RIOBAMBA, 1797.

[Riobamba was situated in the district of Quito, in South America, and in the very shadow, so to speak, of the great volcanic mountain of Tunguragua.*

It is probable that this volcano was the centre of the convulsion which occurred on the 4th of February 1797, and which extended its fatal influence over a tract of country not less than 120 miles in length (from north to south), and 60 miles in breadth (from east to west). Within this area every town and village were shattered into ruins; but the shocks, though in a less violent form, were felt over a far wider region; the northern boundary being Popayan, in New Grenada, while, southward, the earth-wave opened as far as the River Puira, in the north-western angle of Peru. Eastward, the limit was the River Napo, in Ecuador; westward, the sea.

Early in the year 1797, strange subterranean noises proceeded from the volcano

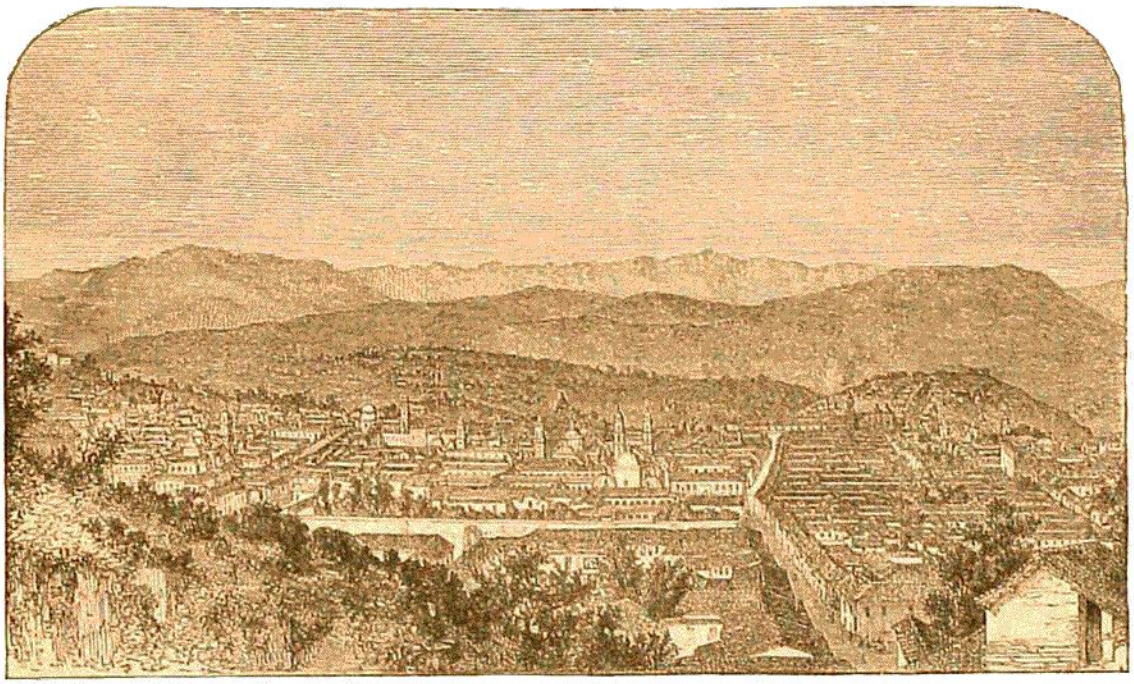

FIG. 135.—QUITO.

of Tunguragua, and these were of such a character that Antonio Pineda, the naturalist, predicted the imminence of some great calamity.

They had wholly ceased for some weeks, however, before the first great shock occurred on the morning of the 4th of February; but about a quarter of an hour *after* this shock, were renewed, with appalling intensity, at Quito, about 200 miles to the north of Riobamba, and Ibana, some miles further north. Yet none were heard at Hambato and Tacunga, about midway between Quito and Riobamba, though at both these places the effect of the earthquake was terribly destructive.

It has been remarked that the special feature of this great catastrophe was the subterranean commotion of the Tunguragua volcano. A check seemed to have been imposed on its usual operations; the igneous forces were evidently diverted in other

* [Humboldt, "Kosmos:" Mallet, "Report to British Association;" Sir Charles Lyell, "Principles of Geology," 10th edit. (London, 1867).]

directions; no volcanic matter was ejected from its crater; but in the ground enormous crevasses opened, which poured out torrents of water, and of a pestiferous mud or slime, called by the natives *Moya*. These floods devastated all the surrounding country, and in some of the neighbouring valleys, though they measured 1000 feet in breadth, accumulated to a height of 600 feet. The mud was heaped up in such vast masses as to obstruct the channels of rivers, and dam their waters into extensive basins, or lakes, which did not subside for nearly three months. It is a curious circumstance that in the volcanic floods thus poured forth from the very womb of earth were found quantities of dead fishes of a novel species, which must have been bred in subterranean reservoirs, at a distance, however, from the volcanic focus. In allusion to their peculiar habitat, they have been named the *Pycnelodes Cyclopum.*

According to Humboldt, the concussion on this occasion was vertical—*i.e.*, from the centre upwards—and so violent that some of the inhabitants were flung across a river several hundred feet broad, and fell on a neighbouring mountain. Consequently, the ground was rent, and twisted, and shattered in a most extraordinary manner, and in the chasms that everywhere opened, horsemen, and pedestrians, and strings of loaded mules were suddenly engulfed. Whole houses sank bodily into the earth, but in many cases were so little injured that their inhabitants remained in them unhurt, and by the light of torches passed from room to room, engaged in their usual domestic avocations, until extricated, after a suspense of two days, by persons despatched to their assistance.

Such was not the case, however, with the majority of the population of Riobamba. The loss of life was terrible—not only in the city, but throughout the region affected by the earthquake—and it is supposed that, in all, 40,000 persons perished.

Riobamba was reduced to a pile of ruins eight or ten feet in height; at Tacunga nothing remained standing but an arch in the great square, and portions of a neighbouring house. The churches were at the time thronged with worshippers; not one of them escaped. The village of San Felipe was swallowed up bodily. At Quito, though situated so far from the pivot of the wave, many of the churches and public buildings were overthrown. The Lake of Quilotou, in the district of Llactagunga, exhaled immense clouds of pestilential vapours, which suffocated the cattle feeding on its shores.

The first great shock, on the morning of the 4th of February, was followed, on the same day, by two of modified severity, at ten A.M. and four P.M., which, unlike their formidable precursor, were accompanied with subterranean noises. Mitigated shocks were repeated during the remainder of February and the month of March. The last, which proved very severe, was felt at half-past two A.M., on the 5th of April.

We proceed to subjoin a list of some of the principal convulsions which have marked the present century, before recording a few details of the great earthquake of Ecuador in 1868:—

July 26, 1805.—At Frosolone, in Naples, 6000 lives were lost.

August 11, 1810.—A village on one of the Azores Islands disappeared, and its site was occupied by a lake of boiling water.

March 26, 1812.—St. Leon de Caraccas, in South America, was almost entirely destroyed; upwards of 12,000 persons perished miserably.

June 1819.—The whole district of Kutch, in Hindustan, sank several feet below its accustomed level, and 2000 persons were buried alive.

June 1819.—In this same month Italy was visited by some severe shocks, and Rome, Florence, and Palermo were greatly injured. They were also felt at Genoa, and on the Mediterranean coast.

March 21, 1829.—Murcia, in Spain, was ravaged; 600 persons lost their lives.

April 29, 1835; *October* 12, 1836.—Calabria afflicted by two earthquakes. On each occasion the death-list exceeded 1000.

February 14, 1840.—The rich island of Ternate was reduced to a scene of chaotic ruin, and thousands of lives were lost.

July 2, 1840.—The territory surrounding Mount Ararat, in Armenia, was terribly scourged; 3137 houses were destroyed, and hundreds of their unfortunate inhabitants killed.

May 7, 1842.—Two-thirds of the town of Cape Haytien, in the island of San Domingo, were overwhelmed; the number of victims was estimated at between 4000 and 5000.

August 14, 1851.—In the convulsion which ravaged Southern Italy, Melfi suffered severely; the cathedral, the college, the military depôt, the episcopal palace, several churches, and 163 houses were razed to the ground. The motion lasted about one minute, first in a perpendicular, and afterwards in a horizontal direction. Upwards of 1000 persons perished. Other towns and villages were visited in the same manner.

September and *October* 1852.—Manilla, the capital of the Philippine Islands, was nearly destroyed by a succession of shocks.

April 16, 1854.—San Salvador, in South America, ceased to exist.

February 28, 1855.—The district of Broussa, in Turkey, was ravaged.

November 11, 1855.—Jeddo, in Japan, was almost laid waste. In this year a great earthquake occurred in New Zealand, and much injury was done in the neighbourhood of Wellington, the ground being raised four feet, and the tide rising above high-water mark every twenty minutes for eight hours.

March 12, 1856.—About 3000 lives were lost by a volcanic eruption and earthquake in the island of Great Sanger, one of the Molucca group.

December 16, 1857.—A terrible affliction befell the ill-fated Calabria, and especially the districts of La Duchessa, Lagonegro, Saponara, Montemurro, Tramutola, Tito, Breniza, and Marsico Nuovo. The area of greatest destruction extended as far as Terracina to the N.W., and in a meridional direction from Melfi, on the N., to Lagonegro, on the S. In some instances whole villages, like Pertosa, Padula, Montemurro, and Saponara, were overthrown, "like a pack of cards on a table," and their ruins hurled headlong into the ravines beneath. According to some authorities, the number of victims amounted to 22,000.

March 21, 1859.—About 5000 persons perished at Quito, in South America, and the city was greatly injured.

June 2, 1859.—At Erzeroum, in Asia Minor, upwards of 1000 lives were lost.

March 20, 1861.—Two-thirds of the South American town of Mendoza were destroyed, and 7000 persons perished.

December 19, 1862.—Guatemala, in Central America, suffered terribly.

June 3, 1863.—Manilla was destroyed, with 10,000 of its inhabitants.

EARTHQUAKE OF ECUADOR AND PERU, 1868.

The belt of country lying between the Andes of South America and the Pacific Ocean, and divided between the republics of Ecuador and Peru, was ravaged by a succession of earthquakes from the 13th to the 16th of August 1868, whose disastrous

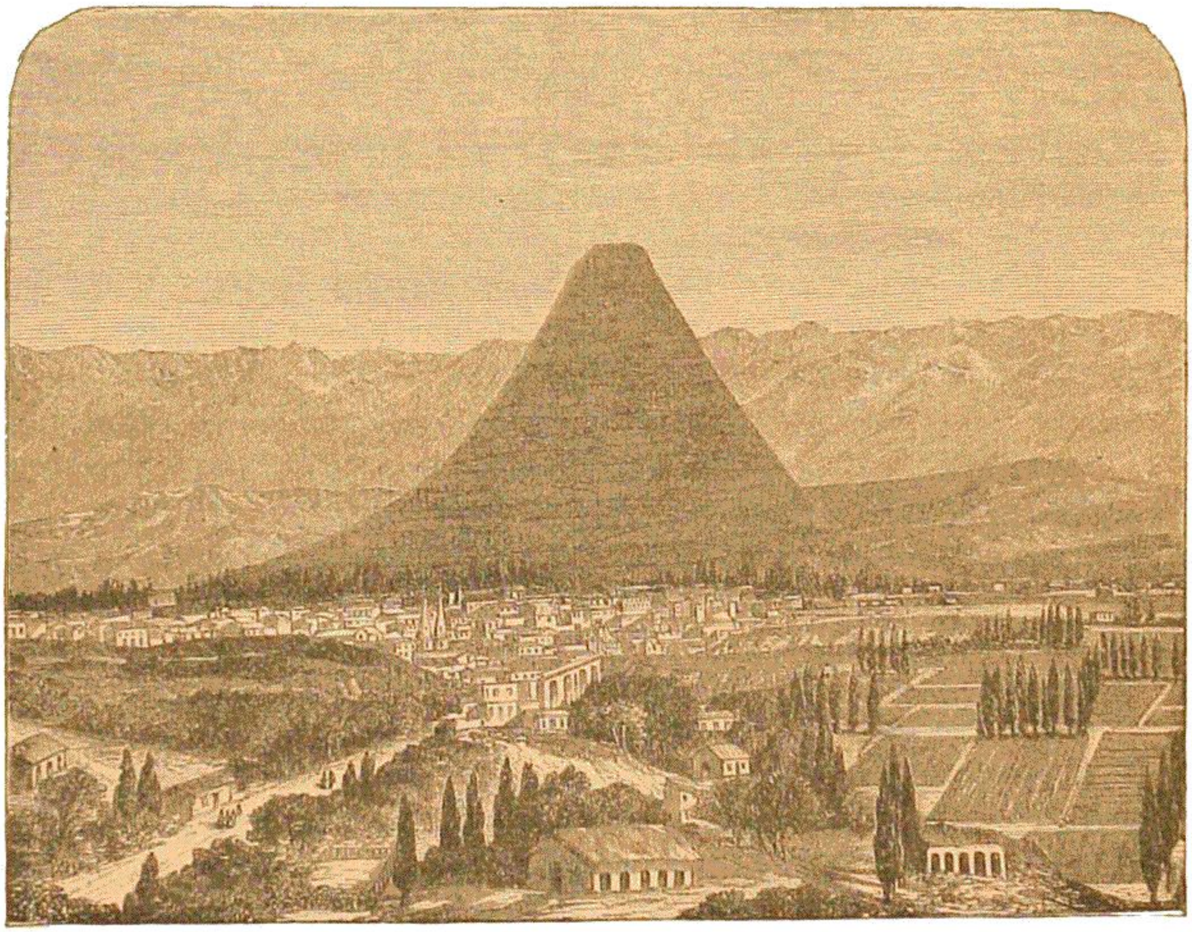

FIG. 136.—AREQUIPA.

effects extended over twenty degrees of latitude (nearly 1400 miles), and levelled to the ground numerous thriving towns and villages. Among others, Arica, Arequipa, Islay, Iquique, Pisco, Juancavelica, and Ibarra. The loss of property on this occasion has been estimated at £60,000,000 ; and it is believed that nearly 50,000 persons perished, and of these, fully 20,000 in Ecuador alone.

The first shock, on the 13th of August, at 5 P.M., was felt at Lima ; by 5.45 P.M. the earth-wave had reached Callao, where the sea rose to an alarming height, and poured on the beach in a mountainous billow, which inflicted great damage on the shipping.

It should be observed that on the 15th a series of enormous waves, swelling to a height of 60 feet above high-water mark, rolled in on the coast of Lower California. The rise and fall took place every half-hour, and the oscillations of the perturbed ocean continued for several hours.

The scene at Arequipa has thus been described by an English resident who escaped from the catastrophe :— *

"Arequipa was completely destroyed by an earthquake on the 13th instant, at 5.15 P.M.; and for a full description of the same, it is utterly impossible for words to do it justice. The 'terremente' came on while I was in a 'botica,' or luncheon-room, and the bottles of the shop commenced to shake and rattle against one another; at the sound of which all the men behind the counter began to run out, and with a good excuse for so doing. I and some friends remained until the earthquake became very bad, and then we ran out into the middle of the street, clear of all the houses, and got out only just in time, for the 'botica' fell down behind us. Fortunately, none of us were hurt. The earthquake lasted for six minutes. It began with a slight jumping, and increased in strength until it got to such a force as to make it very difficult to stand on one's legs. I can only compare it to the idea of a man standing on the back of a hard-trotting horse, accompanied at one and the same time with a long swerving motion. The earth felt to me as if it was trying its best to break open on every lift. I saw one house come down bodily, not far from where I was standing. After that, though walls were falling on all sides, nobody could see them, as the streets were completely filled with dust to such an extent that one could only see the person next to him, and just gasp for breath. It was awfully suffocating. By the puff of wind caused by a falling house, I caught a glimpse of a corner, and away I darted through the gutters, which here are in the middle of the street, until I found the Plaza, or square, which was filled to a crush with people making most horrible noises. One woman was running about screaming with a child in her arms, probably looking for friends; and there were men crying like children, and running as if mad, looking, perhaps, for wives and children. After nearly fifteen minutes' suffocation, I found two of my friends; but, having changed in appearance, recognition was rather difficult. We looked as though a shower of flour had been poured down upon us. You must form your own ideas of the scenes that were going on, and lasting for a while, after the earthquake. Houses are built of immensely large stones, on an average weighing one hundredweight, and the walls are all 5 feet or 6 feet thick. The falling of these can be easier imagined than described. After the excitement was a little gone, people began to rush to the country, and at night nearly every one was either in the 'Plazas' or on the roads to the country."

We have named among the towns destroyed by this catastrophe that of Ibarra. It is situated upwards of sixty miles from Quito—where the damage done was comparatively slight—on a plain 7000 feet above the sea-level. Its population was about 16,000; of these 13,000 perished in the ruins. To the east of Ibarra, and at a greater elevation by 2000 feet, stood Otavala, with a population of 10,000; between 6000 and 7000 lost their lives. The population of the whole province of Imbalrua was estimated at 65,000; of whom upwards of 20,000 were suddenly swept away.

* [Quoted from the *Illustrated London News*, October 10, 1868.]

We may conclude our description of these remarkable phenomena with some remarks upon their causes.

Mrs. Somerville, in her admirable little work on Physical Geography, is of opinion that they are produced by fractures, sudden heavings, and subsidences in the elastic crust of the globe—these fractures and subsidences being due to the pressure of the liquid fiery nucleus of the earth's centre, and affording to its gases and vapours a number of needful vents. The tension acquired by the strata during their slow refrigeration is thus relieved, and an equilibrium restored. The shock, originated at the point where the impulse is first given by the upward movement of the vapours, is propagated through the earth's elastic surface in a series of circular or oval undulations, like those produced by dropping a stone into a pool; and like them, too, they broaden and weaken as they travel further from their point of departure. If the impetus be communicated in the interior of a continent, the wave is carried onward through the solid crust of the earth, as well as in sound through the air; and from the former is transmitted to the ocean, where it expands itself and disappears, or, if of great intensity, is continued on the opposite shore. The most disastrous earthquakes, however, have their origin in the bed of the ocean. In this case two kinds of waves or undulations are simultaneously propagated; one through the ocean-bed, forming the true earthquake-shock, and one on the ocean surface, forming a vast wave or tide which rolls onward to the shore, striking it after the earthquake-shock has been expended.

"The sea rose 50 feet at Lisbon and 60 at Cadiz after the great earthquake (of 1755); it rose and fell eighteen times at Tangier on the coast of Africa, and fifteen times at Funchal in Madeira. At Kinsale, in Ireland, a body of water rushed into the harbour, and the waters in Loch Lomond in Scotland rose 2 feet 4 inches—so extensive was the oceanic wave. The height to which the surface of the ground is elevated, or the vertical height of the shock-wave, varies from one inch to two or three feet. This earth-wave, on passing under deep water, is imperceptible; but when it comes to soundings it carries with it to the land a long, flat, aqueous wave; on arriving at the beach, the water drops in arrear from the superior velocity of the shock, so that at that moment the sea seems to recede before the great ocean-wave arrives."

The velocity of the great *wave* varies as the square root of the depth: hence it travels fastest through deep water. That raised during the Lisbon earthquake sped onward to Barbadoes at the rate of 7.8 miles in a minute, and to Portsmouth at the rate of a little more than two miles per minute. The velocity of the *shock* is proportionate to the elasticity of the strata through which it is transmitted. And it should be observed that the undulatory movements of the earth are governed by the same laws as those of light or sound; so that when the earth-wave is propagated through strata of different elasticity, it is partly *reflected*, and a wave thrown back which produces a shock in a different direction, and partly *refracted*, or changed in course, producing shocks both upwards and downwards, to the right or left of the original line of progression.*]

* [Mrs. Somerville, "Physical Geography," i. 260–266.]

CHAPTER VIII.

ON VOLCANOES—CENTRAL VOLCANOES, AND LINEAR VOLCANOES, OR VOLCANIC CHAINS —GEOGRAPHICAL DISTRIBUTION OF VOLCANOES—VOLCANIC PHENOMENA.

LEOPOLD VON BUCH has divided all the volcanoes on the surface of the globe into two classes: Central Volcanoes, and Linear Volcanoes, or Volcanic Chains.

A Central Volcano is one which stands alone and isolated; a Volcanic Chain is a number of volcanoes, succeeding one another in a longitudinal series and in the same direction, whose craters are so many shafts or vents communicating with one and the same great fissure of the globe.

Volcanoes are also divided into *active* and *extinct.* When a vertical fissure has been established in the earth's crust, through which gases, vapours, smoke, and molten matter are ejected—either at intervals or continually, either separately or in combination—it is called an *active* volcano, and its mouth a *crater.* But when the fissure has been closed up, through some physical change or convulsion, or the operation of natural causes, it is known as an extinct volcano. The area to which active volcanoes are confined may be traced on the surface of the earth with the utmost exactitude, and is, happily, somewhat limited; but there is scarcely a country in the world which does not contain an *extinct* volcano, or exhibit unmistakable traces of past volcanic action.

We propose in the present chapter to describe, in the first place, the principal central volcanoes, and some of their more remarkable eruptions; then to trace the great volcanic chains, and the general geographical distribution of volcanoes; and, finally, to bring together the recognized volcanic phenomena, with an explanation of their causes.

MOUNT ETNA.

[One of the most celebrated volcanic mountains in Europe is that of Etna, or Ætna, situated in the north-eastern district of the rich island of Sicily, adjoining the sea-coast, near Catania. It is now known to the Sicilian peasants as *Mongibello*—a name made up of the Italian *Monte* and the Arabic *jibel*, both words signifying a mountain—but to most European nations it is familiar as Etna. It is the loftiest mountain in Southern Europe, rising to an elevation of 10,874 feet above the sea; its circumference at its base measures not less than 90 miles, so that its mass would completely occupy more than one English county. It is a central volcano—that is, an isolated and lonely mountain—its limits on the east being defined by the Mediterranean, on the south and west by the river Simeto and Giarretta (the ancient *Symaethus*), and on the north by the valley of Alcantara, which, like a deep gulf, separates it from the mountain-groups of Northern Sicily.

Etna is an active volcano. We know from evident geological data that its eruptions must have commenced before the historical age; and since the beginning of human records they have followed one another at irregular but frequent intervals. Diodorus asserts that the Sicanians were driven from their ancient settlements in the eastern part of the island by its numerous and destructive outbursts. On this statement considerable doubt not unnaturally rests; but, at all events, as early as the days of Hesiod its eruptions had attracted the attention and excited the wonder of the Greeks. Pindar would almost seem to have been an eye-witness of them, from the force and truth with which he describes the torrents of fire that burst from its innermost caverns, and the rolling sheets of crimson flame that kindled the darkness of night with their deep glow, and obscured the day with their clouds of smoke. Æschylus has also a fine allusion to the "rivers of fire which with ravenous jaws devoured the smiling Sicily."* Thucydides records an eruption which occurred in B.C. 425, the sixth year of the first Peloponnesian War, but he speaks of it as

* [Pindar, "Pyth," i. 40; Æschylus, "Prometh. Vinctus," 368.]

only the third since the Greek colonization of the island. The fourth is mentioned by Diodorus as taking place shortly before B.C. 396, and ravaging so considerable a tract of the country between Tauromenium and Catania, that the Carthaginian general Mago was arrested in his march along the coast.* History is thenceforth silent until B.C. 140, though we can hardly suppose two centuries and a half to have elapsed without any signs of volcanic activity. If such were the case, in B.C. 140, 135, 126, and 120, the mountain more than compensated for its previous inertness; the outburst in the last-named year almost destroyed the city of Catania. Eruptions also took place in B.C. 49 and B.C. 44, the latter immediately preceding the death of Cæsar, and being accordingly represented by Virgil as a portent of that disaster.†

> "Nor was the fact told by the sun alone:
> Earth, air, and seas, with prodigies were signed,
> And birds obscure, and howling dogs divined.
> What rocks did Ætna's bellowing mouth expire
> From her torn entrails; and what floods of fire!"

These eruptions appear to have been of a tremendously violent character, and to have completely desolated the whole eastern side of the mountain.

Another convulsion is recorded in B.C. 38, and one in B.C. 32, which was accompanied by a great torrent of lava. We read of only two more during the later years of the Roman Empire—one in the reign of Vespasian, A.D. 70; and the other in that of Decius, A.D. 251; and Orosius, who wrote early in the fifth century, speaks of Ætna as in his time having become comparatively quiescent.

That these eruptions were equal in violence to any which have occurred in modern days, may reasonably be inferred from the descriptions recorded by ancient authorities. Livy speaks of ashes and hot sand carried in clouds as far as Rhegium; and Pliny of bellowing noises being heard in the remotest parts of Sicily. The following picture, which we borrow from the third book of Virgil's "Æneid," would serve for any recent eruption in all its impressive details:—‡

* [Diodorus, xiv. 59.]

† [Virgil, "Æneid," iii. 570–577.]

‡ [Professor Conington's Translation, pp. 93, 94.]

". . . . Ætna with her voice of fear
In weltering chaos thunders near.
Now pitchy clouds she bellows forth
Of cinders red and vapours swarth,
And from her caverns lifts on high
Live balls of flame that lick the sky:
Now with more dire convulsion flings
Disploded rocks, her heart's rent strings
And lava torrents hurls to-day,
A burning gulf of fiery spray."

Here we recognize the characteristic phenomena of a volcanic outburst: showers of ashes, fire-balls, clouds of smoke, ejected rocks, and streams of lava.

To account for these wonders, the poets resorted to the agency of Fable, and described them as produced by the violent struggles of the giant Typhoeus—Enceladus, according to some—to relieve himself of the weight flung upon him by Zeus after the war between the gods and Titans.

"'Tis said Enceladus' huge frame,
Heart-stricken by the avenging flame,
Is prisoned here, and underneath
Gasps through each vent his sulphurous breath:
And still as his tired side shifts round,
Trinacria echoes to the sound
Through all its length, while clouds of smoke
The living soul of ether choke." *

The natural features of the mountain were the same in ancient times as in our own. In winter its higher grounds were covered with snow; a contrast to its fiery interior which the poets made the most of. Its mid-regions were clothed in immense forests, from which the Syracusan tyrant Dionysius procured the materials for the vast fleet he constructed in B.C. 399. The lower slopes abounded in rich meadows and prolific vineyards, the decomposition of the volcanic ashes producing a soil particularly well adapted for the cultivation of the vine. The summit, according to Strabo, was a level plain of about twenty stadia in circumference, enclosed by a narrow ridge, like a wall or rampart, and consisting of deep and burning sands. Out of the centre rose a small, bare, and rugged hillock, overhung by a cloud or canopy of smoke, not less than two hundred feet in height. But its aspect, says Strabo,† was constantly changing; sometimes you might see a single crater, sometimes two or more. The ascent of the mountain was by no means an unusual enterprise, and we are told that it was undertaken by the Emperor Hadrian for the purpose of seeing from its lofty watch-tower the glories of an Italian sunrise.‡ At a point about 1400 feet below the summit are still extant the remains of a Roman work, commonly known as the *Torre del Filosofo*, generally associated with the memory of Empedocles; but more probably dating from the epoch of Hadrian's ascent.

In the name Ætna, philologists recognize a reference to the volcanic character

* [Virgil, "Æneid," iii. *ut suprà*.] † [Strabo, bk. vi., pp. 269, 273, 274.]
‡ [Spartianus, "Hadrian," 13.]

of the mountain; it comes from the same root as αἴθω, to burn. But the poets identify it with a nymph, Aetna, the daughter of Uranus and Gaea, or of Briareus and Gaea, who, it is said, acted as arbitrator between Hephaestus and Demeter respecting the possession of Sicily.* According to Euripides, it was in the recesses of Ætna that Hephaestus and the Cyclops forged the thunderbolts of Zeus.

One of the latest traditions of the mountain associates it with the Sicilian philosopher Empedocles, who was said to have perished in its flames; having cast himself into its crater that men might know nothing of his death, and suppose him to have been removed from the earth like a divine being. But the mountain having cast forth the philosopher's sandals, his fictitious immortality was thus exposed. Such is the story told by Lucian: not only is its absurdity self-evident, but we have the direct testimony of Aristotle that Empedocles died a natural death at the age of sixty.

On the old legend Mr. Matthew Arnold has based a semi-dramatic poem of much beauty, from which we borrow a description of Etna, equally remarkable for its fidelity to nature and its charms of language. It refers to the woody region of the mountain:—†

"The track winds down to the clear stream
To cross the sparkling shallows; there
The cattle love to gather, on their way
To the high mountain pastures, and to stay,
Till the rough cow-herds drive them past,
Knee-deep in the cool ford; for 'tis the last
Of all the woody, high, well-watered dells
On Etna; and the beam
Of noon is broken there by chestnut boughs
Down its steep, verdant sides; the air
Is freshened by the leaping stream, which throws
Eternal showers of spray on the mossed roots
Of trees, and veins of turf, and long dark shoots
Of ivy-plants, and fragrant hanging bells
Of hyacinths, and on late anemones,
That muffle its wet banks; but glade,
And stream, and sward, and chestnut-trees
End here; Etna beyond, in the broad glare
Of the hot noon, without a shade,
Slope behind slope, up to the peak, lies bare;
The peak, round which the white clouds play."

The country immediately surrounding the mighty base of Etna is everywhere covered with lava, and everywhere presents abundant traces of past volcanic action. The mountain-sides are also furrowed with broad currents of lava; the more recent, fearfully black and portentous; the more ancient, either partially or wholly decomposed, and thickly clothed with vegetation.

* [Article "Ætna," in Dr. Smith's "Dictionary of Greek and Roman Biography."]

† [Matthew Arnold, "Empedocles on Etna," pp. 16, 17.]

The mountain is divided into certain distinct regions: the first or lowermost (the *Piedimontana*), lying around its roots, an Arcadian scene of fertility and loveliness, where the vine, and olive, and fig, and prickly pear form immense bowers of overarching verdure.

Next we pass into the woody region, which extends upwards for a considerable distance, and consists of vast deep forests of ilex, oak, and chestnut—of groves of "murmurous pines"—and of ample grassy glades, diversified by an occasional clump of trees, and enriched with ferns and aromatic herbs. Here the enterprising traveller meets with the celebrated *Castagno di Cento Cavalli*, or "Chestnut-tree of the Hundred Horses"—situated about six miles above Giarre—which is

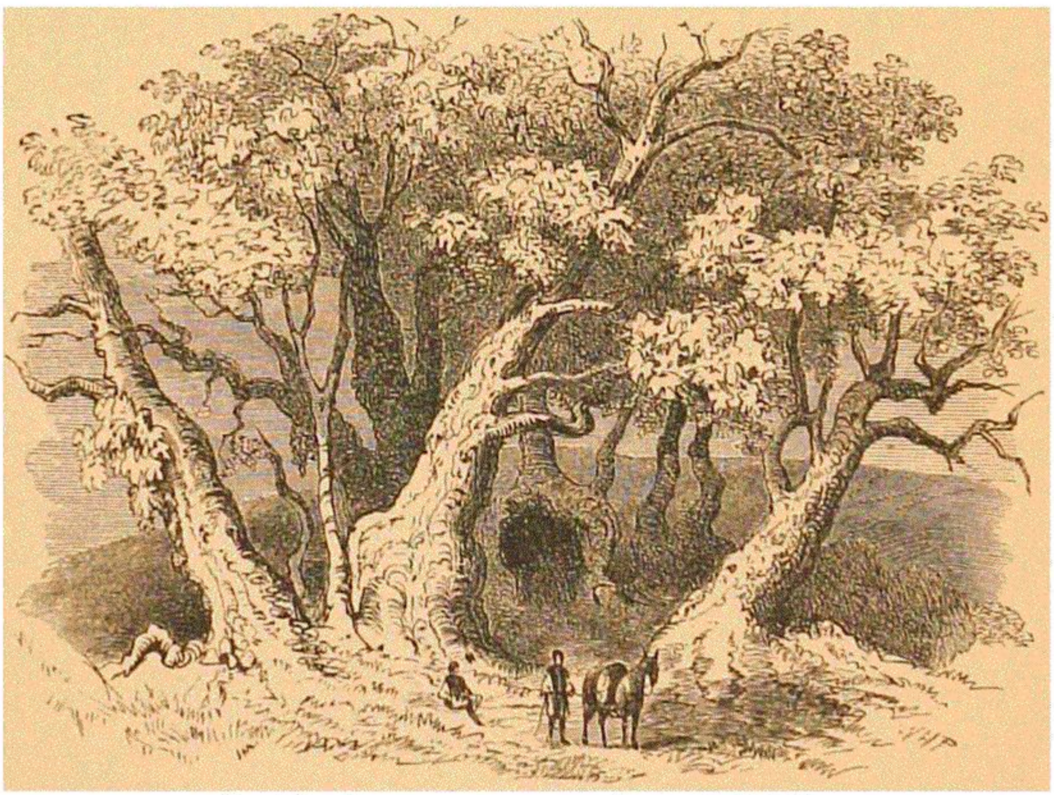

FIG. 137.—CHESTNUT-TREE OF THE HUNDRED HORSES.

not, however, as some have supposed, the mighty offspring of a single root, but consists of several trunks, forming a circle, which, at three feet above the ground, measures about one hundred and ninety feet. Under its umbrageous branches it is certain that a company of cavaliers might easily find shelter.

From the *Bosco* (as it is called) to the summit spreads the third and last region (the *Disarta*, *Netta*, or *Discoperta*); a wild and dreary waste, composed of barren plateaux and deep desolate hollows—

mantled with scoriæ and ashes—and only endurable to the eye when buried, as is the case for several months of the year, in glittering snow. This snow is, we are told, of the highest importance to the population of Sicily, Malta, and even of Barbary, to whom, during the

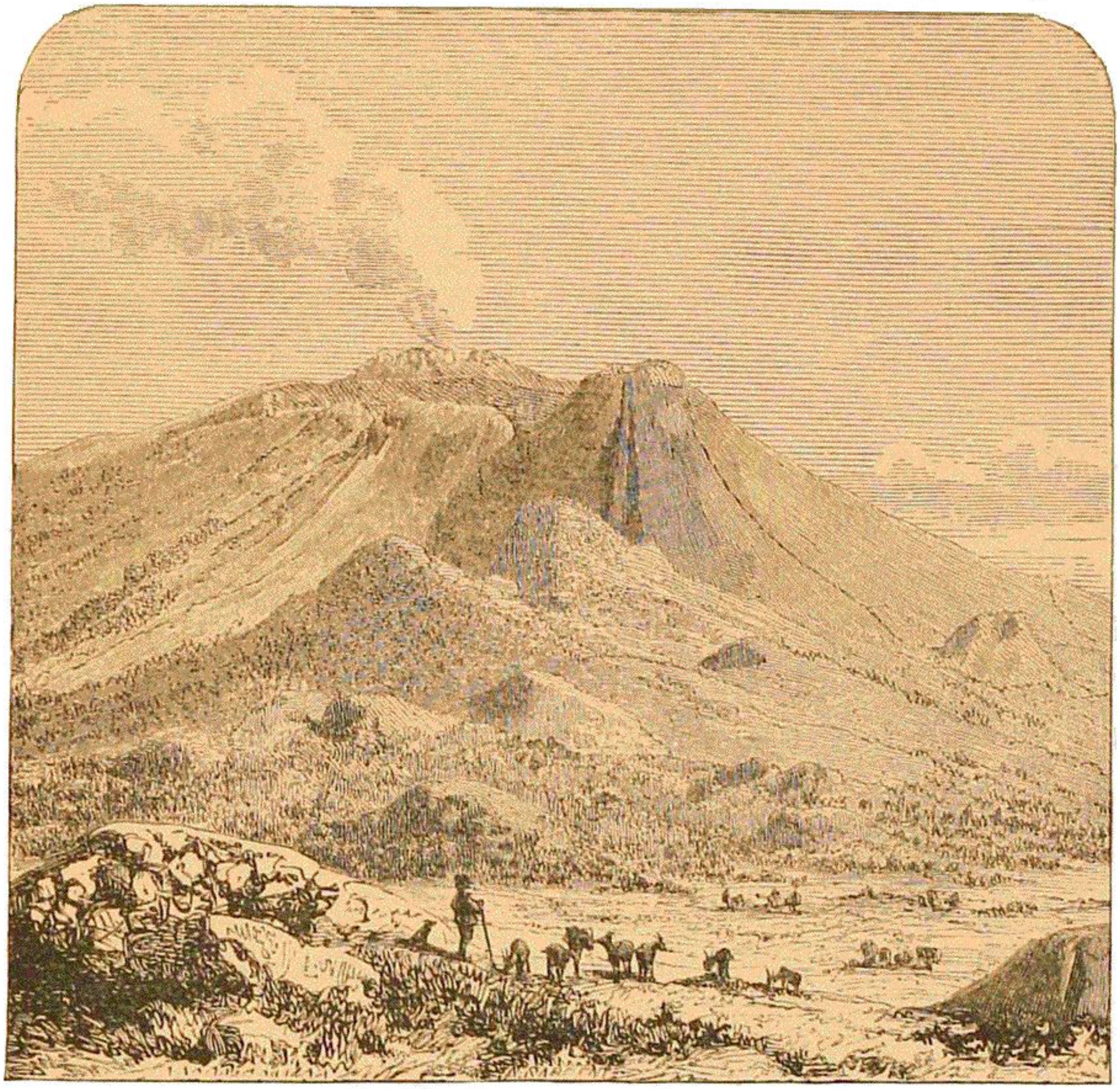

FIG. 138.—ETNA, SEEN FROM CATANIA.

burning summer-days, ices and iced drinks are among the necessaries of life. The exhaustion of the stock has frequently been the cause of serious disturbances; and, on one occasion, the governor of Catania was compelled to offer a large reward to whomsoever should discover a fresh supply.* Happily, a bed of snow was found underlying a torrent of ancient lava.

Among the peculiar features of Mount Etna may be mentioned its

* [Bartlett, " Pictures from Sicily," p. 148.]

numerous subterranean cavities. These are most remarkable in the neighbourhood of two secondary cones, called Monti Rossi. The outermost, the Fosse della Palomba, measures 625 feet in circumference. At the entrance its depth is 78 feet; but beyond this point it opens into another gloomy cavern—the first of a series of Erebus-like pits, conducting into a large gallery, 90 feet in length, and from 15 to 60 feet in breadth. This gallery abuts upon a passage leading to other caverns, which no man has yet ventured to explore.

The great altitude of Etna has had a singular influence on its general configuration. Seldom of sufficient energy to eject the lava from the summit-crater, its forces have contented themselves with forming numerous subsidiary craters and cones upon the flanks of the mountain, so that it seems like a parent volcano surrounded by a ring of volcanic bantlings. These occur chiefly in the woody region, and are about eighty in number; 52 on the west and north, 27 on the eastern side. Monti Minardo, one of the largest, is 700 feet high; Monti Rossi, which consists of two cones united at the base, where they have a circumference of nearly two miles, are 450 feet in height. Many of them are well-wooded, and of a singularly picturesque appearance; the volcanic ashes being completely hidden by a thick mantle of vegetation.

The grandest feature of the Etnean scenery is, however, the *Val del Bove;* a profound valley, or chasm, lying on the eastern declivity of the mountain, and extending from a point near the summit to the very border of the woody region. On one side it is prolonged to the cultivated ground by two smaller, narrow, and very romantic ravines. The Val del Bove itself is between four and five miles in diameter; its general appearance is that of an immense amphitheatre, whose arena or bed has been traversed by the billows of a sea of lava, which have swept round two masses of rock, like islands, and then suddenly congealed in all their tempestuous fury! A wall or barrier of rocks, highly inclined, fences round this awful amphitheatre—a fit scene for the pastimes of gods and Titans!—with a varying altitude of from 1000 to 3200 feet. Ridges of hard lava are encrusted on this wall; it is supposed they were formed by injection from beneath into fissures opened in the previously existing rock.

By some authorities the Val del Bove is regarded as an extinct crater. Sir Charles Lyell, however, ascribes its formation either to the subsidence of a considerable portion of the mountain, or to the long-continued action of water.*

The aspect of the summit—

> "The charred, blackened, melancholy waste,
> Crowned by the awful peak, Etna's great mouth,
> Round which the sullen vapour rolls"—

is described as singularly impressive. It is possible to reach the very brink of the crater, and to look down into its awful depths—to survey its chaos of black scoriæ, and fragments of lava, basalt, and sulphur—the lava boiling and seething below, like oil in a gigantic caldron! In 1834, Elie de Beaumont and Leopold von Buch examined the small active mouth which forms the culminating point —the apex—of the mountain.

"It was for all of us," says Elie de Beaumont, "a moment of surprise very difficult to describe, when we found ourselves suddenly on the margin, not of the great crater, but of a nearly circular gulf, from 260 to 330 feet in diameter, which lies contiguous to the great crater for a small portion of its circumference. Our glances plunged eagerly into this nearly cylindrical funnel, but it was in vain we sought there the secret of the volcanic energy (*la volcanicité*). The nearly horizontal strata which are conspicuously marked upon its almost vertical sides only revealed to us the structure of the upper cone. In endeavouring to count them successively, we saw them gradually lost in the complete obscurity of the bottom. From the gloomy depths not a sound issued; they gave forth nothing but whitish vapours, slightly sulphurous, and principally composed of steam. The melancholy aspect of the black and silent abyss in which our gaze was lost; its obscure and buried sides, along which wound, monotonously and heavily, immense wreaths of vapour of a sad and grayish tint; the great crater on which this narrow gulf abutted, and in which the confused accumulation of substances of various colours, yellow, and gray, and red, seemed the very image of chaos;—all combined to form a funereal and sepulchral scene, whose wild and dreary impression was further increased by the chill morning air and a light cold breeze from the north-east."

* [Sir C. Lyell, "Principles of Geology," bk. ii., c. 26.]

A still more striking description of Etna and its crater is furnished by the eminent naturalist, M. de Quatrefages, who ascended the mountain in 1844 :—*

"At our feet yawned the great crater. It was not a simple inverted cone or funnel, such as we had seen in all the secondary cones, and such as may be observed on the summit of Vesuvius itself. Nor was there before us that uniform blackness of rocks and ashes which characterizes Stromboli. The effects of an eruption which had occurred in 1843 were still apparent ; and the crater, as we saw it, presented the appearance of a deep, irregular valley, broken up by headlands and promontories,

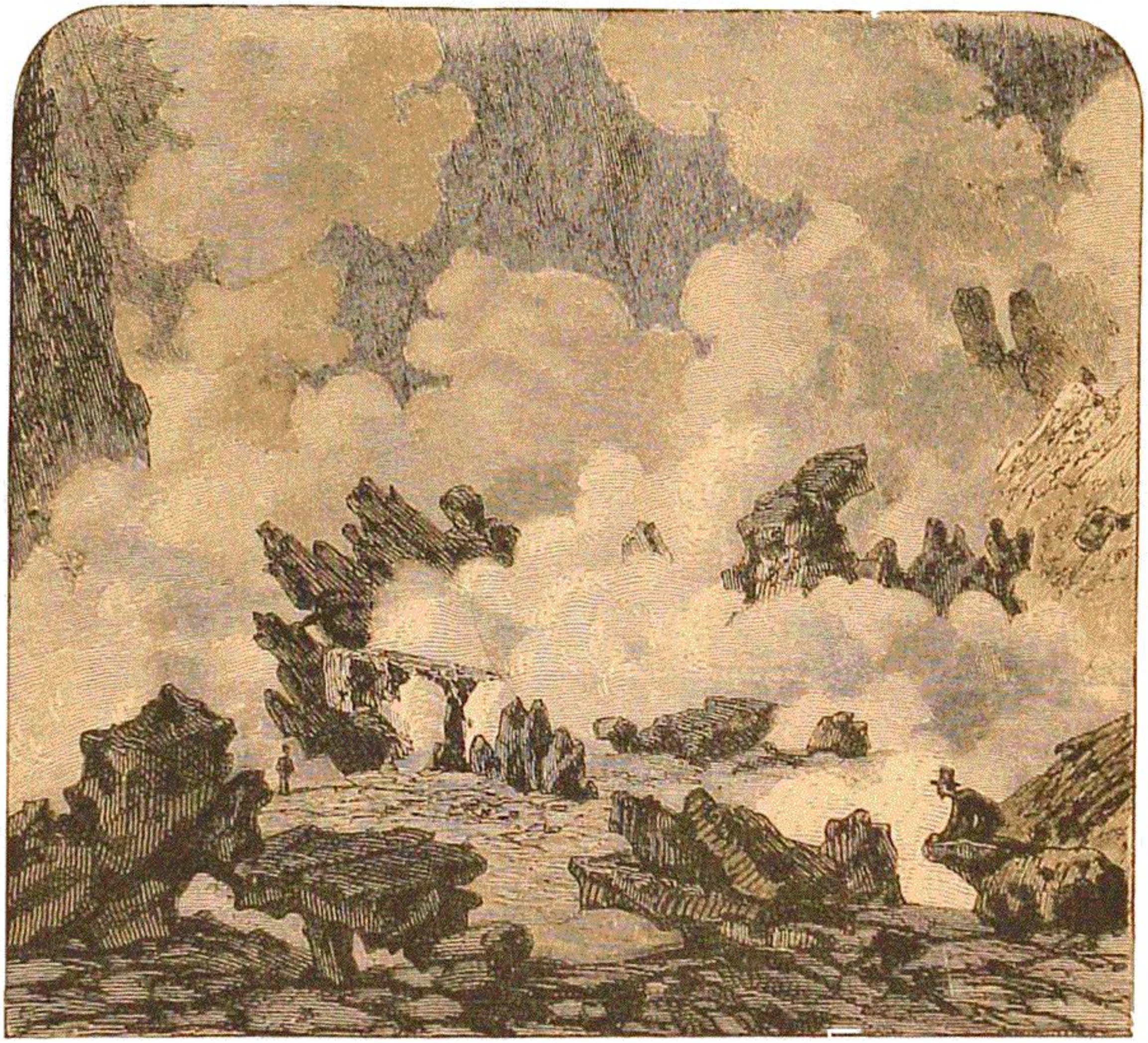

FIG. 139.—THE CRATER OF MOUNT ETNA.

and composed of steep declivities bristling with enormous scoriæ and blocks of lava, heaped up in masses, or rolled and twisted in a thousand different ways by the power of the volcanic forces, or by the accidental influences they had undergone in the act of falling. The blue, green, and white lava, stained here and there with broad patches of black, or streaks of sombre red, contrasted strongly with the livid colour of the environing rocks. Over this chaos prevailed a death-like silence ; long wreaths of white vapour noiselessly escaped from a thousand distant *fumaroles* (or vents), and lazily crept along the sides of the crater, carrying to the spot where we stood suffocating emanations of sulphurous and hydrochloric acids. The wan rays

* [Quatrefages, "Rambles of a Naturalist," pp. 92, *et seq.*]

of the moon, mingling with those of the coming dawn, fitly accompanied this savage scene, whose grand and supernatural character no words can adequately express.

"The soil on which we trod consisted wholly of cinders and scoriæ, was damp and warm, and encrusted with a white efflorescence like hoar-frost. This humidity, however, was simply an effect of the acid exhaled from the crater, which moistened and corroded everything it touched; while the silvery film, on which a few crystals glittered, was a deposit of sulphur sublimated by the volcano, and of salts formed by the chemical reactions that were constantly occurring in this Cyclopean laboratory.

"By following the narrow ridge which borders the crater to the south, we gained the highest point; this is found on the eastern extremity. An indescribable spectacle was here revealed before our gaze. The sky was cloudless, the air exquisitely transparent; while the horizon, which, from the shortness of the twilight, was now brightly illuminated, seemed without other limit than that resulting from the curvature of the earth's surface. From our lofty pedestal we looked down a depth of four or five thousand feet on the loftiest summits of the Pelorian and Madonian Mountains; while the whole of Sicily lay spread before us like a map. . . .

"After throwing one last look at the valley of the crater, we quitted our place of observation, and descended towards the foot of a circular knoll which lay to the east. Our guide soon stopped us near a steep and narrow declivity, which was entirely detached from the rounded margin of the cone, and abutted upon a precipice several hundred feet in depth. There we saw him roll up the sleeve of his jacket, and apply it to his mouth—a proceeding which he signified by signs that we must imitate—and rushing forward across the slope, he exclaimed, *Fate Presto!*—(make haste). We followed him unhesitatingly, and soon reached the margin of the mouth, which, in 1842, had projected its torrents of lava into the Val del Bove, and being re-opened in 1843, threatened all the surrounding district. . . .

"Here all attempts at description are useless. A vast and irregular circular enclosure of perpendicular walls fenced in the chasm. To the left, at the foot of the escarpment, a large vent had been opened, from which clouds of fiery red smoke proceeded. In the centre, everywhere lay immense blocks of lava, that had been cracked, and rent, and shattered; some black, others of a dark red; but all exhibiting in their fissures the glowing tints of the lava from which they had been separated. A thousand wafts of white or gray smoke crossed and re-crossed each other in all directions, with a deafening noise, and with a shrill whistling sound like that of the steam-signal of a locomotive. Unfortunately we could do no more than throw a hasty glance at this singular and fearful scene. The hydrochloric acid entered our throats, and penetrated to the last ramifications of the bronchial tubes. Hastily, and with a feeling like intoxication, we returned to the protecting slope where we might breathe with less difficulty; and then, sustaining ourselves on our staves, we leaped to the edge of the crumbling declivity, and in five minutes had reached the base of the cone, whose ascent had cost us upwards of an hour."

The ascent of the mountain is frequently undertaken for the purpose of viewing the sunrise from its elevated crest. This, indeed, is one of those rare spectacles which indelibly impress themselves upon the mind, and are treasured up among its most precious things in the storehouse of our memory. It can never be forgotten; at the bidding of the will, it returns again and yet again, to illuminate the dark watches of the night, or to stand out conspicuous and unrivalled among all the sights of noon—a wondrous, sublime, and almost awful manifestation of the glory and majesty of the Creator through the medium of his creation. Oh, to see it, as the stars one by one recede from their "azure towers," where, during the still night, they have patiently kept watch and ward,—as the rose of dawn gradually reddens on the distant horizon—as above the darkened earth float, like wraiths, the vast masses of vaporous cloud, rapidly assuming on their upper surface a coloured glow like that of an Arctic Aurora—to see it as the eastward sky becomes barred and checkered with streaks of crimson, and clear against the pure heaven shine the golden crests of the Apùlian mountains—to see it as out of the mysterious infinite rises the radiant orb of day, clothed in unutterable splendour, faint gleams of which are caught by the nearest peaks, and fast transmitted from one to another through all the long, long chain—to see it when the purple shadow of Etna is projected like a mighty pall over half the island, while the other half smiles, dimples, laughs in the exuberant beauty of the morning,—is to see what poet never dreamed of in his boldest vision, and to realize, if only for a moment, some conception of the glories of another world!

The scenic view (if we may use the expression) from the summit is of an imposing character.

Vastness and dreary sublimity predominate, says Mr. Bartlett,* relieved with some few touches of exquisite beauty. Standing on the dread summit of the volcano, the eye takes in with astonishment the immense extent of the region at once desolated and fertilized by its eruptions. Wide beds of lava—black, abrupt, and horrid—may be traced down its sinuosities and chasms, winding half concealed

* [W. H. Bartlett, "Pictures from Sicily," pp. 164, 165.]

among the extensive forests below, even through the midst of the fertile region which reposes at its base, until they pour into the sea; and interspersed with these are broad dismal beds of ashes and scoriæ—the seat of eternal desolation. Beneath the Bosco, and around the base of Etna, the boundary of the region subject to its effects may be distinctly traced. Beyond, in all directions, extend the fertile plains and mountains of the island; the latter, however, of an aspect little less wild and desolate than that of Etna itself. The range of the view is almost boundless—Catania, Syracuse, and even, when clear, Malta itself are visible. Castro Giovanni stands up on its rock, conspicuous in the centre of the island. The expanse of sea is most magnificent, with the distant mountains of Calabria and Apulia, and the entrance to the Faro di Messina.

Our description of Etna will conclude with some notices of its eruptions in modern times.

A remarkable convulsion occurred in 1169, totally destroying Catania, and overwhelming 15,000 persons in its ruins.

We read of outbreaks of a fearful character as taking place in 1329, 1408, 1444, 1536, 1537, 1564, and in 1669—the latter a calamity almost unparalleled in its effects, to which we shall presently allude.

Eruptions are also recorded in 1766, 1787, 1809, 1811, and May 1830—when several villages perished, and showers of ashes were projected almost as far as Rome.

Again, in November 1832, when the town of Bronte was ruined.

Again, in August and September 1852, the streams of lava flowing, and the torrents of scoriæ and ashes continuing for many days.

The last occurred in 1865. It was remarkable for its duration, beginning on the 1st of February, and not terminating until the following July.

It should be noticed that Etna is generally most active when Vesuvius is in repose, though there are several instances of the two volcanoes setting in motion their latent forces simultaneously.

The eruption of 1669, to which we have previously referred, was preceded by an earthquake, which devastated the town of Nicolosi, situated about ten miles inland from Catania, and about twenty from the summit of Etna. Soon afterwards an enormous rent or chasm suddenly opened in the flank of the mountain, extending from a point within a mile of the top of the great cone to a point very near Nicolosì.* It was twelve miles long and about six feet wide, but of unknown depth. It opened with a horrible clang, and gave forth a vivid light. Five other parallel fissures of the same size opened afterwards, and from these vast clouds of gases and vapours proceeded,

* [Dr. Daubeny, "On Volcanoes."]

and detonations like those of an army's heavy cannon, which were heard at a distance of forty miles. Just above Nicolosì two large rents were visible, from which ashes, and stones, and scoriæ, and sand were ejected incessantly for a period of nearly four months. Their accumulation composed the double cone now known as Monti Rossi.

From the first great chasm issued a river of fiery lava, which encountered, in the earlier part of its course, a small cavernous cone called Mompilière, and flowing into its subterranean hollows, melted away its base, so that the cone subsided to a considerable extent. It then resumed its onward progress, and destroying in succession fourteen towns and villages, arrived at the walls of Catania. These formed a

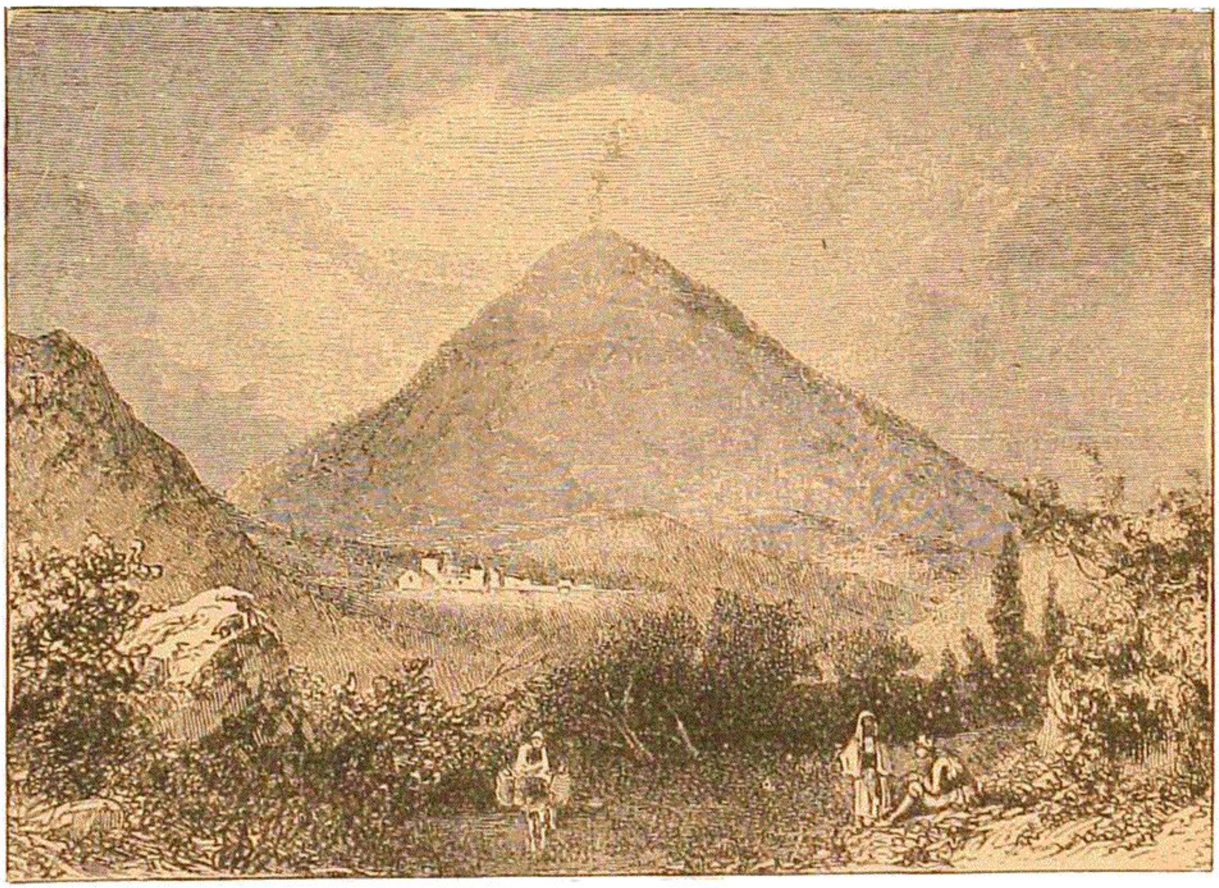

FIG. 140.—NICOLOSI AND MOUNT ETNA.

bulwark sixty feet in height, and of very massive construction, and it was supposed would suffice to arrest the flowing current; but slowly accumulating until it reached the summit of the rampart, it poured down into the doomed city its molten cataracts. Then through street and lane it took its devastating course, and never paused until it reached the sea. Here the petrified stream was found to measure 600 yards in width, and forty feet in depth. The city walls were of such solidity that the lava did not overthrow but bury them, and portions may still be seen with the solidified lava encrusted upon them.

The rate at which the lava-river travelled varied in different parts of its course. It accomplishes the first thirteen miles in twenty days, while twenty-three days were occupied by the last ten miles. Near its source its velocity was estimated at

1500 feet an hour; towards its termination it advanced only a few yards in several days. Its surface became speedily encrusted with slag—as generally happens to lava-streams—which was continually being broken and re-cemented, as the under-current of the incandescent river moved slowly forward. An attempt was made to divert its course from Catania by breaking through the incrustation, and a small stream began to flow off at the side; but as the main stream would have overwhelmed Paterno had it followed this direction, its inhabitants resisted the attempt by force, and, as already narrated, the lava-flood continued to advance upon Catania.

Mompilière was one of the towns destroyed on this occasion, and in 1704, when some excavations were made on the spot, a portion of its principal church was found uninjured, as if it had been embedded in the lava, and swept away by it. The loss of life by this eruption was very terrible, and the country around Etna was ravaged for many miles, as if it had been harried by a victorious army.

In the eruption of 1811 a curious feature was noticeable. A stream of lava burst from the side of the cone a little below the summit, but speedily ceased to flow. Immediately, a second vent was opened on a lower level. In due succession a third was formed—a fourth, a fifth, a sixth, and, finally, a seventh—all in the same vertical direction, indicating that a great perpendicular fissure had been formed in the side of the cone.

In 1819, near the point where the first lava's mouth was opened in 1811, three large vents or apertures simultaneously formed, with loud explosions, and a glare of fire and flame, and incessant discharges of hot cinders and sand. Ere long another mouth was opened lower down, with similar accompaniments; and still lower down a fifth, whence poured a vast river of lava into the Val del Bove. During the first forty-eight hours it progressed nearly four miles. Then the three original vents fell in, and formed one vast crater, from which, and from the other two mouths below, a huge flood of lava rolled headlong into the same valley, and pouring through it, fell over the precipice at its termination in a cascade of fire and smoke and vapour, and with a roar as of thunder, arising from the breaking up of the solid crust and the collision of the falling fragments.

A great eruption occurred in 1852. Two new mouths opened in a ravine called the Val de Leone, and after ejecting vast showers of ashes and stone, and clouds of ammoniacal vapours, poured forth two currents of lava. After these had continued flowing for a considerable time, their pressure broke down the barrier between the two mouths, and threw them into one vast chasm, whence the lava rushed in an augmented volume, shivering the rock into fragments, and hurling them into the air to a great height. In the huge cloud of ashes and vapour which overhung the glaring abyss, electric flashes shot to and fro continuously, and peals of thunder were reverberated in every echoing recess. The lava-river attained an extreme breadth of about two miles, and a maximum depth of 160 feet; and as it spread over a considerable extent of richly cultivated country, the ruin which it caused was immense.

The eruption of 1865 was marked by the same phenomenon as that of 1811; namely, the formation of seven new craters, in a perpendicular line of descent from the summit—the highest being situated 5578 feet above the sea-level.

The next great central volcano of Europe, and one which may justly be designated classical, is

VESUVIUS.

Its early history presents some peculiar features. From the original colonization of Southern Italy by the Greeks down to the first century of the Christian era, a period of several hundred years, Vesuvius afforded no other indications of its volcanic character than such as the naturalist might reasonably infer from the analogy of its structure to other volcanoes. These characteristics were recognized by Strabo, but Pliny saw no reason to include Vesuvius in his list of active vents.* The volcanic forces of the district at this time were manifested at other points, which have now, in their turn, become quiescent. Terrific convulsions took place at irregular intervals in Pithecusa (the modern Ischia), and seem to have spread as far as Prochyta (Procida), which, according to Strabo and Pliny, was made an island by being violently separated from Ischia. To a subsequent eruption of Monte Epomeo, in Ischia, is ascribed the formation of the cone and crater of Monte Rotaro, now covered with arborescent shrubs, and a vegetation no less vigorous than beautiful; and of the promontory of Zaro and Caruso.†

The Solfatara, near Puzzuoli, which may be described as a nearly extinguished crater, seems, from the accounts of ancient writers, to have existed before the Christian era in very much the same condition as at present, continuously ejecting aqueous vapour, and sulphureous and muriatic acid gases. It broke into active eruption in 1198.

It is also evident that Lake Avernus, a circular basin near Puzzuoli, about two miles in circumference, four feet above the sea-level, and 250 feet in depth, formerly exhaled mephitic vapours of a volcanic character. As it lies embosomed among lofty hills, which were formerly clothed with dense forests, the escape of these

* [Sir C. Lyell, "Principles of Geology," bk. ii., c. 24.]

† [Ischia was disturbed by earthquakes, however, in 1301; in 1302, when an eruption of lava took place; and, more recently, in 1828.]

vapours must have been rendered difficult, and we may almost credit the statement of the poets that no birds durst fly across it.

> " O'er that dread space no flying thing
> Unjeopardied could ply its wing;
> Such noisome exhalations rise
> From out its darkness to the skies."*

Hence it was supposed to derive its Greek name 'Αόρνος from ἀ and ὄρνις, the absence of birds. But the engineering works of Agrippa, intended to unite Lakes Avernus and the Lucrine with the sea, by cutting down the forests and clearing the ground, opened up fresh channels of egress to the noxious vapours, and the place is now deprived of all its terrors.

The Lake of Fusaro, the *Palus Acherusia* of the poets, is also supposed to be the crater of an extinct volcano. "It is a black volcanic-looking pool of water, about a league in circumference, which lies between the site of the Lucrine lake and the ruins of the town of Cumæ, and is still extant, being devoted to the highly profitable art of oyster-farming, and yielding from this source an annual revenue of about twelve hundred pounds."† In 1838 it emitted such quantities of mephitic gases that the oysters were all destroyed.

The entire northern shore of the Bay of Baiæ, the *Phlegræi Campi* of the ancients, was a volcanic district, subjected to repeated and alarming convulsions, which only ceased when the igneous forces were recalled to their main channel, and Vesuvius commenced that career of activity which has continued down to our own times.

VESUVIUS,‡ or *Monte Vesuvio* (in Greek, Οὐεσούϊος), is situated on the shore of the gulf called the Crater or Bay of Naples, from which

* [Virgil, "Æneid," vi. 239, *et sqq.*] † [" Cornhill Magazine," xi. 53.]

‡ [" If we suppose the name of Vesuvius to have been imposed by early Greek settlers, ΣΒΕ, the radical of several words implying *extinction*, offers itself for adoption. In this case the prefix being taken as negative, the meaning of the word is 'unextinguished;' and it would lead us to accept as probable some knowledge or tradition of habitual or frequent eruptions in pre-historic times. If, on the other hand, a Phœnician origin be preferred, and Vo-Sever—the place of fire—be thought probable, the same conclusion as to the fact of very ancient knowledge of earlier volcanic violence may be maintained."—PROFESSOR PHILLIPS, " Vesuvius," pp. 8, 9.]

it rises directly to a height of 4020 feet; forming an isolated conical mass nearly thirty miles in circumference at the base, and separated from the Apennines on all sides by a broad intervening plain.

Of old it was noted for the extraordinary fertility of the country around its roots, and of its sloping sides; a fertility mainly due to the enrichment of the soil by ancient deposits of volcanic matter.

> "The soil, exhaling clouds of subtle dews,
> Is good for olives, and aspiring vines,
> Embracing husband-elms in amorous twines!
> Such is the soil of fat Campanian fields,
> Such large increase the land that joins Vesuvius yields." *

Strabo also describes it as "surrounded by fields of remarkable

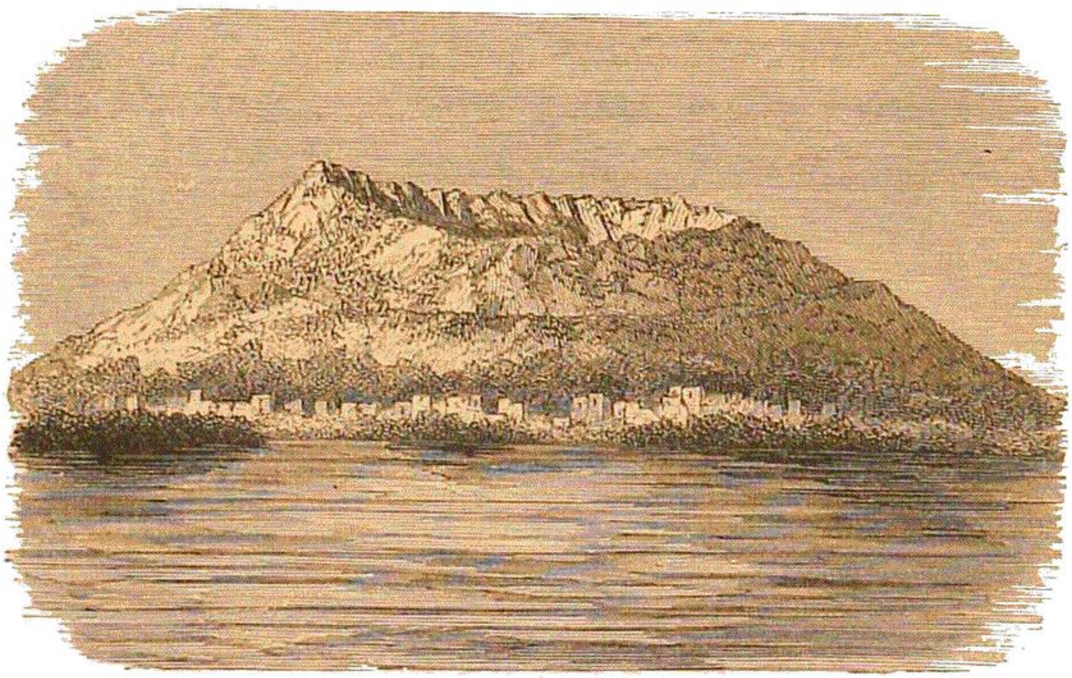

FIG. 141.—VESUVIUS BEFORE THE ERUPTION OF A.D. 79.

fertility, with the exception of the summit, which was mostly level, and entirely barren, covered with ashes, and furrowed by clefts and hollows, opening among rocks of a burnt aspect, as if they had been eaten away by fire." †

The name of Vesuvius twice occurs in history before the Christian era. It was at its foot, in B.C. 340, the great battle was fought between the Romans and the Latins, in which Publius Decius devoted himself to death for the sake of his country. And it was in his

* [Virgil, "Georgics," bk. ii. 220–227.]

† [Strabo, "Rerum Geographicarum," lib. v., c. 4.]

extinct crater, then overgrown with trees and shrubs, that Spartacus, with his army of gladiators and fugitive slaves, encamped, in B.C. 72, before his victory over Clodius Glabrus and the Roman legions.*

The first recorded eruption of Vesuvius is, in some respects, the most memorable. It took place in A.D. 79, on the 24th of August, and destroyed the cities of Herculaneum, Pompeii, and Stabiæ. Forewarning of it had been given in A.D. 63, when Pompeii and Herculaneum suffered severely from an earthquake. But they had begun to rebuild their shattered edifices when the more terrible catastrophe occurred.

Its incidents have been minutely described by the younger Pliny,† whose uncle,

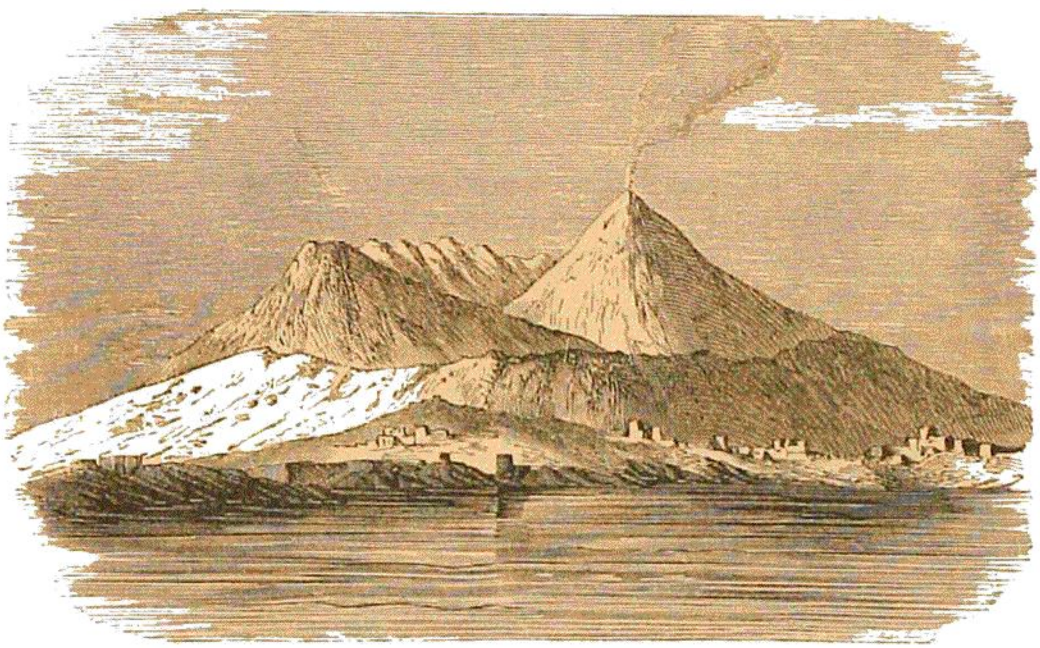

FIG. 142.—VESUVIUS AFTER THE ERUPTION OF A.D. 79.

the author of the "Historia Naturalis," was one of the victims. He particularly notices the phenomenon of a huge cloud of smoke and vapour, which rose above the mountain, and which he compares to a pine-tree, shooting up to a great height like a trunk, and extending itself at the top into a canopy of branches. He also alludes to the darkness which prevailed; the incessant showers of cinders, pumice-stones, and black pieces of burning rock; to the noisome exhalations and suffocating gases which filled the air; the electric flashes that occasionally lit up the scene; the agitation of ocean, and violent oscillations of the earth;—in a word, we may gather from his narrative the principal features of a volcanic eruption. Pompeii was overwhelmed by showers of calcined pumice-stone, or lapilli, and by vast streams of water and wet sand, which thickened into a species of volcanic paste. Herculaneum owed its destruction to the torrents of volcanic mud, which rolled over the

* ["Florus," lib. iii., c. 20.]   † [Pliny, "Epist.," (ad Tacitum), lib. vi. 16, 20.]

city with irresistible force, and filling all its edifices nearly to the roof, hardened as it dried into a coarse tufa. To exaggerate the horrors of such a catastrophe is, perhaps, impossible. "The rumbling of the earth beneath—the dense obscurity and murky shadow of the heaven above—the long heavy roll of the convulsed sea—the strident noise of the vapours and gases escaping from the mountain-crater—the shifting electric lights, crimson, emerald green, lurid yellow, azure, blood red, which at intervals relieved the blackness, only to make it ghastlier than before—the hot hissing showers which descended like a rain of fire—the clash and clang of meeting rocks and riven stones—the burning houses and flaming vineyards—the hurrying

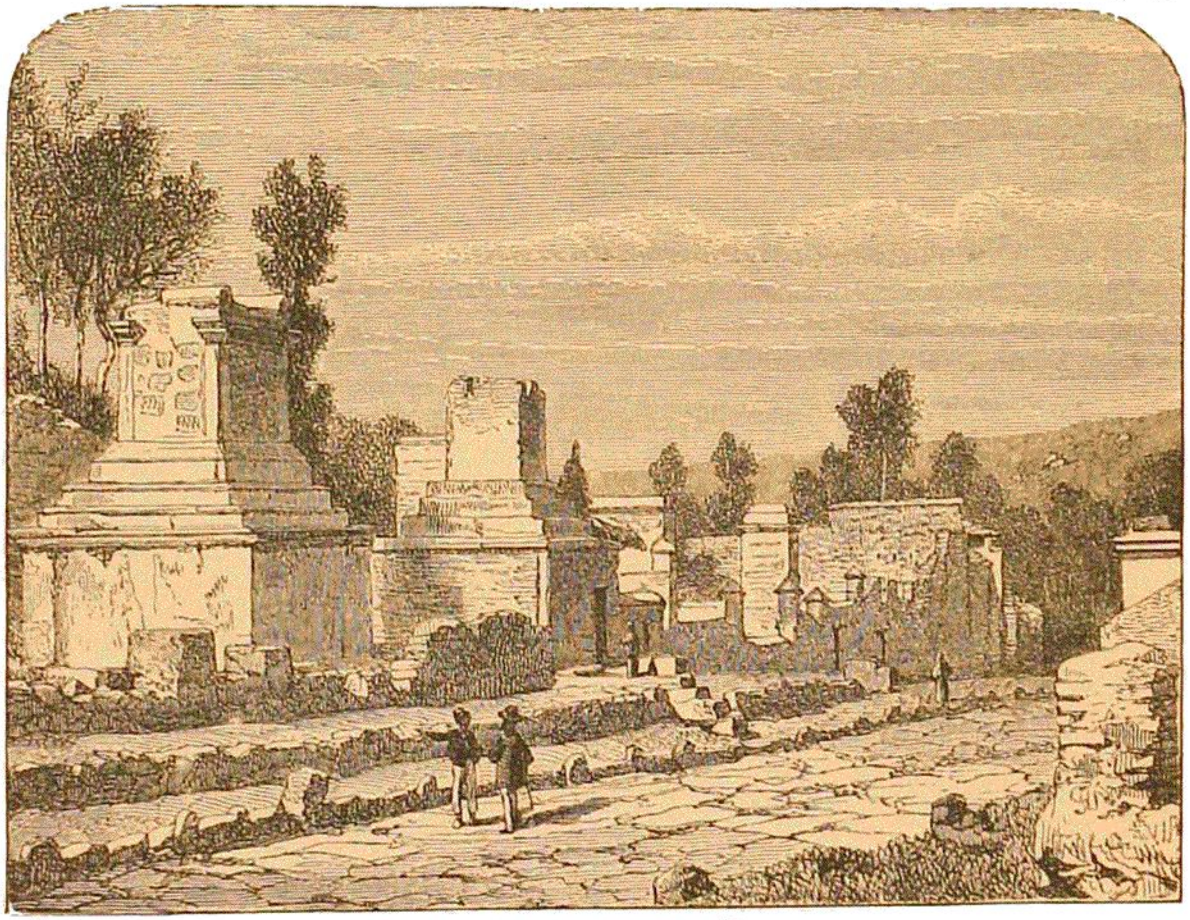

FIG. 143.—STREET OF TOMBS AT POMPEII.

fugitives, with wan faces and straining eyeballs, calling on those they loved to follow them—the ashes, and cinders, and boiling mud, driving through the darkened streets, and pouring into the public places—above all, that fine, impalpable, but choking dust which entered everywhere, penetrating even to the lowest cellar, and against which human skill could devise no effectual protection ; all these things must have combined into a whole of such unusual and such awful terror that the imagination cannot adequately realize it." *

In this eruption the seaward flank of Vesuvius was wholly destroyed, and of the ancient crater the only remains were a narrow ridge, on the south side, now called *La Pedamentina*, and that part of the wall or rampart which, under the name of *Somma*, encircles about two-fifths of the new cone. This cone is the modern Vesuvius, and the source of nearly all the later eruptions.

* ["Buried Cities of Campania," p. 41.]

For a long period the mountain remained tranquil, and we hear of no fresh outbreak until A.D. 203, which is described by Galon and Dion Cassius. A third took place in A.D. 472, which spread clouds of fine ashes over all Europe; and a fourth, recorded by both Procopius and Cassiodorus, in the reign of Theodoric, king of the Goths, A.D. 512. These eruptions were accompanied by streams of lava, which inflicted terrible devastation on the surrounding country.

A fifth eruption is said to have occurred in 685; a sixth, in 993; a seventh, in 1036, when the lava-torrents reached the sea; an eighth, in 1049; a ninth, in 1138–39, when the discharges of lava endured for eight, and of ashes for thirty, days; a tenth, in 1306; and an eleventh, in 1500, when a crater was formed, five miles in circumference and 3000 feet in depth.*

The interval between the eleventh and twelfth eruptions was marked by an amazing event in the Phlegræan fields—the sudden formation of a mountain, ever since called *Monte Nuovo*, 460 feet in height, and upwards of a mile and a half in circumference. The depth of its crater is 421 English feet from the summit of the hill, so that its bottom is only nineteen feet above the sea-level. The cone partly occupies the site of the Lucrine Lake, the crater of a pre-existent volcano, almost entirely filled during the explosion of 1538.

Von Buch is of opinion that Monte Nuovo was formed, not by the ejection of pumice, scoriæ, or ashes, but by the upheaval of solid beds of white tufa, previously horizontal, which were pushed up so as to dip away in all directions from the centre.† This opinion, however, is controverted by Sir Charles Lyell, and he asserts that the mountain is composed of pumiceous mud, which hardened as it dried, just as some cements, made of volcanic ashes, are known to consolidate with facility.

The twelfth eruption of Vesuvius occurred in December 1631,

* [Della Terre, "Storia del Vesuvio," 4to, 1775; Lobley, "Mount Vesuvius" (London, 1868). The two latter eruptions are not mentioned by Sorrentino, who says the crater of Vesuvius remained empty from 1139 to 1630.]

† [Sir C. Lyell, "Principles of Geology," bk. ii., c. 24.]

FIG. 144.—TORRE DEL GRECO IN 1861.

when seven torrents of lava poured simultaneously from the crater, and overwhelmed several villages on the flanks and at the foot of the mountain. Among others, Resina, partly built over the ancient site of Herculaneum, was destroyed. "Great floods of mud," remarks Lyell, "were as destructive as the lava itself, no uncommon occurrence during these catastrophes; for such is the violence of rains produced by the evolutions of aqueous vapour, that torrents of water descend the cone, and becoming charged with impalpable volcanic dust, and rolling along loose ashes, acquire sufficient consistency to deserve their ordinary appellation of 'aqueous lava.'"

Torre del Greco and part of Portici were swept away by this catastrophe, in which eighteen thousand persons are said to have perished. The eruption did not entirely cease until February 1632, when it was found that the cone had so decreased in height as to be 1530 feet lower than Monte Somma.

The thirteenth eruption took place in July 1660.

The fourteenth, in August 1682.

The fifteenth, March 12, 1694.

The sixteenth, September 1696, when a portion of the cone was blown away on the side next Torre del Greco.

The seventeenth and eighteenth, in May 1698, and July 1701, respectively.

The nineteenth began on the 20th of May 1707, and lasted until August of the same year. It had been preceded by earthquakes, and was accompanied with violent ejections of ashes, which, at four o'clock on the afternoon of August 2nd, involved Naples in such darkness that persons could not recognize one another in the streets.

The twentieth eruption occurred in February to November 1712.

The twenty-first, on June 7th, 1717, when a stream of lava descended to within three miles of Torre del Greco.

The twenty-second, May and June 1720.

The twenty-third, July 26th, 1728.

The twenty-fourth, on the 14th of March 1730.

The eruptions then succeeded one another at such frequent intervals, that we must be contented with a bare enumeration of dates :—

May 20, 1737.

October to November 1751.

December 3, 1754.

January 24, 1758.

December 24, 1760.

March 28, 1766.

October 19, 1767.

March 14, 1770.

January 3, 1776.

August 8–11, 1779.

October 12, 1784, to December 20, 1785.

October 31, 1786.

July to December 1787.

February 1793 to June 1794. This was one of the most formidable eruptions on record. A stream of lava flowed through Torre del Greco—destroying great part of the town—which is estimated to have contained 46,098,766 cubic feet. The showers of ashes fell at Taranto, and at places in Calabria, 140 miles distant.

August 12th to December 3rd, 1804.

August 12, 1805.

September 4, 1809.

June 12, 1812.

December 25, 1813.

December 22, 1817.

April 1820.

October 22, 1822. "Between the end of the eighteenth century and the year 1822," says Sir Charles Lyell, "the great crater of Vesuvius had been gradually filled by lava boiling up from below, and by scoriæ falling from the explosions of minor mouths which were formed at intervals on its bottom and sides. In place of a regular cavity, therefore, there was a rough and rocky plain, covered with blocks of lava and scoriæ, and cut by numerous fissures, from which clouds of vapour were evolved. But this state of things was totally changed by the eruption of October 1822, when violent explosions, during the space of more than twenty days, broke up and threw out all this accumulated mass, so as to leave an immense gulf, or chasm, of an irregular, but somewhat elliptical shape, about three miles in circumference when measured along the very sinuous and irregular line of its extreme margin, but somewhat less than three-quarters of a mile in its longest diameter, which was directed from N.E. to S.W. The depth of this tremendous abyss has been variously estimated; for from the hour of its formation it diminished daily by the *dilapidation* and falling-in of its sides. It measured, at first, according to the account of some authors, 2000 feet in depth from the extreme part of the existing summit; but Mr. Sarpo, when he saw it, soon after the eruption, estimated its depth at less than half that amount. More than 800 feet of the cone was carried away by the explosions, so that the mountain was reduced in height from about 4200 to 3400 feet."

March 11, 1828.

September 18, 1831.

August 1834.

March 6, 1838.

April 22, 1845.

November 13, 1847.

February 6–28, 1850.

May 1855. Accompanied by a destructive discharge of lava.

May 1858.

December 1861. On this occasion a number of small cones opened in the rear of Torre del Greco, along a fissure of about 2000 yards in length, and continued in eruption for several days. The town was nearly destroyed.

February 1865.

November 1868. This eruption began on the 16th. Vast streams of lava poured down the mountain-side, taking the same course as in 1855, and filling up and overflowing a ravine called *Fossa Vetrana*. In the first twenty-four hours it accomplished a distance of 2180 yards. Afterwards its progress was slower, but it invaded the cultivated region, doing serious damage, and threatening the villages beneath. On the night of the 16th, the vapour-clouds assumed the shape of a gigantic pine-tree, as described by Pliny. Discharges of stones and ashes were numerous, and several new cones, in active eruption, opened at the foot of the great cone.

Having thus recorded the eruptions of Vesuvius, from the earliest known period down to the present time, nothing more remains but to describe its scenery and physical characteristics. For this purpose we invite the reader to ascend the mountain in company with Mr. Babbage, and avail himself of that eminent savant's experiences to form a just and accurate conception of its successive landscapes:—*

When he reached the summit of the cone, the sun had not risen. An obscure twilight still prevailed, as he and his companion stood upon the irregular edge of a vast gulf, spread out below at the depth of about 500 feet. The plain at the bottom would have been invisible but for an irregular network of bright red cracks extending over its entire surface. At intervals the silence was broken by the upward rush of a flight of red-hot scoriæ from the diminutive crater within the large one. These missiles, however, though projected high over the summit of the cone, never fell far beyond the margin of the small cavity whence they issued.

Those who have observed the blood-vessels of their own eye by the aid of

* [Babbage, "Passages in the Life of a Philosopher," pp. 216–222.]

reflected light will have seen, on a miniature scale, as Mr. Babbage remarks, an exact resemblance of the plain which formed, on the occasion of the philosopher's visit, the bottom of the great Vesuvian crater.

As the morning advanced, the light increased; and sometime before sunrise the adventurers had completed the circuit of the crater. Then followed that magnificent spectacle—sunrise from the top of a lofty mountain.

Mr. Babbage now began to speculate upon the means of securing a nearer view of the little miniature volcano in action at one corner of the gulf beneath him.

The two explorers had brought with them a supply of ropes, and, in their tour round the crater, had carefully marked every dike of congealed lava by which the massive cone was split. These presented buttresses, with frequent ledges, or huge steps, by which they hoped, with the aid of their ropes, to let themselves down into the subjacent Tartarus.

On consulting their chief guide, they found him unwilling to dare the attempt, and more disposed to remain with the other guides on the upper edge of the crater. Nor was this an unsatisfactory arrangement, on the whole; because it left a responsible person to keep the other guides in order, and also sufficient force to raise up the adventurers bodily by the ropes, should such a course become needful.

They were compelled, by the abrupt incline of the rocky buttresses, to have recourse to ropes; but any attempt to traverse the steep slopes of light ashes and fine sand would have been far more dangerous, from the risk of being engulfed in them.

Having thoroughly examined the several disadvantages of these rough-hewn, irregular, and Titanic stairs, one was selected as offering the greatest facilities for the descent into the crater. Mr. Babbage was scarcely "in trim" for his work: he was encumbered with one of Troughton's heavy barometers strapped on his back; looking much like Cupid's quiver, but certainly heavier! In his pocket he carried an excellent box sextant; and in a rough kind of basket two or three thermometers, a measuring tape, and a glass bottle enclosed in a leather case—commonly called "a pocket-pistol"—accompanied by a few biscuits.

They began the descent by two ropes, each steadied above by a couple of guides. The adventurers first planted their feet wherever they could find a vantage-point; then, holding on to the rope, sprang down to the next ledge. In this manner they proceeded, step by step, until they gained the last projection of the dike, when nothing more remained but to let themselves slide down the long steep incline of smooth shifting sand. Fortunately it was not very deep, and was underlaid by some solid material. Mr. Babbage soon found it was impossible to stand; he therefore took his seat on the moving mass, which evidently intended to accompany them in their journey. At first, to Mr. Babbage's great dismay, he was relieved from the care of his barometer, of which the sliding sand immediately took charge. However, both the barometer and its owner accomplished the rapid descent in safety, and Mr. Babbage and his companion found themselves standing on the burning plain.

The area of this plain was perfectly flat, and of an elliptical form. Its surface consisted of a black scoriaceous rock, reticulated with ditches from one to three feet wide, which crossed one another in every direction. From some of these arose the most disagreeable odours. All above two feet in depth showed a bottom of dull red heat, and it was these glaring heated fissures which had presented the extraordinary spectacle described above.

At one extremity of the oval area was a small cone, from which the eruptions apparently proceeded. On observing them accurately, it was found that they occurred at tolerably regular intervals, but the observers were compelled to maintain a respectful distance, out of the reach of the red-hot scoriæ-showers. During the ten to fifteen minutes, however, that elapsed between each explosion Mr. Babbage was able to make a rush towards the opening in this subsidiary crater, and to look down upon the liquid lava seething and boiling in its natural caldron.

"Presently," he says, "I observed a small bubble swelling up on the surface of the lava; it became gradually larger and larger, but did not burst. I had some vague suspicion that this indicated a coming eruption; but on looking at my watch, I was assured that only one minute had elapsed since the termination of the last. I therefore watched its progress: after a time the bubble slowly subsided without breaking.

"I now found the heat of the rock on which I was reposing and the radiation from the fluid lava almost insupportable; whilst the sulphurous effluvium painfully affected my lungs. On looking round, I fortunately observed a spot a few feet above me from which I could, in a standing position, get a better view of the lake, and perhaps suffer less inconvenience from its vapours. Having reached this spot, I continued to observe the slow formation and absorption of these vesicles of lava. One of them soon appeared. Another soon followed, at a different part of the fiery lake; but, like its predecessor, it disappeared as quietly.

"Another swelling now rose about half-way distant from the centre of the caldron, which enlarged much beyond its predecessor in point of size. It attained a diameter of about three feet, and then burst, but not with any explosion. The waves it propagated in the fiery fluid passed on to the sides, and were thence reflected back, just as would have happened in a lake of water of the same dimensions.

"This phenomenon re-appeared several times, some of the bubbles being considerably larger in size, and making proportionally greater disturbance in the liquid of this miniature crater. I would gladly have remained a longer time, but the excessive heat, the noxious vapours, and the warning of my chronometer, forbade it. I climbed back through the gap by which I descended, and rushed as fast as I could to a safe distance from the coming eruption.

"I was much exhausted by the heat, although I suffered still greater inconvenience from the vapours. From my observation of the eruptions before my descent into this little crater, I had estimated that I might safely allow myself six minutes, but not more than eight, if I descended into the crater immediately after an eruption.

"If my memory does not fail me, I passed about six minutes in examining it, and the next explosion occurred ten minutes after the former one. On my return to Naples, I found that a pair of thick boots I had worn on this expedition were entirely destroyed by the heat, and fell to pieces on my attempt to take them off."

The reader will probably be disposed to ask, What *is* Lava? It is simply a stream or river of molten matter poured forth from a volcanic aperture, either by land or water. It is composed of various materials—all fused together by the vast heat of the internal fires of the earth—which, as they cool, congeal into a solid substance. The surface, cooling and hardening more rapidly than the interior, which often remains in a liquid condition for a considerable time, is usually quite porous and vesicular, from the escape of the pent-up gases. According as the process of congelation is accomplished slowly or quickly, the internal structure of a lava-stream assumes a more or less crystalline character. Caverns are frequently produced in the mass by the escape of the molten matter underneath, leaving the indurated crust standing like the roof of an arch.*

In the common description of volcanic eruptions, allusion is frequently made to "discharges of flame" and "clouds of smoke." Such expressions, however, are used only in a figurative sense. What is commonly mistaken for flame consists of vapour, or scoriæ, and impalpable dust, illuminated by that vivid light which is emitted from the crater below, where the lava shines with all the splendour of the

* [Although common lava, says the late Professor Forbes, is nearly as liquid as melted iron, when it issues from the orifice of the crater, its fluidity rapidly diminishes, and as it becomes more and more burdened by the consolidated slag through which it has to force its way, its velocity of motion diminishes in an almost inconceivable degree; and at length, when it ceases to present the slightest external trace of fluidity, its movement can only be ascertained by careful and repeated observations, just as in the case of a glacier.—*Philosophical Transactions*, for 1846, p. 148.

Dr. Clarke also observes that "the lava, at a small distance from its source, acquires a darker tint upon its surface, is less easily acted upon, and as the stream widens, the surface, having lost its state of perfect solution, grows harder and harder, and cracks into innumerable fragments of very porous matter, to which they give the name of scoriæ, and the appearance of which has led many to suppose that it proceeded thus from the mountain. There is, however, no truth in this. All lava, at its first exit from its native volcano, flows out in a liquid state, and all equally in fusion. The appearance of the scoriæ is to be attributed only to the action of the external air, and not to any difference in the materials which compose it, since any lava whatever, separated from its channel, and exposed to the action of the external air, immediately cracks, becomes porous, and alters its form. As we proceeded downward, this became more and more evident; and the same lava which at its original source flowed in perfect solution, undivided, and free from incumbrances of any kind, a little further down had its surface loaded with the scoriæ in such a manner that, upon its arrival at the bottom of the mountain, the whole current resembled nothing so much as a heap of unconnected cinders from an iron-foundry."—OTTER, "Life of Dr. Clarke," cit. by Lyell.]

sun. On the other hand, the smoke-clouds are formed either of aqueous and other vapour, or of finely comminuted scoriæ.*

Another phrase frequently met with in popular narratives is even less supported by fact; namely, that "a stream of lava was seen to issue from the crater." It may be doubted whether this is ever the case. Let the reader consider what an enormous mass of molten matter would require to accumulate, before it could fill up and overflow so great a basin as is presented by most volcanic craters. The source of the lava-stream is almost invariably in the *flank* of the mountain, and at a considerable distance below the crater-lip.

At the risk of wearying our readers with quotations, we cannot refrain from extracting the following account of an ascent to the crater of Vesuvius from a London journal.† It is not only remarkably graphic, but its unexaggerated details are so clear and so precise, as to furnish the reader with all the requisite data for forming a correct conception of what a volcanic crater really *is*.

"The ascent was made during an eruption, when crash was following crash in a manner that was sufficiently terrible. All the suffocating steams and vapours were being driven to one side of the mountain by a strong wind, so that the adventurers were able to go up from the windward side, stand upon the lip of the crater, look down into the roaring abyss, and see what a volcanic eruption looked like on the spot. The spectacle will not disappoint the most extravagant expectations. It is full of awe and majesty.

"The suddenness with which you come upon it is quite startling. Going up you neither see nor hear anything. One moment you are clambering up the side of the cone amid profound silence; the next moment, as your head rises above the crater-lip, you encounter a roar and a blaze which make you shrink back a little. This surprise is probably occasioned by the formation of the crater. It is a huge bowl, which comes up to quite a sharp lip, about half a mile in diameter and some hundred yards in depth. Towards the bottom of this bowl, on the opposite side to where we stood, was a great hole, from which all the projectiles of the eruption were shot; the surface of the bowl being composed of lumps of lava, stones, and cinders, all of them smeared with sulphur, precisely like those upon which we were standing. As you mount the cone there is between you and the gulf an enormous wall, which dulls everything alike for eye and ear.

"Even while on the steeps of the cone itself you might be unaware that the mountain was disturbed. But a single step seems almost enough to transfer you from

* [Sir C. Lyell, "Principles of Geology," bk. ii., c. 25.]

† ["Pall Mall Budget," vol. i., Nov. 21, 1868—Art. "At the Crater of Vesuvius."]

the most death-like stillness to the grandest exhibition of force it is possible to conceive. Instead of the monotonous dull black of congealed lava on the lower levels, you have the deep brick-red of stones that have been under the action of fire, the brightest vermilion, and every imaginable shade of orange and yellow that sulphur-deposits are capable of taking. The ground is hot too; so hot, indeed, that you cannot keep your foot on the same spot for many seconds together. Between the chinks of the stones you can see that a few inches below the surface it is actually red-hot. You thrust in the end of your stick for a moment, and pull it out charred.

"Over all the further half of the crater there hangs a dense cloud of smoke and vapour; all around you there is an atmosphere of sulphur which sets you coughing; from numberless small holes about your feet there issue with a hiss sulphurous jets of steam, which nearly choke you as you pass over them; and then, as you look down into the actual abyss, you are face to face with the most appalling phenomena both of sight and sound which perhaps the whole of Europe has to offer.

"Amongst the crowd of strange sensations that are experienced at such a time, the phenomena of sound are perhaps the most wonderful of all. What meets the ear is, if anything, even more terrific than what meets the eye. Even to sight the eruption is not exactly what the imagination paints it beforehand. It does not consist, as the pictures necessarily lead one to suppose, of a *continuous shower* at all. Still less does it consist of a continuous shower of black ashes shot out from a fire blazing on the top of the mountain: it is rather a series of explosions. But the roar and glare of the great abyss is continuous. You look into the pit, and though you see no actual flame, yet its sides are in a state of constant incandescence; from the mouth of it there roars up incessantly a dense cloud of steam; and in the depths of it below you hear the noise of preparation for the outburst that is next to come. Then you hear a sharper crackle, and then without further warning follows a loud explosion, which shoots into the air a torrent of white-hot missiles of every shape and size. So enormous are the forces at work that not only small pieces of stone and sulphur, such as you might carry away as mementoes of your visit, but huge blocks of mineral, each enough to load a railway ballast-waggon, and all in a state of perfectly white heat, are tossed up as though they were so many cricket-balls. The explosion lasts, perhaps, no longer than a minute; and then there is a cessation of some seconds, with the noise only of internal preparation once more, after which the explosion is repeated. So it goes on again and again, as long as the eruption continues.

"The noise that accompanies the projection of these enormous missiles, which from below seem to be shot up in profound silence, is something quite without a parallel in ordinary experience. One of our party said he had been shipwrecked three times, and the crash of the waves against the timbers of a helpless ship was one of the most terrible accompaniments of such scenes; yet that was nothing to the almost stupefying din that was going on before us—moments when the daylight was over, and the world below could no longer be distinguished—when we had nothing but the clear starlight overhead, and were truly alone with the mountain; when the varied colouring of the ground had disappeared in the darkness, and nothing could be seen but the gleam of the burning earth through the chinks at our feet; while the white-hot glaring ribbon of molten lava glided languidly down the mountain at our side, and before us was the flashing of the inner fire upon the cloud of vapour overhanging the abyss. Take all these together, and the scene is indeed rather different from what you picture to yourself as you calmly read in your newspaper that Vesuvius is once again in a state of eruption."

Our attention must next be directed to the volcanoes of—

THE LIPARI AND CYCLOPEAN ISLANDS.

The *Lipari Islands* consist of seven principal islands, and several inconsiderable islets. They lie between Sicily and Calabria, to the south-east of Ischia, and are all of volcanic character. The seven largest are:—Lipari (anc. *Lipara*), Vulcano (anc. *Hiera*), Stromboli (anc. *Strongyle*), Salina (anc. *Didyme*), Feliardi (anc. *Phœnicusa*), Alicudi (anc. *Ericusa*), and Panaria (anc. *Euonymus*). Of these, Stromboli and Vulcano are active volcanoes.*

In ancient times, contrary to what is now the case, the eruptions of Vulcano appear to have been both more frequent and more violent than those of Stromboli. Hence the former was fabled to be the residence of Vulcan, and its subterranean noises were ascribed to the forges and hammers of the god and his workmen—the Cyclops. So Virgil tells us, in a peculiarly animated passage:—†

"Fast by Æolian Liparè
 And fair Sicania's coast,
An island rises from the sea
 With smoking rocks embossed;
Beneath, a cavern drear and vast,
Hollowed by Cyclopean blast,
 Rings with unearthly sound;
Bruised anvils clang their thunder-peal,
Hot hissing glows the Chalyb steel,
And fiery vapour fierce and fast
 Pants up from underground;
The centre this of Vulcan's toil,
And Vulcan's name adorns the soil.
Here finds he, as he makes descent,
The Cyclops o'er their labours bent. . . .
Some make the windy bellows heave,
Now give forth air, and now receive;

* [Admiral Smyth, "Sicily," c. vii., pp. 274–278; Dr. Daubeny, "On Volcanoes," pp. 245–263.]

† [Virgil, "Æneid," viii. 418, *et sqq.* (Professor Conington's translation).]

The copper hisses in the wave;
The anvils press the groaning cave;
With measured cadence each and all
The giant hammers rise and fall;
The griping pincers, deftly plied,
Turn the rough ore from side to side."

Strabo speaks of three craters as existing in the island—the principal of which was visited by Polybius, and is described as five stadia in circumference and one stadium in depth. At times it vomited forth flame; at others, red hot stones, ashes, and cinders, which were carried a considerable distance.

Though some of the old writers speak of Stromboli as "burning with perpetual fire," its eruptions were evidently inferior in violence. Now, however, its crater is constantly active, so that it is frequently described as "the lighthouse of the Mediterranean." The island consists of a single conical mountain, with a total elevation of about 2000 feet; the largest (and active) crater being about 600 feet below the summit. Its minor explosions are continuous, and at intervals of from seven to fifteen minutes are varied by more furious eruptions. It has frequently been ascended. One of the latest to accomplish this somewhat perilous feat was M. de Quatrefages, who, with a companion, reached the summit of the ancient cone, whence they looked down upon the abyss kindling at their feet, whilst a grand column of fire rose towards them with a noise resembling the rapid discharge of artillery.

"Standing immediately above the crater," says Quatrefages,* "and unable to advance to any distance over the shifting soil, we were impeded in our observations by the mountain itself; whilst, moreover, we were almost incessantly surrounded by clouds impregnated with choking gases. To avoid these inconveniences, we descended a lateral ridge, where we could contemplate at our leisure the savage scene unfolded before our eyes. Three concentric ridges, of which the outer ones are partly destroyed, encircle the volcanic crater. Behind us, steep declivities stretched down to the cultivated regions, which we had found it an arduous task to traverse; but which appeared, when seen from our elevated position, to be merely a gentle plain. To the left, our gaze rested on the loftiest peak of the island, which was once a portion of the most ancient and the outermost of the three concentric ridges, and was separated from us by a deep ravine. To the right rose the small elevation from

* [Quatrefages, "Rambles of a Naturalist," ii. 24.]

which we had just descended; whilst, in front of us, the ridge on which we were posted curved in a semicircle towards a mass of lava suspended over a precipice, and, at the same time, enclosed a steeply-inclined mass of the cinders and scoriæ, abruptly broken by the edges of the abyss into which the present crater opens.

"This crater includes within its walls six distinct vents. Two of these eject that cloud of hydrochloric and sulphurous acid gases which at all times overhangs the summit of the mountain. The third mouth, which is situated to the right, also belches a thick and whitish smoke, in whose midst red-hot stones flash to and fro like sparks, as they incessantly rise and fall, with a strange reverberation, like the sound of heavy surf on a storm-beaten coast, making the hearer involuntarily think

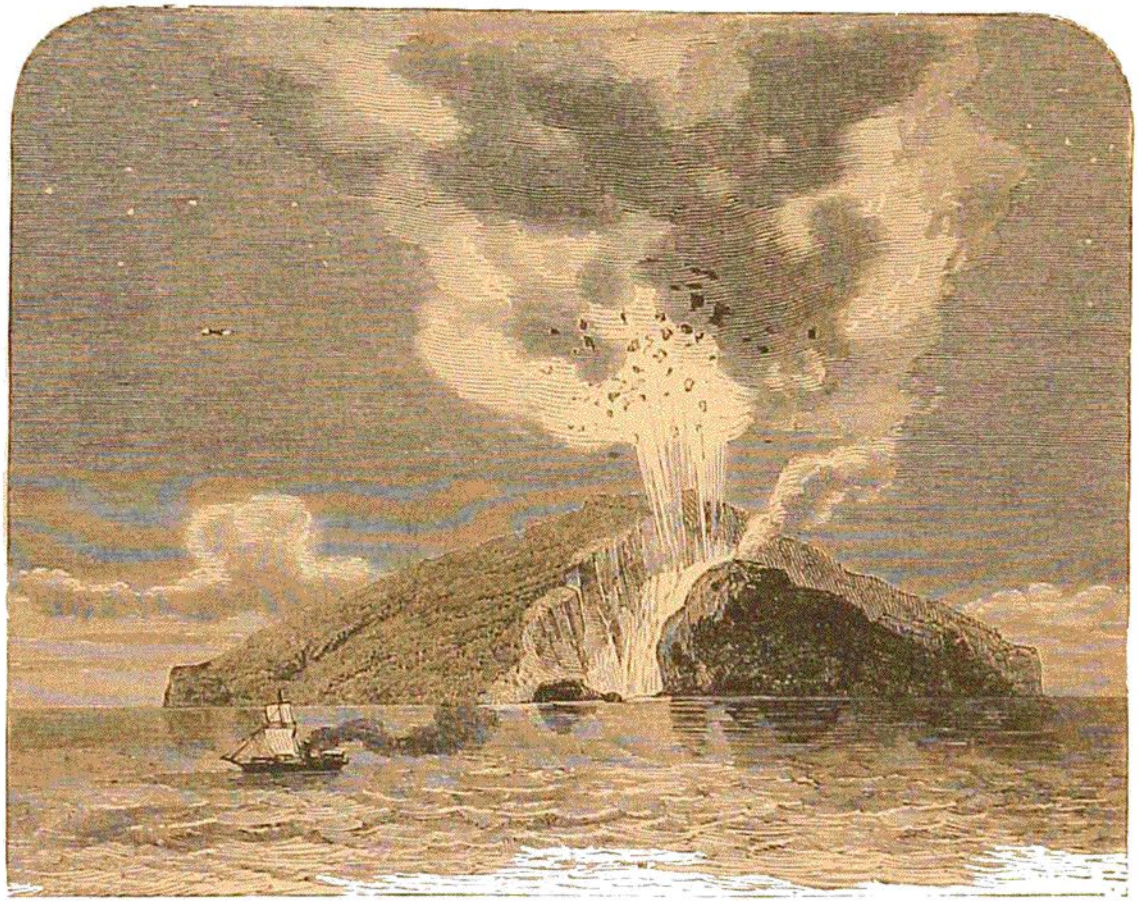

FIG. 145.—VOLCANIC ISLAND OF STROMBOLI.

of the fabled caves of the demons. To the left three other vents exhibit only intermittent eruptions; of these, two evidently open on the same focus, inasmuch as they are always kindled and extinguished simultaneously. The third, whose eruptions are the least frequent, lies nearest to the spectator. It is from hence the most formidable detonations proceed, and the highest discharges of rocks and burning cinders.

"As we had arrived in broad daylight, we had been enabled to examine thoroughly all the lava-masses, the steep ridges, the declivities of ashes, and the various features of the remarkable scene, whose uniform blackness was only relieved here and there by fragments of dull red scoria. But the sun now set, and the short twilight of southern latitudes was rapidly giving way to night. In proportion as the glow faded from the sky, the glare seemed to deepen in the depths of the abyss. The smoke assumed a redder tint, gradually growing more and more intense. The showers of fiery sparks increased; while the concentrated light within the crater itself enabled us more easily to mark each varying phase of the eruption. The explosions of the two smaller vents recurred every seven or eight minutes, whilst between those of the larger crater intervened ten or twelve minutes. The phenomenon always exhibited the same details—for example, so soon as the volcano showed any signs of activity, the smoke, which was ejected from the vents on the right, assumed a bright and glowing red; while detonations, succeeding each other with constantly increased rapidity, preceded every jet of burning matter. These jets were thrown up in divergent directions, and with scarcely any smoke, from one of the two sister craters; whilst from the other they rose upwards with a leap, as if impelled by the current of violet-hued vapour that escaped from the mountain with a loud shrieking sound. The principal crater threw out a broad expanded jet of incandescent rocks and lava, which nearly reached the platform where we were standing, and fell with a great crash; one portion being carried into the sea, and the remainder thrown back into the abyss whence it had been ejected, while the wind surrounded us with a cloud of fine black sand and ashes.

"The night had long since gathered over us, and our guides were urgent we should make the descent. We were, therefore, constrained to yield, and prepare for our return; but before beginning to retreat we waited for another eruption, which, fortunately, proved one of great magnificence. The three vents played simultaneously, reflecting the crimson glare of the lava; while the threefold rampart of the crater was once more revealed to our gaze."

Friedrich Hoffmann, the great Prussian geologist, ascended the peak of Stromboli in 1828. Having reached the crater, he lay down and hung over its precipitous side, while held firmly by his companions. He was thus enabled to look right down into its fiery depths, and of the scene which they presented he has left on record a vivid description.

At the bottom of the crater were three mouths in a state of activity. The central and principal one was 200 feet in diameter; it was in no way remarkable; it smoked slightly, and its sides were encrusted with several coats of yellow sulphur. By the side of this main vent, but nearer the precipice, was another, only twenty feet wide, in which I observed the glow of the liquid column of lava that at intervals played upon the surface.

The lava was not, as an ardent imagination depicts it, a burning mass, vomiting forth flames; but shone like molten metal, like iron flowing from the furnace, or like silver at the bottom of a heated crucible.

This molten mass oscillated to and fro, and rose and sank. It was evidently impelled by the terribly elevated tension of elastic vapours enclosed in its interior, and the effect could easily be seen of the balancing between the weight of the melted masses and the pressure of the aqueous vapours which uplifted them. The surface regularly rose and fell at rhythmic intervals. A peculiar noise was audible, like the decrepitations of the air entering by gusts through the door of a mining furnace. A cloud of white vapours rose at each decrepitation, upheaving the lava, which fell back after each commotion. These vapour-clouds carried off the surface of the lava numerous fragments of red-hot scoria, which danced in the air as if tossed to and fro by invisible hands, in a rhythmic measure, above the edge of the opening. This regular and attractive movement was interrupted at intervals of fifteen minutes by more violent oscillations. The mass of whirling vapours then remained immovable for a moment, or even made a short hurried motion of retrogression, as if it was

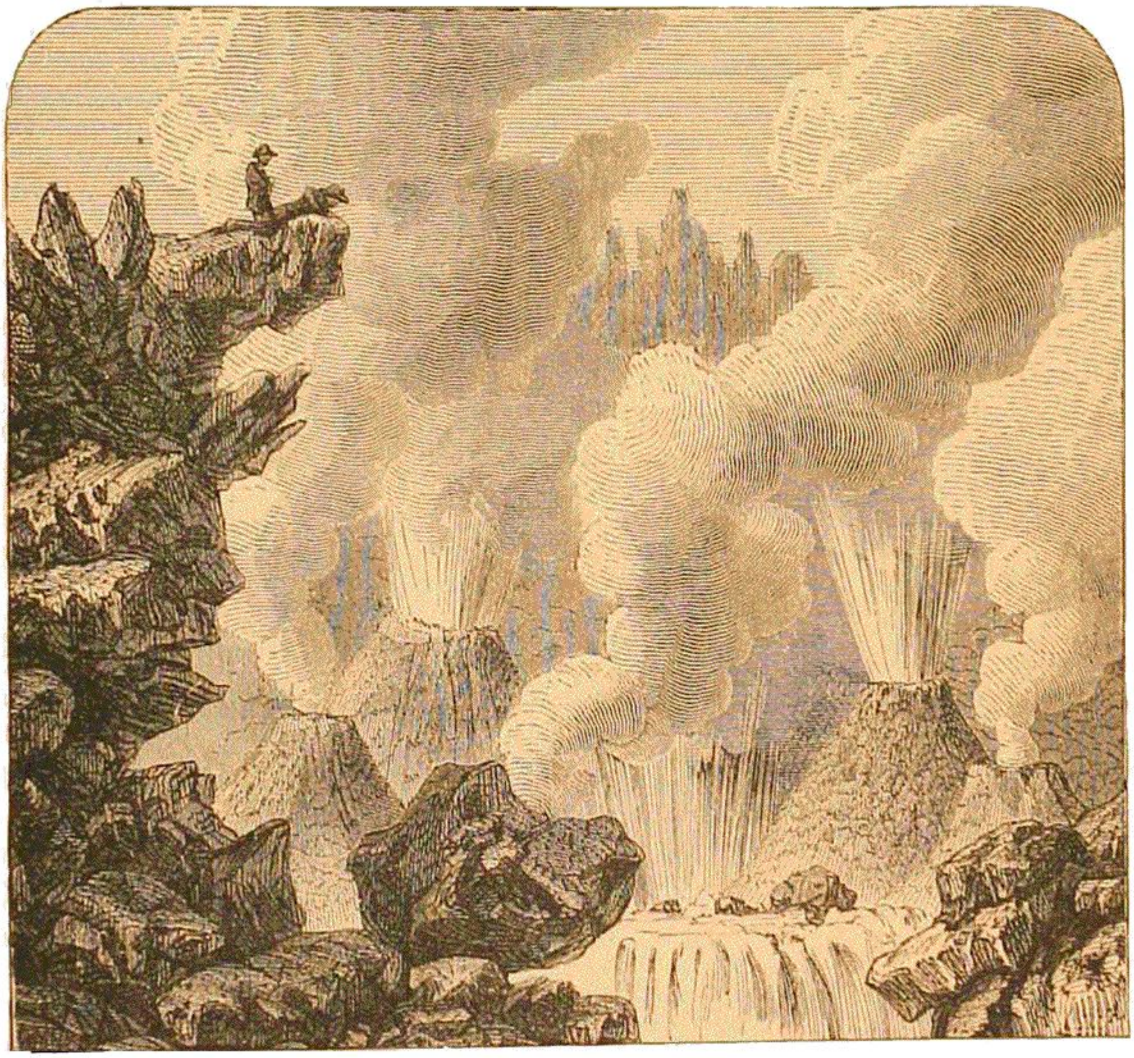

FIG. 146.—CRATER OF STROMBOLI.

inhaled by the crater, from whose depths the lava surged up more furiously, as if to encounter it. Then the ground trembled, and the sides of the crater *shivered* as they inclined inwards. It was a veritable earthquake. From the mouth of the crater proceeded a hoarse reverberating bellow, and at the end an immense balloon of vapour grew on the surface of the lava, rising up with a sonorous and thundering clash. The whole surface of the lava splintered into incandescent fragments was then ejected into the air.

The heat now became insupportable; and a sheaf of flames shooting suddenly upwards, fell back in a fiery rain on the surrounding district. A few balls rose to a height of 1200 feet, and described, as they swept over the heads of Hoffmann and his companions, parabolic curves of fire.

Immediately after each of these explosions, the lava retired into the bottom of the crater, which yawned like a black and awful gulf; but speedily its glittering surface rose again, and recommenced its ordinary rhythmic play.

To the south of the Lipari Islands, and close to the eastern coast of Sicily, lies the Cyclopean group, remarkable for their precipitous cliffs of basalt, arranged in irregular rows of huge Titanic pillars. Though now detached, these islets must at one period have formed an unbroken stratum: they are covered with a bed of marl, which seems evidently to have extended in a continuous mass from one to the other. This circumstance, remarks Dr. Daubeny,* and their general compactness, may be accepted as proofs that the volcanic convulsions to which their formation is due took place under the surface of the water.

We must now carry the reader far away from the "blue Mediterranean" and the "genial South" to the bleak inhospitable regions of the Arctic Pole. The northernmost of the volcanoes of Europe is found in

THE ISLAND OF JAN MAYEN.

This island, so named from its discoverer,† lies off the coast of Greenland, in a wild and dreary sea, where its snow-shrouded cone may occasionally be seen emerging, like a silver spire, from the clouds and mists that gather round its rugged flanks and wave-worn base. It was visited in 1817 by Captain (afterwards Dr.) Scoresby, who discovered on its summit a colossal crater, about 2000 feet in diameter, and 500 feet in depth. He also explored another volcano, called Esk, whose height he computed at 1500 feet. In 1856, Lord Dufferin coasted the island in his yacht *The Foam*, and we are indebted to him for the following graphic description of its romantic aspect.‡

* [Dr. Daubeny, "On Volcanoes," p. 202.]

† [A Dutch Navigator, who discovered it in 1611.]

‡ [Lord Dufferin, "Letters from High Latitudes," p. 140.]

The veil of mist which at first, he says, concealed its sombre magnificence having suddenly lifted, a long line of coast became visible —in reality, the roots of Mount Beerenberg, the island-peak, dyed of the darkest purple; at the same time, the clouds fell away from the summit, and left the mountain standing in all the grandeur of his 6870 feet, girdled by a single zone of pearly vapour, from underneath whose floating folds seven enormous glaciers rolled down into the sea.

Although, to Lord Dufferin, by reason of his having hit upon its side instead of its narrow end, the outline of Mount Beerenberg appeared more like a sugar-loaf than a spire—broader at the base and rounder at the top than he had imagined—in size, colour, and effect it far surpassed anything he had anticipated. The glaciers which load the flanks of this volcano were quite an unexpected element of beauty. Imagine a mighty river of as great a volume as the Thames, started down the side of a mountain, bursting over every impediment, whirled into a thousand eddies, trembling and raging on from ledge to ledge in quivering cataracts of foam, then suddenly struck rigid by a power so instantaneous in its action, that even the froth and fleeting wreaths of spray have stiffened to the immutability of sculpture. Unless you had seen it, reader, it would be almost impossible to conceive the strangeness of the contrast between the actual tranquillity of these silent crystal rivers and the violent descending energy impressed upon their exterior. Remember, too, that all this is upon a scale of such prodigious magnitude, that when our navigators subsequently succeeded in approaching the spot where, with a leap like that of Niagara, one of these glaciers plunges down into the sea, the eye, no longer able to take in its fluvial character, was content to rest in simple astonishment at what then appeared a lucent precipice of gray-green ice, rising to the height of several hundred feet above the ship's masts.

Jan Mayen is not at present an active volcano.

ICELAND.

Our ideas of volcanic activity in this snow-bound island are generally associated with Mount Hekla, long ranked as one of the three great European volcanoes; but, in truth, no less than twenty volcanic mountains are found therein, and of these, eight are in full activity. And, notwithstanding its celebrity, Hekla is neither the largest nor the most formidable. If any should bear the palm, it is that which lies near the south coast of the island, the region most frequented by voyagers. All Iceland, however, is a land of eruption, where, underneath a crust of ice and snow, the volcanic fires are incessantly seething.

There are four volcanoes in the northern part of the island—Krafla, Leirhnukur, Trolladyngur, and Skaptá; three in the southern—Hekla, Eyafiall, and Katlugia; and one in the eastern—Oeräfa. Our limits compel us to restrict our notices to the two best known,—Hekla and Skaptá-Jokul.*

No record occurs in history of any eruptions in Iceland previous to the ninth century. From the twelfth century they have been remarkably numerous; an interval of twenty years seldom passing without some eruption or violent shock. Frequently has Hekla maintained its terrible activity for six successive years. Such long-continued convulsions have had their effect in breaking up the mountains into the most rugged and violent outlines, diverting the courses of the rivers, and creating new lakes and valleys. All Iceland is furrowed with fissure and crevasse, and covered with masses of lava of dimensions which cannot be paralleled in any other country of the world.

The first eruption of Hekla of which history takes notice, occurred in 1004. Down to the present time, about twenty-two have been noticed, according to the Icelandic historians Olafsen and Paulsen. One of great violence broke out in 1766. Then, after a repose of seventy-nine years, the igneous forces again manifested their

* [*Jokul* is an Icelandic word, signifying a mountain covered with perpetual snow.]

colossal power in 1845. On the 1st of September the inhabitants were alarmed by a severe earthquake, followed by awful subterranean noises. Next day, about noon, two new mouths suddenly opened in the sides of the volcano, and rolled forth two huge rivers of incandescent lava, which descended over the barren heaths and scanty pasturage, scorching and destroying all they touched. The mountain was obscured by the thick vapours and clouds of ashes which were almost constantly ejected. The neighbouring rivers grew so hot that the fish in them were killed, and it became impossible to cross them even on horseback.

A fortnight later, the commotion was renewed. It was accompanied by reports and discharges, which echoed over the whole island, and lasted for two-and-twenty hours. Again two new craters were opened, one on the southern, the other on the eastern side of the cone; and the lava ejected from these descended a distance of upwards of twenty-two miles. At a point three thousand yards from its origin the "river of fire" was a mile in width, and forty to fifty feet in depth. The havoc committed by it was necessarily very great.

On the 12th of October, a fresh stream burst forth from the southern crater, and accumulated at the base of the mountain in a mass of scoriæ, slag, and fused materials, from 40 to 60 feet in height. At the same time, from each of the three recently opened mouths issued a vast column of dust, ashes, and vapour.

During the remainder of 1845, and for a considerable part of 1846, the activity of the mountain continued, though not on so formidable a scale, until it finally terminated, in the October of the latter year, with an explosion of aggravated fury, volumes of ashes and scoriæ being ejected to an immense height, while, kindling with the glare of the incandescent lava within, they shone from a distance like Cyclopean pillars of fire.

Of the force of the explosions, an idea may be formed from a consideration of the fact that a block of pumice weighing nearly half a ton was hurled to a distance of five miles. The ice and snow which burdened the mountain-sides being melted by the heat, descended in immense floods, swelling the rivers, and inundating the lower grounds. The whole scene was attended by so many circumstances of horror that the spectator might well have imagined the "foundations of the earth to be broken up." *

The most terrible eruption, however, of which Icelandic history takes account was that of Skapta-Jokul, in 1783. This huge mountain, with its roots, its icy ridges and snowy slopes, its glaciers and its ravines, occupies an area of four hundred square miles untrodden by the foot of man. It is a region of desolation — a wilderness inaccessible and impassable — which seems to have been barred off by a Divine fiat from the remainder of the world, and which, had it been known to the ancient poets, would have furnished them with an appropriate theatre for their fabled contest between gods and Titans.

Various signs portended this awful catastrophe. Toward the end of May a light bluish haze hovered on the confines of the *regio incognita* of Skapta, followed early in June by a great tremor of the earth. On the 8th of that month pillars of smoke rose over the northern highlands, and, coming down in a southerly direction, wrapped the whole district of Sida in twilight gloom. Then over the startled island swept a torrent of ashes ; and on the 10th spouts of fire were seen to leap and toss in wild fantastic play among the mountain's icy hollows, and the river Skapta, having first absorbed vast volumes of fetid sand, suddenly disappeared.

Two days later a flood of lava, issuing from sources unknown to man, rolled down the bed of the dried-up river ; filled up its channel — a vast gorge of six hundred feet in breadth and two hundred feet in depth ; and then, overflowing its banks, poured like a deluge of molten metal over the surrounding country, and gathered itself in a great deep lake, whose waters were summarily expelled by this formidable intruder. In a few days the basin of the lake was also filled up ; and the lava then resumed its course, dividing into two streams, one of which continued to follow the channel of the Skapta river, while the other went headlong over the lofty cataract of Stapafoss.

On the 18th of June a second torrent of lava, proceeding, it is supposed, from a higher level than its predecessor, and taking a different direction, accumulated within the channel of the Hverfisfliot, overflowed its banks, and rolled southward, scorching, withering, and devastating. Fresh quantities of lava were ejected on the 3rd of August, and, with occasional pauses, continued for two years ; forming, on the whole, a mass which, if it could be collected in one spot, would equal in magnitude Mont Blanc. Of the two principal lava-floods, the Skapta measured some fifty miles in length by twelve or fifteen in breadth ; that of the Hverfisfliot forty miles in length by seven in breadth. Both currents in the deep gorges had a depth of six hundred feet ; on the plains, of about one hundred feet. As late as 1794 they continued to exhale clouds of vapour, and the water in their fissured crust was hot.

* [Compare Baring-Gould, "Iceland and its Sagas ;" Dr. Henderson, "Residence in Iceland" (2 vols., 1819) ; Symington, Captain C. S. Forbes, Chambers, and others.]

A canopy of ashy cloud darkened over the island for a whole twelvemonth, and eruptions of ashes, pumice, and lava destroyed thousands of acres of fertile pasturage. The showers were carried as far as the Shetlands and the Orkneys: impalpable volcanic dust even contaminated the atmosphere of England and Holland.

The damage inflicted upon Iceland was terrible—not by the eruptions so much as by the poisonous vapours, which induced a murrain among the cattle and a contagious disease among men. Of human beings 9000 perished; besides 28,000

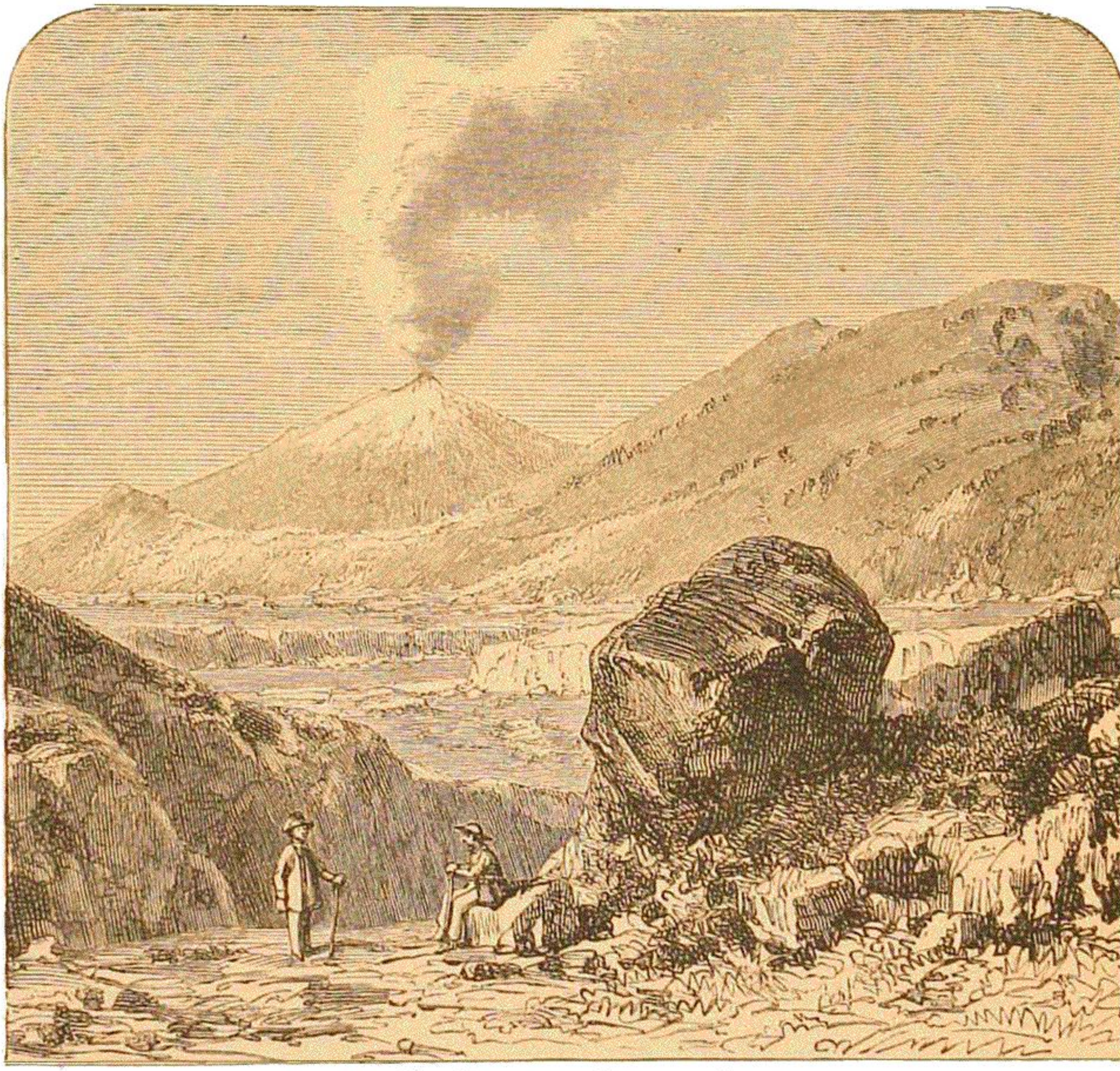

FIG. 147.—THE VOLCANO OF HEKLA, IN ICELAND.

horses, 11,000 cattle, and 190,000 sheep. A more moderate computation, however, reduces the number of human deaths to 1300, and of cattle to about 156,000.

A month previous to this formidable catastrophe, a submarine eruption took place at about eight miles south-west of Cape Reykiavers, which covered the sea with pumice-stones and ashes for a distance of one hundred and eighty miles. An island issued from the waters, which measured a mile in circumference, and was taken possession of by the King of Denmark under the name of *Ny-Oë* (or New Islet). However, in less than a twelvemonth it returned to the depths of ocean, and the place where it had been was only marked by a dangerous reef.

THE GEYSERS.

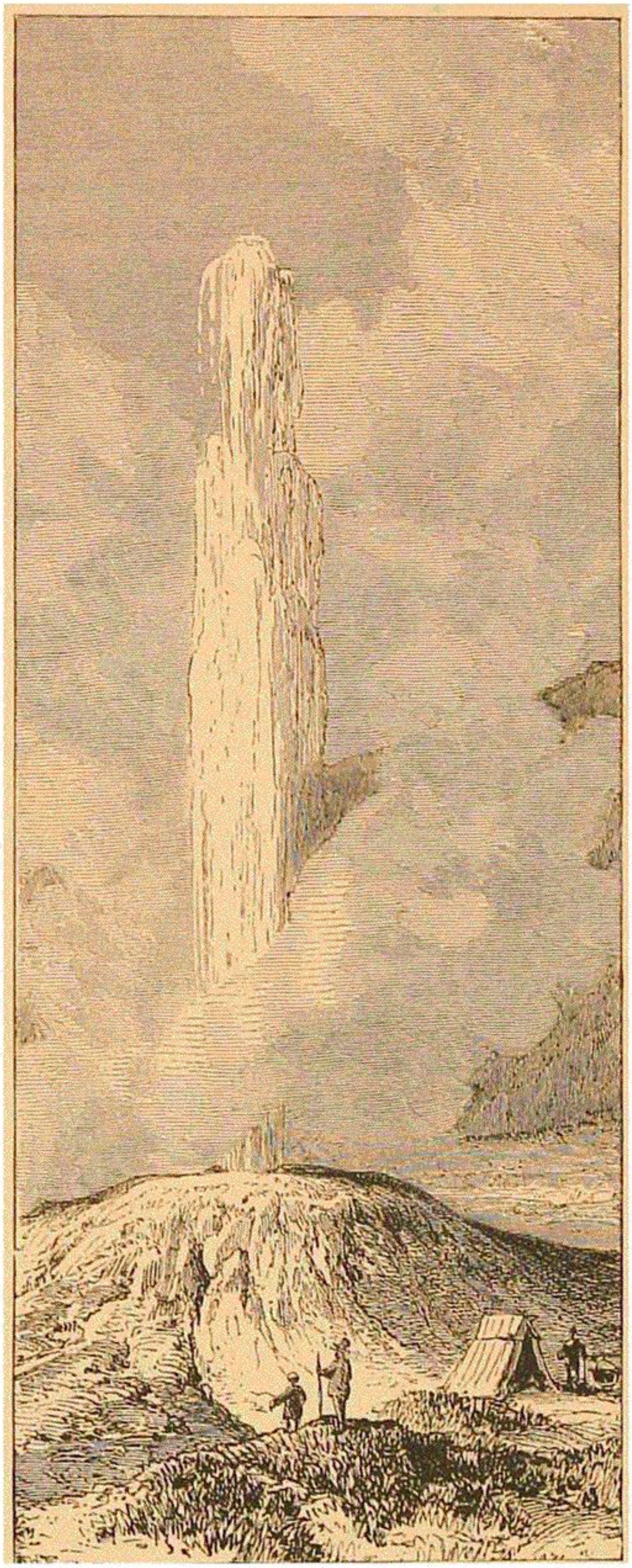

FIG. 148.—GREAT GEYSER OF ICELAND.

Of all the physical phenomena of Iceland, however, the most remarkable are its *Geysers*.

These have been admirably described by Lord Dufferin in his account of a visit to Iceland and an exploration of its natural curiosities :—*

We found ourselves, he says, in the presence of the steaming geysers.

I do not know that I can give you a better notion of the place than by saying that it looked as if—for about a quarter of a mile—the ground had been honeycombed by disease into numerous sores and orifices : not a blade of grass grew on its hot, inflamed surface, which consisted of unwholesome-looking, red, livid clay, or crumpled shreds and shards of slough-like incrustations. Naturally enough, our first impulse on dismounting was to scamper off at once to the Great Geyser. As it lay at the furthest end of the congeries of hot springs, in order to reach it we had to run the gauntlet of all the pools of boiling water and scalding quagmires of soft clay that intervened, and consequently arrived on the spot with our ankles nicely poulticed. But the occasion justified our eagerness. A smooth silicious basin, seventy-two feet in diameter and four feet deep, with a hole at the bottom as in a washing-basin on board a steamer,

* Lord Dufferin, "Letters from High Latitudes."

stood before us brimful of water just upon the simmer; while up into the air above our heads rose a great column of vapour, looking as if it was going to turn into the Fisherman's Genie. The ground about the brim was composed of layers of incrusted silica, like the outside of an oyster, sloping gently down on all sides from the edge of the basin. . . . .

We kept watch, continues Lord Dufferin, for three days over the geyser in expectation of the eruption. On the morning of the fourth day a cry from the guides made us start to our feet, and with one common impulse rush towards the basin. The usual subterranean thunders had already commenced. A violent agitation was disturbing the centre of the pool. Suddenly a dome of water lifted itself up to the height of eight or ten feet, then burst and fell; immediately after which a shining liquid column, or rather a sheaf of columns, wreathed in robes of vapour, sprung into the air, and in a succession of jerking leaps, each higher than the last, flung their silver crests against the sky. For a few minutes the fountain held its own, then all at once appeared to lose its ascending energy. The unstable waters faltered—drooped—fell, "like a broken purpose," back upon themselves, and were immediately sucked down into the recesses of their pipe.

The spectacle was certainly magnificent; but no description can give any idea of its most striking features. The enormous wealth of water, its vitality, its hidden power — the illimitable breadth of sunlit vapour, rolling out in exhaustless profusion — all combined to make one feel the stupendous energy of Nature's slightest movements.

And yet, says Lord Dufferin in conclusion, I do not believe the exhibition was so fine as some that have been seen. From the first burst upwards to the moment the last jet retreated into the pipe was no more than a space of seven or eight minutes, and at no moment did the crown of the column reach higher than sixty or seventy feet above the surface of the basin. Now, early travellers talk of three hundred feet, which must, of course, be fabulous; but many trustworthy persons have judged the eruptions at two hundred feet, while well-authenticated accounts —when the elevation of the jet has been actually measured—make it to have attained a height of upwards of a hundred feet.

We now resume our survey of the principal volcanoes and volcanic districts of the globe, passing from northern Europe to tropical Africa.

AFRICAN VOLCANOES.

The archipelago of islands known by the separate names of the Azores, the Canary Islands, and the Cape Verd Islands, lying off the west coast of Africa, are all of volcanic origin.

In the AZORES the principal and the only active volcano is *El*

Pico, remarkable for its perfectly regular trachytic cone, and its constant ejection of clouds of smoke. It is 7613 feet above the sea-level, and its sides are rugged with solidified lava. In most of the islands hot springs are found, and they are all subject to considerable earthquake shocks. It has been conjectured that they are therefore the Islands of Fire marked upon various fourteenth century maps.

The CANARY ISLANDS are a more interesting, as well as a more beautiful group. They are all of volcanic origin; extinct craters being found on the summits of the loftiest elevations, which are also furrowed by deep fissures, exposing to view the successive strata of volcanic rock. The famous *Pico de Teyde*, or Peak of Teneriffe, whose snow-crowned height has been the beacon of so many wandering vessels, attains a total altitude of 12,182 feet, of which the actual cone is about 550 feet. Its summit-crater occasionally discharges columns of sulphurous vapour, but has not ejected lava or ashes since the discovery of the island by Europeans. Two lateral eruptions in 1704 and 1706, however, terminated in the ruin of the principal harbour.

A subsidiary elevation of the Peak, named Chaborra, also contains a crater, which opened in 1798, and continued in eruption for upwards of three months, pouring out great quantities of stones and ashes, and streams of lava. To such a height were some of the stones projected that their fall occupied twelve to fifteen seconds, showing that they must have attained an elevation of not less than 3000 feet.

The summit-crater of the Peak was visited by Humboldt, who found it to be of an oval form, 300 feet in its major and 200 feet in its minor diameter, with a depth of 100 feet. But Von Buch, who examined it more closely, estimates its depth at upwards of 650 feet.

The island of Palma contains a huge crater, called the Great Caldera, not less than 5000 feet in depth. The mountain itself is cleft with deep *baraccos*, or ravines, which are supposed to be the results of past igneous action.

In Lancerota a volcano opened as recently as August 1824, and ejected a quantity of matter, which in four-and-twenty hours accumulated so as to form a hill of considerable proportions.

Its eruptions in the first half of the eighteenth century were, however, on a far more formidable scale. They began on the 1st of September 1730, and lasted for more than six years. First, a great chasm opened in the earth, and threw up a vast amount of volcanic matter. A few days later, from a second mouth poured forth an overwhelming river of lava. From the depths of this river, on the 7th of September, rose up a huge and solid rock, dividing the current into two channels, one of which struck towards, and inundated, the large and thriving town of Santa Catalina. Increasing in volume, and constantly rolling forward, the lava at length advanced into the sea, roaring frightfully. Then, after an interval of repose, three new craters opened on the site of ruined Santa Catalina, and ejected great quantities of stones, ashes, and sand.

A singular occurrence marked the 28th of October; all the cattle of the island, we are told, perished on that one fatal day; choked by the noisome vapours which rose from the ground, and, being condensed in the atmosphere, fell in a "deadly rain."

On the 10th of January 1731 a high hill was thrown up, but a few days afterwards it subsided into the crater which had cast it forth, and which then poured out its fury in streams of hissing lava.

New lava-ejecting cones were afterwards created until their number amounted to about thirty, and various phenomena of volcanic action were repeated on a more or less terrible scale until 1736.

The cones of eruption thus strangely formed were all situated, according to Leopold von Buch, in a right line nearly due east and west; the highest rising 600 feet above its base, and 1378 feet above the sea-level. On its summit is a precipitous crater, so rugged and dark and sulphurous, that it might have furnished Dante with the conception of a *bocca del inferno;* and to the westward spreads a bleak, desolate, treeless sheet of black lava, covering the surface of the ground for three square miles.

The CAPE VERD ISLANDS (*Ilhas Verdes*) are also volcanic. They reach their highest elevation in a volcanic peak of the island of Fogo, which is 9157 feet above the sea, and after a silence of fifty years, broke out into violent eruption in 1847; from seven mouths vomiting streams of lava, which blasted a considerable extent of fertile country.

The islands of MAURITIUS and BOURBON, on the east coast of Africa, are both of volcanic origin. In the latter exists a still active volcano, the *Piton de Fournaise*, 7200 feet high, which exhibits its igneous violence generally twice a year. It occupies with its huge bulk nearly one-sixth of the whole area of the island, and is surrounded by a district of about 10,000 acres, so dreary and so blasted that it is expressively called the *Pays Brulé*.

A volcanic group, known as the Zebayer Islands, is situated in the Red Sea.

ASIATIC VOLCANOES.

Our survey now brings us to old historic Asia, the cradle and earliest home of civilization. On the mainland the volcanoes are not numerous; and the greater number of these seem to be pent up, as it were, in the comparatively narrow region of KAMTSCHATKA; forming a part of the great volcanic chain of the Pacific Ocean. Here are found fourteen volcanoes, traversing the centre of the peninsula, and attaining in the cone of Plutchevsky an elevation of 16,000 feet. The latter was accustomed to break into violent action every seven or eight years, but of late has emitted only smoke and ashes.

Almost at the other end of the old continent lie the cold, leafless plains of Armenia, traditionally famous as the first dwelling-place of man, but bearing now no trace of the life and splendour of the Adamite Paradise. Here rises Mount Ararat, a lonely majestic volcanic cone, 17,260 feet above the sea, and robed in perpetual snow.

The Elburz chain of the Persian Mountains attains its culminating point in the volcanic peak of Demavend, near Tehrân, which, though situated ninety miles inland, is a landmark to sailors on the Caspian.

The Persian province of Azerbijan, the "fire-country" of Zoroaster, is a volcanic table-land, crowned by the volcanic cone of the Koh Salavan.

In the table-land of Eastern Asia a solitary instance of volcanic force is found at a distance of 1500 miles from the sea, in the volcanic chain of the Thian-Tchan.

Besides the two active volcanoes of the Pe-shan and the Ho-tcheou in the chain itself, separated from each other by an interval of 650 miles with a *solfatara* between them, it is the centre of a very extensive "land of fire," extending northward to the Altaï Mountains, and with many points of connection between the atmosphere and the interior of the earth by solfataras, hot springs, and sulphurous vapours. No active volcanoes, in the ordinary sense of the term, are known to exist in China; but there are numerous fire-hills and fire-springs; the latter are described as real Artesian wells, five or six inches wide, and from 1500 to 3000 feet deep. The water which bubbles up from some of these contain large deposits of chloride of sodium (common salt); while from others gases issue, which, if ignited, break forth into great jets of flame with a noise of thunder.

ASIATIC ISLANDS.

JAVA.

There is no island in Asia—nay, there is not an island in the whole world—where the volcanic forces are manifested on so colossal a scale as in Java. As Michelet says, it is dowered with fire. Notwithstanding its comparatively small dimensions, it possesses as many volcanoes as all America, and each more terrible than Etna. Think, also, of its liquid volcano; of that vein of sombre azure—*the Black River* of the Japanese—which, after bathing the island's fertile shores, strikes away towards the North Pole, warming the seas with its waters, salter than human blood.

Java has a hot sea, a burning sun, a volcano of fire, a volcano of life.* Not a day passes without a storm upon the "Blue Mountains," and terrible lightnings, which dazzle the spectator. Torrents of electric rains intoxicate the earth, and madden vegetation. Even the forests, smoking with clouds of vapour in the sun, seem volcanoes situated half-way down the mountains.

The more abrupt acclivities are frequently inaccessible, and sometimes the forests are so dense and gloomy that he who would penetrate into their glades must carry torches at noon-day. There, without any human eye to witness, Nature celebrates at ease her orgies of vegetation, fashions her gigantic animals and river-monsters.

Stemless rhizanthaceæ seize upon the foot of a tree, and gorge themselves with its pith and life. Spines have been discovered six feet in circumference. In the deep darkness of the woods they shine with a splendour that astonishes and almost terrifies. These daughters of the shadow owe nothing of their luminous colours to the light; and planted so low in the warm vapours and rich breath of earth, seem like luxurious dreams and strange phantasies of desire.

To obtain them, frequently costs the traveller his life. In the introduction to Blume's "Flora Javæ" occurs a melancholy record of victims to their love of science. Blume himself, undiscouraged by their destiny, found himself on one occasion at Nusa—a little island remarkable for its flowers and poisonous atmosphere—in a desperate condition. His most faithful servants had perished around him, and he was left alone. The Javanese fortunately discovered and rescued him; yet, though he had been face to face with death, he felt no regret, for he had made the miracle of flowers his own. "Ill and in danger," he says, "I write hurriedly and print hastily; for perhaps I may die to-morrow."

Java, continues Michelet, has two faces. To the south it looks upon Oceania, with its pure atmosphere, and its rocks alive with polypes and madrepores. To the north, it is India still, with all

* [Michelet, "La Montagne" (ed. 1868), pp. 169–179.]

its greatest unwholesomeness; a black alluvial mould ferments there with the deadly travail of Nature within herself, composition and decomposition. It has compelled the abandonment of the rich town of Bantam, which is now a pile of ruins. Superb Batavia is one tremendous cemetery. In less than thirty years of the last century (1730–1752) it devoured a million of men, and in one year (1750), sixty thousand. It is less terrible to-day, the air being to some extent purified.

But over all these terrors rises the sublime horror of the volcanoes. They have the air, says Michelet, of being *persons;* and the old inhabitants of the island, regarding them as gods, sought to appease them by erecting temples in their honour, and statues, and altars. Fear inspired art. Sculptures still extant bear witness to the dread of the Malay, his skill, and manual ingenuity.

All these "giants of fire" differ from one another. They have, too, their separate names, some borrowed from the Hindu gods and the heroes of the Râmâyana; others, apparently, the names of the aboriginal divinities of the island. Gunung Tengger yawns with a monstrous crater, 20,000 feet in diameter, where four Etnas smoke and vomit, at the bottom of a frightful precipice of 2200 feet. One of these, called Bromo, has but recently ceased ejecting lava. Another kindles its flames in a strange desert, encrusted by saline springs. One belches periodically; another boils with sulphurous waters which, even after they have cooled in little lake-like basins, exhibit a feverish agitation. Another pours out a milky flood of phantasmagorical whiteness.

Moreover, the entire region is honey-combed with copious saline springs, of which the largest sports and dances, growling and thundering, underground. It plays at ball with enormous pellets of earth, balls twenty feet in diameter, which crack, and burst, and scatter on every side. The Arjouna and the Rao roll torrents of smoke and acrid boiling water. The Idjen, waking up, one sunny morning, poured out a river.

Such are some of their caprices, and each one has its own. But at bottom they are less distinct than is apparent to the eye. Sometimes, when one lights up, another also takes fire—and not the nearest, but a volcano situated at some considerable distance off. When a shock of earthquake occurs, a remote volcano is frequently extinguished, like a taper suddenly blown out.

One of their most marked characteristics is, that they are all deeply furrowed. Seated on the ancient basalts which seem the foundation of the island, they love the basaltic form. Their beams and profound grooves rudely imitate the architecture of those black eldest-born of earth, the colonnades of Staffa and Fingal. An explanation of this has been sought in the influence of water, but it would never have worked with so much regularity. It could not have displayed their cones in that singular fashion which resembles nothing so much as the radiation of the whalebone of an umbrella. This singular uniformity of structure is prominent among all their other diversities. Thus they are all brothers, yet all different, of a capricious, fantastic, and terrible aspect.

The central crest of Java is formed of a range of volcanic mountains, from 5000 to 13,000 feet in height, which ends on the east in a series of thirty-eight separate volcanoes, rising into cones from colossal bases. They are all situated on a plain of no great elevation above the sea, and each individual mountain has apparently been formed in entire independence of its neighbours. Most of them are very ancient, and their flanks labour with a rich, dense vegetation. Some are extinct, or only emit smoke; others eject with great fury clouds of sulphurous vapour; the crater of one is filled with boiling water; a few, even of recent years, have broken into violent eruption.*

In 1772, the greater part of one of the largest (Papandáyang) was swallowed up after a brief but severe combustion: a flame-kindled mass of cloud enfolded the mountain on the 11th of August, and shortly afterwards the huge bulk actually disappeared within

* Sir Stamford Raffles, "On Java."

the earth with tremendous noise, engulfing with it about ninety square miles of the surrounding country, forty villages, and 2957 of their inhabitants.*

Another of the volcanoes of this island, named Guntur, ejected great quantities of lava during its eruption of 1800: its crater is of an oval form, with a diameter of about one hundred yards, and emits clouds of hot sulphurous vapour.

Galon-goon was in eruption on the 8th of October 1822. It had previously been regarded as extinct, but now compensated itself for its prolonged inaction, pouring forth immense volumes of boiling water and mud, and ejecting ashes and small stones to a distance of forty miles. An area extending to a distance of twenty-four miles from the mountain was so thickly overlaid with a black-blue mud, that the villages and their inhabitants were buried beneath it. A second eruption occurred on the 12th of October, and the two disasters cost the lives of four thousand persons.

Among the more remarkable of the Javanese volcanoes must be named Guevo-Upas, or the Valley of Poison; a half-extinct crater, which seems to have originated the fable of the Upas Tree. It measures about 800 yards in circuit, and evolves a quantity of carbonic acid gas, which proves fatal to every living thing that ventures within its reach. The valley is said to be strewn with the blanched skeletons of the animals that have fallen victims to its deleterious effects.

Another crater, named Taschem, contains a lake about 500 yards in length, from which a small river flows; and both lake and river are so charged with sulphuric acid that nothing can live in their waters.

Tangkuban Prahu is so named from its resemblance to an inverted boat. Its crater is funnel-shaped, with very irregular sides, and about a mile and a half in circumference; forming, in fact, a vast deep gulf, divided by a narrow rocky partition into two nearly equal elliptical basins, and filled with great clouds of rushing, hissing

* Dr. Horsfield, "Batavian Transactions," vol. ix.

vapour. The eastern basin is named by the natives "The King's Crater;" the western, "The Poison Crater."

SUMBAWA.

Separated by narrow channels of the sea, the islands of Bali and Sumbáwa are but a continuation of Java in nature and structure, but on a smaller scale, their mountains scarcely exceeding 800 feet in height.

Sumbáwa, however, contains the most formidable volcano—Tomboro—in this part of the world. It broke out into eruption in 1815 on a colossal scale, the discharges continuing from the 5th of April till July. The explosions were heard at the distance of 970 miles; and in Java, at the distance of 300 miles, the darkness during the day was like the depth of midnight from the immense quantities of ashes which filled the air; they were swept even as far as Bencoolen, a distance of 1100 miles, which is just as if the ashes of Vesuvius fell at Birmingham.

SUMATRA.

The great volcanic chain of the East Pacific is continued in Sumatra, where the submarine fire obtains access to the atmosphere through three volcanoes on the southern, and one on the northern side of the island. The most important of them, called Berapi, is 12,000 feet in height, and constantly smoking; though no records are extant of any Sumatran eruptions.

THE MOLUCCAS.

The third and greatest of all the belts of volcanic islands includes Gilolo, one of the Molucca group, which is covered with volcanic cones."

In Sangir, lying immediately north of Celebes, is an active volcano, which broke out into a furious eruption in March 1856. Upwards of twenty-eight hundred persons perished, and numerous villages were destroyed. The volcano, on this occasion, ejected vast streams of lava, torrents of water, and incalculable quantities of stones and ashes, sand and mud.

A violent eruption occurred in the island of Machian in 1646, when the mountain was rent in twain from summit to base. It has ever since continued to be two mountains.

In 1693 an eruption of the volcano of Sorea took place on a gigantic scale; the cone gradually crumbling down into a vast crater, which, converted into a lake of fire, spread over nearly half of the entire island.

An eruption of a volcano in the island of Banda, in November 1835, was accompanied by a severe earthquake.

THE NORTHERN ISLANDS.

The volcanic chain is continued from the Moluccas to the north through the Philippine Islands and Formosa. It then strikes to the north-east, and traverses Loo-Choo, the Japanese Islands—where the most remarkable volcano is Fusi-Yama, 11,000 feet in height—the Kurile and Aleutian Islands, to Kamtschatka. In the Kurile Islands there are eighteen vents, and the submarine eruptions in the beginning of the present century raised two islands; one four miles in circuit, and the other 3000 feet in height.

Thus, says Mrs. Somerville,* some long rent in the earth has extended from the Tropics to the gelid seas of Okhotsk, probably connected with the peninsula of Kamtschatka: a new one begins to the east of the latter in the Aleutian Islands, which are of the most barren and desolate aspect, perpetually beaten by the surge of a restless ocean, and bristled by the cones of twenty-four volcanoes; they sweep in a half-moon round Behring's Sea till they join the volcanic peninsula of Russian America.

We must now turn to the South Pacific Ocean, where signs of great internal activity are visible in

* Mrs. Somerville, "Physical Geography," i. 255.

THE SANDWICH ISLANDS,

whose principal island, *Hawaii*, or *Owhyhee*, contains four volcanoes of awful sublimity :—Mouna Loa, Mouna Rea, Haialai, and Kohola. The first-named is about 18,000 feet, and the second about 16,000 feet, in height; but their bases are of enormous circuit, and the ascent to the summit is consequently very gradual. The bulk of

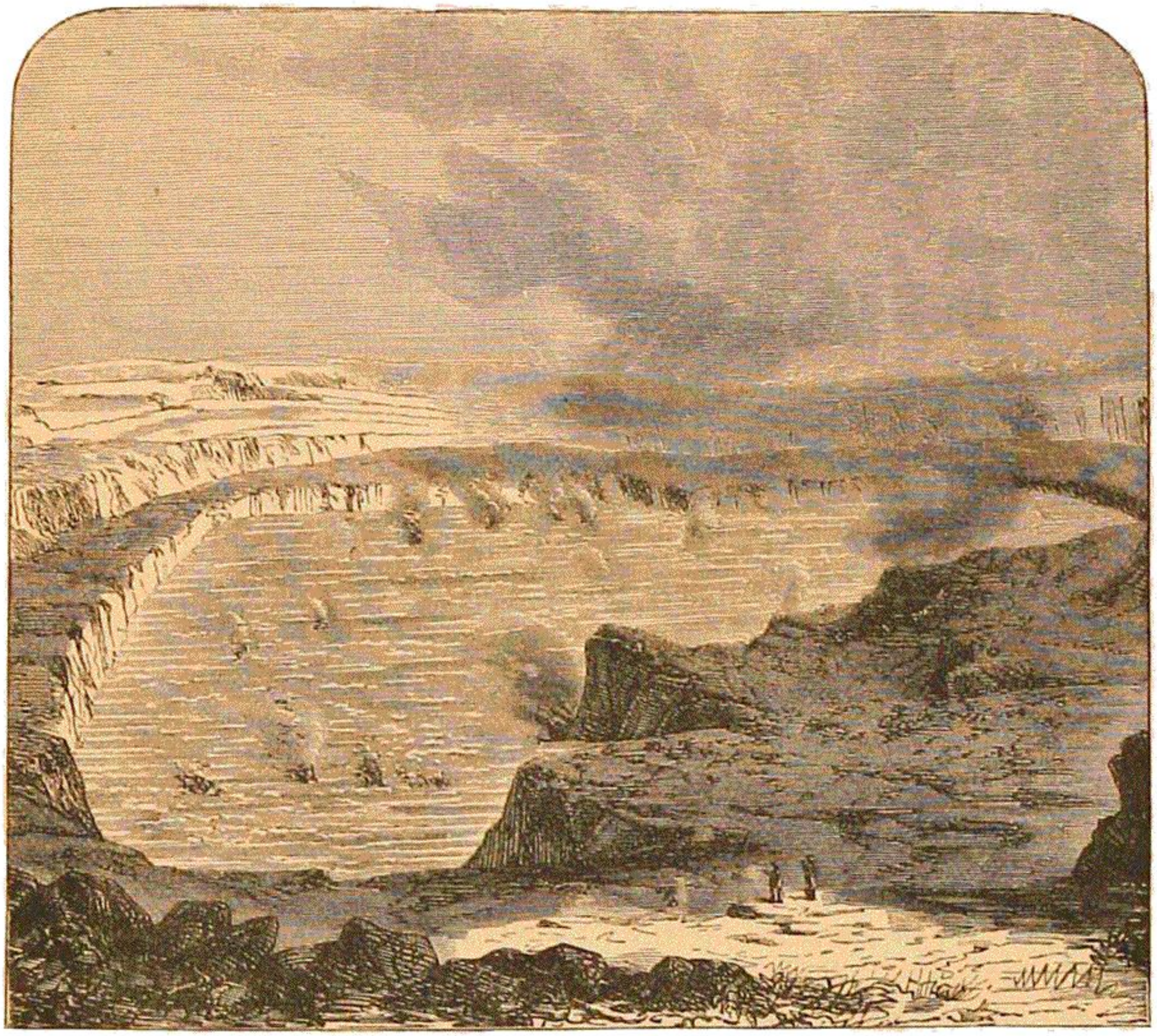

FIG. 149.—THE KILAUEA CRATER OF THE MOUNA LOA VOLCANO (HAWAII).

each is reckoned at about two and a half times that of Etna. Some of the lava-rivers ejected by them are twenty-six miles long, by two miles broad.

The characteristic feature of Mouna Loa is its possession of two distinct and apparently unconnected craters; one on the summit, the other on the flank of the mountain, at a considerably lower level.

This last is known by the name of Kilauea, or Kirauea, and is, perhaps, the most wonderful volcanic crater in the world.

The following description of it is borrowed from the pages of the Rev. W. Ellis :—*

The approach to the mountain is over a tract of lava, which resembles in appearance an inland sea surrounded by distant mountains. Once it has certainly been in a fluid state, but apparently it has undergone a sudden petrifaction, or been converted into a glassy stone, while its agitated billows were rolling to and fro. Not only are the large swells and hollows distinctly marked, but in many places the surface of these billows is covered by a smaller ripple, like that observed on the surface of the sea at the springing up of a breeze, or the passing currents of air which produce what the sailors call a cat's-paw.

After journeying for some hours across this lava-plain, the crater of Kilauea suddenly bursts upon the view. Mr. Ellis and his companion expected to have seen a mountain with a broad base and rough, indented sides, composed of loose slags or hardened streams of lava, and whose summit would have presented a rugged wall of scoria, forming the rim of a mighty caldron. But, instead of this, they found themselves on the edge of a steep precipice, with a vast plain before them, 15 or 16 miles in circumference, and sunk from 200 to 400 feet below its original level. The surface of this plain was uneven, and strewed with huge stones and volcanic rocks; and in its centre was the great crater, at the distance of a mile and a half from the place where they were standing. They walked on to the north end of the ridge, where, the precipice being less steep, a descent to the plain below seemed practicable. But with all their care they did not gain the bottom without several falls and slight bruises. After walking some distance over the sunken plain, which in several places sounded hollow under the feet, they at length arrived on the edge of the greater crater, where their eyes rested on a sublime and even appalling spectacle.

Immediately in front yawned an immense crescent-shaped gulf, about two miles long from north-east to south-west, nearly a mile in width, and apparently 800 feet in depth. Lava covered the bottom, and the south-western and northern parts were one immense flood of burning matter, in a state of terrific ebullition, rolling to and fro its "fiery surges" and flaming billows. Fifty-one conical islands, of varied form and magnitude, containing as many craters, rise either round the edge or from the surface of the burning lake: twenty-two of those constantly emitted columns of gray smoke or pyramids of brilliant flame; and several of these simultaneously vomited from their ignited mouths streams of lava, which rolled in blazing torrents down their black furrowed flanks into the boiling mass below.

From the existence of these conical craters Mr. Ellis concluded that the boiling caldron of lava before him was not the focus of the volcano, but comparatively shallow, and that the basin containing it was separated by a stratum of solid matter from the great volcanic abyss, which incessantly poured out its molten contents

* [Rev. W. Ellis, "Polynesian Researches."]

through these numerous craters into the upper reservoir. The sides of the gulf, though composed of different strata of ancient lava, were perpendicular for about 400 feet, and rose from a wide horizontal ledge of solid black lava of irregular breadth, but extending completely round. Beneath this ledge the sides sloped gradually towards the burning lake, which was, as nearly as could be computed, 300 or 400 feet lower. It was evident that the large crater had been recently filled with liquid lava up to this black ledge, and had, by some subterraneous canal, emptied itself into the sea or under the low land on the shore. The gray, and in some places apparently calcined, sides of the great crater ; the fissures which intersected the surface of the plain ; the long sulphur-banks on the opposite side of the abyss ; the vigorous action of the numerous small craters on its borders ; the dense columns of vapour and smoke that rose at the north and west end of the plain, together with the ridge of steep rocks by which it was encircled, and which in some places were probably 300 or 400 feet in perpendicular height ; combined to form an immense volcanic panorama, whose effect was greatly augmented by the constant roaring of the furnaces below.

The gigantic crater of Kilauea seems to realize the ancient fable of Phlegethon,

"Whose waves of rushing fire inflame with rage."

The American naturalist, Dana, says that the glow of the lava is so intense as to irradiate the passing rain-clouds with beautiful iris-bows. He describes the lava as an agitated sea, which is nearly as liquid as water, whose waves clash like breakers on the edges of the terraces, and, sometimes rising to the height of the topmost crag, is precipitated over it in seething cascades. Isolated jets are frequently thrown up to an elevation of 60 and 70 feet. After such an explosion the molten lava subsides, congeals, and grows black : but suddenly the crust is broken anew, and traversed by fissures of dazzling radiance ; black fragments, upheaved, float on the boiling surface, like masses of ice on a river at the epoch of its floods. Yet all this change and commotion take place—so vast is the orifice of the crater—in a complete silence, and without any convulsion of the ground.

Of the mountain, Mouna Loa, itself, a fearful eruption took place in 1840, and it has since given repeated evidences of its activity. An eruption also occurred in 1843 from a crater about 2000 feet below the summit. A river of lava pouring down the mountain-side, rolled over the elevated plain between Mouna Loa and Mouna Kea for a distance of five-and-twenty miles. But this was exceeded during the eruption of August 1855, when the "fire-stream" continued to flow for many months, and by July 1856 had accomplished a distance of sixty miles from its source. In January 1859 the volcano was again in convulsion, flinging up shafts of *white-hot* lava to the estimated height of 800 or 1000 feet. Numerous streams went hissing, burning, and destroying down the mountain-sides, and carried desolation in every direction.

An eruption also occurred in 1865, accompanied by the usual phenomena ; by leaping jets of lava, whose wild eëry play continued for twenty days and nights, and by explosions so loud that they were heard at a distance of forty miles.

POLYNESIAN ISLANDS.

Several of the other islands in the Pacific are of a volcanic character. Volcanoes exist among the *Marquesas* group, whose principal formation is trachyte: in the *Society Islands* the central volcano, Tobreonou, is as lofty as Etna; in the *Friendly Islands* the volcano of Tofua is described as continually in eruption. If we

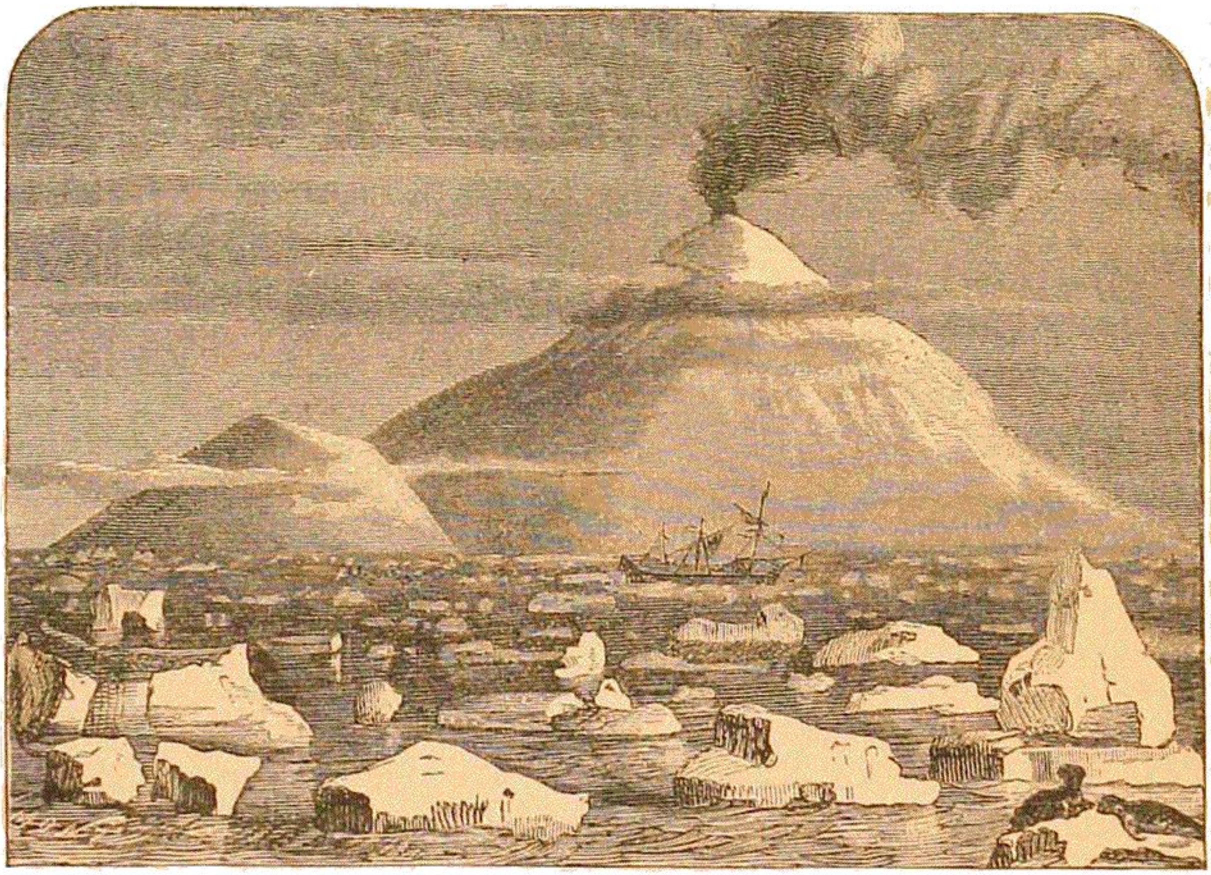

FIG. 150.—MOUNT EREBUS.

voyage further south we shall find two "mountains of fire" in the dreary ice-deserts which prevent the approach of man to the Antarctic Pole. They were discovered by Sir James Ross in 1841, and named after his two famous discovery ships, the *Erebus* and the *Terror*. Mount Erebus (lat. 77° 32′ S.) is about 12,000 feet high. Its sides are densely covered with snow and ice, which mantle up to the very edge of the huge crater, whence are continually ascending vast clouds of volcanic smoke to an estimated height of 2200 feet.

NEW ZEALAND.

New Zealand, we may remind the reader, consists of two large islands and one small, named respectively North, Middle, and South (or Stewart's) Island. They are of volcanic origin, and a great portion of their area is occupied by a few active and several extinct volcanoes. In North Island the volcano of Tongariro is 6000 feet high, and constantly emitting clouds of smoke. In Middle Island, around Lakes Rotomahana and Rotorua, numerous grand and superb geysers have been discovered, which eject columns of water heated two degrees above boiling-point. But even of greater interest is the volcanic district round Lake Taupo (30 miles long by 20 broad), in North Island, as will be evident from the following summary of Ferdinand de Hochstetten's interesting narrative of exploration :—*

Lake Taupo, says the German traveller, is a veritable inland sea, 25 miles long from S.W. to N.E., 20 miles broad, and of an unfathomable depth. It is situated 1250 feet above the level of high-water mark, and surrounded in all its circuit by volcanic formations, where predominate the trachytic lavas, rich in quartz, as well as gigantic masses of pumice-stone. These igneous formations compose a great table-land, from 2000 to 2200 feet in height, in whose centre lies the lake, which has evidently been formed by a violent rupture of this lofty plateau, succeeding upon the subsidence of certain subterranean cavities.

All the western shore of the lake is composed of precipitous rocks, which in some places attain an elevation of upwards of 1000 feet. The long wooded summits of Mounts Rangitolo and Tuhua, 3000 feet high, disappear in the horizon in a north-west direction ; it is but as a mere point that we can distinguish the mass of Mount Titiraupenga, whose pyramidal summit resembles the ruins of a dismantled castle.

The eastern bank is almost everywhere level, and forms a continuous beach, along which a road has been laid down. At a certain distance, glittering rocks of pumice-stone bound this beach or shore :

* [Hochstetten, in "Tour du Monde," vol. for 1866, pp. 291, *et sqq.*]

they are covered with vegetation, and gradually ascend to the foot of a lofty wooded mountain, Kaimanawa, about fifteen miles from the lake.

The southern shore of Lake Taupo extends to a great distance: it is bordered by a range of volcanic cones, in whose rear soar the magnificent volcanic peaks of Tongariro and Ruapahou. These two giants are not visible, however, from the southern banks; but everywhere, from the east shore to the northern, they may be seen tower-

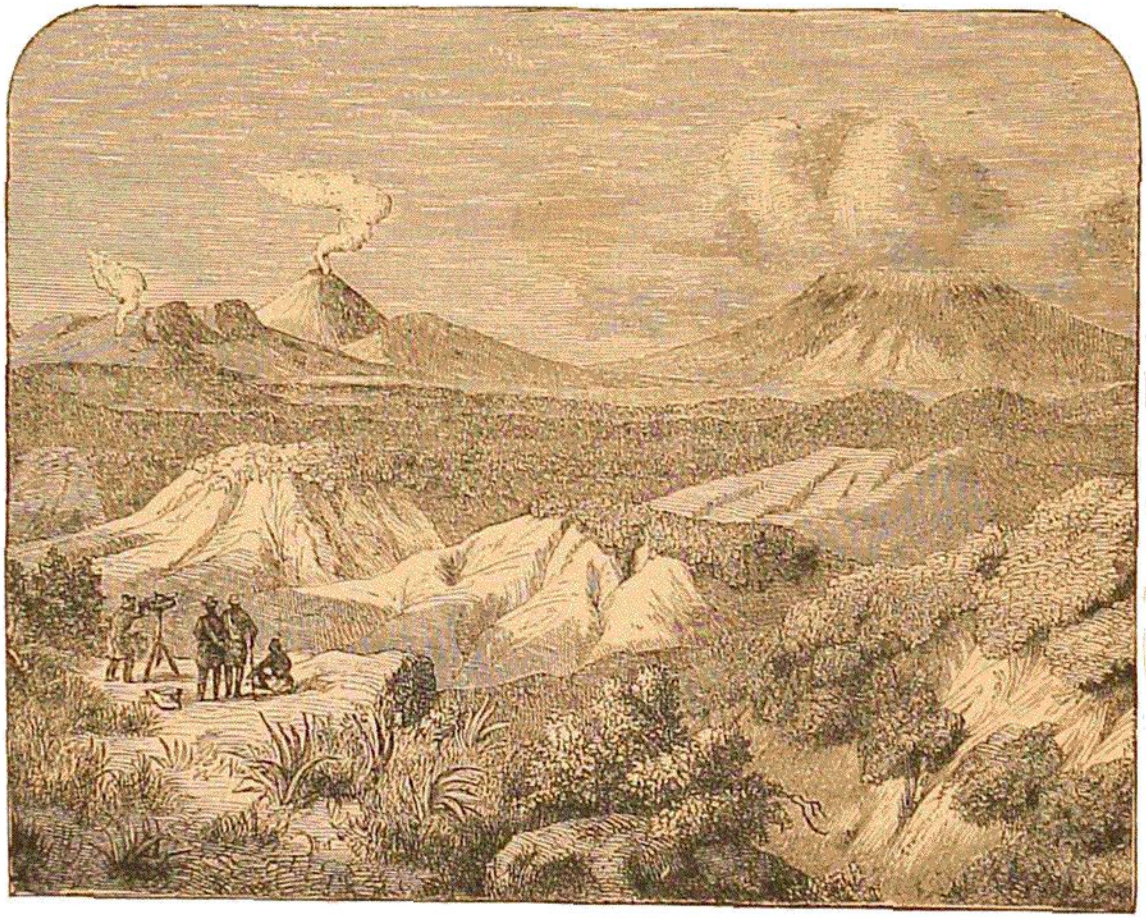

FIG. 152.—THE VOLCANOES TONGARIRO AND RUAPAHOU (*seen from the south-west*).

ing above those little conical mountains which the natives, in their picturesque language, designate their "wives" and "children."

The base of Mount Tongariro is about twelve miles distant from the lake. Between it and the mountains Pihanga and Kakaramea intervenes a broad valley, inclosing the beautiful lake Rotoaia, about three miles long. It is by this road the traveller passes to ascend Tongariro; but as the mountain is "tabooed" by the Maori chiefs, and as the weather was unfavourable for such an enterprise, M. Hochstetten did not attempt its ascent.

FIG. 151.—LAKE TAUPO (NEW ZEALAND).

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Tongariro is not an isolated conical mountain, like Ruapahou; on the contrary, it is rather a very complicated volcanic system of powerful and still active cones: Ngauruhoe, a very superb and regular cone of eruption, with a vast funnel-shaped crater, is the most important part of it. This cone of cinders and scoria exceeds the other loftiest points by about 500 feet.

I have never heard, says Hochstetten, that any native has ascended Tongariro; the dread of the infernal powers seems to have diverted them from such a design.

Only two Europeans have succeeded in climbing the cone of eruption, Ngauruhoe—namely, Mr. Dyson, in March 1839, and Mr. Bidwell, in March 1851. The following extract is from the narrative of the latter, as it appeared in the columns of an Auckland journal, *The New Zealander.*

"In the month of March 1851," says Mr. Bidwell,* "a little before sunrise, I started from lake Rortorua. I traversed the plains, and ascended the heights to the north of the river Whanganni; I then arrived in a valley covered with great blocks of lava, which greatly obstructed my progress. It is in the bottom of the valley the Whanganni flows; I crossed the river, which at this point is only three feet broad, and found on the other side a soil of great unevenness, and very difficult to traverse. I ascended as straight as possible towards the most elevated summit, and at length I reached the foot of the cone, round which huge fragments of lava were lying, that had evidently been ejected from the crater. This was the most critical moment of my perilous enterprise. I had to scale the precipitous cone, which seemed to me to form a fourth of the total elevation of the mountain. I climbed for some time on my hands and knees, and as the slope is covered with scoriæ and friable ashes, it frequently happened that I slipped down several feet. There was no snow on the mountain, except in some deep chink where not a single sunbeam could penetrate; no vegetation, not even the large coarse grass scattered in patches at the foot of the cone.

"At least four hours, I think, were occupied in the ascent; but as I had no watch, it is possible that, owing to my fatigue, the road seemed much longer than was really the case. I hailed with joy the opening of the vast shaft or pit, near which I had experienced so much difficulty in arriving. It may have been then about an hour past noon, so that I had been climbing for about eight hours, but I ought to say that I walked at a good pace, and without stopping.

"I had expected a beautiful prospect from the summit of Tongariro, but it was wreathed in clouds, and I could scarcely distinguish a single object. The crater of

* [The Translator, not having been able to obtain a copy of *The New Zealander*, is indebted for the above extract to Hochstetten.]

Ngauhuroe is nearly circular, and, according to my computation, about 1800 feet in diameter. Its borders bristle externally with scoriæ and friable cinders; in the interior, I remarked great rocks of a pale yellow, evidently composed of sublimated sulphur. The rim of the volcano is not of equal height throughout its entire circuit, but I thought it might have been possible to accomplish the tour. It was impossible to think of a descent into the crater; I cast my eyes on a frightful gulf which yawned before me; dense whirling vapour-clouds impeded the view, and I could not see more than thirty feet in depth.

"I flung into the abyss several large stones, and trembled as I heard them rebound from rock to rock. I threw in some more stones, but not a sound was audible. All the time I was on the summit, I distinguished the hiss of smoke mingled with steam, as at the thermal springs of Rotomahana and Taupo; the sound resembles that of a steam-engine in motion.

"No eruption took place in my presence of cinders or water, and I could detect no sign of one having recently occurred; I saw no lava of fresh formation. I must confess that when I thought of the possibility of an outbreak on the place where I was standing, my sensations were anything but agreeable.

"About two o'clock I began to retrace the road by which I had ascended; I was enveloped in fog and cloud, and for some considerable time strayed from my route. I then caught sight of a lake between Tongariro and Ruapahou, about a mile in diameter. I could not discover any river issuing from this lake on the west; but at a short distance from Tongariro I came upon an extinct crater. It was already dark when I reached the river Whanganni, and though I am of a robust constitution, and a good pedestrian, I felt myself completely exhausted, and fell asleep in a ravine. The night was cold, but my sleep was prolonged until morning without inconvenience. With the first rays of dawn, I resumed my route, and at ten o'clock arrived at home, with my shoes falling from my feet in strips."

To the south of Tongariro rises Ruapahou, the bases of the two mountains blending into one another by an imperceptible incline, and forming a kind of table-land about ten miles broad. On this table-land lie four lakes, two of which are about three miles across; the others considerably smaller. One of them is named Taranaki; the river to which it gives birth empties its waters into the Whanganni, and a singular tradition attaches to this lake.

The natives tell you that the mountain Taranaki (the *Mount Egmont* of the settlers) formerly stood, like a third giant, by the side of Tongariro and Ruapahou. They remained on friendly terms, as giants should, until Taranaki attempted to carry off Pihinga, the wife of Tongariro. Thereupon the latter quarrelled with him, and dealt him a blow on the head which made him fly. He descended the course of the Whanganui, and following the deep chasm of that river, approached the sea, where to-day he rears his colossal but solitary bulk near the coast. During his journey, a couple of fragments detached themselves from his forehead; and to-day, by way of proving the truth of their story, the natives point out two masses of rock, differing from the volcanic formations around the Whanganni, which are found at about eighteen miles from its source.

Ruapahou, the loftiest summit in North Island, has the form of a considerably truncated cone, and rises into the region of perpetual snow. It has never been ascended or explored; however, no doubt can be entertained as to its volcanic nature, but it appears to be completely extinct, and at a distance no trace of a solfatara can be detected either on its sides or its summit. The exact configuration of this vast cone is not known—whether it forms a table-land or terminates in a crater. It is rarely free from clouds; but in clear weather, great masses of snow can be distinguished on its flanks, which, plunging deep into their numerous furrows, apparently end in glaciers.

Most of the hot springs of this region lie on the southern shore of the lake, near the Maori village of Tokanu, and not far from the river of that name. They extend from the little conical mountain Manganamu, to the mouth of the river Tokanu, and cover an area of two English square miles. The thick column of vapours which is discernible on the borders of the lake, belongs to the great spring of Pirori. From an orifice on the left bank of the Tokanu soars a column of boiling water, two feet in diameter, always undergoing the action of vapour, and whirling round in the air to a height of six to ten feet. Occasionally, it reaches an elevation of forty feet, with a loud detonation. A few feet distant is a basin eight feet broad by six feet deep, in which the water is constantly boiling.

These thermal springs are also numerous in the valley of the Waikato. The Waikato, forming in its course a succession of rapids, pours headlong through a narrow ravine, deeply immured among precipitous mountains. Its waters swirl and foam around two rocky islets placed in the middle of its bed, and penetrate with a thunderous roar into the valley. On its banks float white clouds of vapour, created by the leaping springs which flow towards the river. Here mounts a fountain of vapour, to re-descend in rain; there another rises, and suddenly stops; at the same moment a third and fourth begin to play; thus the game is varied and renewed, as if art had here constructed a Versailles on a colossal scale. Even when all the fountains open simultaneously, enough water remains for the cascades. Our traveller set himself to work to count the different places where

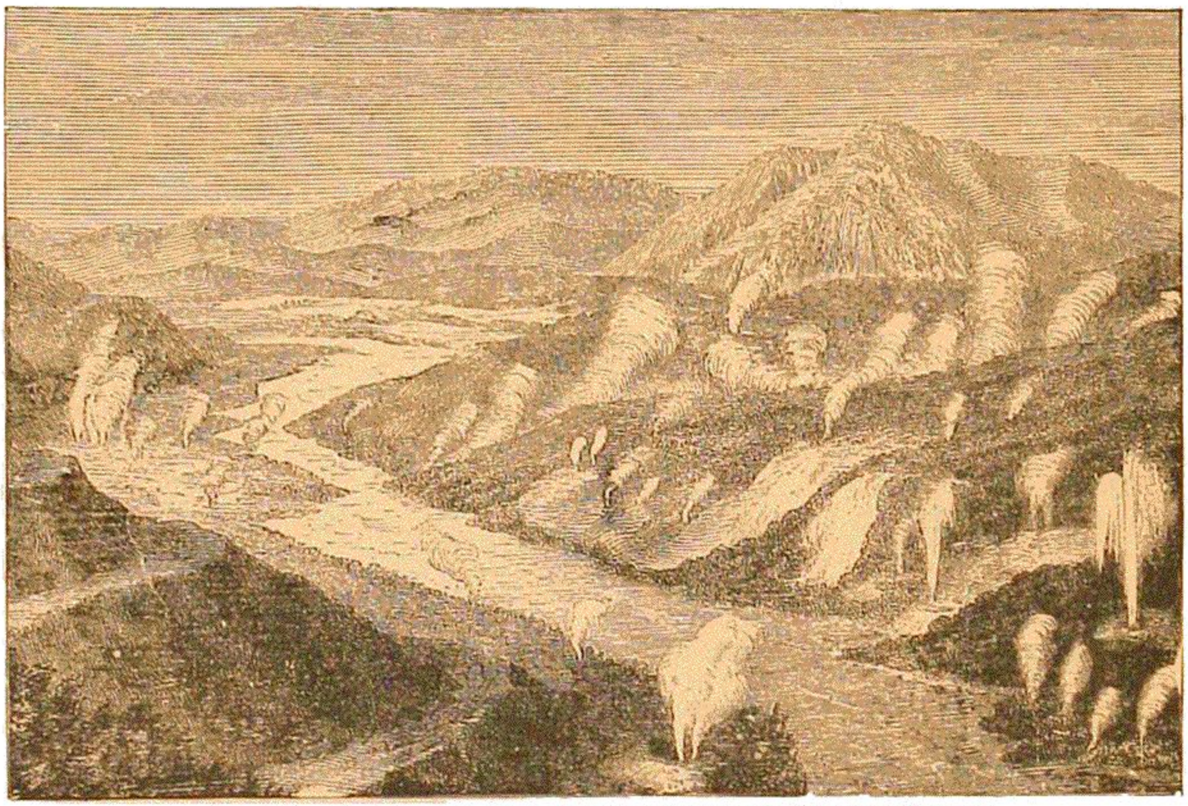

FIG. 153.—GEYSERS AND THERMAL SPRINGS IN THE WAIKATO VALLEY.

a basin of boiling water was visible, or a vapour-cloud resulting from the same cause. He numbered sixty-six, without, however, being able to include the whole in his survey; and, moreover, many springs break out after long intervals of rest, like the geysers of Iceland.

The basin of these springs extends along the Waikato for about a mile, from the steep cone of Whakapapataringa, on the south, to the wooded mountain of Tutukan on the north. The greater number are found on the right bank, but are not easily accessible, for it is impossible to traverse the rapid current right opposite the springs; the passage must be attempted above or below, and the traveller must then climb up the steep woody bank, where he is every moment exposed to the risk of slipping on the completely soaked soil, and falling into the burning mud. M. Hochstetten accordingly contented himself with a close examination of the more accessible springs on the left bank.

A great platform, about one hundred and twenty yards square, composed of a whitish silicious tufa, and extending from the base of the mountain Tutukan to the Waikato, embraces some of the most remarkable springs of the basin, and notably that of Homaiterangi.

This spring is situated close to the river-bank, on a hillock shaped like a church-spire. Great precautions are indispensable on the part of the traveller who, without an experienced guide, for the first time approaches one of those *pinas*. M. Hochstetten's companions wished to enjoy the pleasure of a bath in the Waikato, and had already deposited their clothes near a basin of thermal water, when loud reports suddenly deafened their ears, and they saw the water rising and boiling in the basin. They had scarcely time to escape a douche-bath of anything but an agreeable character, for a liquid column mixed with vapour sprang up, with a hiss and a roar, to a height of twenty feet. Startled by this adventure, M. de Hochstetten's companions hastened to relate it to him; but when he arrived on the spot, the geyser had subsided into a sulky repose, and nothing was visible in its basin but water limpid as crystal, and very slightly agitated. Its temperature proved to be 94° C. (= 201° R.), and its taste was not unlike that of broth.

The first explosion of which Hochstetten himself was a witness, did not take place until near noon. Shortly before the basin was full to the brim; suddenly masses of water and vapour shot up to an elevation of from twenty to thirty feet, under a circle of 70°. This lasted for several minutes; then the force of projection diminished; the water rose only one or two feet; and then the jet disappeared in the centre with a hoarse, dull sound. When he again approached the basin it was empty, and he could see to a depth of eight feet in a funnel-shaped opening, whence gusts of vapour escaped with a constant hiss. Then the water recommenced its upward movement, and in the course of ten minutes the basin was filled anew: the eruptions appeared to take place at intervals of ten hours. The bottom of this *pina*, like that of the surrounding springs, is of silicious tufa. The deposit of the waters, when recent, is of a gelatinous white; after awhile it acquires consistency, and ends by forming a solid rock of very different colour and structure. Sometimes it is a granular mass; sometimes a chalcedony hard as steel, or else a gray silica.

A second *pina*, about thirty paces distant, is named Orakeikorako. It is an oval basin, eight feet long by six feet broad, and half filled with a transparent and lightly boiling water.

But the most remarkable of all the springs is situated at the foot of the hill: it forms a boiling jet of two or three feet in height, whose water is exquisitely bright and clear, though impregnated with an odour of sulphur. The Maori chief who accompanied M. Hochstetten in his excursion informed him that, after the earthquake at Wellington in 1848, this spring was transformed into a geyser, which leaped to the height of one hundred feet—an exaggeration, no doubt—and ejected with terrible force the stones flung into its basin. Three smaller basins which, previously, were independent sources, are now filled by the overflow of the great jet, and form excellent natural *piscinæ*. The water passes from one reservoir into another, so as to afford a choice of three temperatures. The third, about three to five feet deep, is about the size of a large bath. Its bed is composed of silicious tufa, white as snow, which seems to possess the purity of marble, and its limpid wave was so attractive that our traveller could not deny himself the pleasure of bathing in it.

Great curative virtues are attributed to these springs. M. Hochstetten met with an Irishman at Orakeikorako who informed him that he had been brought thither paralyzed, but that a brief use of the baths had restored him to his feet.

On both sides of the river the dense brushwood covers tracts of

Fig. 154.—The Te-ta-Rata (New Zealand).

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boiling mud, which require to be approached with great caution, for the soft soil, not being covered by any mixture of tufa, yields upon the slightest pressure. The largest of these muddy basins is of an elliptical form, fourteen feet long by eight broad, and as many deep. The mud boiling within is an oxide of iron of a bright red, and viscous bubbles of slime, rising to the surface, burst, and emit a fetid sulphurous stench: the scene is described as "truly infernal." Woe to him whose foot slips in this dread locality! It is certain death, and a death of terrible agony.

On the opposite bank is the *pina* of Tuhi-Tarata. The azure blue water flowing from its basin descends, in a cloud of vapour, a succession of terraces of tufa, which shine with the most various colours—white, yellow, and red. The same spectacle is reproduced at different points, accompanied by periodical jets at longer or shorter intervals.

Our enterprising traveller next proceeded to visit Rorotua, a volcanic lake fed by these thermal springs, and recommended by an ancient legend to the reverence of every devout Maori. Most of the principal families of North Island trace back their ancestry to Hine-Moa, the virgin of Rorotua. We have no space to reproduce here the story of this New Zealand beauty; but our readers will find it narrated in the "Polynesian Mythology" of Sir George Grey.

In the vicinity of this lake lies a small basin, the Rotomahana, which measures about 1500 yards in length by 600 in breadth. It is a real crater of explosion, deep in the centre, bounded by marshes on the north and south, and hemmed in by rocks on the east and west. It is justly entitled a *thermal* lake: the quantity of boiling water flowing from the contiguous springs is so considerable, that the whole lake is heated by it.

To the north is situated the Té-ta-Rata, a boiling spring, which, descending from terrace to terrace down to the lake, is the greatest marvel of this marvellous region.

On a ferny hill-side, about eighty feet above the Rotomahana, occurs the principal basin, whose sides of reddish clay are from thirty to forty feet in height. It measures about eighty feet in length and sixty in breadth, and is filled to the brim with a perfectly clear and limpid water, which, owing to the snowy whiteness of the stalactites on its borders, appears of a rich turquoise blue, occasionally *rainbowed* with lustrous opal tints.

On the edge of the basin the thermometer stands at 183° F.; in the middle, where the water rises to an elevation of several feet, the thermometer stands at boiling point (212° F.)

Immense clouds of vapour, reflecting the exquisite blue colour of the basin, swirl and hover above it, and impede the curious gaze; but the hoarse sound of the boiling waters is ever distinctly audible. Sometimes, according to the natives, the entire mass of seething fluid is ejected with almost inconceivable force, and then, at a depth of thirty or forty feet, may be seen the empty basin, which, however, fills very speedily. If this fact be true, the spring of the Té-ta-Rata is undoubtedly a geyser, acting at long intervals, like the Great Geyser of Iceland; only here, the basin being much larger, the quantity discharged must necessarily be more considerable.*

The water has a brackish flavour, but not strongly disagreeable, as in the springs of Iceland. The deposit is a silicious stalactite. In overflowing the basin, this thermal water has formed a series of ledges, or stages, which, white, and, as it were, hewn out of Parian marble, present a *coup d'œil* beyond all description. You must have ascended these alabaster steps, O reader! and examined the peculiarities of their structure to comprehend their wonderful magnificence.

The foot of the hill stretches far forward into the Rotomahana: above commences a range of terraces, containing several basins, whose depth corresponds to the height of the steps of this gigantic staircase. Each step is bordered by a slightly elevated rim, over which a host of beautiful stalactites falls upon the step underneath; and each presents a platform of greater or lesser extent, enclosing one or more basins of an exquisite azure. These are so many natural baths, which

* [Hochstetten, *Voyage à la Nouvelle Zealande*, in the "Tour du Monde;" vol. for 1866, p. 303.]

the most refined art could not render more convenient or more elegant. You may choose among them the dimensions which you prefer and the temperature you desire; for the latter diminishes in proportion to the distance from the principal spring. Some are of such a size and depth that one might swim in them conveniently.

The most elevated terrace surrounds a large platform, in which are excavated numerous pretty basins from five to six feet in depth, whose water has a temperature of 86°, 90°, 104°, and 122° F. In the centre of this elevated platform, and near the chief basin, rises a rock about twelve feet high, covered with a thick growth of manuka, lycopodiums, mosses, and ferns; the traveller can ascend it without danger, and from thence look down into the blue vaporous depths of the central reservoir. Such is the celebrated spring of the Té-ta-Rata. The pure white of the stalactites contrasting with the intense blue of the water, the verdure of the surrounding vegetation, the bright red of the naked walls of the aquatic crater, and, finally, the clouds of vapour, which are incessantly renewed and incessantly revolving on their own axes, contribute to form a picture as unique as it is impressive.

The splendours of the Té-ta-Rata, says M. F. de Lanoye,* have a pendant on the opposite bank of the lake, in those of a spring not less remarkable for its temperature and its encrusting qualities. It has received from the natives the expressive name of Otaka-Puarangi, the "Cloudy Atmosphere." Its white silicious deposits also descend from its orifice down to the lake, and the traveller scales them by a marble staircase, so sharp in its outline, so regular in its construction, and so adorned with graceful borders of evergreen shrubs, that it seems as if Nature had designed it in very mockery of the skill and industry of man.

It may be that the superimposed terraces of the Otaka-Puarangi are not as majestic as those of the Té-ta-Rata; but they are more elegant and graceful, and a light rosy tint overspreading the whole calcareous deposit communicates to the scene a peculiar beauty. The

* [Felix de Lanoye, "Les Grandes Scènes de la Nature."]

basin of the spring, forty to fifty feet broad, encloses a tranquil sheet of water of a beautiful azure blue, which evaporates, but does not boil. At the northern base of the terraces smokes a solfatara, the Whaka-Taratana, a complete pond of sulphur, whose superabundance empties itself into the lake with a muddy current.

With these details, whose length, it is hoped, the reader will excuse on account of their comparative novelty, we turn from the volcanic region of New Zealand to that of South America.

SOUTH AMERICA.

The chain of the Andes, from Quito to Patagonia, and from thence to its termination in Tierra del Fuego, furnishes a magnificent ex-

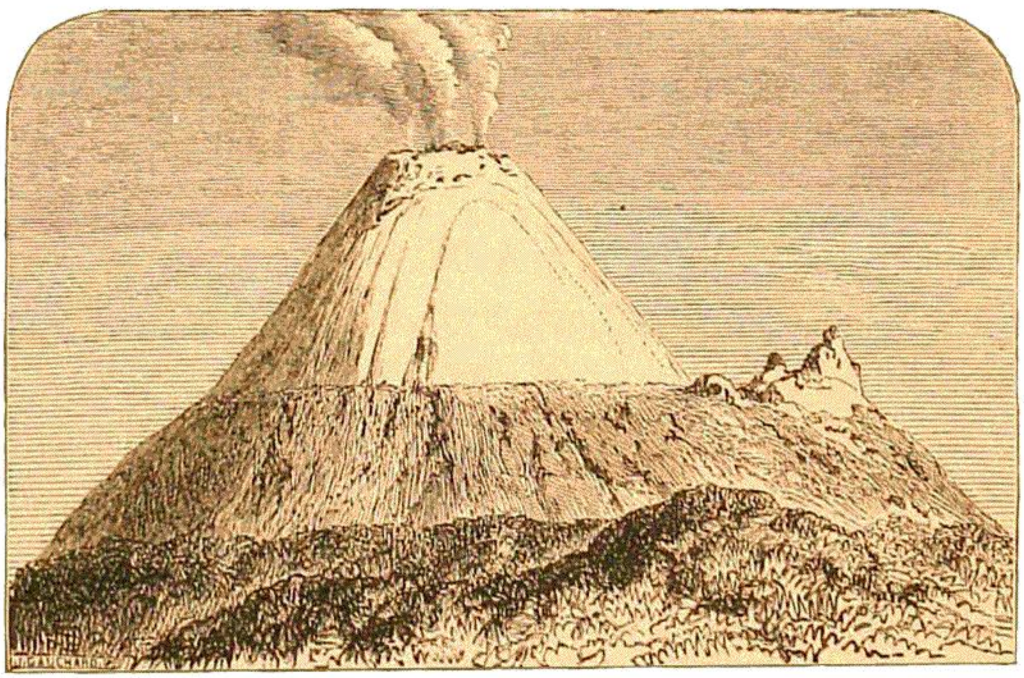

FIG. 155.—COTOPAXI (AFTER HUMBOLDT).

ample of linear volcanoes. This is particularly the case in that portion of the great mountain-range which hems in the valley of Quito. Here, on the east, rise the snow-shrouded summits of Antisana, Cotopaxi—one of the most superb of active volcanoes, whose "dazzling cone" soars to a height of 18,775 feet—and Tunguragua. On the west soars the pyramidal peak of Illinissa, "the wreck of an ancient volcano;" close to the city of Quito, the volcano of Pichincha, 19,535 feet; and to the north towers the beautiful snow-clad mass of Cayambè Urcu. Eleven volcanoes are visible from the plain of Quito. Cotopaxi is the king of these, the monarch of mountains, crowned long ago by the shadows of departed ages. Its configuration is so extremely regular that the Spanish-Americans speak of it as moulded by a turner's wheel. In 1741, La Condamine and Bouguier, while engaged in their measurement of an arc of the meridian, had an opportunity of observing the eruption of this mountain, when it hurled shafts of fire to a height of 5000 feet. The outbreak continued for three years, and inundated with floods of lava an immense extent of fertile country.

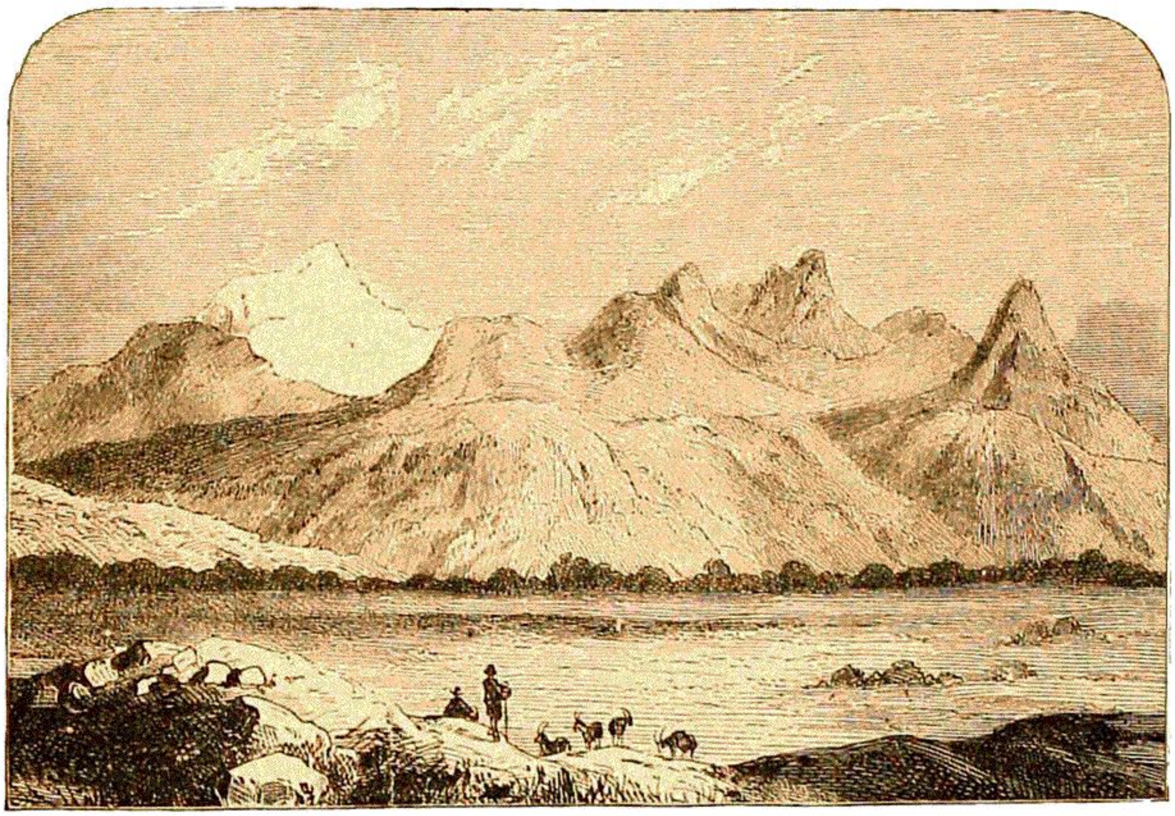

FIG. 156.—VOLCANO OF PICHINCHA.

Pichincha served as the asylum of La Condamine and Bouguier, in 1742, during the astronomical researches we have already spoken of. They spent three weeks at an elevation (15,924 feet) equal to that of Mont Blanc, and the cross which they erected as a landmark still stands upon one of its summits.*

* [Humboldt, "Kosmos;" English translation, vol. v.]

We say one of its summits, for Pichincha has four. The southern, named *Ruas* ("Father") Pichincha, contains the crater of eruption.

Pichincha was ascended by Humboldt. He approached the very edge of the crater, and saw the curdling lava boiling in the black depths of the dread abyss. Misdirected by his guides, he had advanced, in the midst of a thick fog, to within a few feet from the rapid slope which descends into the crater, and with difficulty saved himself from plunging headlong into the burning, seething gulf.

Antisana is the only one of the great American volcanoes which pours forth lava. Its paroxysms were frequent between 1590 and 1718, but since the latter date it has shown no signs of activity. At an elevation of about 13,600 feet above the sea lies a plain, which was formerly the bed of a considerable lake, now reduced to very confined limits. From the centre rises the snow-clad dome, which a series of jagged and abrupt peaks connects with a truncated cone of eruption on the north side. The ejected lavas have accumulated at the foot of the mountain in massive basaltic walls.

Sangay, which exceeds 18,000 feet in absolute elevation, has been in almost continual activity since 1728. Its eruptions are accompanied by loud detonations, which roll afar in the distance like peals of thunder, and have been heard as far as Payta, on the Peruvian coast. The smoke-clouds emitted from the crater are of different colours; sometimes red, sometimes gray, and sometimes orange. Cinders, scoriæ, and stones are also ejected in very considerable quantities, and, in some parts, are piled up in beds of from 300 to 400 feet in thickness.

Among the Chilian Andes we find Raneagua and Chillan in a condition of almost constant restlessness. The latter broke out into eruption in November 1864, when a new crater was formed, and the snowy summit of the cone thickly encrusted with fresh volcanic deposit.

NORTH AMERICA.

Crossing the Isthmus of Panama, we arrive at the remarkable series of the Mexican volcanoes, which are all arranged in a right line running due east and west, some of them being situated at a considerable distance from the ocean. The principal active vents are those of the "starry" Popocatepetl, Colima, Tuxtla, Orizaba, and Jorullo: the latter is of recent origin. In June 1759 occurred a series of earthquake shocks, which greatly alarmed the inhabitants of the richly cultivated estate of Don Pedro di Jorullo, and continued for a period of nearly two months. On the night of the 28th of September they were renewed with increased violence; a tract of ground between three and four miles square was bodily lifted up until its highest point reached an elevation of 524 feet, while that of its borders was 39; flames broke out at various points along the surface; the earth rolled to and fro in billows like an agitated sea; great clouds of ashes, illuminated by the subterranean fires, seemed to obscure the very heavens; white-hot stones were thrown to an immense altitude; chasms suddenly opened, and swallowed up streams and springs; and the spectator might well have been forgiven for thinking that the foundations of the round earth were broken up.* Thousands of small cones sprang everywhere into existence, which the Indians named *hornitos*, or "ovens;" and from their summits jets of steam and vapour were emitted, with a subterranean noise like that of boiling water. Six larger elevations—one of which, 1600 feet high, now forms the principal volcano of Jorullo—rose out of a great crevasse in the midst of these "ovens;" the smallest of the six was 300 feet in height.

For nearly five months a state of violent activity prevailed. Then the eruptions became less frequent and less furious, but the principal crater and many of the *hornitos* still continue to discharge volumes of vapour.

* [An animated description of this remarkable catastrophe will be found in the 5th vol. of Humboldt's "Kosmos" (English translation). See also Daubeny "On Volcanoes;" and Sir C. Lyell, "Principles of Geology," 2 vols., new edition.]

It should be noted, as an unusual circumstance, that Jorullo is 120 miles distant from the sea, and 80 miles from the nearest volcano.

The grandest of the Mexican volcanoes is, however, Popocatepetl, 17,850 feet in altitude, which, since the epoch of the conquest of Mexico by Cortez, has given few indications of activity. Its crater is a vast circular basin, whose perpendicular sides are in some parts of a jet black, in others of a rose pink.

Orizaba has enjoyed a profound repose since 1560. It was

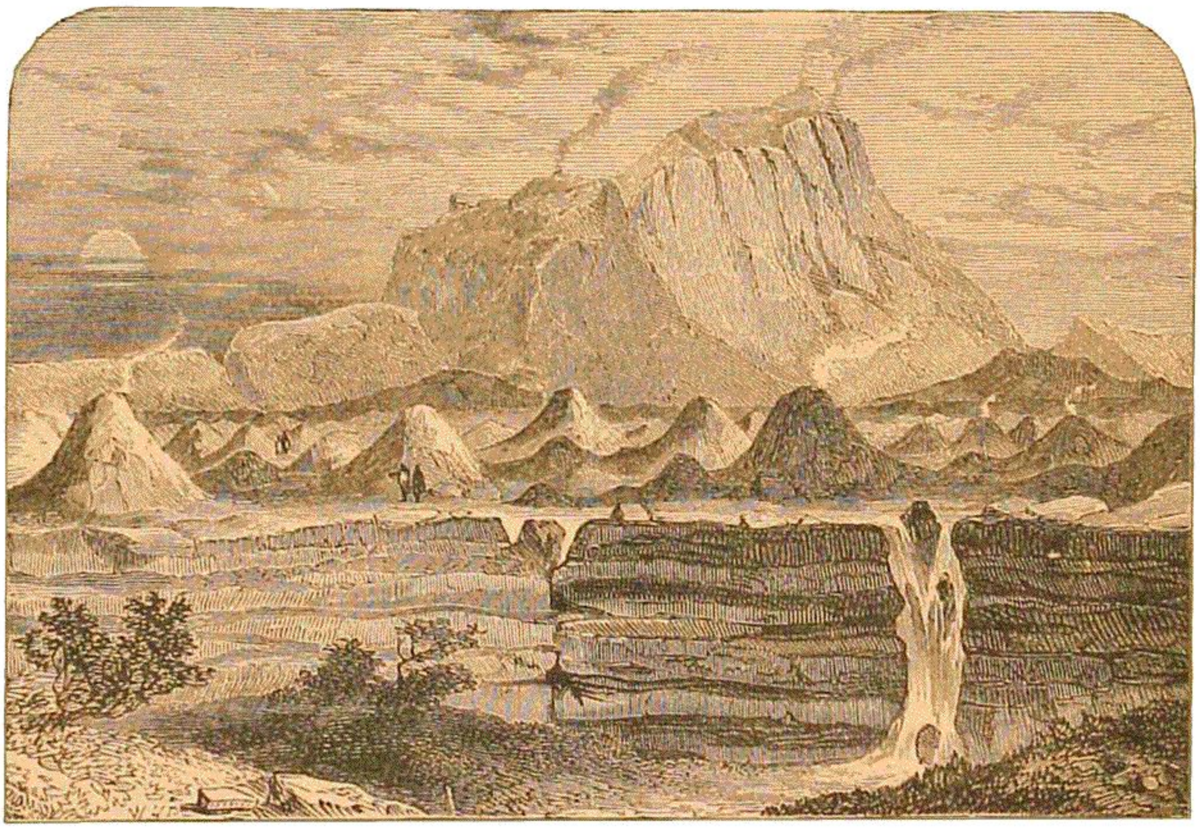

FIG. 157.—THE VOLCANO OF JORULLO, IN MEXICO.

ascended in 1866 by Baron Muller, who likens its crater to the gloomy portals of Erebus.

In Lower California there are several volcanoes, of whose history, however, nothing is known. That of Mount St. Elias exceeds 17,000 feet in height.

Several of the West Indian Islands are of volcanic origin, and not a few contain active volcanoes. The whole region of the Mexican Gulf seems peculiarly affected by the earth's internal fires, and is the frequent theatre of the most tremendous catastrophes. The cone of Le Souffrière, in the island of St. Vincent, gave vent in 1812 to torrents of lava which desolated a wide tract of country, and ejected showers of ashes and stones to so great a height that the atmospheric currents bore them as far as Barbadoes.

Guadaloupe also contains an active volcano, which burst out into furious paroxysms in 1797. That of La Pelée, in Martinique, was in eruption in August 1851; it ejected no lava, but quantities of ashes and sulphurous mud.

All volcanic phenomena, we may observe, in conclusion—whether those of eruptions, earthquakes, geysers, hot springs, or mud volcanoes —originate in one and the same cause: the subterranean heat. The centre of the earth, at a varying depth, is filled with matter fused by the intense igneous forces into a liquid—a kind of molten sea—whose tidal motions produce those upheavals or subsidences of the ground which characterize the more violent earthquakes, and which are necessarily most felt where the intervening solid crust of the globe has its minimum density. Volcanic eruptions occur when, through some displacement of the earth's strata, the waters of the ocean, great lakes, or rivers obtain access to the highly-heated fused matter lying underneath; the waters being raised above boiling-point, immediately on their encountering any subterranean cavity, generate into steam, and burst with a tremendous explosive force, like a discharge of gunpowder. Or the waters come in contact with veins or beds of certain metals—such as calcium, magnesium, aluminium, sodium—set them on fire, and produce a volcanic paroxysm. In support of this latter hypothesis, it may be mentioned that the majority of volcanoes are situated on the sea-coast, or in the neighbourhood of great lakes; and the most violent eruptions proceed from those mountains which, like Vesuvius, Hecla, and Etna, are nearest the sea. And even in the case of inland volcanoes it is probable there may be fresh waters percolating to considerable depths in the immediate vicinity of their subterranean vents.

We now terminate, for the present, our additions to M. Figuier's work, and leave him to dilate in his own words upon some other aspects of volcanic action.*]

SUBMARINE VOLCANOES.

Underneath the basin of the seas, the soil occasionally opens after an earthquake, and from the bosom of the waters rises a volcano. Submarine volcanoes are by no means rare; their débris frequently accumulate into islands; and, in fact, many existing islands, such as Iceland and Sicily, are, to a great extent, the products of volcanic eruption. It is not often, however, that the isles or islets formed by the ejections of a volcano continue to exist, for the shifting materials of which they are composed are quickly carried away by the incessant action of the waves.

In our own time, men have seen the formation of a new island in the bosom of the Mediterranean; that of *Ferdinanda*, or *Julia*, which made its appearance in the month of July 1831, to the north-west of Sicily, and disappeared after a brief existence of two months. We shall place before the reader some accurate details respecting this curious apparition, which so quickly vanished—like the shadow evoked on the surface of a magic mirror.

If the island of which we speak had not already been interesting in its origin, it would have been rendered so by the multiplicity of the baptisms it was fated to undergo. It received seven different appellations. At first it was called *Sciacca*, from the small Sicilian town situated in its vicinity; afterwards *Nerita*, because it was supposed to be placed on the Nerita sandbank, whose position is shown in the excellent charts of the late Rear-Admiral Smyth. But it was quickly discovered that the island did not lie anywhere near the Nerita bank, which, moreover, is situated in 500 to 650 feet of water; a designation which would have given rise to serious errors was accordingly abandoned. M. Constant Prévost, the scientific plenipotentiary whom the Academy of Sciences, of Paris, had dispatched in all haste to the spot, to study the new-born islet from a geological point of view, agreed with the crew of the brig *La Flèche* to name it *Julia Island;* "a sonorous name," says the learned geologist, "whose harmonious Italian termination would readily be adopted by the nearest inhabitants." The name "Julia" would, moreover, recall the month of July, when it made its appearance on the surface of the waters. Some authors, however, designate it by the name of the Sicilian captain *Corrao*, or that of the English Vice-Admiral *Hotham*, who were the first to perceive it on its emergence into "life and light."

Afterwards, the Royal Society of London adopted the name of *Graham*, pro-

* [In the preceding pages we have been indebted to Dr. Daubeny, "On Volcanoes;" Landgrebe, "Die Vulkanen;" Sir C. Lyell, "Principles of Geology;" Poulett Scrope, "On Volcanoes;" Professor Phillips, "Vesuvius;" Ansted, "Physical Geography;" Zurcher and Margollé, "Volcanoes and Earthquakes" (Eng. transl.), ed. 1868; besides various primary authorities.]

posed by Captain Lenhouse, who first set foot on the virgin land. But that of *Ferdinanda*, chosen in honour of the King of Naples, prevailed at a later period as the general appellation of an island as ephemeral as Frederick's crown.

It was, perhaps, for the purpose of reconciling the etymologists, and terminating the discussions of nations all eager to dispute the name and possession of the new island, that *Ferdinanda* disappeared one fine morning, as suddenly as it had appeared, and with it vanished the ground and motive of a "very pretty quarrel."

The island of Ferdinanda, which rose thus unexpectedly in 1831, was the result of a veritable volcanic eruption operating in the bosom of the Mediterranean; a volcano probably in connection with Etna, and which opened in the ocean-bed. The discharges of the volcano filled up the depth of 80 to 100 fathoms of water which at this point the Mediterranean presents, and their accumulated products, rising above the level of the sea, formed, as already stated, an island of no inconsiderable elevation.

All the little islets situated between Sicily and Africa are of volcanic formation, and dependent upon Etna.

Among these we may particularize *Pantellaria*, situated nearly midway between the south-west coast of Sicily and the Gulf of Bona, in Africa. It is a nearly desert island, whose calcined soil nourishes with difficulty a few goats. If the reader drew a straight line from this island towards Etna, it would pass through the small town of Sciacca, on the south-west coast of Sicily. Opposite this town, and at about mid-distance between the coast of Pantellaria, in 37° 8′ 30″ N. lat., and 12° 42′ 15″ E. long., was formed the volcano which, in 1831, by its accumulated discharges created the new island. The English hastened to take possession of it, as if every unknown or new-born territory belonged of right to the sceptre of haughty and encroaching Albion.* But two months afterwards Julia Island disappeared. Was it to escape the rule of the English? So said the Sicilians.

Some precursory phenomena had foretold this remarkable occurrence. From the 28th of June to the 2nd of July 1831, light shocks of earthquake had been felt at Sciacca, where they had been attributed to the vicinity of Etna. On the 8th of July, the Sicilian brigantine *Il Gustavo* passed out at sea within six miles of Sciacca; suddenly the crew perceived a waterspout, one hundred feet in height, which rose for ten minutes with a noise of thunder—then fell back into the sea—rose again—and again subsided, at intervals of fifteen minutes. The leaping shaft or column of water produced a dense cloud of vapour, which brooded over the agitated sea. The waves, covered with reddish foam, tossed to and fro a number of dead fish. According to Captain Corrao, of the *Gustavo*, on the 10th of July the column was 75 feet high and 2600 feet in circumference; the jet of thick vapour which succeeded to the liquid jet rose, according to the captain's estimate, to a height of 1800 feet.

* [The translator need hardly say that it is here the original author who speaks. Few French writers can deny themselves "a fling" at England.]

"The watery volume trembling to the sky,
Burst down, a dreadful deluge from on high!"

Sir Pulteney Malcolm, when navigating the same waters on the 28th of June, had seen nothing; but experienced some smart submarine shocks, as if his ship had touched a sandbank.

While the volcanic jet was rising in the midst of the waters, the inhabitants of the Sicilian coast remained undisturbed, though a thick fog shrouded their horizon. But on the 12th of July, the population of Sciacca felt that the air was impregnated with a strong odour of sulphurous acid, and saw floating on the waves a quantity of small, black, and very porous scoriæ, which, driven ashore by the breeze, formed a stratum four inches thick. The fishermen's boats with difficulty made their way through the volcanic débris and dead fish swirling on the surface of the water.

On the following day was witnessed the apparition out at sea of a column of smoke which, like the guiding beacon of the Israelites, became at night a pillar of fire. It was visible all day; at intervals loud reports were heard; and during the night flashes of brilliant lightning played athwart the dense cloud of smoke and vapour.

On the 18th of July, Captain Corrao discovered, at the same point of disturbance, an island 10 to 14 feet in height, with a central crater, whence issued volcanic discharges and volumes of vapour. The crater of the volcano had gradually arisen, and had terminated by creating an island with its accumulated discharges. The scoriæ which covered the sea all around the new volcanic island were of a chocolate colour; the waters boiling in the circular basin of the crater, of a reddish tint.

On the same day, a small English bark, dispatched by Vice-Admiral Hotham, then commanding-in-chief in the Mediterranean, estimated the elevation of the island at 80 feet, and its circumference at 4500 feet: the sea poured into the interior basin through a profound gap.

The eruption continued with great violence until the end of July. At that time it was visited by Captain Swinburne, and by Hoffmann, the eminent Prussian geologist, who devoted himself to the special study of volcanoes, and to whom geology is indebted for some valuable observations *de visu* on this class of phenomena.

It was with considerable difficulty Hoffmann prevailed on the fishermen of Sciacca to carry him into the neighbourhood of the volcanic island. So great, and, moreover, so natural was their terror in presence of the violent character of the eruption, which he proposed to confront in a frail fishing-boat, that Hoffmann could only persuade them to put to sea by making, in case of death, certain legacies and testamentary dispositions in their favour, and by promising them an exorbitant remuneration. Conquered by his munificence, the fishers equipped a boat for an exploration of the insular volcano.

It was more distant than they had supposed, and it was not until after a long night's sail Hoffmann, on the 24th of July, approached the island, within the distance of about a quarter of a league. It was impossible to draw nearer. Burning scoria rained down upon the boat, which the extraordinary agitation of the waves prevented from advancing. Hoffmann, however, was sufficiently near for all scientific purposes.

According to our observer, the diameter of the crater was 650 feet. The outline was continually enlarging, and was enlarged even under his eyes, by the aggregation of the scoriæ incessantly descending upon its borders. Great balloons of aqueous vapour liberated themselves from the mouth of the volcano, with great violence, but without noise.

These watery vapours and other discharges blended in a luminous column upwards of 1950 feet in height. From time to time this whirling, rotating pillar was traversed by a jet of black ashes, swift as lightning. But it was in the eruption of solid matter that the true magnificence of the phenomenon revealed itself. A dense column of black smoke then rose with incredible fury, sombre and menacing, side by side with the white radiant column of aqueous vapour. It formed in

FIG. 158.—THE ISLE FERDINANDA, IN THE MONTH OF AUGUST 1831.
(From the original drawing by M. Kellin.)

the air, at an elevation of 650 feet, a sheaf, or plume, or canopy; recalling the memory of that celebrated pine-tree cloud which everybody has invoked, since Pliny, to give an idea of the vaporous masses that overhang Vesuvius during an eruption.

In this column the spectator might see dancing and whirling cinders, and stones, ashes, scoriæ, and all kinds of volcanic débris, which afterwards fell back into the surrounding waters. Each stone launched on high drew with it a train of black sand, so that it resembled an infernal comet. And thus on the blue ground of the sky were described the most fantastic figures, lit up with arrows and stars of fire and flame.

The waters, heated by the incandescent masses which continually descended, boiled as in a caldron, and wreathed the entire circuit of the island with an immense belt of snow-white vapour. The stones, striking against each other in their aërial courses, produced a noise like that of a heavy shower of hail. The crater emitted no flames; but electric coruscations and lightnings shot across the black smoke which it exhaled, and in the womb of the cloud incessantly rolled loud peals of thunder.

These paroxysms never lasted less than from eight to ten minutes, sometimes even an entire hour; then all again became tranquil, and the balloon-vapours, white as snow, alone dominated over the silent crater.

Hoffmann published in the German journals the narrative of his curious visit to Ferdinanda, which he described as from 50 to 90 feet high, and about three-quarters of a mile in circumference.

Figure 158 represents the island from a water-colour drawing taken on the spot, in the month of August 1831, by an Italian painter, M. Kellin, and given by him to M. Constant Prévost. We are indebted for the communication to M. Desnoyers, librarian of the Museum of Natural History.

On the 3rd of August Ferdinanda was sighted at a distance by Captain Savy de Mondiol. It appeared to him to lie very low, and an enormous column of smoke was incessantly issuing from it. According to other accounts, its elevation, on the 4th of August, exceeded 200 feet, and its circumference measured from 5500 to 6600 yards.

After this date, the islet began to give way before the incessant action of the waves. The materials composing it were essentially movable. The scoriæ, the basalts, and the other volcanic discharges were not connected by an intermediary adhesive material, or by a natural cement. They were consequently unable to resist the billows for any considerable length of time. On the 25th of August, it did not exceed 4400 yards in circumference; and when it was visited, on the 3rd of September, by Captain Wodehouse, its circuit was already reduced to about 1100 yards. At this date, its greatest elevation above the water was 110 feet, and its crater measured 800 feet in circumference.

The eruptions ceased completely on the 12th of August, but at the same time the public mind began to be disturbed by apprehensions, the offspring of a thousand wild hypotheses.

The sun, which for a month had lighted up the novel scene, had invested itself in those sickly hues which the ancients regarded as ominous of great disasters. The sky, obscured during the day, was furrowed during the night by electric flashes; it seemed to carry on with the abyss a frightful colloquy, on which the destiny of nations depended. What was really the signification of this new volcano, this island which had so unexpectedly emerged from the bosom of the waters? Was the already difficult communication between Italy and the East about to become further impeded? Would new reefs and banks narrow that Sicilian channel, which is hemmed in by such dangerous coasts? Was this recently elevated land only the first visible point, the precursor, the commencement of a long submarine chain, which, in due time, would rise above the surface of the waters and form a natural bridge, connecting Sicily with Africa? Would the Straits of Messina become for the Mediterranean what the Dardanelles is for the Euxine, and so modify the relations of the peoples of Europe and Africa? Ought not men to see in so remarkable an event the prelude of a great geological catastrophe?

Brooding over so many subjects of anxiety, the minds of the inhabitants of the Mediterranean coasts fell a prey to the gravest pre-occupations. Men of science accordingly urged their various Governments to dispatch commissions of inquiry to the scene of the disturbance. The French administration determined that the brig *La Flèche*, commanded by Captain Lapierre, should reconnoitre the exact position of Ferdinanda, and enlighten navigators on the nature of this geological upheaval. M. Constant Prévost, a geologist of deserved repute, was appointed by the Academy of Sciences to sail on board *La Flèche*, and collect the data necessary for elucidating the question. M. Constant Prévost took with him M. Edmond Joinville, a skilful draughtsman, well acquainted with Sicily.

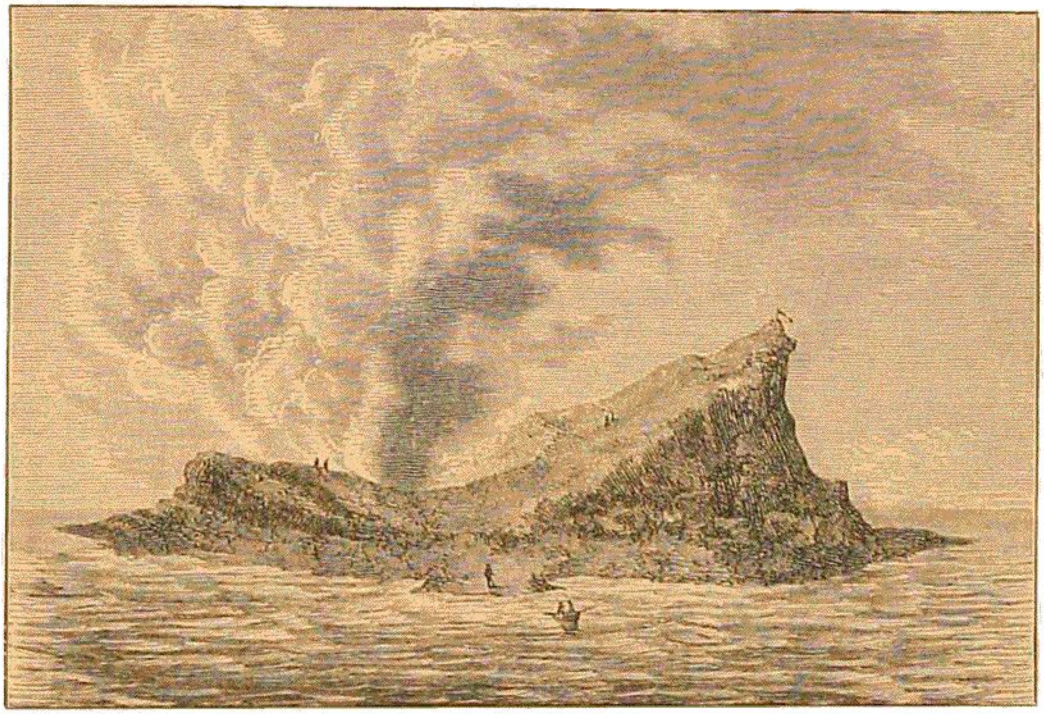

FIG. 159.—VIEW OF THE CRATER OF FERDINANDA ISLAND, SEPT. 29, 1831.
(*After M. Constant Prévost.*)

They quitted Toulon on the 16th of September 1831, and after traversing the channel which separates Corsica from Sardinia, arrived, on the 25th, in sight of the new volcano. They were compelled by a succession of storms to keep to windward until the 29th, when they succeeded in making the island.

It was then a black and desolate mass, 2250 feet in circuit and 230 feet in height. Two peaks, separated by a broad valley, rose above the crater. The shores were precipitous, and broken up into sharp jagged ridges, except on the side where clouds of vapour still issued in abundance from the soil. This vapour escaped simultaneously from an interior cavity and from the surface of the sea.

The brown and sometimes oily colour of the abrupt walls of the island apparently indicated a massive rock, such as basalt or serpentine. But later observations proved that it was wholly composed of loose and shifting materials.

At noon on the 28th, M. Constant Prévost in one of the ship's boats surveyed the breakers, which were produced by the billows breaking furiously on a narrow strand, terminated abruptly by a rapid incline. The water was of an acid taste, and a yellowish-green colour. Soundings taken not far from the shore discovered bottom at from forty to fifty fathoms.

On the same day, one of the brig's officers, accompanied by two sailors, succeeded in swimming ashore. He made his way to the crater, and brought back some specimens of the scoriæ, among which M. Prévost discovered a fragment of chalk.

The next day, the 29th, a boat, furnished with all the necessary instruments of observation, landed on the island, and M. Joinville made a drawing of the crater, which at the time was full of fresh water. It proved to be about 200 feet deep, and the water, of a reddish colour, showed a temperature of from 203° to 208° F. Through the quantity of bubbles it disengaged, it seemed to be boiling; but the same escape of bubbles was visible at every chink in the soil.

The sand, washed by the sea, was literally burning to the pedestrian's feet; the thermometer, when placed upon it, rose to 198° and 203° F. The water in its hollows seethed and hissed, though not quite at boiling point. M. Prévost, having thrust his hand into the sand, found it quite cool at a few inches in depth; but his finger coming in contact with a bubble of gas as it rose through the soil, was immediately burned. Each of these gas-bubbles, coming up from a great depth, projected, with a feeble report, a small puff of cinders and sand, representing thus a miniature vent of eruption.

Among these thousands of miniature volcanoes, M. Prévost noticed one which served to give his companions an idea of the formation of the island. It was about one foot in diameter, and five to six inches in height. This kind of molehill was formed by the sand and scoriæ which, incessantly launched to an elevation of two feet, fell back around the small centre of eruption. By crumbling away the sides of the cone, and imitating thus the action of the "sad sea-waves" on the new islet, M. Prévost made a crater in every respect analogous to that of Ferdinanda.

The gases escaping through the crevices of the soil were without odour and uninflammable; but, at a few paces from the crater, you might see volumes of sulphurous vapour evolving and depositing salt and sulphur. The shifting scoriæ and pulveruient materials which composed the soil were absolutely burning, and impeded movement. M. Prévost met with a few blocks which, in the middle, had all the appearance of lava. In a word, the French geologist arrived at this conclusion: that Ferdinanda was itself the mouth of a volcano, a *crater of eruption*—that is, an agglomeration, in the shape of a cone, of substances piled around a volcanic duct.

The sides of the islet inclined towards the interior had a slope of 45° towards the crater. Alternate and superimposed strata were discernible in their section; on the outward declivities, the stratification had taken place in an opposite direction. The precipitous formation of the cliffs seemed to be an effect of the action of the waves.

After a careful examination of these peculiarities, M. Prévost predicted that the clash and collision of the foaming waters would gradually lower the mass of scoriæ of which Ferdinando virtually consisted, until it became a submarine volcanic bank, supported by a cincture of rocks, which he supposed to have been elevated from the ocean-bed.

And in truth, towards the close of October, nothing remained to mark its former site but a small pile of sand and scoriæ; and six months afterwards it had wholly disappeared.

Early in 1832, Captain Swinburne found only a reef or sandbank in this locality. Towards the close of 1833, a dangerous reef, of an oval form, and about one thousand yards in length, was still in existence. About its centre, and at two fathoms under the water, was discernible a black rock, about 160 feet broad, encircled by sand and volcanic matter. Some 500 feet to the south-west of the great reef lay a second reef, surrounded, like the other, by deep water, and resulting from a second eruption,

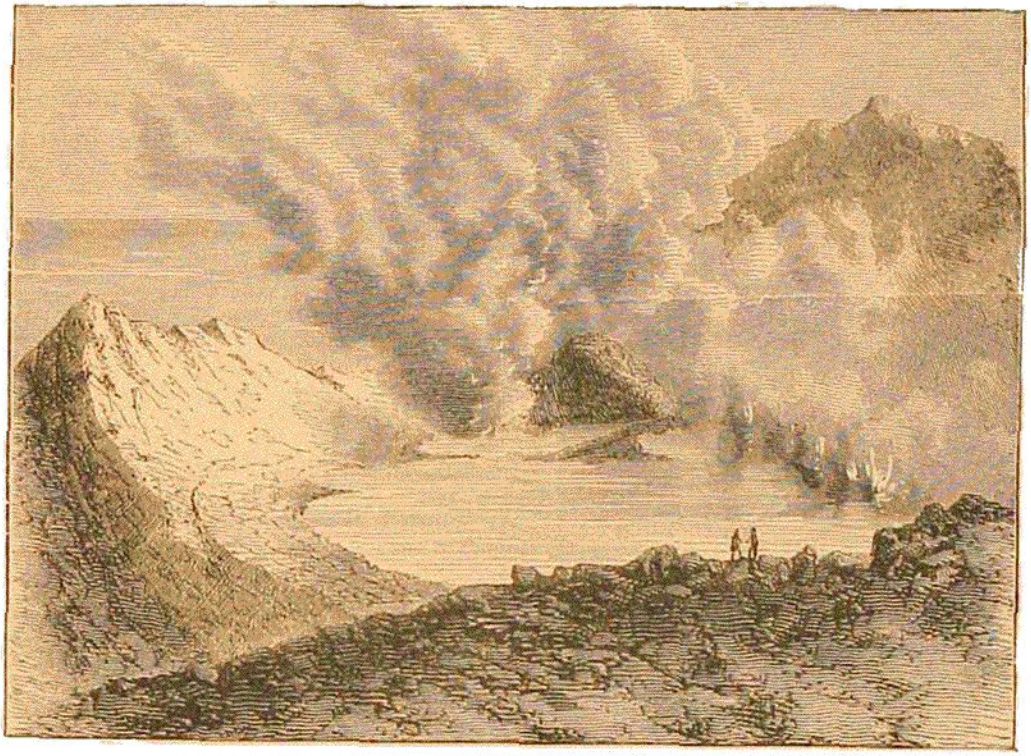

FIG. 160.—INTERIOR VIEW OF FERDINANDA ISLAND, SEPT. 20, 1831.
(After M. Constant Prévost.)

which had occurred, in August 1831, to the south-west of Ferdinanda. These rocks seemed to consist of solid lava embedding veins of augite.

A few years later, according to M. C. Vogt, who puts forward the fact in his "*Leçons de Géologie*," the sounding-lead gave no indication of any upheaval of the ocean-bed. The whole mountain of heaped-up scoriæ, nearly 800 feet in height, had been swept away by the waves, like the snow-wreath of a Highland glen by the winter's gales.

In M. Prévost's Memoir on Ferdinanda Island, he demonstrates, by a geological examination of the soil of the island Pantellaria, and of that of the coast nearest to the new-created isle, as well as by a host of historical testimonies, that for upwards of three centuries the area in whose centre the submarine volcano had arisen, like Venus Anyadomene from the bosom of the waves, has been one of the most convulsed regions of southern Europe; so much so, that the Abbé Ferrara, a man of high scientific acquirements, long ago foretold the event that has caused us moderns so much astonishment. Pantellaria was disturbed of old by severe shocks of earthquake; but after 1740, remained exempt from these terrible visitations until 1816, when certain movements were felt there which extended to the opposite coast of Sicily, and resembled the precursory signs, in 1831, of the birth of Ferdinanda Island. These shocks have invariably taken place in the direction of S.W. to N.E.—that is, in the linear direction of the Italian volcanoes.

It was reported, early in 1864, that Ferdinanda was again rising, and that the ocean-bed, at the present time, is not very far removed from the surface. Supposing the phenomenon to be real, there would be nothing in it to surprise us, after the retrospective *exposé* in which we have just indulged: it would be the preparation for a new eruption of the same submarine volcano, and would again afford, perhaps, the marvellous spectacle which, in 1831, the geologist Hoffmann contemplated at the hazard of his life.

More than one example might be given of the ephemeral appearance of an island through the effect of volcanic forces. It will be sufficient to name the island Ny-Oë, which rose off the coast of Iceland in 1783; and that of Hiera, off the volcanic island of Santorin, in 1480.

BOOK V.

THE FRESH WATERS.

The watery throng.
Wave rolling after wave, where way they found,
If steep, with torrent rapture; if through plain,
Soft ebbing; nor withstood them rock or hill;
But they, or under ground, or circuit wide
With serpent error wandering, found their way.

MILTON.

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BOOK V.

THE FRESH WATERS.

CHAPTER I.

SPRINGS AND NATURAL FOUNTAINS.

WHEN the moist air, propelled by the wind, wreaths along the flanks of a mountain, it gradually cools, and, at a certain elevation, condenses into cloud or mist. On rising higher it is resolved into rain.

If this rain should fall at a very great height, it congeals, and covers the mountain-summit with a thick veil of snow.

The cooling of the atmosphere in these upper regions—"the difficult air," as Byron finely calls it, "of the iced mountain-top"—is owing to the rarefaction which it necessarily undergoes in the higher aërial strata. A few hundred yards suffice, at this elevation, to effect a lowering of the temperature by one or more degrees. The reader will therefore comprehend how enormous a mass of snow must result from the condensation of the vapours floating in those great volumes of air, loaded with marine exhalations, which the winds carry to the crests of the Alps, the Andes, or the Himalaya. It is for this reason that the mountain-chains are the nursery or cradle of the greatest rivers. The Rhone and the Rhine, for example, owe their origin to the humid south-west wind which passes over the Alps; the basin of the Po is similarly fed by the breezes of the soutn; and the Danube by those of the east, which deposit their aqueous burdens on the great central chain of Europe.

Having thus descended on the heights, the water filtrates through the soil, reappearing at remote points and at a lower level under the form of *Springs*, which pour down into the valleys. At the same time, the annual melting of the snows which crown the soaring peaks with so radiant a diadem abundantly nourish the little rivers that flash and leap along the mountain-sides; so that the winter floods caused by the winter rains are followed by the summer floods arising from the universal thaw. Thus, between the atmosphere and the earth, enormous masses of vapour are in constant circulation, are incessantly falling in snow and rain to reascend continuously in vapour; this everlasting exchange or alternation producing the irrigation (*arrosement*) of the globe—a remarkable phenomenon, and an essential agent of its fertility.

The all-important part played by the Rains in the economy of Nature is finely set forth by Lucretius in the noble verses where he describes the various products of the earth, the fruits, the cereals, and the forest-greenery, springing into existence through the genial showers, by a kind of fecundation in the maternal bosom of the Earth.

> "Postremo pereunt imbres; ubi eos pater aether
> In gremium matris terraï præcipitavit?
> At nitidæ surgunt fruges, ramique virescunt
> Arboribus: crescunt ipsæ, fœtuque gravantur.
> Hinc alitur porro nostrum genus atque ferarum,
> Hinc lætas urbes pueris florere videmus,
> Frondiferasque novis avibus canere undique silvas."

> [At length the rains depart:—whither, O say,
> Into the womb of mother earth has Heaven
> Precipitated quick their genial wealth?—
> But see the glowing grain once more appears;
> Once more the boughs assume their leafiness,
> And flourish fair, and droop with heavy fruit.
> Hence does the human race—hence, too, the brutes,
> Derive their nourishment; and hence the towns
> Are busy with the hum of youth, while loud
> The forests echo with the song of birds.]

[Fully to comprehend the mechanism of this beautiful phenomenon, which is of such vital importance to the existence of men and animals, and without whose constant recurrence the earth would speedily become a dreary lifeless wilderness, the reader should bear in mind a few leading principles. 1st, He should remember that an uniform temperature of the atmosphere would be fatal to the production of dew, rain, snow, or hail; because the water absorbed by it in evaporation would incessantly descend in an imperceptible vapour, or, when the air was fully saturated, would cease to be absorbed. 2nd, The atmosphere absorbs and retains much more readily in warm than in cold air. 3rd, The air is warmest when nearest to the earth's surface. Every mountain-climber knows that the higher he ascends, the greater becomes the rarefaction, and, consequently, the coldness of the atmosphere. Now, when from continual evaporation the air is loaded with vapour, if its temperature be suddenly lowered by the influence of a cold current descending from above, or rushing from a higher to a lower latitude, its capacity to retain moisture is diminished, clouds gather, and rain falls. Air condenses as it cools: it resembles a sponge filled with water, and then vigorously compressed, which pours out the moisture its diminished capacity is unable to hold.

Thus simple and thus beautiful is the philosophy of rain. How black were earth without it! How all the beauty of colour would vanish from the landscape! What a constant depression would affect the mental and physical faculties of man, even supposing that under such altered conditions he could exist at all! A glory, a life, and a music would vanish from our world!

Reflecting upon these considerations, the reader will appreciate the philosophy that mingles with the poetry of the following passage:—*

"He can behold
Things manifold
That have not yet been wholly told—
Have not been wholly sung nor said.
For his thought, that never stops,
Follows the water-drops

* [Longfellow, "Miscellaneous Poems:" *Rain in Summer*.]

Down to the graves of the dead,
Down through chasms and gulfs profound,
To the dreary fountain-head
Of lakes and rivers underground;
And sees them, when the rain is done,
On the bridge of colours seven
Climbing up once more to heaven,
Opposite the setting sun.

"Thus the Sun,
With vision clear,
Sees forms appear and disappear,
In the perpetual round of strange,
Mysterious change
From birth to death, from death to birth;
From earth to heaven, from heaven to earth."]

The waters which are condensed in the bosom of the atmosphere, and which descend upon the earth in the shape of rain, are, chemically speaking, almost pure. They are named *fresh waters*, in opposition to the *salt waters* of ocean.

[Rain is a capricious phenomenon, which it seems very difficult to fetter with any general laws. In certain parts of the globe, which are known as Rainless Regions, it seldom or never falls: such is the case in the valley of the Colorado and Columbia, in North America; on the Peruvian coast of South America; in the Sahara Desert of Africa; and the Desert of the Great Gobi, in Asia. In other places, as in Patagonia, it rains almost daily.

The quantities descending even in the more temperate climates are very irregular, and differ in successive years. They differ also at places situated within a comparatively short distance. Thus, in England, a rainfall of an inch in one day is considered very heavy. But in the Scotch Highlands it will often exceed three inches. On the 5th of December 1861, 12½ inches fell at Portree, in the island of Skye, in thirteen hours. On the 27th of November 1845, at Scathwaite, in Cumberland, 6.62 inches fell.

The heaviest rainfall is, of course, found in tropical countries, but undergoes considerable modification from local causes, such as the contiguity or absence of mountains, forests, swamps, or great lakes. The maximum for the whole world is met with on the Khasia Hills, where in a single twelvemonth it reaches the astonishing amount of 600 inches. But, at twenty miles inland, the rainfall sinks to 200 inches; at Gowadatty, in Assam, it is only 80 inches; at Madras, 45 inches; at Bombay, 75 inches; at Seringapatam, only 24 inches.

We subjoin a table of the rainfalls at various points of the globe, which will show the capricious character of this meteorological phenomenon :—*

	ANNUAL RAINFALL IN INCHES.
Vera Cruz, South America, ...	183
St. Benoit, Isle of Bourbon, ...	163
Caraccas, South America, ...	155
Island of St. Domingo, ...	107
Pernambuco, ...	106
George-town, Demerara, ...	100
Sierra Leone, Africa, ...	87
Canton, China, ...	78
Barbadoes, West Indies, ...	72
The Bahamas, Atlantic Ocean,...	52
Mobile, Alabama, United States, ...	64
New Orleans, Louisiana, United States,...	52
Fort Vancouver, British Columbia, ...	47
Valley of the Rhone, Europe, ...	30
Great Britain, west, inland, ...	30 to 45
Do., east, inland, ...	20 to 28
Do., lake districts, ...	85 to 150
France, Nantes, ...	51
Do., average, ...	30]

A portion of the water which falls in the shape of dew, rain, or hail, is evaporated anew by the terrestrial or solar heat; another portion glides over the surface of the ground, and descends its slopes in tiny rills. These are the "wild waters," which one sees flowing over the soil after a heavy shower. A final portion infiltrates through the earth, penetrates it at variable depths, and collects in subterranean masses, which make their way between the superimposed strata. Such is the origin of the bed or sheet of water which exists at a moderate depth in all permeable strata, and feeds the wells of our houses. In many localities, this bed is very near the surface. At Paris, for instance, you cannot dig some eighteen or twenty feet

* [M. Belgrand states that, between October 17th and 18th, 1868, there fell in eight hours, at Clermont l'Herault, in France, more than seven inches of rain; and, according to M. Renan, on May 20th, at Moliting, near Prades, there fell twelve inches in ninety minutes.—"The Student," vol. i., Jan. 1869, p. 480.]

without coming upon it; and the establishment of sewers under the streets of the capital necessitates, as a preliminary operation, the exhaustion of the aquiferous strata of the soil.

In this cause, also, we must seek the origin of *springs*, or *natural fountains*. These, in fact, are simply the pluvial waters re-united in subterranean courses, and emerging into the light at a point below their first level. The water furnished by the springs, added to the so-called "wild waters," give birth to brooks, which, when combined, form *streams* and *rivers*.

The two latter denominations are applied to water-courses of a more or less considerable volume. The borders of a running stream are called its *banks*. The right and left bank are on the right and left hand respectively of a spectator standing at the source, and looking in the direction of the current. When the bank is steep it is sometimes called a *cliff* or *scaur;* the level border of a river is, in Scotland, named the *haugh*. The *bed* of a river is the space ordinarily covered by its waters. Streams which precipitate themselves impetuously from mountains, through broken and rugged ravines, are designated *torrents*.

When the waters can find no issue, or make for themselves no channel, they expand into a *marsh*, *swamp*, or *morass*. These accumulations of stagnant waters are generally produced by water-courses checked in their advance by a horizontal or ascending surface; sometimes they are formed *in situ* by the gathering of spring-waters, which force a passage through the soil. If the ground subsides into larger or smaller depressions in which the water is able to collect, we witness the result in *mountain-lakes*, *basins*, or *ponds*—natural reservoirs, which are situated at all degrees of elevation. It is no infrequent circumstance for a river to traverse these basins, its waves constantly refreshing and renewing those of the lake or pond.

According to the preceding division of the fresh waters, we shall have to consider successively—*springs*, *rivers*, and *lakes*.

Let us commence with an examination of the *springs*, or *natural fountains*.

These more or less ample threads of silver water which escape from the chinks and crevices of a solitary rock, or, like the Thames, from the soil of a verdant meadow, form in a landscape one of its most pleasing and poetical features. By the translucency of their waves, which have sprung from the mysterious depths of the earth—by the musical murmur of their unbroken flow—and by the rich ferns, grasses, and flowers, or delicate velvety mosses which clothe their banks and derive nourishment from their copious freshness—they exercise a peculiar and powerful influence upon the soul of man. The genial moral impression which they awaken in us, has rendered famous certain springs of antiquity. Who knows not the source of Hippocrene, situated at the foot of the haunted slopes of Mount Helicon; or

"The inspired
Castalian spring,"

in the sacred valley of Parnassus, both consecrated to the Muses of Paganism? A mean and gloomy village marks to-day the site where formerly stood the renowned Delphos, and that mysterious temple of Apollo where the Pythoness drew her inspiration from the sweet "waters of Castaly." The fountain, immortalized by so many memories of classic Greece, is now dedicated to St. John; near its margin a small chapel has been erected; a fig-tree, surrounded by bushes and thick grasses, overshadows its basin. The freshness of its waters is so remarkable that only to dip your hand into them brings on a fit of shuddering. Did not the Pythoness mistake for the divine inspiration that access of fever which the icy touch of this cold wave could not fail to produce?

[Shelley, in bright-coloured verse not unworthy of his theme, has celebrated one of the ancient fountains named after the nymph Arethusa. It was situated in Eubœa:—*

"Arethusa arose
From her couch of snows
In the Acroceraunian mountains,
From cloud and crag
With many a jag
Shepherding her bright fountains.
She leapt down the rocks
With her rainbow locks
Streaming among the streams;
Her steps paved with green
The downward ravine
Which slopes to the western gleams:
And gliding and springing,
She went, ever singing,
In murmurs as soft as sleep;
The earth seemed to love her,
And heaven smiled above her,
As she lingered towards the deep."]

Another famous fountain of Arethusa is that in the island of Ithaca, where the flocks of Ulysses quenched their thirst. "Go," said

* [Shelley, "Poetical Works," ed. 1853, p. 514.]

the goddess Calypso to the hero, when about to return to his kingdom, "go, and first find him who guards the herds near the Coracian rock where flow the black waters of Arethusa." It is situated near the south-eastern extremity of the island at a distance of three leagues from the sea, and consists of a narrow basin, at the summit of a lofty ravine, fed by waters which trickle from the overhanging rocks. The traveller, seated near the ruins of the temple which formerly covered the spring, beholds the soft slopes of the valley richly mantled with large-leaved plants and odoriferous bushes; at a distance, through an opening in the "verdurous gloom," his eye catches sight of the azure sea. From the crest of the rock is unrolled an extended panorama, embracing the blue mountain-peaks and fairy isles of Greece. Into this enchanting solitude came the hero of the Odyssey, three thousand years ago, to take his rest on the margin of the spring which to-day refreshes the Ithacan goat-herds. Dr. Dodwell praises its waters as clear, fresh, and agreeable to the taste; they issue, he says, from a massive crag, still called Korax (Κόραξ). The basin is about three feet and a half in depth; it has been surrounded with a parapet, to prevent the water from overflowing. On issuing from an orifice pierced in the encircling wall, it flows into a trough for the benefit of the thirsty cattle. In 1798, the island of Odysseus was in the possession of the French, and they have left a souvenir of their brief sojourn in the inscription which still may be read on the rock of Arethusa, and which recalls the troubled associations of a stormy time: "Liberté, Egalité, Fraternité."

Everywhere beneficent, springs acquire a peculiar importance in the sterile deserts of Africa; where, in the grim solitude, they give life and freshness to those islands of verdure which are called *oases*. The Bible speaks of the fountains of Marah and Elim, in the desert of Arabia; whose brackish waters the Israelites corrected, as the Arabs still modify those of the desert, by mixing them with the juice of certain plants.

[Palestine, according to Dean Stanley,* is a land of springs; a land of brooks

* [Dean Stanley, "Sinai and Palestine," pp. 122, 123.]

of water, of fountains and depths that spring out of "plains" and "mountains." This mountainous character—this abundance of water both from natural sources and from the clouds of heaven—was absolutely peculiar to Palestine amongst the civilized nations of the East. "Feeble as its brooks might be—though, doubtless, they were then more frequently filled than now—yet still it was the only country where an Eastern could have been familiar with the image of the Psalmist: 'He sendeth the springs into the valleys, which run among the "mountains."' These springs, too, however short-lived, are remarkable for their copiousness and beauty. Not only not in the East, but hardly in the West, can any fountains and sources of streams be seen so clear, so full-grown even at their birth, as those of the Kishon, the Jordan, and the whole of the Jordan valley. Wales or Westmoreland are, doubtless, not regarded as fertile regions; and the green fields of England, to those who have come fresh from Palestine, seem, by way of contrast, to be indeed 'a land of promise.' But transplant Wales or Westmoreland into the heart of the Desert, and they would be far more to the inhabitant of the Desert than to their inhabitants are the richest spots of England. Far more; both because the contrast is in itself greater, and because the phenomena of a mountain country, with wells and springs, are of a kind almost unknown to the dwellers in the deserts or river-plains of the East."]

Springs are found in all varieties of soil and at all degrees of elevation; but are most numerous in the stratified formations, which permit the waters to assemble together, and to excavate for themselves a subterranean channel.

The granite and schistose mountains give birth to numerous springs, but their volume is generally weak. The ancient rocks, such as the porphyries and the trachytes, also produce a considerable number. Many are found, for example, in the chain of the Mont Dore, where they frequently tumble and flash in beautiful cascades.

Springs are also met with at the base and in the neighbourhood of volcanoes, but rarely on the volcanic mountains themselves; a fact which is attributable to the porosity of the lavas and scorified rocks, which allows a ready passage to the water, and suffers them to escape into the lower strata of the soil.

The frequency, but comparative insignificance, of the springs which issue from the granite, gneiss, and mica-schist, is readily explained by the fissures and crevasses of these strata, which, dividing the infiltrating water into an infinite number of crystal threads, permit it to percolate in every direction. Nevertheless, as the granitic mountains are usually of a lofty elevation, their snowy summits give birth to copious springs, which speedily swell into great rivers. The Rhone, the Po, the Rhine, the Danube, have their origin in the High Alps. In the limestone mountains, consisting of soft, friable rocks, horizontally stratified, the water easily penetrates through the vertical chinks, and collects in subterranean reservoirs, or caverns, which are found in great numbers in the limestone formations. It is for this reason that springs are sometimes of so ample a volume, and immediately expand into powerful water-courses. Fed by a myriad tiny tributaries, they widen and deepen into rivers as soon as they emerge from their hiding-places. Such is the case, in the Jura, with the Loire, which no sooner issues into daylight than it is employed as the motive-power of several mills; such, too, is the case with the Fountain of Vaucluse, near Avignon, the Fountain of Nîmes, and a great number of other springs in France.

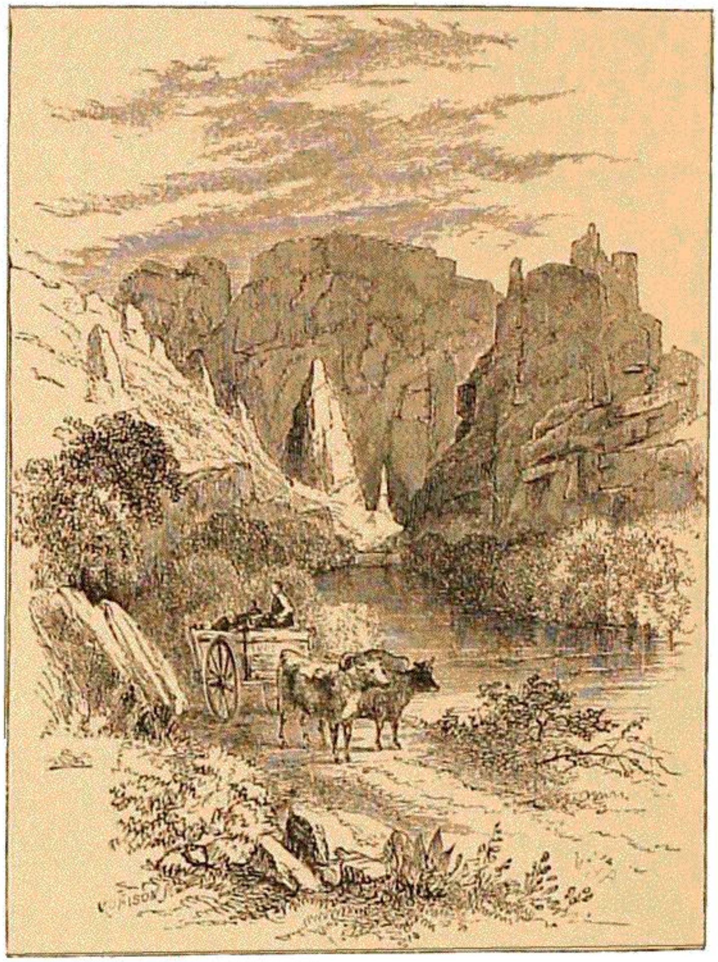
Immortalized by the loves of Petrarch and Laura, the fountain of Vaucluse rises at a distance of five leagues from Avignon, and about one thousand yards from the village of Vaucluse. Above the village he will catch sight of some ruins, which are absurdly named the *Château of Petrarch*. He then enters into a narrow valley, bordered by steep rocks, which abut on a precipitous wall, terminating the valley abruptly like a *cul de sac;* hence its name of Vaucluse (*vallis clausa*). The spring rises at the foot of this wall. A score of torrents leap forth and sparkle, dashing headlong in noisy rage, and forming the river Sorgue. Below the wall that shuts in the valley lies a circular basin about seventy feet in diameter, surrounded by enormous rocky masses, and hollowed out in the fashion of a funnel, within which the waters are maintained at varying levels. The bottom of this abyss has never been discovered. Its excavation extends far under the rocks, and vast subterranean channels conduct to it the supplies resulting from the liquefaction of the snows. The blocks piled up in front of the basin are covered with a blackish-green moss, which grows on a white powdery limestone earth deposited by the waters.

On the border of the basin was erected, in 1809, a column with this inscription:—"To Petrarch." Though modelled in imitation of the Column of Trajan at Rome, it appeared so paltry in effect when compared with the grandeur of the surrounding scenery, and was so dwarfed by the elevation of the immense rocks heaped up in the neighbourhood, that it was found necessary to remove it. Accordingly, it was transported to the entrance of the village, where it is still standing.

Who will not remember that it was in this delightful seclusion the immortal Petrarch sought the consolations of solitude and meditation?

"In quest," he says, in his "Epistle to Posterity," "of a retreat which should serve me as an asylum, I found, about fifteen miles from Avignon, a very narrow but solitary and delectable valley, named Vaucluse, in whose recesses rises the Sorgue, the most celebrated of fountains. Fascinated by the charms of this locality, I retired thither with my books. My narrative would be too long if I recounted all that I have done in this solitude, where I have passed a great number of years. I may give the reader an idea of it by saying, that of all the works which have issued from my pen there is not one but was there written, conceived, or commenced; and these works are so numerous that at an advanced age they still occupy and fatigue me. . . . .

"My retreat has inspired me with reflections on the solitary life and repose of cloisters, of which I have recorded my eulogium in two separate treatises. Finally, it is under these lonely shades that I have endeavoured to extinguish the devouring fire which consumed my youth. Thither I withdrew myself as into an inviolable asylum: imprudent! the remedy aggravated my sufferings. Finding no one, in a solitude so profound, to arrest the progress of the disease, I suffered all the more keenly. And the fire of my heart bursting its bonds, I made these valleys resound with my melancholy cadences, which, according to indulgent readers, are not without a sweet melody of their own."



(*From a photograph by Baldus.*)

The effect, sometimes majestic, sometimes smiling and picturesque, of the fountain of Vaucluse, is explained by the alternations which take place in the irruption of the waters. At the actual point of emergence an enormous rock rises in an unbroken mass, overhanging in a threatening manner the tourist's head. If the waters are low, the tourist sees at his feet a horrible precipice, only partially filled with water; if they are high, he has before him a cascade dashing over a succession of ledges a formidable "sheet of silver," which breaks and shatters into spray with awful roar.

In the ordinary annual inundations, the water is divided by falls of unequal height among the crags and rocks, which are generally encrusted with a blackish-green moss; the aspect of the cascade is then most richly diversified in form and colour. But after heavy rains, owing to the abundance of the water, it is a veritable river which issues from the cliff, like an immense mantle of sapphire fringed with silver foam.

The fountain of Nîmes, celebrated by Ausonius—

"Non Aponus potu, vitrea non luce Nemausus purior"—

rises at the foot of a hill about 230 feet in height, on whose summit is planted the ancient but dilapidated monument of antiquity known as the *Tour-Magne* (Turris Magna), variously regarded by archæologists as a tomb, a pharos, or a watch-tower. The waters were utilized by the Romans for their public baths, whose ancient buildings may still be seen above the regular basins constructed, in the reign of Louis XIV., to transform the banks of the stream into a magnificent ornamental promenade. To the left of the great basin lie the ruins of the so-called *Temple of Diana*. The hill which impends over the fountain of Nîmes is now clothed with leafy trees, forming sweet and grateful alleys, which ascend, with a gentle inclination, to the *Tour-Magne*. The entire scene, with its happy mixture of Art and Nature, is singularly pleasant and picturesque.

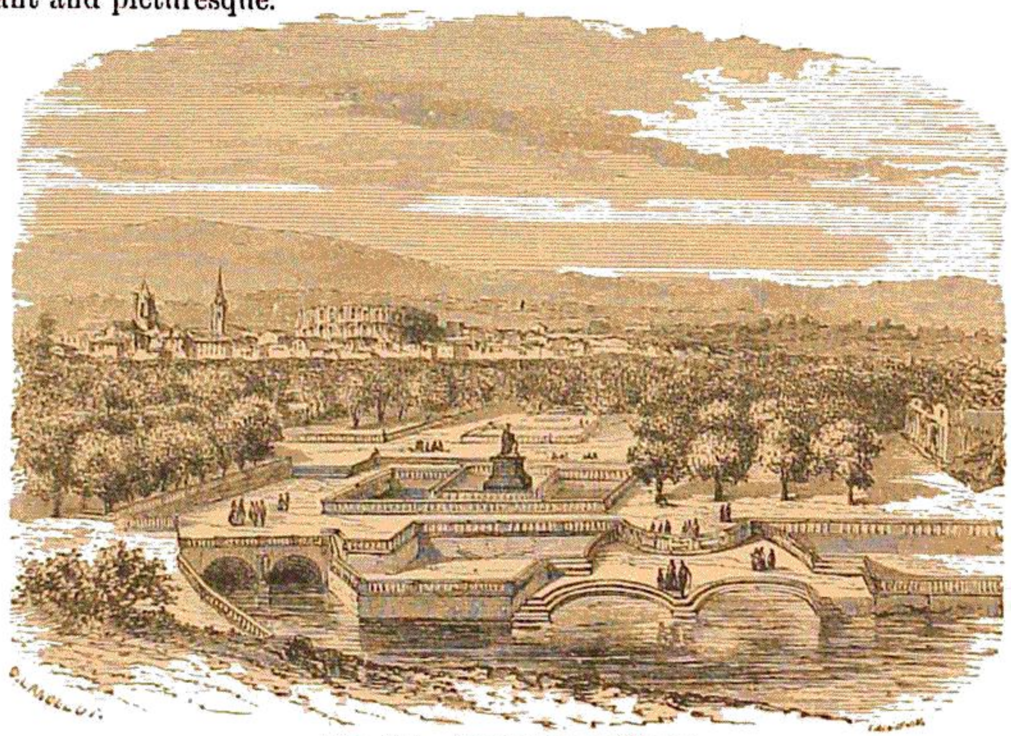


FIG. 162.—FOUNTAIN OF NÎMES.

[Among inexhaustible springs, one of the most celebrated is that of St. Winifred's, at Holywell, in Flintshire. Its source is in a bed of shingle at the foot of a steep hill, whence it rushes with great impetuosity, flowing into and over the main basin into a smaller one in front. It is enclosed by a building in the Perpendicular Gothic style (dating from the beginning of the reign of Henry VII.), which "forms a crypt under a small chapel contiguous to the parish-church, and on a level with it, the entrance to the well being by a descent of about twenty steps from the street. The well itself is a star-shaped basin, ten feet in diameter, canopied by a most graceful stellar vault, and originally enclosed by stone traceried screens filling up the spaces between the supports. Round the basin is an ambulatory similarly vaulted."*

The ornamental sculpture consists of quaintly carved animals and the rich armorial bearings of various benefactors of the shrine; as Catharine of Arragon, Margaret Tudor, and different members of the Stanley family.

The stones at the bottom of the well are covered with the fragrant *Byssus iolithus*, and a species of red *Jungermannia* (Scale-moss), locally known as St. Winifred's hair and blood.

The water was formerly held in high repute for its curative powers; and when Pennant visited it, in the last century, he found the vaulted roof hung with the crutches of grateful cripples. "In the summer," he says, "still a few are to be seen in the water, in deep devotion, up to their chins for hours, sending up their prayers, or performing a number of evolutions round the polygonal well; or threading the arch between well and well a prescribed number of times. A crowned head," he adds,† "in the last age dignified the place with a visit. The prince who lost three kingdoms for a mass, paid his respects, on August 29th, 1686, to our saint; and received as a reward the very shift in which his great grandmother, Mary Stuart, lost her head."

The quantity of water furnished by the well is computed at 21,000 gallons per minute. It flows into the Irish Sea, which is about half a league distant, and in its course sets in motion ten or eleven mills.]

In the south of Mexico, on the bank of the river Zuni, or *Rio del Pescado*, is another very celebrated spring, which bears the name of the *Sacred Fountain*. The basin receiving its waters measures 26 feet in diameter and 14 feet in depth.

When the water, descending from a certain elevation, infiltrates

* ["Archæological Journal," iii. 148.]
† [Pennant, "A Tour in Wales" (ed. 1778), p. 36.]

through a porous stratum, which is in itself confined between two impermeable beds, at a gradually rising inclination, it tends to mount upwards, in obedience to a well-known hydrostatic law; and if it finds an opening in the upper stratum, it escapes violently, producing what is called a "jet" or "leaping fountain." Examples are found in the sources of the Loiret and the Touvre, which issue boiling from profound gulfs, regarded by the natives as bottomless abysses. These springs almost immediately after their emergence from the earth are deep enough to carry boats. The Touvre, an affluent of the Charente, furnishes the latter river with half its waters. It is formed of three springs opening in the bed of the ravine at about eight miles east of Angoulême. At the point of confluence of these springs, the channel is 320 feet wide by 7 feet deep. The forges and foundries of Ruelle are situated along its banks for an extent of nine miles.

At the castle of Sozay, near Clamecy, is a fountain of this kind, named *The Abyss*, which issues from a very deep well about 13 feet in diameter.

On the shore of Alvarado, in the Gulf of Mexico, is a hill of sand some 140 feet high, on whose summit rises a beautiful jet of pure limpid water, which furnishes the vessels of the port with their supplies.

Numerous similar fountains are scattered over the peninsula of the Morea.

Sometimes they are found escaping from the very bosom of the sea, as in the Bay of Jagua, on the warm southern coast of Cuba.

At a distance, says Humboldt, of two or three leagues from the land, springs of fresh water rise in the midst of the salt water. Their eruption takes place with so much force, that it is dangerous for small boats to approach their vicinity, on account of the waves, which are high and rolling, and clash against one another with surprising violence. Sometimes the coasting vessels draw near, however, in order to take on board a stock of fresh water, which is much sweeter than can be obtained from wells of a very great depth.

A remarkable example of a leaping fountain in the midst of the sea is found in the Gulf of Spezzia. The water mounts above the waves, and forms a kind of dome, more than 65 feet in diameter, and from 12 to 16 inches in height: in the centre may be observed a great number of vertical jets, of such impetuosity that the course of a boat can with difficulty be arrested in the midst of their liquid elevation. One hundred and seventy feet distant from the shore Spallanzani sounded the depth, and obtained bottom at 50 feet.

There are many springs, and especially these jets, distinguished by an intermittent character. Philosophers attribute the phenomenon to the presence of subterranean cavities, in which the water accumulates, and returns through canals or ducts curved in the form of siphons.

If the quantity of water *flowing out* is greater than that which *flows in* from the upper regions, there comes a time when the level of the reservoir sinks below the top of the siphon: then the spring ceases to flow until the reservoir is filled anew.

These interruptions and returns are frequently as regular in their periods as the tides of ocean. Pliny has described the periodical fountain of Como, in Milan, whose intermissions occur hourly. That of the Abbey of Haute-Combe, in Savoy, appears every twenty minutes, in the interior of the mountain of Dent-du-Chat, through a vertical canal which it has wrought of calcareous secretions. It is situated at about 420 feet above the Lake of Bourget.

We may also refer to the spring of the *Puits-Gros*, a short distance from Chambéry, which flows at sunrise and sunset, at noon and midnight; that is, at intervals of six hours.

The fountain of Boulaigne, near Fressinet, in the Coyrons mountains, sometimes ceases for twenty years; then it flows for several months, stops or trickles hour by hour, and ends in again disappearing for a considerable period.

The Pool of Siloam is a basin situated at the foot of Mount Sion, in the celebrated valley of Jehoshaphat, and fed by the waters of the Virgin's Well, which descend into it by means of a subterranean canal pierced through the rock. The basin is surrounded by masonry, and measures 56 feet in length by 20 feet in breadth. The waters flowing from it are employed to irrigate the fruit-gardens situated along the valley. This fountain dries up and flows again at regular intervals. The people of the country say that it is inhabited by a dragon, and only flows when the dragon is lulled asleep. One could wish for a theory less eminently Oriental.

[All accounts, says Dean Stanley,* combine in asserting that the water of the pools of Siloam proceeds from a spring or reservoir beneath the Temple-vaults. There was no period of its history when such a provision would not have been important to the Temple, for the ablutions of the Jewish no less than of the Mussulman worship; or to the city, which else was dry even to a proverb. It was the treasure of Jerusalem, its support through its numerous sieges, the "fons perennis aquæ" of Tacitus; the source of Milton's

"Brook that flowed
Hard by the oracle of God."

But more than this, it was the image which entered into the very heart of the prophetical idea of Jerusalem. It is the source of all the beauty and freshness of the vale of Hinnom. And in Ezekiel's vision, adds Dean Stanley, the thought is expanded into a vast cataract flowing out through the Temple-rock eastward and westward into the ravines of Hinnom and Kedron, till they swell into a mighty river, fertilizing the desert of the Dead Sea.]

We may also mention the spring of *Fontesorbe*, near Belesta, in the Pyrenees; the *Bullerbronn*, in Westphalia, which stops twice a

* [Dean Stanley, "Sinai and Palestine," pp. 180, 181.]

day; the spring of *Fonzanches*, in Languedoc; that of *Madame* and *Boulidou* (which flow thirty-six times in twenty-four hours), on the banks of the Gardon; that of *Engstler*, in the canton of Berne; those of *Torbay*, *Buxton*, and *Giggleswick*, in England; and of *Dixon's* and *Northwill*, in America.

In this category may likewise be ranged the natural wells which at certain epochs overflow; such as the *Frais-Puits*, near Vesoul, in France. In 1557, the town of Vesoul, then being beleaguered, was delivered by a sudden overflow of this spring, which inundated the whole district, and swept away the works of the besiegers.

Near Brest, and about 80 feet from the sea, is a well, whose level rises as the sea sinks, and sinks as the tide rises. In the Bermuda Islands, on the contrary, the fresh-water springs, as well as the salt, rise and sink simultaneously *with* the tide.

The latter fact may be accepted as a proof that springs sometimes originate in the capillary infiltrations of the ocean waters. The ancients, and even some modern writers—among others, Descartes—were of opinion that all springs were produced by the penetration of the sea-waves into subterranean cavities. Having arrived at this point, they are heated by the action of the central fire and reduced into vapour, which, rising into the upper strata, are there condensed, and afterwards emerge in springs and fountains. Like everything which sprung from the imagination of Descartes, it was a subtilely reasoned theory, but as an hypothesis superfluous, for the quantities of rain which annually fall upon the earth suffice, and more than suffice, to account for the origin of all our water-courses.

Bernard Palissy is one of the first observers who suspected the true cause of streams and springs.

"The reason," says the immortal potter, in his book, "Sur les Eaux et Fontaines," "why more rivers and fountains proceed from mountains than from all the rest of the earth, is simply because the mountain-rocks retain the rain-waters as a vessel of brass might do;

and the said waters, falling on the said mountains, through chinks and crevices, constantly descend without encountering any impediment, until they have found some place composed of stones or rocks, lying close together, and thoroughly compact; and then they repose upon this bottom, and having discovered some channel or duct, they issue in fountains, or in brooks and rivers, according to the dimensions of the openings and the reservoirs."

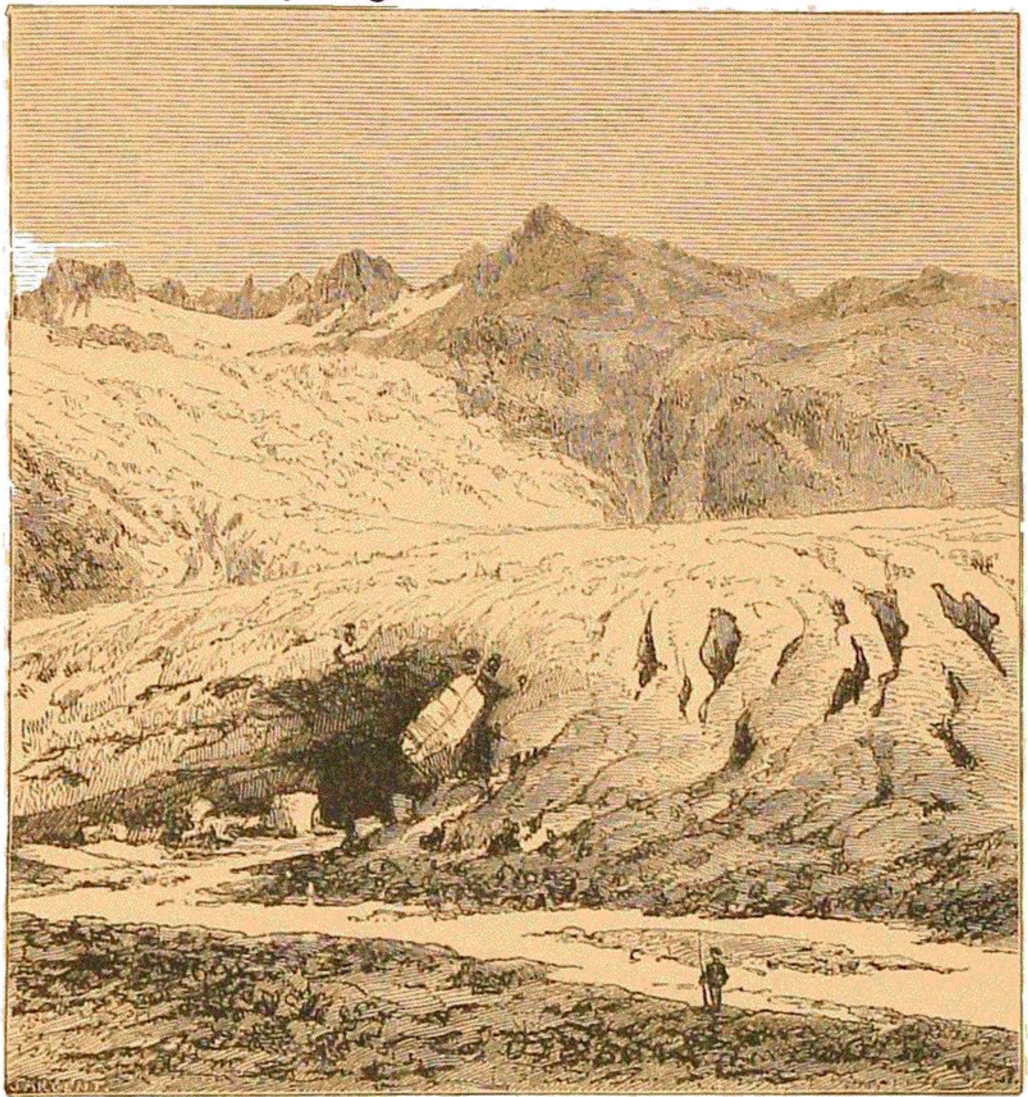


FIG. 163.—SOURCE OF THE RHONE. (*From a Photograph by Ferrier.*)

The subterranean waters which re-appear in the light of day by following the strata superimposed upon one another, are due, as we have said at the commencement of this chapter, to the condensation of the vapours upon the mountains, to the rains, and the melted snows. Sometimes a river emerges directly from beneath a glacier, as is the case, for instance, with the Arveiron, whose source is situated at the base of the Glacier des Bois. The source of the Rhone, as we have described in a preceding chapter, is at the base of an Alpine glacier.

Subterranean water-courses which glide between two impermeable strata may be brought to the surface by means of deep narrow orifices excavated in the soil; a work, at times, of extreme difficulty. The famous *Artesian Well* is so named from the province of Artois, in France, where it has been in use from time immemorial. The ascending force of water in a well of this description increases in proportion to the elevation of the reservoir: their abundance in certain countries is a proof of the existence of veritable subterranean rivers.

Soils consisting of strata alternately porous and impermeable are those in which the well-digger's chances of success are greatest. Often in these deep beds numerous sheets of water exist at different levels, and are endowed—so to speak—with very unequal ascending powers.

The empirical art of discovering springs gave rise to the strange practices of the *diviners*, who were much in favour with the vulgar up to the very close of the last century.

[Divination by the rod or wand is an imposition of the highest antiquity. Hosea reproaches the Jews for believing in it:—"My people ask counsel at their stocks, and *their staff* declareth unto them" (iv. 12). It was a custom in vogue among the Chaldeans, among almost every nation with any pretence to scientific knowledge, and also among the wilder, ruder races, as the Alani and the ancient Germans.

In our own country it prevailed from a very early period. Dr. Henry states that after the Saxons and Danes had embraced Christianity, the priests were commanded by their ecclesiastical superiors to preach very frequently against *diviners*, sorcerers, augurers, and "all the filth of the wicked and the dotages of the Gentiles."*

It was still in repute in the day of the Commonwealth. The

* [Henry, "History of Great Britain," ii. 550.]

following is from a book of Epigrams, by S. Sheppard, published at London in 1651 :—

"*Virgula divina* :—

"Some sorcerers do boast they have a rod,
Gathered with vowes and sacrifice,
And (borne about) will strangely nod
To hidden treasure where it lies;
Mankind is, sure, that rod divine,
For to the wealthiest ever they incline."

The divining rod, *virgula divina*, or *baculus divinatorius*, was a forked branch of hazel, cut in the form of a Y, and was supposed to reveal not only the latent spring, but mines of gold or silver, lead or coal, and any other concealed treasure. It was employed in the following fashion :—The person carrying it walked very slowly over the supposed localities of the springs or mines, until the effluvia exhaling from the metals, or the vapour from the water impregnating the wood, made it dip or incline—which was the indication of the diviner's success.*

The following extract from the *Gentleman's Magazine* † will amuse the reader :—

"So early as Agricola the divining rod was in much request, and has obtained great credit for its discovery where to dig for metals and springs of water; for some years past its reputation has been on the decline, but lately it has been revived with great success by an ingenious gentleman, who, from numerous experiments, hath good reason to believe its effects to be more than imagination. He says that hazel and willow rods, he has by experience found, will actually answer with all persons in a good state of health, if they are used with moderation and at some distance of time, and after meals, when the operator is in good spirits. The hazel, willow, and elm are all attracted by springs of water: some persons have the virtue intermittently; the rod, in their hands, will attract one half-hour, and repel the next. The rod is attracted by all metals, coals, amber and limestone, but with different degrees of strength. The best rods are those from the hazel, or nut tree, as they are pliant and tough, and cut in the winter months. If a shoot that terminates equally forked is not to be met with, two single ones, of same length and size, may be tied together with a thread, and will answer as well as the other."]

The art of discovering springs is, at the present time, a simple application of the principles of geology and hydraulics. Nevertheless, to practise it successfully, a special ability is indispensable; a kind of *coup d'œil*, like that which distinguishes a

* [Brande, "Popular Antiquities," ed. 1855, iii. 332–336.]

† [The *Gentleman's Magazine*, Nov. 1751, xxi. 507.]

great physician in the accuracy of his diagnosis. In our own days, the Abbé Paramelle has made of hydroscopy an absolute profession. By examining the direction and nature of the superficial strata, the vegetation by which they are covered, the position of wells or natural watercourses, he frequently succeeds in divining the traject of the subterranean waters, and excavations made according to his instructions have often proved his sagacity. A rival of the Abbé Paramelle is the Abbé Richard, who for some years has pursued the same career, and has displayed in many foreign lands his *hydroscopic* skill.

Natural *mineral waters* are those which hold in solution recognizable quantities of mineral substances, with which they become charged during their subterranean traject. They may be divided into four classes :—1. *Saline Waters*, as those of Carlsbad and Kissingen; 2. *Alkaline Waters*, as those of Vichy and Tœplitz; 3. *Chalybeate Waters*, as those of Bath, Spa, and Pyrmont; and 4. *Sulphurous Waters*, as those of Baréges and Aix-la-Chapelle. The medicinal properties of these various categories of mineral waters are known to everybody.

When the temperature of the natural waters exceeds that of the surrounding atmosphere, they are called *Thermal Waters*. Sometimes their degree of heat is very elevated, as may be seen in a previous chapter. Humboldt discovered in the neighbourhood of Valencia, in America, a spring which raised the thermometer to 210°. M. Boussingault, in the same part of the world, observed three springs situated at different heights: that of Trincheras, near Puerto-Cabello, almost on the sea-level, showed a temperature of 206°; that of Mariana, nearly 2000 feet above the sea, a temperature of 148°; and that of Onoto, at 2300 feet, only 113°.

Thermal waters bubble up in every variety of soil, and originate even in the midst of rivers and in the bosom of the sea. The Rhone, near St. Maurice, and the Gulf of Naples, offer examples of these remarkable locations.

Their heat arises from the following cause: penetrating deeply into the interior of the earth, they become heated by contact with the rocks which the vicinity of the central fire renders burning. At a depth of 9000 feet, as we have said in a preceding chapter, the strata have a temperature of 100° : accordingly, if through a fissure of sufficient length the rain-waters descend to this depth, they are heated up to 100° : the heat increases their lightness—they rise to the upper portion of the column of water—and if on their passage they encounter a free channel opening externally, they come forth into the light of day with a more or less elevated temperature.

Thermal waters abound in volcanic formations ; because the eruption of igneous matter, fused in the interior of the globe, has partially opened up the vertical or sinuous channels by which the waters penetrate to great depths, are heated at these points, and escape into another part of the soil, with the elevated temperature obtained from the low-lying strata, and the sulphurous compounds which they have absorbed during their contact with the volcanic products. For this reason, sulphurous thermal springs are very numerous in the region of the Pyrenees, in Auvergne and the Alps, in France, in Sicily and the environs of Naples, and in many parts of Italy.

Captain Burton, in his expedition to the Lake-Region of Central Africa, met with thermal springs in the district of Zoungomero, an unhealthy, humid, and sulphurous country, which the traveller crosses on his route to the mountain-chain of Ousagara.

The same enterprising traveller visited, in 1860, the celebrated *Hot Springs* of Utah, in North America, which are situated about two and a half miles from the Mormon capital, the so-called "City of the Saints." They issue from the western face of the neighbouring mountains, escaping in an abundant flood from the solid rock, behind Ensign Peak, and falling into a basin, whence they overflow into a little lake, about one to three miles in circumference, according to the season.* Where the water first issues, it will boil an egg ; a little lower down its temperature is 128° F. At a considerable distance from the spring it still preserves a certain degree of warmth. It is frequented in winter by troops of waterfowl, which flock thither for the purpose of warming themselves ; and by the children of the

* [Captain R. F. Burton, "The City of the Saints," pp. 288, 289.]

Indians, who kneel upon its banks to thaw their half-frozen limbs. The Mormons pretend that in purifying virtues it surpasses the rivers of ancient Judæa.

Some mineral waters possess the property of depositing on any objects exposed to their action a calcareous sediment proceeding from the carbonate of lime which they hold in solution. These are called *incrusting waters.* It is owing to the free carbonic acid gas which they contain, and the effect of the pressure to which they are subjected in the interior of the earth, that the carbonate of lime is dis-

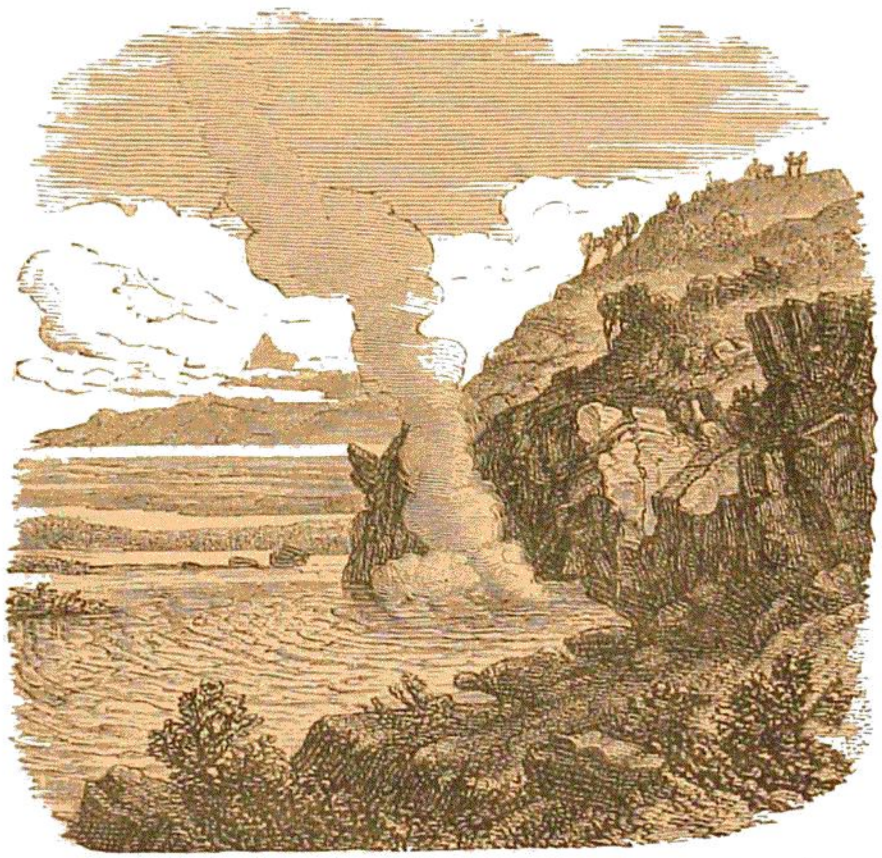


FIG. 164.—HOT SPRINGS NEAR UTAH (NORTH AMERICA).

solved in their waters. But when they reach the surface of the soil, the excess of carbonic acid is disengaged, owing to the diminished pressure; accordingly, the carbonate of lime is deposited in the form of earthy sediments, which harden into solid incrustations.

It is by this kind of chemico-physical process that the waters of Saint Alyre, at Clermont-Ferrand (in Auvergne), *petrify;* that is to say, cover with a crust of carbonate of lime the foreign bodies which are deposited in their basin, and which of old produced the curious natural bridge beneath whose span they flow to-day. The waters of

Carlsbad, which also deposit much carbonate of lime, have themselves constructed their own basin. We may also refer to the petrifying springs of St. Vignone, in Tuscany; the falls of Tivoli; the waters of St. Nectaire, in the department of the Puy-de-Dôme. The vapours of

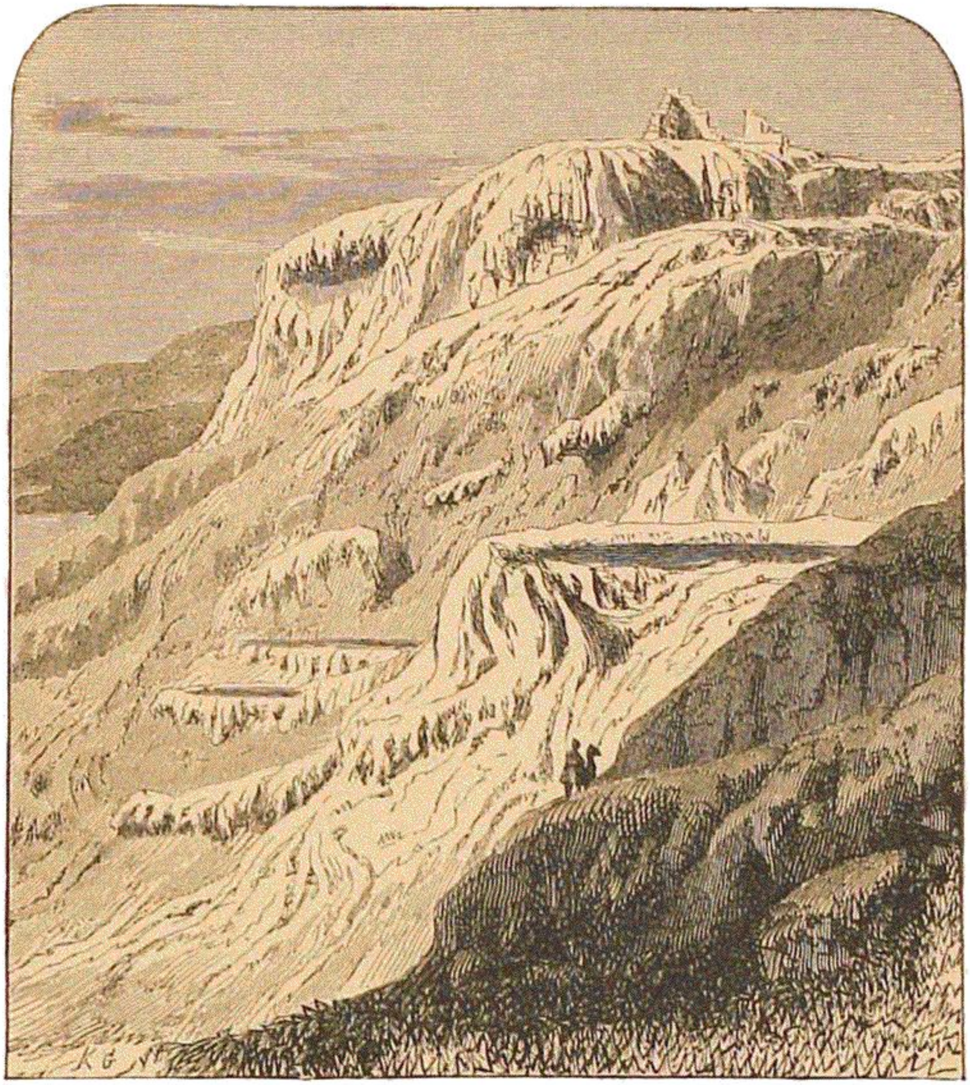


FIG. 165.—PETRIFIED CASCADE OF PAMBUK-KALESSI.

the hot spring of Mont Dore deposit a silicious coating on the vault overarching the basin.

There exists in Peru a calcareous incrusting spring, which deposits so great a quantity of carbonate of lime as to form regular blocks of stone, useful for building purposes.

One of the most beautiful incrusting springs in the whole world is that of Hierapolis, celebrated in ancient times. Its hot waters produce, as they issue from the soil and flow down the mountain-side, a series of petrifying cascades.

In our Illustration we represent the limestone rocks formed by the deposit of these waters, as they descend into the valley of Pambuk-Kalessi, in Asia Minor. They have been visited by several travellers, who have all noticed the incrustations first spoken of by the ancient geographer Strabo. They appear to have been much used for dyeing.* Chandler describes the fall as "an immense frozen cascade, the surface wavy, as of water at once fixed, or in its headlong course suddenly petrified."

* [Strabo, xiii., pp. 629, 630.—See also the Travels of Chandler, Hamilton, Leake, and Pococke.]

CHAPTER II.

GROTTOES AND CAVERNS.

IN succession to the subterranean waters, we have to notice the Grottoes and Caverns of our earth. Subterranean water-courses play, in truth, an important part, not in the primitive formation of these cavities, but in their enlargement, which results from the erosion of their sides by the action of underground streams.

Caverns are usually composed of several compartments, which are frequently of almost incredible extent. The tortuous ramifications which they form are not always parallel to the soil. Some of them gradually descend, as it were, by steps; others sink vertically, like wells.

To caverns of inferior magnitude is given the name of *Grottoes*.

Frequently we meet in caverns with vast reservoirs of water, and even with rivers, which traverse them for a portion of their extent. The sides of caverns are occasionally smooth and uniform; occasionally hollowed out, broken up, rugged—according to the nature of the rock which composes them.

The death-silence which reigns in these vast and tenebrous solitudes; their fantastic architecture; their walls glittering with quartzose crystals, which coruscate bewilderingly when lit up by the flickering torch-light; the immense columns which rise at intervals like pillars destined for the support of these remarkable edifices; their spacious corridors, which reverberate and intensify every sound; the oppressive and difficult air which circulates slowly through their labyrinthine recesses;—all the conditions and characteristics of these sombre regions form a cause of superstitious terror. Many legends of evil omen are, therefore, associated with their mysterious depths. Of old, it was in such places that the Pagan priests celebrated their sanguinary rites, as tradition relates, for example, of the cavern of the god Thor. In Hindustan, at Ellora, at Elephanta, at Salsette, caverns are still consecrated to religious mysteries. In France, those which extend for uncounted miles beneath the mass of the mountains of the Cevennes, furnished, in the days of the Protestant persecution (1670-1700), a secure asylum to the proscribed religionists. Under Louis XIV., a fierce and an unwise fanaticism condemned to exile or death the Protestants who refused to abnegate their creed. During the peasants' war originated by this iniquitous persecution, the numerous caverns which exist beneath different mountains of the Cevennes chain served the insurgents as places of concealment for their wounded, their munitions, their arms, and their stores of provision. In these unknown centres were performed the ceremonies of the proscribed worship; earth concealed in her bosom the simple rites which a pitiless fanaticism forbade, under the penalty of death, from being produced in the light of day.

[The Covenanters, when persecuted by Claverhouse and his coadjutors, in like manner sought the protection afforded by the dens and caverns of Galloway, Nithsdale, and Ayrshire; caverns whose mouths were concealed by thick brushwood or drooping rowan-trees, and whose roofs and sides dripped with unwholesome moisture.]

What is the origin, the mode of geological formation, of Caverns and Grottoes?

These great subterranean excavations are the result of the fractures or fissures of the globe, occasioned by its cooling. The great voids which remained yawning open through the fissures of the globe have been, for the most part, filled by eruptions of granitic matter, basalt, or the like; and in this way *beds* and *veins* have been produced. But every cavity was not so filled, and consequently are still empty as caverns. Their dimensions, frequently very moderate at the outset, have been, in course of time, considerably aggrandized by the current of waters and subterranean rivers which have eaten into their sides. The capacity of many caverns has also been increased by the waters of the deluge at the quaternary epoch. To this their rounded outlines bear witness, and the smooth surfaces of their interior, and especially the deposits of mud, mixed with fossil bones and rolled pebbles, which are discovered beneath their crust of stalagmites.

It is probable that the bones of antediluvian animals which fill so many caverns have been forced into their depths through the vertical openings, or shafts, in which the swirling waters of the deluge engulfed themselves.

In the *Bone-Caverns** the soil is usually covered with a thick layer of stalagmites (fragments of carbonate of lime formed by the infiltrating waters). Remove this stratum with a pickaxe, and you arrive at a bed of clay and rolled pebbles enclosing fossil bones.

Where this layer of stalagmites does not exist, fossils are never found; perhaps because it is precisely the stalagmites which preserved the bones from decomposition. *Above* these stalagmites, whose origin apparently dates back from a very distant epoch, we generally meet with much more recent deposits of alluvium, which are composed of a gray or blackish clay, mixed with organic débris. All these sedimentary strata, which, in the bone-caverns, overlay the various organic débris, long prevented geologists from suspecting the fossil wealth of certain localities, which, in other respects, were well known.

The most famous bone-caverns are those of Gailenreuth, near Muggendorf, in Bavaria; of Baumann, in the Harz Mountains; of Kluterhohle, in Westphalia; of Adelsberg, in Carniola; of the Peak in Derbyshire, Kirkdale in Yorkshire, and Kent's Hole, near Torquay; of Lunel-Viel, Mialet, Nabrigas, Bize, Echenoz, and Fouvent, in France; of Chokier, near Liége, in Belgium; and the Mammoth's Cave, in Kentucky, U.S.

The cavern of Gailenreuth, which has furnished inquirers with a vast number of bones, is situated near the village of that name. Its mouth does not exceed 8 feet in height, and 13 feet in breadth. A first compartment, 60 feet long, communicates by a narrow passage of 3½ feet in extent, with a second chamber, 140 feet long by 45 feet in breadth. At the threshold it is about 20 feet high, but it gradually

* [A stalactite cave has been discovered in the rocks near the Clifton station of the Bristol Port and Pier Company. When explored to the distance of some 20 or 30 yards, under the superintendence of Mr. Wilkinson, the manager of the line, many beautiful stalactites were disclosed, some of them extending from the roof to the earth beneath, and, from their size, temporarily preventing the further passage of the explorers. Some bones of animals and birds were also found among the soil, including part of a skull, which seemed to be that of a hyæna. The cave is apparently of considerable length and depth.—*The Times*, December 22nd, 1868.]

diminishes in elevation until it is not quite 7 feet. A narrow passage and several tiny ducts conduct to a third chamber, about 7 feet high and 33 feet broad. At the entrance of this grotto, a cavity of 16 to 20 feet, into which you descend by means of a ladder, opens upon a vault 16 feet in diameter by 33 feet in height. Adjoining this lofty dome-like recess lies a grotto, whose soil is strewn with the bones of the *Ursus spelæus.* A little lower the explorer passes through another corridor into a saloon about 44 feet long, terminating in a well fully 20 feet deep, by whose means he next arrives at a grotto about 45 feet in height. Two passages lead from hence

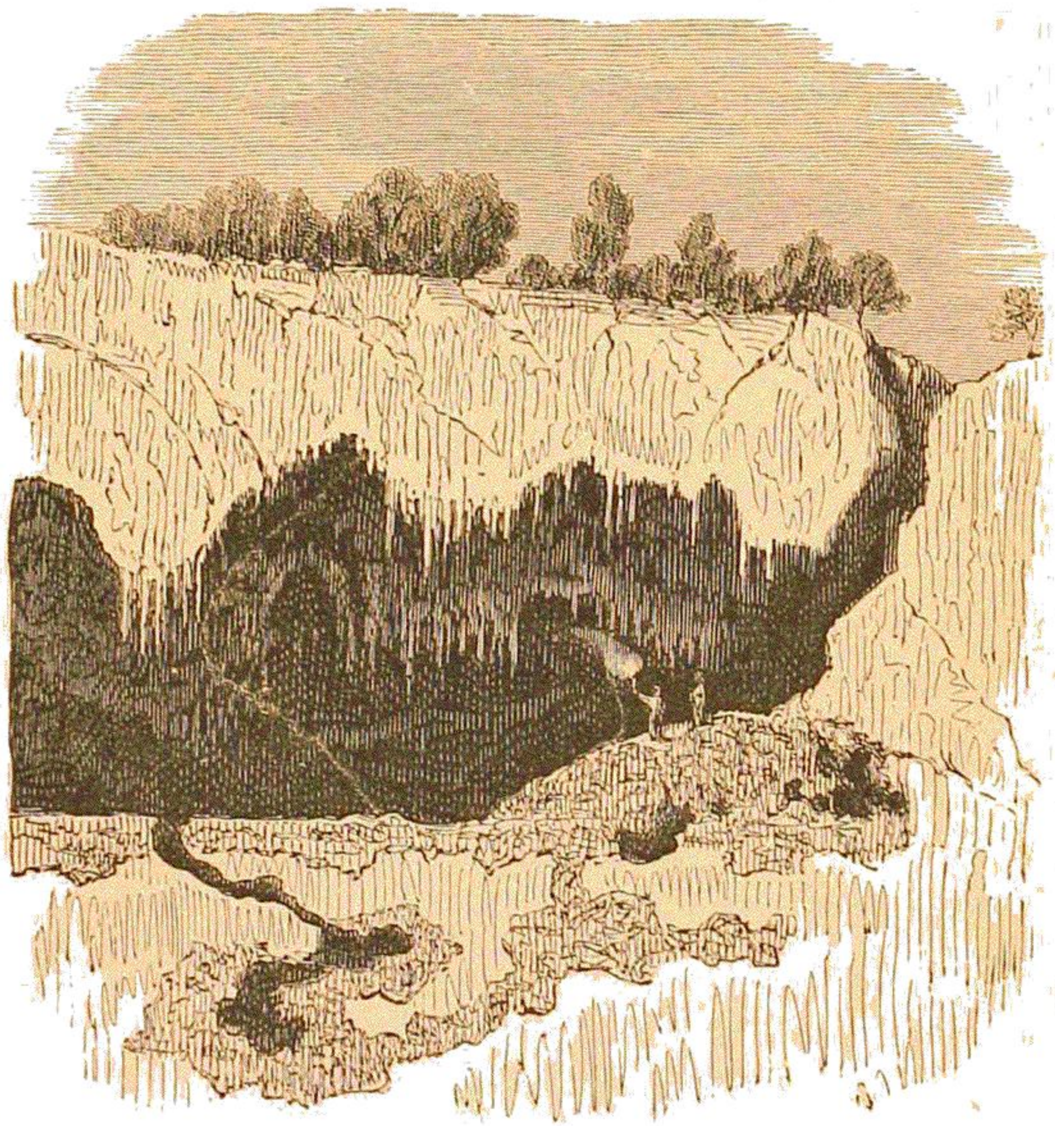


FIG. 166.—BAUMANN'S CAVERN.

into two tolerably spacious chambers. Next he is ushered into a grand hall, 85 feet broad by 13 feet high. A seventh and last chamber must be traversed to reach the end of this subterranean labyrinth.

Two other caverns of the same nature exist in the neighbourhood of Gailenreuth.

Baumann's cavern, in the Hartz, consists of five chambers situated on very different levels. From the first to the second is a descent of 33 feet. To reach the third, the tourist must be hauled up to a certain elevation; then he alternately rises and descends, until he comes to a gallery full of water, where the bones of bears, hyænas, and tigers are found in great quantities. The cavern derives its name from an unfortunate miner who lost his way therein in 1690, and after wandering for three days and three nights in the obscure Dædalian maze, effected his escape, but in such a state of exhaustion, that he died almost immediately afterwards.

The cavern of Adelsberg, three leagues from Trieste, consists of three immense saloons situated in due succession. The Poigk river sinks and re-appears in it at various points. A naturalist explored it for 3270 yards, when his advance was effectually barred by a spacious lake. It is generally identified with the *Poedicum* of the geographer Ptolemy.

[Kirkdale Cave, in the vale of Pickering, Yorkshire, was discovered in 1821, in the course of some excavations of the oolitic limestone rock in which it is situated. It was examined minutely by the eminent geologist, Dr. Buckland.* Its length is estimated at 245 feet, but its elevation is inconsiderable, and there are few places where a man can stand erect. The remains have been discovered here—under a deposit of mud, incrusted with stalagmites—of the hyæna, bear, wolf, tiger, elephant, hippopotamus, rhinoceros, horse, ox, deer, weasel, rabbit, hare, raven, pigeon, duck, lark, and water-rat. Some idea of their quantity may be formed from the fact that of hyænas alone upwards of three hundred have been counted.

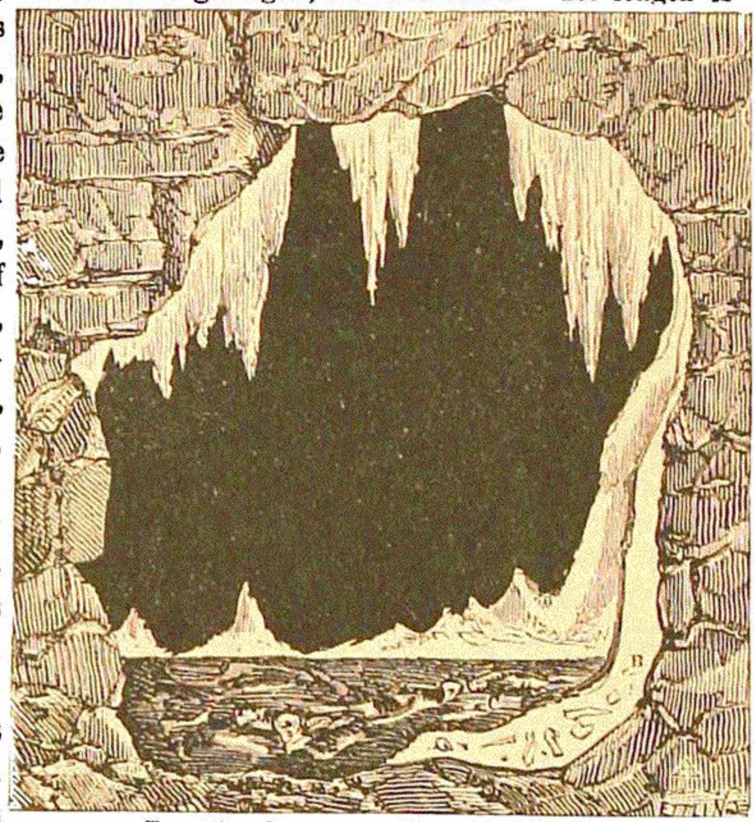


FIG. 167.—SECTION OF KIRKDALE CAVE.

Kent's Hole lies about three-quarters of a mile from Torquay, in Devonshire. Its floor was first examined in 1827, and found to be abundantly rich in the remains of animals no longer existing in this country, such as the elephant, rhinoceros, bear, and hyæna. Flint arrow-heads and pottery were also met with. The entrance is about 5 feet in height. The interior has a maximum height of 18 feet, a breadth varying from 2 feet to 70, and may be explored for a distance of 650 feet, until the way is barred by an impassable pool. The inner chambers are reached by a difficult and unpleasant defile through two very narrow passages, called the *Great* and *Little Oven.*

At fifteen miles from Totnes, elevated some few feet above the level of the river Tamar, is the celebrated Yealm-bridge Cavern, also stocked with the fossil remains of elephant, rhinoceros, horse, ox, dog, wolf, sheep, bear, hyæna, water-rat, and hare; all contained in a stratum of loam, and forming the upper bed of a series of deposits from 18 to 30 feet in thickness.

* [See his account of the cavern in his "Reliquiæ Diluvianæ."]

Ossiferous caverns are likewise found at Hutton, Wirksworth, Clifton, Oreston, and Paviland. In the latter locality, a very lofty rock, which faces the sea on the Glamorganshire coast, presents two apertures, sometimes washed by the waves in stormy weather.]

The caverns we have been speaking of interest the geologist on account of their considerable deposit of fossil bones, and the difficulty he experiences in attempting to explain the accumulation of such widely-different remains in one and the same place. But there are many which possess no memorial of the antediluvian world, no relic of pre-historic ages, and yet are endowed with high attractions for the geographer, the artist, or the tourist. Some of these, the most famous and the most widely known, we shall now pass rapidly in review ; confining ourselves to a picturesque sketch of the underground regions which it is the lot of few men to explore.

[Among the greatest caverns may be named that of Guacharo, situated in the valley of Caripe, in Columbia.* It is approached by a vault of 78 feet in height and 60 in breadth. When Humboldt visited it, he entered by a vault 80 feet in height and 88 feet in width. The precipitous rock which overhangs it is mantled with a luxurious vegetation, composed of gigantic trees, flowering bushes, and lianas which droop from the vault in garlands and festoons, incessantly stirred to and fro by the currents of air. Following, for some forty yards, the bed of an ample brook which issues from the grotto, M. Humboldt found it bordered with large-leaved bananas, which attained the stature of twenty feet. Up to a distance of 450 feet from the mouth, the daylight penetrated so effectively that torches were unnecessary, for the grotto preserves the same direction to a very considerable extent. Proceeding further, our traveller heard the shrill cries of the night-birds, called *Guacharos*, which make their dwelling-places in this obscure retreat. They build their nests in the innumerable crevasses of the rock, at a height of about 65 feet from the ground. Their harsh strains, reverberated by the sides and roof of the cavern, create an indescribable clamour.

For about five hundred yards from the entrance, the grotto preserves the same dimensions. The fantastic shadows of the stalactites is projected in black on the luminous ground of a beautiful hill, which the sun illuminates with its rays, and which rises opposite the cavern's mouth. The traveller has then to drag himself up an abrupt ascent, over whose rocky ledges the brook falls in a shimmering cascade. From this point, the height of the roof diminishes to about 45 feet, and the soil is covered with a black mould, nourishing only a few stunted herbs. In proportion as the corridor grows narrower, the cries of the birds become more deafening ; and their uproar made so great an impression on the timid natures of Humboldt's Indian

* [Humboldt, "Personal Narrative of Travels in Equatorial America," &c.]

guides, that they refused to advance any further, and our philosopher's exploration was brought to a sudden close. When compelled to retrace his steps, he had penetrated to a distance of 2670 feet from the opening.]

At the foot of the calcareous hills which line the Green river in Kentucky (United States), more than one hundred and thirty miles to the south of Louisville, is hidden, beneath the shroud of a prodigal vegetation, the entrance of the most spacious cavern known to exist in the modern world: the celebrated *Mammoth's Cave.*

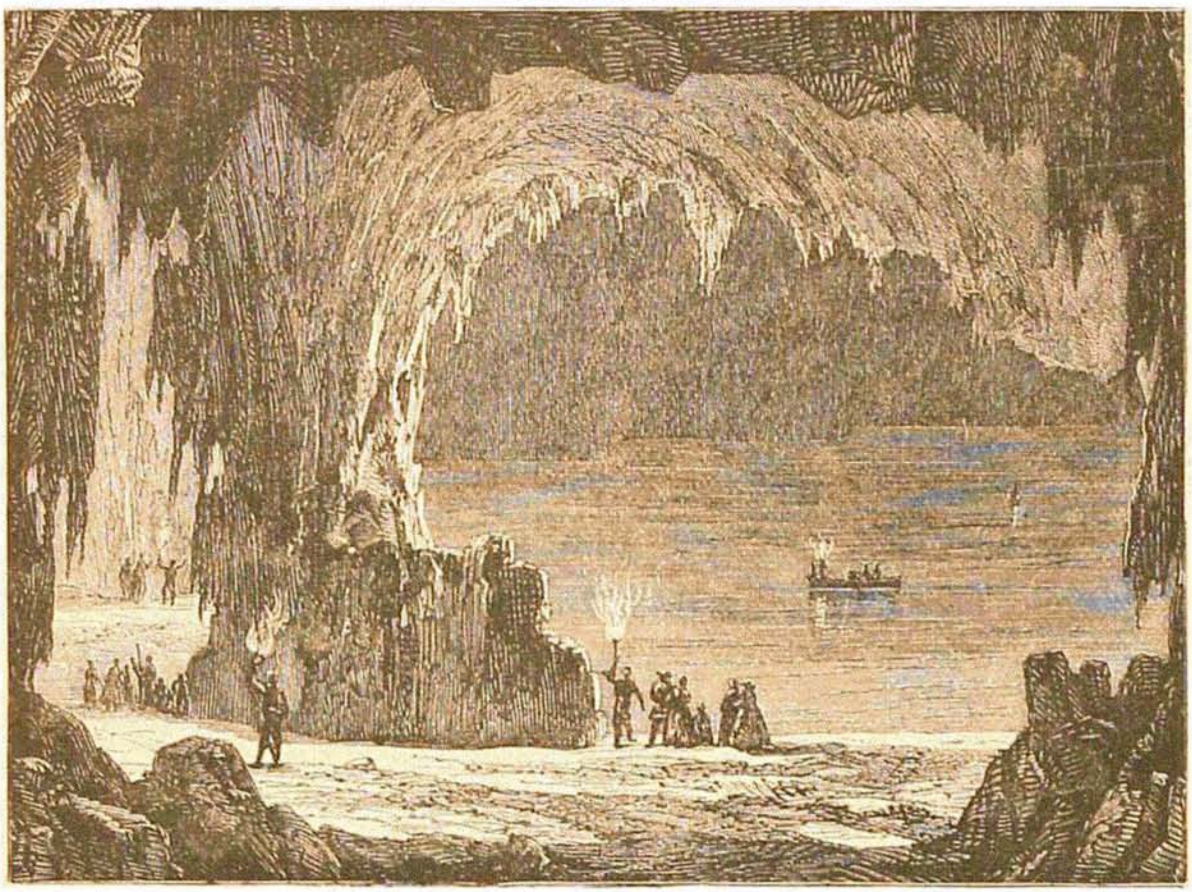


FIG. 168.—MAMMOTH'S CAVE, KENTUCKY, U.S.

This subterranean labyrinth has already been explored to a distance of ten miles, though many of its winding recesses, heavy with darkness and silence, have been passed over. A French traveller, M. L. Deville, has recently published a very interesting description of it.*

Accompanied by an experienced guide, and furnished with a miner's lamp, our traveller first descended sixty steps, to find himself

* [Deville, "Visite aux Grottes de Mammouth," in "Tour du Monde," 1863, 2e semestre.]

in a broad and lofty gallery about a thousand yards in length, which, after the great American naturalist, has been named *Audubon's Hall.* It abuts on the *Rotunda,* a vast circular saloon, whence numerous passages radiate. One of these leads to a square apartment, which is fashioned like a colossal nave, and decorated with immense stalactites: it is called *the Church.* Here the stalactitic concretions assume the shape of aisles and stalls, and even of a kind of pulpit, in which more than one Protestant clergyman has preached the Word of God.

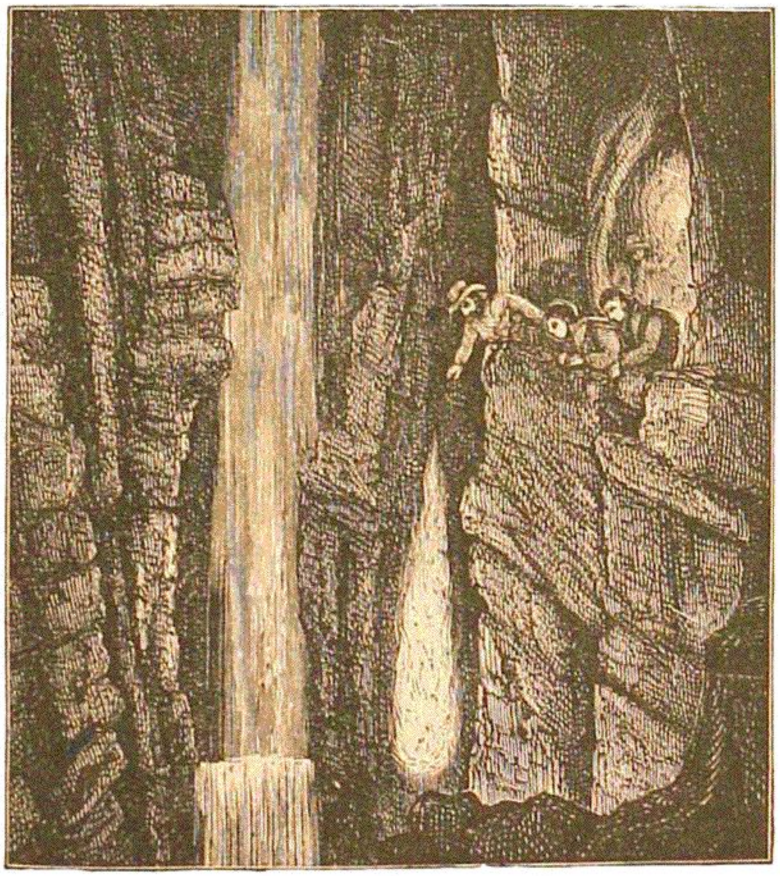


FIG. 160.—THE BOTTOMLESS PIT.

Emerging from this magnificent natural temple, we arrive, through a series of corridors, at the *Ghost's Chamber,* where an extraordinary quantity of Indian mummies was formerly discovered. This vast cemetery of an unfortunate race has been converted into a *restaurant;* where the wives of the guides supply various refreshments, and even the daily newspapers. [As the uniform temperature and nitrous atmosphere of the cavern were considered beneficial in cases of disease of the lungs, a hotel was formerly built here for the accommodation of asthmatic and consumptive patients; but it has been discontinued.]

Descending a succession of ladders, and crossing an old wooden bridge, whose appearance of antiquity is not very reassuring, we reach a narrow pathway, where the roof is so low that it is impossible to walk upright; this passage has been very expressively named *Humility Road.* It opens on the *Devil's Chair,* a kind of balcony situated beneath an aperture in the rock, which leads to the *Bottomless Pit.* The depth of this black awful precipice cannot be conceived by the most excited imagination. Twisted wreaths of oiled paper, which are lighted and flung down into the chasm, die out before they can reach the bottom. It is said that two runaway negroes, hunted to the death in this gloomy labyrinth by their cruel pursuers, precipitated themselves headlong into the shadowy gulf. A sounding-line of 970 feet has failed to make the bottom.*

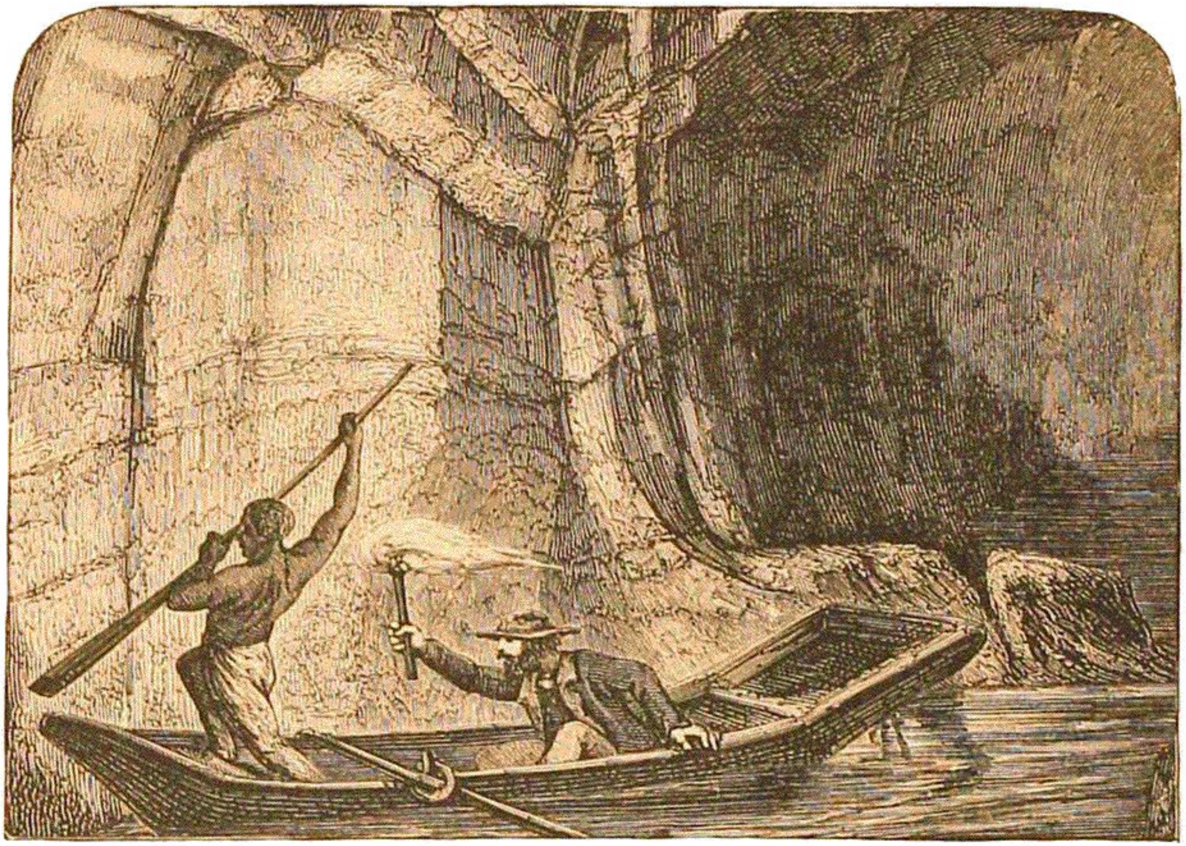


FIG. 170.—THE STYX RIVER, IN THE MAMMOTH CAVE.

Continually ascending and descending, we arrive under the immense *Mammoth Dome*, whose cupola, 425 feet high, is lost in the flickering shadows. A winding pathway leads to a point very near its summit, which consists of a black vault besprinkled with shining crystals: this is known as the *Star Chamber.* Illuminated by a lamp, this cupola, all incrusted with brilliant stalactites, sparkles like the heaven on a summer night. By a skilful management of their

* At Frederickschall, in Sweden, there is a fissure in the granite of so amazing a depth that a stone is a minute and a half or two minutes in falling; equal to a descent of 13,100 to 19,600 yards.

torches, the guides contrive to imitate the approach of morning or of evening.

After traversing, at some distance from this wonderful recess, a basin of 25 to 35 feet in circuit, called the *Dead Sea*, we find ourselves on the bank of a broad watercourse known as *the Styx*, which must be crossed in a boat.

"I embarked," says Deville, "in Charon's wherry. My black boatman uttered a few shouts, and the vaults resounded afar; one would have said they were the groans of suffering souls condemned to these eternal shadows. Our lights shed lurid colours on the rocks which they outlined in a fantastic fashion, while on the waters of the Styx, all enamelled with brilliant gleams, was strongly marked the *silhouette* of the negro.

"This strange spectacle had awakened in my mind some curious reflections, when an awful sound suddenly re-echoed through the cavern. It was like the crash of an avalanche. Nevertheless, it was only a surprise on the part of my guide, who burst out laughing, displaying his white teeth. Absorbed in my musings, I had forgotten his presence, while he had leaped ashore, and repeatedly striking a piece of rock, had created the clashing echoes which had so abruptly checked the course of my reflections."

After half an hour's navigation, we land on a bank of fine sand. At a short distance we catch sight of a small sulphurous spring; then of the *Cleveland Avenue*, which leads to the *Hall of Snow*, whose walls dazzle with their resplendent whiteness. Singularly rugged paths conduct us to the so-called *Rocky Mountains*, through whose detached and scattered masses we make our way to the *Fairy Grotto*, where the stalactites are aggregated into colonnades, arches, and trees of magical aspect. The quick sound of drops of water falling at every point creates strange noises in this gloomy maze. At the extremity of the hall is a graceful group, imitating an alabaster palm-tree, with a fountain gushing from its summit.

The Fairy Grotto is about ten miles from the mouth of the cave. The journey there and back occupies ten hours; and when returning from the prolonged excursion the traveller once more salutes the light of day, it is with a satisfaction easily comprehended.

[We may add that, in the opinion of our most eminent geologists, this remarkable cavern is part of the channel of a subterranean river which existed in a former condition of the earth's surface.]

The great caverns of the valley of Castleton, in the Peak district of Derbyshire, whose total length exceeds one thousand yards, recall, though on a smaller scale, the magnificent subterranean grottoes of North America, which we have just described. They offer a similar succession of cavities and defiles, of bottomless abysses, of subterranean lakes, and of massive columns, formed of brilliant stalactites, which support the gloomy roof, and glitter in the reflected light of the torches ; in a word, they combine all the marvels of the subterranean world.

[Who has not heard of Eldon Hole, a deep yawning chasm opened in the solid limestone rock ! In the reign of Elizabeth, the Earl of Leicester is said to have bribed a man to descend into it for the purpose of ascertaining its extent and configuration. He was lowered a distance of seven hundred feet, and for a while remained suspended in the abyss ; then he was drawn up to the surface, but in a frenzied condition, and never recovering his senses, he died eight days afterwards. To this incident Cotton alludes in some quaint verses :—

> " Once a mercenary fool, 'tis said, exposed
> His life for gold, to find what lies inclosed
> In this obscure vacuity, and tell
> Of stranger sights than Theseus saw in hell ;
> But the poor wretch paid for his thirst of gain.
> For being craned up with a distempered brain,
> A faltering tongue, and a wild staring look,
> He lived eight days, and then the world forsook."

But, in reality, Eldon Hole is not more than 200 feet in depth, 20 in width, and 60 in length. In the " Philosophical Transactions for 1781," the descent is recorded of a Mr. Lloyd, who was let down with a rope by eight men, and found the light at the bottom of sufficient clearness for him to read a printed book.

The Peak Cavern in Castleton Dale is surrounded by still grander accessories. The approach to it is in itself a magnificent picture. Immense perpendicular rocks rise on either hand, hemming in a rugged and gloomy defile, through which a rivulet issues from the cave, and tumbles and foams over a limestone bed. Suddenly a wall of rock rises sheer and abrupt before the traveller, and in it the mouth of the cavern, presenting the form of a depressed arch 120 feet wide, 42 feet high, and about 90 in depth. On entering, you observe with surprise that a colony of twine-makers have established themselves within the recess ; their machinery and strange appearance blending not inharmoniously with the strange features of the scene. We advance about thirty yards, to find the roof diminishing in height, the day utterly disappearing, and a settled darkness brooding in the narrow corridor, which is but partially dissipated by the light of the flickering torches. After moving forward with bent head for some thirty yards, we come upon a spacious opening, which admits us to the margin of a lake called the First Water, whose surface the impending rock at some points approaches within twenty inches. We cross the lake in a small skiff, and on the other side enter a vast chamber, 220 feet long, 200 feet broad, and 120 feet high. Then, by the margin of the Second Water, we observe the piled up mass of rock, named, in allusion to the incessant dripping of water from the roof, Roger Rain's House; beyond which opens another recess, the Chancel, where the walls are resplendent with stalactical incrustations. Here we are welcomed by a concert of wild and eery noises, proceeding from the upper regions of the cavern, where a group of women and children are stationed for the purpose.

Passing the Devil's Cellar and the Half-Way House, the path leads beneath three natural arches to another great cavernous hollow, so like a gigantic bell that it has received the appellation of "Great Tom of Lincoln." From this point the vault diminishes in height, the passage contracts, and becomes at length no more than the narrow channel of a rippling streamlet. The total length of this grand excavation is 2250 feet; its depth from the surface of the mountain about 620 feet. An impressive effect is here produced by the explosion of a small quantity of gunpowder compressed into a crevice of the rock; the report reverberates along the roof and sides like a continuous peal of thunder among the Alpine valleys.]

A stalactite grotto of enduring celebrity is that of the island of *Antiparos* (the ancient Oliarus), in the Greek Archipelago.* The traveller descends into it by a shaft or well, and finds himself in a beautiful cavern, about 260 feet wide and 235 feet high, extending nearly 1000 feet under the surface of the ground. In the centre of the Great Hall rises a magnificently large stalagmite, termed the Altar, 20 feet in diameter and 24 feet in height, at which high mass was celebrated in 1673 by the Marquis de Nointel. Four hundred lamps on this occasion were kept burning day and night for the three days of the Christmas festival; a hundred wax tapers dispersed the gloom; and the voices of five hundred worshippers blended in solemn music.

The *Grotto of Han*, near Dinant, is the greatest natural curiosity in Belgium. Fourfold the size of that of Antiparos; traversed, like that of Adelsberg, by a subterranean river—capable of being explored from one end to the other without necessitating the explorer to retrace his steps—situated in a delectable valley, which is refreshed and irri-

* [See Leake, "Northern Greece," vol. iii., p. 87, *et seq.*; Fiedler, "Reise durch Griechenland," vol. ii., pp. 191, *et seq.*]

gated by the river Lesse,—the Grotto of Han deserves to be visited by all lovers of natural wonders.*

The word *Han* is of Turkish origin, and signifies a covered place, divided into several compartments, or chambers, and serving as a centre of reunion. It is probable the grotto was devoted to some such use in ancient days. It has given name to the little village of Han.

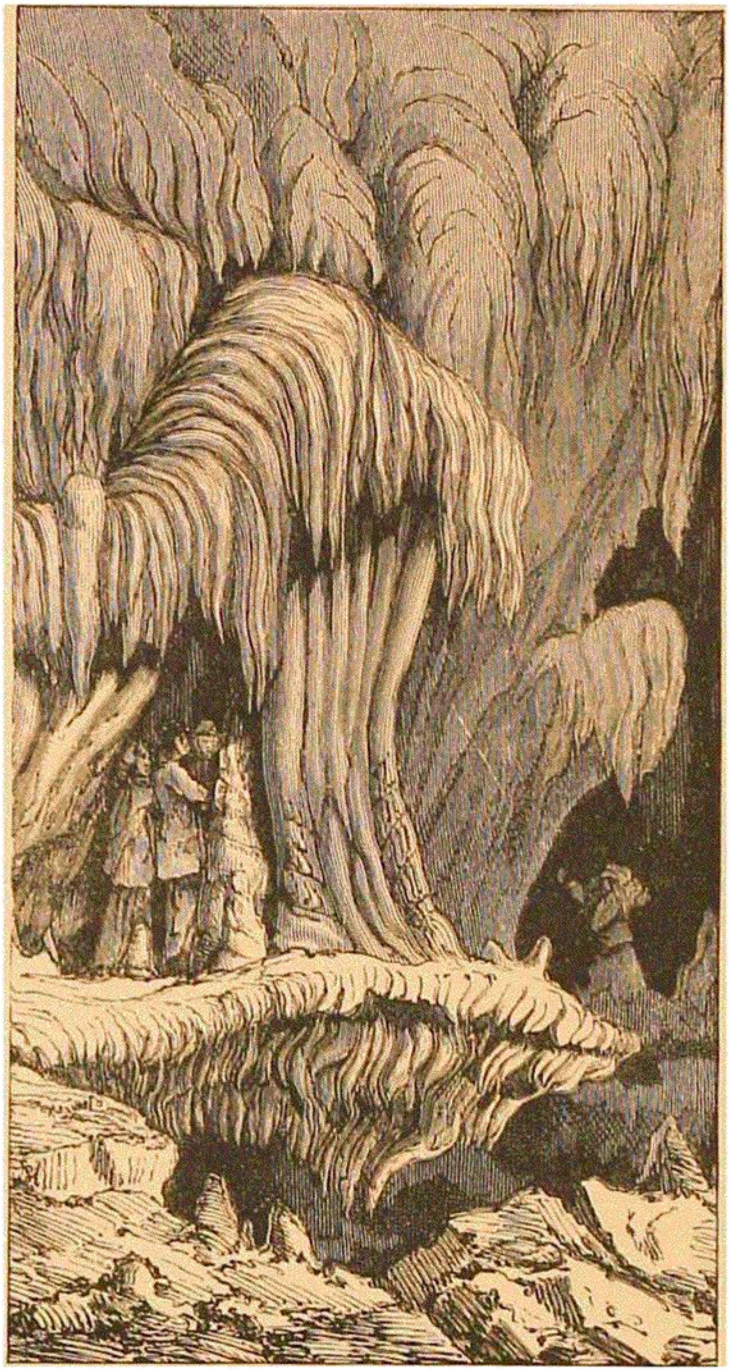


FIG. 171.—INTERIOR OF THE GROTTO OF HAN (BELGIUM).

It is very evident that the entrance, or vestibule, of the grotto was formerly inhabited. The discoveries made there, at different epochs, of various coins, ancient keys, smiths' tools, and human bones, are an undeniable proof. It has never been used, however, as a *permanent* dwelling-place, owing to the dampness caused by the stream which traverses its interior.

The traveller who starts from Brussels by rail reaches, in a few hours, the station of Jemelle, three miles distant from Han. On his way from Jemelle to the

* [Several authors have discoursed of the Grotto of Han. The Abbé de Feller, who long inhabited the little town of Marche, descended into it in 1771, and after a second visit in 1776, published an interesting description. Messieurs Kichx and Quetelet made a scientific examination of it in 1822. Another account will be found in the "Voyage Pittoresque au royaume des Pays-Bas" (1825); but the best work on the subject is by M. Phileas Collardeau, issued in 1865.]

village, he passes through Rochefort. Before venturing into the profound recesses of the subterranean grotto, where a thousand marvellous spectacles await him, he contemplates the gulf into which the waters of the Lesse dash with foam, and fury, and a roar of contending sounds. It descends into this part of the grotto in a series of cascades, to reappear at some distance in the interior.

Our space forbids our giving a detailed description of the numerous natural curiosities which meet the visitor's eye at every step, during his three or four hours' exploration of the interior of this remarkable grotto.

Let us content ourselves with the general observation that he traverses a series of spacious halls of different elevations, decorated, as is the case in all similar caverns, with stalactites, which sparkle bravely in the torch-light, and broken up by precipices which threaten the unwary with a thousand dangers.

The names of these different chambers are fantastic, or significant: such as the Hall of Beetles, the Foxes' Hall, Frogs' Hall, so called from the animals which formerly frequented these retreats; the Gallery and Hall of the Precipice, the Unrivalled, the Hall of the Mamelon, the Trophies, the Alhambra, the Mysterious, the Place of Arms, the Portico, and the Hall of the Dome.

The concluding part of the journey is performed in a boat, whose oarsman gently propels it with his sculls, while the visitor surrenders himself for a few moments to the emotions which agitate his soul. The guides toss to and fro their resinous torches; they kindle wisps of straw, and the mingled flames reveal a semi-ogive roof, semi-horizontal, formed, as it were, by two huge blocks of stone throughout its entire length, and embellished with a profusion of glittering stalactites.

Slowly, slowly does the little skiff drop down the murmuring stream. The deep intense silence which prevails in this mysterious *under-earth* is only interrupted by the shrill cry of the bats, by the monotonous babble of drops of water which, falling from the roof, drip, drip into the river, and by the incessant bounds and somersaults of the fish attracted to the surface of the water by the wavering light.

It is thus the traveller reaches the entrance of the grotto. But before revisiting the glimpses of the day, he enjoys the pleasure of listening to the marvellous echo which repeats itself *ad infinitum* in the sides of the cavern.

"The report of a gun," says Dr. Alleweireldt, who visited the cavern in 1830, "fired at the place where the waters quit the cavern, resembles that of a field-piece! Immediately after the first discharge, a second follows, then a third, a fourth, the echoes reverberating for from twelve to eighteen seconds. At each repetition, the sound appears to recede, and the latter is apparently audible at a few leagues distant, when it appears to die away in the bosom of the earth. The combined noises are not unlike a very loud and prolonged peal of thunder. Any unprepared visitor would think the thunder was breaking and clashing on every side of him. The rock seems to split; in all directions are repeated the crackling, the explosion, the detonation, the roar; peal upon peal is reproduced; the earth is apparently shaken to its foundations; the vaults of the immense cavern yawn, as it were, and rend themselves apart. To all this frightful hurly-burly succeeds tranquillity and a profound silence."

Instead of the carbine formerly used for this purpose, a small cannon is now employed, and the effect is consequently greater.

But far more charming is the concert of sweet sounds produced by musical instruments; and every year, numerous choral and instrumental associations make these sombre regions re-echo with their dulcet harmonies.

Through this last saloon the tourist passes out of the cavern and regains the day.

No optical effect, says the "Guide du Voyageur à la Grotte de Han," can be compared with the *coup d'œil* reserved for the visitor, when, the guides extinguishing their torches, the obscurity of these tenebrous recesses gives place to the twilight which advances towards the gondola undulating slowly along the surface of the waters. He is restored to life; his emotions are sweet and tender. He no longer lives to admire a panorama unique of its kind. If he be fortunate enough, on his going forth, to encounter one of those Italian sunsets which Nature frequently prodigalizes on our mountains, he remains motionless with admiration. Finally, all the authors who have written on this subject agree in saying, that the water-journey is undoubtedly the most beautiful episode of the excursion; they call it the *bouquet.*

On the visitor's regaining the daylight, he experiences a singular sentiment of happiness; all his fears, his apprehensions, his lugubrious emotions have disappeared, to give place to a keen enjoyment of nature and of the exquisite picture unrolled before his eyes. He quits his boat, advances slowly towards the rock which crowns the extremity of the mysterious cave, and finally emerges through the funnel or shaft, called the *Trou de Han.* . . . .

The tourist now finds himself in a delicious valley, in the midst of meadows, leas, and gardens, each possessing a peculiar charm; he casts a last glance on the grotto, and leaves, on the left, a charming little residence named the *Pavillon de la Grotte,* which is enviously regarded by every lover of the picturesque beauties of nature; follows up a long avenue of chestnut-trees; and speedily regains the centre of the village of Han.*

In France, the *Grotte de Miremont,* also called the *Trou de Granville,* situated at a short distance from Bagne, consists of a long series of very regular chambers, whose roofs are covered with siliceous incrustations.

A grotto characterized by the shapeliness of its columns and stalactite pillars is that of Ganges, in the department of the Hérault, more popularly known as the *Grotte des Demoiselles.* It is hollowed out in the Silurian formation, though most caverns belong to the Jurassic limestone.

* "Guide-Album du Voyageur à la Grotte de Han-sur-Lesse," Brussels, 1859.

The *Grotte des Demoiselles* or *des Fées* ("Baoumas de las Doumaïsallas") occupies the interior of the hill of Taurat, a few hundred yards distant from the village of Saint-Bauzille, and about a league from the town of Ganges. Its mouth is placed on the platform of the hill, which, crowned with leafy oaks, dominates over the valley, a sweet Arcadian valley, fenced round by mountains, and watered by a pleasant river.

A French traveller, Ernest Hamelin, published in 1861, in the "Messager du Midi," a Montpellier newspaper, his narrative of an excursion to the *Grotte des Demoiselles.* M. Figuier reproduces a portion of this interesting account of one of the natural wonders of France, which we here translate :—

Towards the northern extremity of the platform of the Taurat hill, the rock seems to have been crushed in over an area of several yards, and presents a circular excavation of considerable depth ; this is the mouth of the grotto.

An iron staircase, and, lower down, a ladder, are arranged to facilitate the access. In a few minutes we found ourselves all reassembled at the bottom of this kind of well. The tapers and torches are lighted, and bidding adieu for a few hours to the sun, we disappeared, with our guides, through a fissure which forms the entrance to the *Vestibule.*

We had scarcely advanced a few steps, before we were able to form an idea of the immense calcareous deposits accumulated in the cavern. Enormous stalactites present their white fantastic outlines; the rocky walls seem covered with petrified snow, besprinkled here and there by crystals, transparent as blocks of ice, and irradiated with all the colours of the spectrum in the flashing splendour of our lights.

This, however, is only the prelude to far stranger marvels. We descended to the bottom of the Vestibule, which a door separates from the other recesses, a precaution designed against imprudent persons whom a thoughtless curiosity might induce to adventure, without guides, into the inextricable maze we were about to penetrate. We ceased to descend a few moments, and mounted upwards to gain the saloon of the *Royal Mantle.* There we were met with a fantastic but magnificent surprise : an immense drapery in stone, artistically flung over a projection of the rock, droops from an angle of the vaulted roof, and displays its folds, harmonious and wavy as velvet or satin. Nothing more astonishing and curious than this work of nature can be imagined ; some of the details are really modelled with fairy art.

Tearing ourselves from this spectacle, we descended towards the *Grand Hall,* or *Hall of the Virgin.* Hitherto our subterranean peregrination had been accomplished without much difficulty ; a few narrow fissures, some tolerably rough escarpments,—to crossing or avoiding these had been confined our gymnastic exertions. But each person was now called upon to display all the resources of his agility and muscular vigour; to assume positions the most foreign to his usual habits, to creep upon his stomach or drag himself along upon his back, to glide along the sides on a ledge not more than a couple of hands' breadths across, to walk with his body bent in every possible and impossible curve, to descend rocks almost as steep and as lofty as houses, to cling—with taper or torch in one's teeth—to every rugged projection or corner, and not to make a step without carefully examining beforehand the place

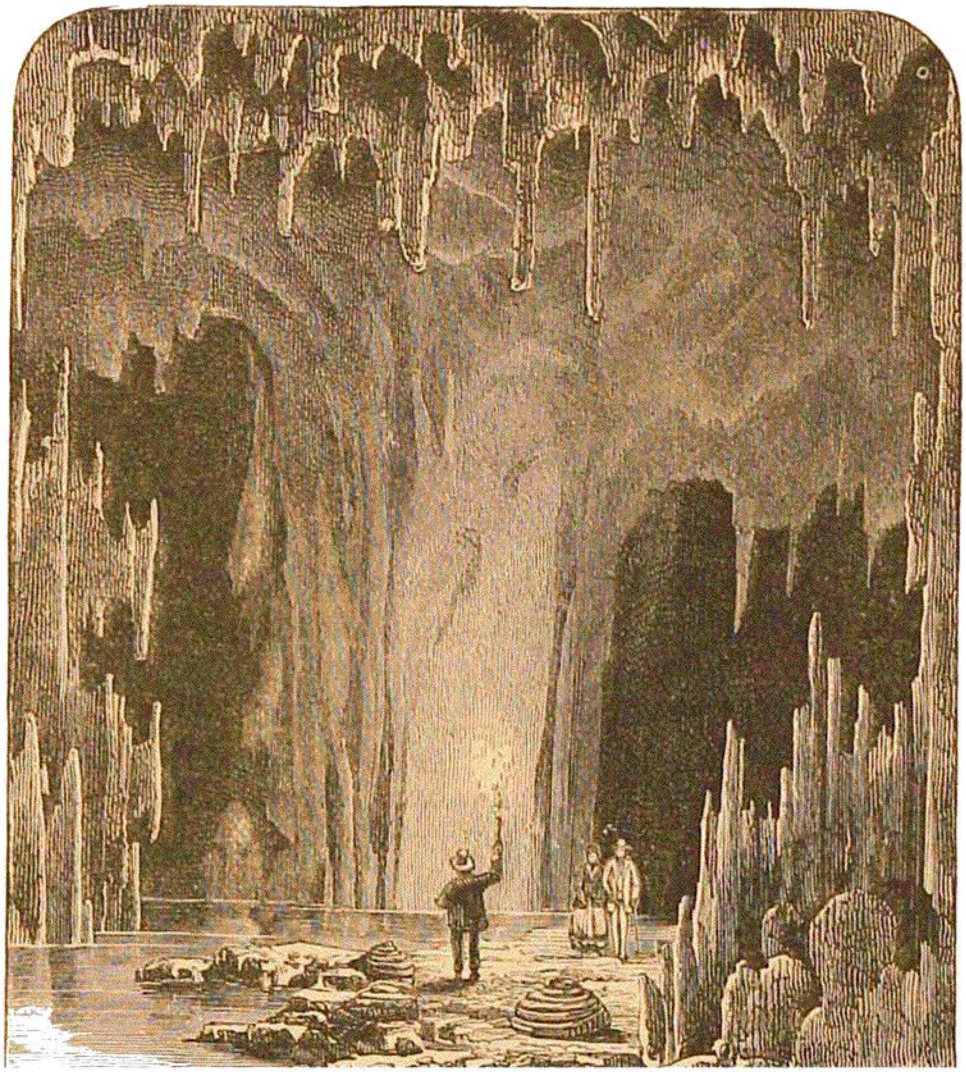


FIG. 172.—GROTTE DES DEMOISELLES, AT GANGES, IN THE HÉRAULT—HALL OF THE VIRGIN.

where he was about to plant his foot. We do not put ourselves forward, however, as heroes; no serious danger now-a-days exists. The really perilous places, such as, for instance, the famous *Pas du Diable*, by which you enter the Grand Hall, has been provided with iron railings, and a ladder of the same material replaces the adventurous rope-ladder formerly in use. No accident has ever occurred, though delicate women have several times most gallantly explored the grotto even to its most trivial details.

And for any fatigue undergone by the tourist the compensation made to him is magnificent. The *Hall of the Virgin*, into which we have just penetrated, is literally gorged with the strangest and most surprising formations ; assuredly, in no other part of the wide world has nature accumulated in greater profusion her most marvellous works. Let us cite only the *Imperial Mantle*, an exquisite drapery of the same kind as that which we saw on leaving the Vestibule, and especially the *Grand Organ*, the most imposing and fantastic of these creations of chance. At the sight of its alabaster columns, lofty as cathedral-spires ; of those enormous *buffets* standing detached in terrific relief from the circular wall ; of that cupola enriched with white needle-like ornaments, dentelated, and foliated as if by the patient chisel of a mediæval sculptor ; you feel for a moment deprived of all sensation. When lit up by Bengal fires, each illuminating the splendid scene with a different lustre, cries of admiration are uttered by every lip.

But we now approach the legendary part of the cavern, the locality which has given name to the vast hall wherein we now find ourselves. Our principal guide neglects no opportunity of displaying it under its most magical aspect, and not unnaturally makes the skilfullest use possible of the natural mise-en-scène. It is truly a dramatic surprise, and one of a gigantic character. We reach a point where our advance is suddenly impeded by a precipice, which the rock embraces in a semicircular sweep. At the request of our guide, all the torches are extinguished. Meanwhile, he glides along the wall, above the profound abyss, and places a Bengal fire upon a rocky ledge. Suddenly the flame leaps up, and falls full upon the statue of a woman, robed and crowned, rising apparently from the very depths of profundity, and outlining, on the intense black of the background, a weird and marvellous sketch of her colossal proportions. This is THE VIRGIN. The first impression is truly powerful, and easily accounts for the wild miraculous stories to which the singular phenomenon has given birth amongst the common people.

The *Virgin* is the last tableau in this long fantastic gallery ; but we were resolute to descend to the very bottom of the grotto. It was a tourist's weakness, but also originated in a desire to ascertain the exact height of the vault, which Marsollier, in 1782, as well as later explorers, had estimated at 325 feet.

Soon with full lungs we breathe the fresh air on the table-land of Taurat. We take leave of our brave guides, with memories full of ineffaceable impressions ; and our carriage speedily conveys us towards the charming little town of Ganges.

In the desert of the Thebaid, in Egypt, may be seen the celebrated Grottoes of Samoun, or the *Crocodiles' Grottoes*, which are entered through an irregularly shaped crevasse, on a level with the ground, and about three feet broad by ten feet deep. With their black walls encrusted in a pasty material, they contain innumerable mummies of all kinds, and especially of embalmed crocodiles. Their recesses afford a shelter for clouds of bats, which, when disturbed, dash wildly against the visitor's face.

The decomposition and modification of basaltic strata effected by the atmospheric influences or the agency of water, has led to the formation of numerous natural grottoes, which derive a characteristic poetry of aspect from their lofty prismatic columns. Undoubtedly the most famous of these is to be found in the island of Staffa, where it is known as Fingal's Cave.

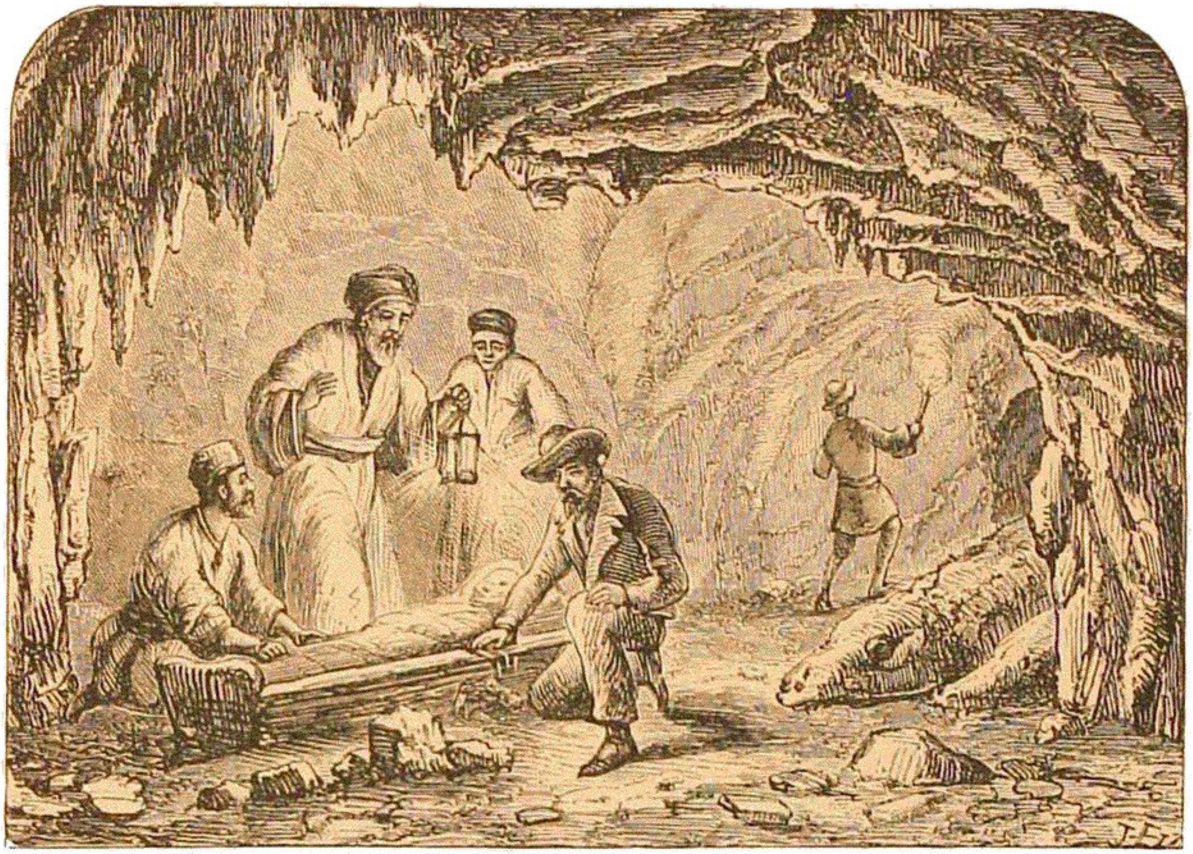


FIG. 173.—INTERIOR OF THE GROTTO OF SAMOUN.

[This justly celebrated natural curiosity derives an additional interest from Wordsworth's beautiful Sonnet :—*

"Thanks for the lessons of this spot—fit school
For the presumptuous thoughts that would assign
Mechanic laws to agency divine;
And, measuring heaven by earth, would overrule
Infinite Power. The pillared vestibule,
Expanding yet precise, the roof embowed,
Might seem designed to humble man, when proud
Of his best workmanship by plan and tool.
Down-bearing with his whole Atlantic weight
Of tide and tempest on the Structure's base,
And flashing to that Structure's topmost height,
Ocean has proved its strength, and of its grace
In calms is conscious, finding for his freight
Of softest music some responsive place."]

* [Wordsworth, "Poems of the Imagination:" *Sonnets.*]

Staffa is an irregularly shaped island, of a general oval form, extending from north to south, and measuring about a mile and a half in circumference. It may best be described as an uneven table-land, partly sloping towards a rocky and wave-worn shore; but, in the main, supported upon huge mural columnar cliffs, which are freely pierced with caves. The maximum height is obtained on the south-

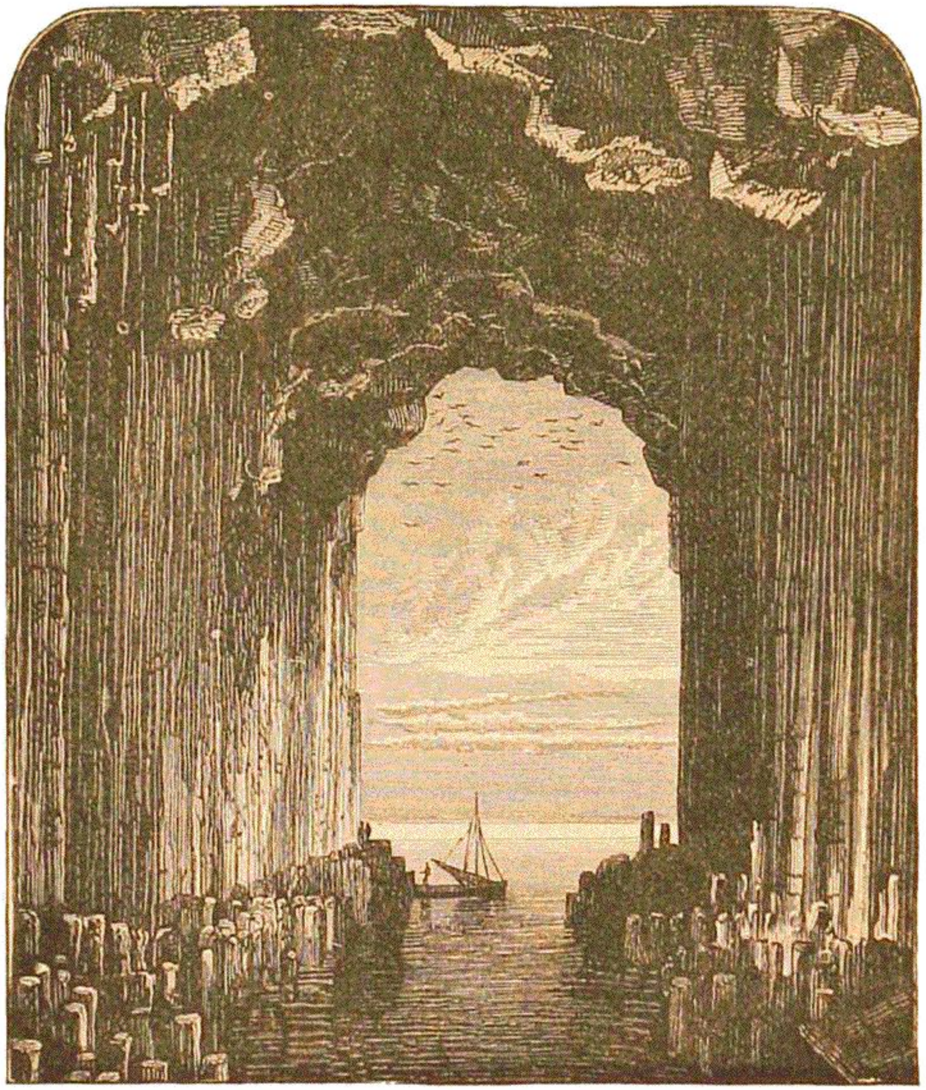


FIG. 174.—INTERIOR OF FINGAL'S CAVE.

west side, where the crest of the sea-wall is 129 feet above high-water mark. Its rocky shore on the north-east is flat, narrow, and low, but tolerably sheltered from the prevailing winds. At the other parts of the coast, the cliffs vary in height from 80 to 112 feet. They are composed of three kinds of rocks: the lowest is a foundation of conglomerated tufa; next is the columnar basalt, arranged in rows of Cyclopean pillars, and forming both the façades of the cliffs and the walls of the principal caves; above rests a ledge of amorphous basalt, of varying thickness, and curiously tesselated with angular blocks and the capitals of columns. The surface is in some places bare, but mostly clothed with a rich, grassy, and odoriferous sward. The objects for which the island is generally visited by tourists are four in number, and are found on its eastern coast:—The Scallop, or Clamshell Cave; the Buachaille, or Herdsman; the Great Colonnade and Causeway; and Fingal's, or the Great Cave.

The *Scallop*, or *Clamshell Cave*, measures 30 feet in height and 17 feet in width at the entrance, but gradually contracts as it approaches its interior termination. On one side runs a range of regular columns, curved so as to resemble the ribs of a ship; on the other, the columns assume a mural appearance, with "a general resemblance to the surface of a honeycomb."

The *Buachaille*, or *Herdsman*, is a conical-shaped islet, only a few paces from the main shore, and about 30 feet in height. It rests on a basis of curved horizontal columns, visible only at low water, and consists of a mass of small but closely compacted pillars, which seem to have been piled by a giant's hand against a central nucleus, like lances against a military trophy. The general outline is harmoniously symmetrical and exquisitely beautiful.

On the main coast, a short distance beyond the Herdsman, rises the pillared range of the *Great Colonnade*, with an average elevation of 36 feet; but diminishing in some places to three, and in others soaring to 56 feet. The columns are about two feet in diameter, and of various shapes; trigonal, quadrilateral, pentagonal, and hexagonal; but are all set together in marvellous order. At the base of this wonderful Colonnade, and inclining from it towards the sea, runs the Great Causeway; consisting of the tops of extensive series of columns, which in the course of centuries have been swept away by the storm-driven billows of the Atlantic.

Fingal's, or the *Great Cave*, opens beyond a rounded cliff at the termination of the Great Colonnade and Causeway. The entrance is worthy of a palace for the ocean-god of Greek mythology, consisting of huge columnar ranges, spanned by a magnificent Gothic arch; the sides are formed of lofty pillars; the floor is the rippling azure of the sea; and the general appearance is that of an ancient cathedral, into whose recesses the waters have made their way, filling roof and aisles with solemn mysterious music.

Its exact dimensions are:—288 feet in length from the east high-water point to the head; 212 feet in length from the commencement of the arch to the head; 33 feet in width at the entrance; 59 feet in height from high-water to the point of the arch; and the depth of water in it 25 feet at the entrance, and generally about 24 feet to the head.

"The shores of Mull on the eastward lay,
And Ulva dark, and Colonsay,
And all the groups of islets gay
  That guard famed Staffa round.
Then all unknown its columns rose,
Where dark and undisturbed repose
  The cormorant had found,
And the shy seal had quiet home,
And weltered in that wondrous dome,
Where, as to shame the temples decked
By skill of earthly architect,
Nature herself, it seemed, would raise
A Minster to her Maker's praise!
Not for a meaner use ascend
Her columns, or her arches bend;
Nor of a theme less solemn tells
That mighty surge that ebbs and swells,
And still, between each awful pause,
From the high vault an answer draws,
In varied tone prolonged and high,
That mocks the organ's melody.
Nor doth its entrance front in vain
To old Iona's holy fane,
That Nature's voice might seem to say,
'Well hast thou done, frail child of clay!
Thy humble powers that stately shrine
Tasked high and hard—but witness mine!'" *

Other caves on the further parts of the coast also exhibit the basaltic columnar arrangement. Thus: the *Boat Cave* measures 16 feet in height, 12 feet in width, and 150 feet in length; and the *Cormorants' Cave*, 50 feet in height, 48 feet in width, and 224 feet in length. The columnar sweep at the entrance, and the pillared aisle of the interior, are of a beauty that would almost justify any exaggeration of

* [Sir Walter Scott, "Lord of the Isles," Canto iv. s. 10.]

description; and the shifting effects of light and shade could only be realized by the magic brush of a Turner.

The curiosities of Staffa were first made known to the world in 1774 by Sir Joseph Banks, the eminent naturalist.]

A natural cavern, which owes its formation to some volcanic convulsion of the surface, is the celebrated *Azure Grotto, Blue Grotto,* or *Grotta Azzurra*, excavated in a precipitous cliff of the island of Capri (the ancient *Capreæ*), which lies at the entrance of the Bay of Naples, about three miles from Cape Campanella.

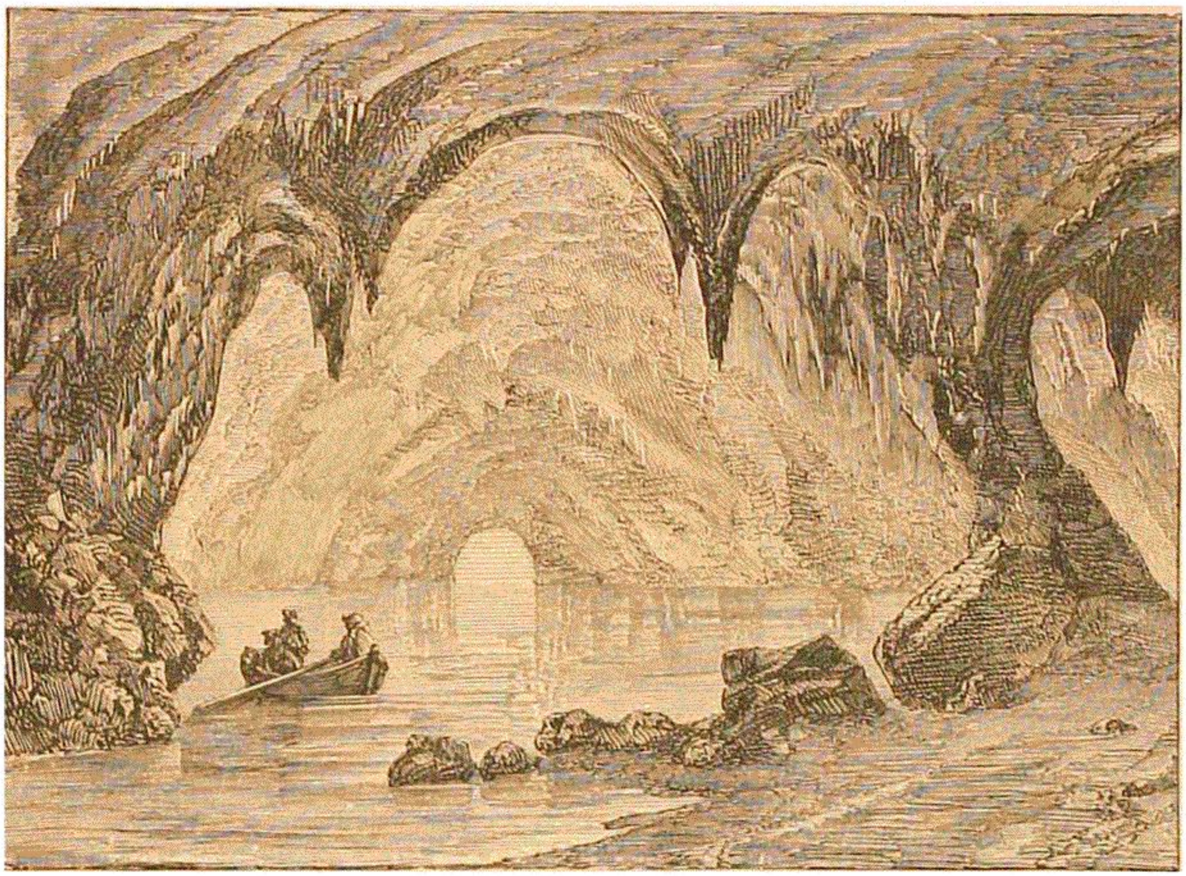


Fig. 175.—The Blue Grotto.

This lovely island was the retreat of the Emperor Tiberius during the latter years of his life, and the scene of his tyranny, his cruelties, his vices, and debaucheries.

["Caprea at this time, indeed, was little better than a barren rock, the resort of wild goats, from which it derived its name, about eleven miles in circuit; but it lay within two hours' row of Misenum, the great naval station of the Lower Sea. Easily accessible from the mainland at one point, which it required little vigilance to secure, the island is singularly difficult of approach at every other. Its shores consist of limestone cliffs, sheer precipices, in most parts plunging directly into the deep sea. They are furrowed here and there by those caverns celebrated for the play of coloured light in their recesses, which, after having amused and astonished the curious of our time as recent discoveries, are now ascertained to have been the forgotten haunts of Roman luxury. In the interior, an uneven but cultivable surface rises at either end of the island to the height of 1000 and 2000 feet respectively; the eastern or lower promontory having been, according to tradition, the favourite sojourn of Tiberius, and its dizzy cliff the scene of his savage executions. While few other spots could have combined the requisites of solitude and difficult approach with such actual proximity to the seat of government, Tiberius was not insensible to the charms of its climate, and even the attractions of its scenery; to the freshness of its evening breeze, the coolness of its summers, and the pleasing mildness of its winters."*]

Five or six hours suffice, in the summer season, for a steamboat to transport the tourist from the Port Santa Lucia, of Naples, to the island of Capri. On disembarking in the island, he will immediately engage a small boat to carry him to the Grotto Azzurra, where his astonished eyes will rest delighted on a truly faëry spectacle.

[On reaching the entrance, the tourist must lie down while the boat is driven under a rocky arch, about three feet high, and so narrow that it seems to the unobservant a mere crevice in the rugged cliff. The threshold crossed, he sees before him a scene which surpasses the airiest creations of the Arabian Nights, and even those caverns under the "sunny pleasure-dome" which Kubla Khan of old made his residence in Xanadu,—

> "Where Alph, the sacred river, ran
> Through caverns measureless to man
> Down to a sunless sea."—(COLERIDGE.)

The rippling wave, and the walls and roof of the grotto, assume an exquisite, an indescribably lovely ultramarine colour; produced, no doubt, by the light from without, which the water absorbs, and reflects *upwards* into the grotto. The effect of this rich blue lustre spreading over rock and wave is something magical.†

The length of the grotto is 165 feet; its maximum breadth, 100 feet; its maximum height, 40 feet; the depth of water about 8 fathoms. It produces a singular impression on the mind of the spec-

* [Merivale, "History of the Romans under the Empire," v. 345, 346.]

† [A picturesque description of this natural curiosity will be found in the "Lettres inédites de Mendelssohn" (Paris, Hetzel), letter xxxi., p. 156; also, in Mr. Charles Lever's novel of "The Bramleighs of Bishop's Folly."]

tators,—a kind of mysterious awe and subdued dread, as if one momently expected the sea-goddess to rise from the depths, attended by her conch-blowing Tritons and sleek-tressed Nereids,—as if one felt that the place belonged to another world, where the myths of the poets might suddenly be converted into realities.

> "A savage place, as holy and enchanted
> As e'er beneath a waning moon was haunted
> By woman wailing for her demon lover."

The common story runs that the grotto was discovered in 1822, by two English visitors; or, more truly, by a fisherman of the island, called Ferrara. But it was not only known when Addison travelled through Italy, and when Capaccio described it in 1605, but was frequented by the Romans, who seem to have used it as a bathing-place.

Between the landing-place known as the Marina Grande and the Blue Grotto, lies the *Grotto of the Stalactites*, discovered in 1851, and deriving its name from the rich fantastic decorations of its roof.

On the south side of the island are the *Passaggio e Grotta Verde*, or the Green Passage and the Green Grotto, forming a cavern of no great extent excavated in the limestone rock. Their roofs and sides assume a bright green tint, as if studded with dazzling emeralds. The entrance is about twenty feet high.]

The water which is found in all caverns occasionally passes into the condition or form of ice. Among these natural glaciers, or ice-caves, the most celebrated are those of Fondeurle; of La Chaux, six leagues from Besançon; Saint-Georges, in the Jura; and finally, that of Mont Vergy, in the Valley of Reposin, near Cluses. The latter was visited, in 1861, by M. Thury, who describes it as presenting a spectacle of great magnificence.

In these interesting and very curious cavities the soil is nothing more than a sheet of limpid ice, while their roofs are embellished with large pendent icy lustres, resembling brilliant stalactites. When lit up by the glare of torches, innumerable crystals catch and reflect the wavering gleams, until the eye of the spectator is dazzled by the extraordinary magnificence of the picture.

Produced by the extreme cold of a very severe winter, the ice in these caverns, when once formed, is prevented from melting by the imperfect manner in which the air acts as a conductor of caloric.

From certain caverns, and even from simple fissures, currents of

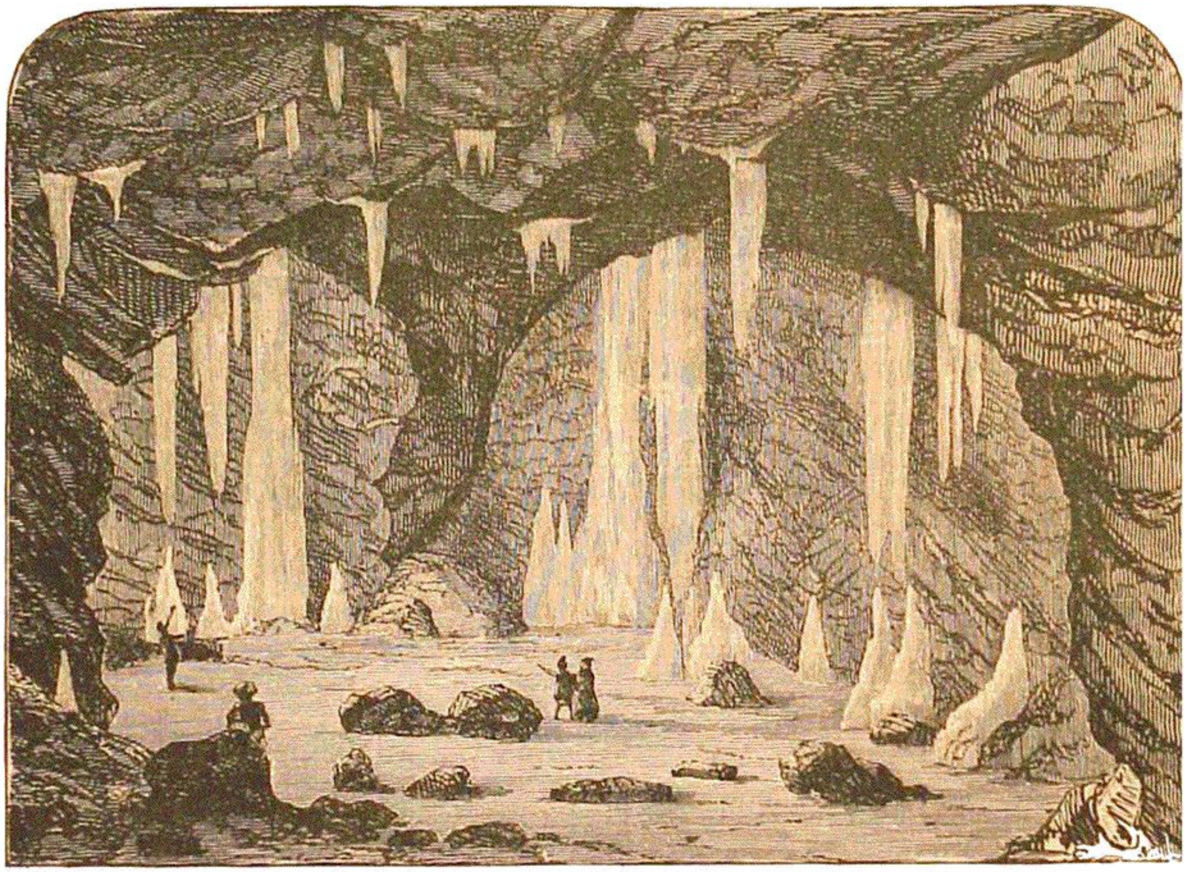


FIG. 176.—ICE CAVERN OF MONT VERGY.

cold air are known to escape; a phenomenon which has much engaged the attention of the scientific. Saussure refers to the cold-air caverns of the Monte Testaceo at Rome; of the island of Ischia; of Saint Marino, Cesi, Chiavenna, Caprino, Mendrisio, and Hergisweil. They are also found in Catalogne, at the foot of the Batet volcano, where they are popularly called *bufadors*, and are regarded as a positive benefit.

In winter, the current grows enfeebled, and ceases completely, or even changes into a breath of warm air. The caves of the village of

Roquefort, situated about two leagues from Saint Affrique (in the department of the Aveyron), owe their special qualities for the manufacture of the famous Roquefort cheese to a continuous cold-air current which traverses the subterranean grottoes of the mountain.

All these phenomena may be explained by the existence of correspondent orifices, situated at higher levels than the ordinary entrances; these create and maintain fresh currents of air, so long as the external and internal atmospheres are not in equilibrium—that is, do not enjoy the same degree of temperature; a law of nature which we have already discussed when speaking of the air-currents that escape from beneath the glaciers.

When any local accident has broken up or swept away the roof of a cavern or grotto, the cavity, ordinarily closed in, is then changed into a *gulf* or *chasm*.

In many of these abysses copious streams of water lose themselves. They are not uncommon in the Jura, and, according to all appearance, communicate with extensive caverns. Numerous remarkable examples may be found in Greece. In each enclosed basin of that classic land, there exists one or more deep cavities into which the lakes and "wild waters" disgorge themselves, that otherwise, if they spread over the argillaceous soil, would commit great havoc among the crops. These apertures which absorb the superfluity of the surface waters were called by the Greeks *chasma* (χασμα); they are now known as *katavothra*. In general they are situated at the foot of the mountains which encircle the basin or valley.*

* P. de Boblaye, "Expédition Scientifique de Morée," tome ii., 2e partie.

CHAPTER III.

RIVERS AND STREAMS:—UPPER COURSE OF RIVERS AND STREAMS—TORRENTS, WATERFALLS, CATARACTS, AND RAPIDS.

THE rivers and the mountains form the most natural divisions of the earth's surface; they are the boundary-lines which frequently mark the frontiers of empires or countries, and limit nationalities. The basins of rivers belong more particularly to the inclined strata which, rising with a gradual ascent, form a kind of intermediary between the table-lands and the low plains (the *Stufenlaender* of Carl Ritter). Their more or less rapid incline, their relative situation in connection with the great plains and the ocean, and, finally, the direction of their course, are so many distinct features which invest with an individuality of its own each of those great stages or terraces of the globe technically known as *geographical* or *orographical basins*. Their importance depends on the number of rivers and streams which they produce; while, as for the rivers, *their* importance is estimated by the volume of their waters and the length of their course.

The volume of a river is computed by the depth and width of its channel, as well as by its slope, which is in correlation with the rapidity of its current. Its *development* results from the distance between its source and its mouth on the one hand, and from the number of its ramifications and tributaries on the other. A river insignificant in appearance, may be raised into importance by the circumstances of the soil. To cite but one example, the Iser, a small Bavarian stream, receives in its course 860 affluents on the left bank, and 433 on the right; it is therefore fed by 1294 springs, to which 136 lakes are added: all these waters are poured into the Iser through 103 tributaries. It is easy to understand the usefulness of such a river to the country it irrigates, drains, and refreshes. Yet the Iser, "rolling rapidly," is but one of the 34 tributaries of the Danube, which of itself is not included among the greater rivers of the earth.

The geographical canon which imposes the designation of "stream" (*fleuve*) on every watercourse flowing into the sea, and of "river" * on the affluent of a stream, is by no means well established; and, considering the numerous exceptions, can only be accepted in a very general manner. Malte Brun, in his elaborate work on Universal Geography, thus sets forth the qualifications which, according to their origin and affluents, may be accepted as appertaining to flowing waters :—

"The expansions of springs and the overflow of melting glaciers create small currents, more or less tranquil; these are called *brooks*. The waters of the heavy rains dash headlong with greater rapidity, and furrow the mountain-sides with impetuous and wandering *torrents*. The confluence of these currents forms *rivers*, which, following the dip of the soil, unite very frequently in a broader channel, which is named *a stream* (*fleuve*), and carries to ocean the tribute of the earth."

But the principal tributary of a basin is not always named a *stream*. On the other hand, not a few *rivers* lose themselves in marshes, in the sand, or in an abyss; others there are whose flood is subject to excessive variations.

All this proves that in geographical questions we must not define words with absolute rigour, or establish too severe distinctions. When we aim at systematizing a natural science with too subtle a niceness, we do but establish rules which suffer as many exceptions as they receive confirmations.

The general combination of slopes and valleys, whence well out the crystal brooks which help to swell the flood of a great river, is called its *basin* or *hydrographical region*. The *bed* of a river is

* [It is almost unnecessary to say that this distinction does not obtain in our English language.]

simply the channel in which its waters flow; it invariably follows the direction of the principal valley, and receives the tributaries dispatched to do it honour by the transversal or secondary valleys.

The mountain-groups, which are the cradle of the springs, and the nursery, so to speak, of the streams and rivers, form the *water-sheds,** or lines of partition between the waters descending from their opposite declivities. The study of these projecting and salient masses of our earth is of the highest interest for all engineers called upon to construct and superintend hydraulic works; who, consequently, ought to be acquainted with the season of the floods and inundations of rivers—the rapidity, volume, and depth of their waters—as well as with their physical qualities, which necessarily depend on the nature of the soils they traverse.

The inhabitants of Mongolia look upon the water-sheds as sacred localities; they collocate there immense piles of stones, on which they plant their floating banners, and the wayfarer stops to bend before them in prayerful worship. The Tungusians never pass these heaps without making it a duty to add to them a branch of cedar, that the "sacred summits" may never be diminished.

The water-sheds, in the interior of the mountains, sometimes bring close together two currents of water which in our thoughts we are not accustomed to associate with each other. Like two foster-brothers, destined to be separated when they grow up to manhood, the Rhone and the Rhine have their birth in the High Alps, their cradles being divided by an inconsiderable distance; afterwards they part, the one to empty itself into the North Sea, the other into the Mediterranean. The springs of the Missouri and the Columbia, in the Rocky Mountains, are scarcely half a league apart; yet the mouths of these two rivers, one situated on the Atlantic, the other on the Pacific Ocean, are about a thousand leagues distant in a direct line. The same statement may be made in reference to the Dwina, the Niemen, and the Volga, which diverge in three widely different directions. Their sources blend together, as it were, in the midst of a vast morass; a fact which proves, moreover, that the soil does not always present a marked elevation at the point of separation of two opposed basins. Nevertheless, this elevation is the most general rule; and the mountains ordinarily serve as the natural hydrographic frontiers.

Two great rivers, or basins, which are apparently opposed in every feature, may, however, be brought into contact through the intermediation of tributaries rising in the same high ground. When

* [Water-shed, from German *wasser-scheiden*, signifying, the ground where the waters are *shed* off, or parted, in different directions.]

the springs are contiguous, and situated on accessible table-lands, in such a manner that it is easy to open a communication between them by means of a canal, these points of proximity are sometimes known as *portages* (a word whose primary signification is that of a *lacuna* or blank in the navigation; the point where it becomes necessary to carry, *porter*, the boat from one place to another).

We find an instance and an illustration in the Carpathian Mountains, where the Donajec and the Poprad, two tributaries of the Vistula, well up into the daylight at no great distance from the springs of the Gran, the Hernath, and the Waag, which flow into the Theiss, the principal affluent of the Danube; it has, therefore, been proposed to construct a canal, which would afford the means of direct communication between the Baltic and the Black Sea.

The course of a stream or river is divided into three parts, which are respectively designated its upper, middle, and lower course, each presenting its individual and sufficiently distinctive characters. In the upper part, the water often dashes headlong rather than flows, between steep scarped banks which closely hem in and obstruct its channel. It thus becomes an impetuous torrent, precipitating itself furiously from rock to rock, and cleaving a passage through the gorges and sinuosities which impede its foaming waves—here running wildly in a dangerous *rapid;* there descending abruptly in a *fall* or *cascade.*

[These features of a river's advance into the lowlands have been admirably described by the poet of "The Seasons":—

"Smooth to the shelving brink, a copious flood
Rolls fair and placid, where collected all
In one impetuous torrent, down the steep
It thund'ring shoots, and shakes the country round.
At first an azure sheet it rushes broad,
Then whitening by degrees, as prone it falls,
And from the loud-resounding rocks below,
Dashed in a cloud of foam, it sends aloft
A hoary mist, and forms a ceaseless shower.
Nor even the torrid wave here finds repose,
But raging still amid the shaggy rocks,
Now flashes o'er the scattered fragments, now
Aslant the hollowed channel rapid darts,
And falling fast from gradual slope to slope,
With wild infracted course and lessened roar
It gains a safer bed, and steals at last
Along the mazes of the quiet vale."]

In the Pyrenees, the torrents which we have been describing are named *gaves.* If they dry up in summer, the Spanish call them *quebradas;* in Sweden they bear the name of *elfs*. These untamed waters charge themselves with air in their multiplied falls, and thus obtain a silvery colour; in their mid-course, however, they become more limpid, and assume a deep blue or emerald tint, according to the nature of the soil over which they flow. Certain rivers preserve a torrent-like character for the greater part of their course, as the traveller does not fail to observe in the rivers of the Pyrenees, Scandinavia, and Scotland. In the latter country we may point to the Spey and the Tay as sweeping onward in fall and rapid from their source almost to their mouth. Such streams, it is almost unnecessary to remark, however pleasing to the artist and the lover of the picturesque, are of no commercial value, and can only be navigated for a short distance from their point of termination.

Undoubtedly a *Cascade* is one of the most attractive spectacles which Nature presents to the admiration of man. Its waters, from the summit of a rugged precipice, seem to hurl themselves into space, but descend into the chasm beneath with a bewildering rush and thunderous roar, which confound the senses and appall the imagination. Or it appears to the spectator a mere strip of silver ribbon outlined on the mountain-side, which rapidly narrows, and finally disappears in mist and spray. If the sunlight falls upon its vaporous clouds, it changes them into coruscating diamonds, or irradiates them with ever-shifting and undulating rainbows.

> "Horribly beautiful! but on the verge,
> From side to side, beneath the glittering morn,
> An Iris sits, amidst the infernal surge,
> Like Hope upon a death-bed; and, unworn
> Its steady edges, while all around is torn
> By the distracted waters, bears serene
> Its brilliant hues, with all their beams unshorn:
> Resembling, 'mid the torture of the scene,
> Love watching Madness with unalterable mien." *

We shall now pass in review some of the most picturesque and impressive of the world's Cascades and Cataracts, briefly describing their peculiar characteristics.

One which justly claims the admiration of the tourist, and has employed and inspired the pencil of many famous artists, is the cascade of Gavarnie or of Marboré, in the French Pyrenees. Ascending the Gave de Pau, we reach the ridge or tableland of the Pimené, which separates the two valleys of Estaubé and Gavarnie. The Gave traverses a series of defiles, ever increasing in narrowness, and of basins, ever decreasing in magnitude, as we mount towards its source. All these basins were formerly lakes, whence the waters fell, stage after stage, in terrible cataracts, before they had hollowed out the channel in which they now-a-days flow.

* [Byron, "Childe Harold," canto iii.]

The appellation of *Cirque de Gavarnie** is given to an immense semicircular amphitheatre of rocks, from whose crest a great number of torrents precipitate their boiling floods. Gavarnie itself is a small village of a few hundred inhabitants, but its neighbourhood is justly famous for the savage grandeur and romantic beauty of its landscapes.

The *Cirque* is enclosed by a precipitous wall or rampart not less than 1300 feet in height, surmounted by vast terraces, and crowned by enormous rocky pinnacles—

FIG. 177.– CASCADE OF GAVARNIE, IN THE PYRENEES.

the remains of disrupted and ruined mountain. From its summit ten to twelve torrents roll headlong their "sheeted silver." The principal of these is considered to be the source of the Gave du Pau.

From an interesting volume on the Pyrenees, by M. Adolphe Joanne, we borrow the following description of the Cirque and its cascades.†

The Cirque, he says, is 11,750 feet in circuit; has three stages of perpendi-

* [The Pyrenean mountaineers calls these cirques *oule*, a word signifying *a pot* or *caldron*.]

† Joanne, "Itinéraire des Pyrénées."

cular walls; and on each stage an innumerable succession of terraces. The eternal snows which shroud its summits are dominated on the east by the enormous masses of Astazon or Frazona (10,000 feet); on the west, by the lofty ridges of Taillon; in front rises the Cylinder (10,800 feet), the towers of Marboré, and the famous Roland's Breach (*Brêche du Roland*);* but the objects which arrest every glance are the Cascades.

Threads of water, says Henri Taine,† arrive by thousands from the most elevated crest, leaping from ledge to ledge, crossing their rays of foam, winding, blending, and falling into some ten or a dozen brooks which descend from the lowest terrace in feathery spray to lose themselves among the glaciers.

Their number varies according to the seasons and the bulk of the snow, but two of them never dry up. One, the third in the gorge, is 1370 feet in height.

It falls slowly, says Taine, like a descending cloud, or like an expanded veil of softest muslin; the air breaks its descent; the eye follows complacently the graceful undulation of the beautiful aerial veil. It glides along the rock, and seems rather to *float* than *flow*. The sunlight illuminates the plumed canopy with the softest and most delightful splendour. It arrives in the low lands like a bouquet of delicate, wavy feathers, and leaps up again in silvery dust; the fresh transparent vapour balances itself around the mossy crags, and its reascending cloud mounts lightly from stage to stage.

The snow scarcely ever disappears in the bottom of the Cirque, and the Gave, formed by the waters of the cascades, is compelled to pass under a long bridge of snow, which varies in length and solidity, according to the seasons. Few travellers are curious enough to advance any further; yet it is impossible to form an accurate idea of the cascade, situated about three miles off, but by examining it from a nearer point of view.

In summer two-thirds of its descent are cut off by a projection of the rock, and when the spectator arrives underneath it, he sees only the lower part of the fall, which is about 425 feet in height. "These waters," says M. de Chausenque, "which seem to fall from the clouds, form at first but an unfolded sheet. The resistance of the air divides it into vapour, which the lightest breeze scatters abroad; a humid fog hovers in the atmosphere. But beautiful as is the cascade in the autumn sunlight, when the glaciers are most reduced in size, how majestically terrible must it be in spring, when, the wind of Spain driving before it the accumulated snows, the waters are rapidly swollen, and precipitate themselves from the upper terraces in an enormous mass which shakes the mountain to its foundations! That is the fitting time to visit it: the projecting rock which now divides its fall is no longer visible; throughout its entire descent of more than 1300 feet it is a broad, uniform, unbroken sheet, and all the tiny silver threads which festoon the borders of the Cirque are augmented into copious and important falls. They are the trumpets of heaven sounding a simultaneous peal."

It was formerly asserted that the cascade of Gavarnie originated in a frozen

* [So called because this huge gap in the mountains is said to have been cloven by the legendary Roland with his magic sword.]

† Taine, "Un Voyage en Pyrénées."

lake situated on the heights of the Marboré. This is an error, as any one may convince himself who surveys the Marboré from the summit of the Vignemale. The source, first discovered in 1847, is 7500 feet above the sea-level. The average elevation of the Cirque is estimated at 3960 feet.

A French cascade which deserves mention, not so much on account of its height as of its beauty, is that of the Druise, in the Dauphiné. It is formed by the Gervanne, which, soon after it has emerged from the gorges of Omblize, reaches the brink of an escarpment about 130 feet high, and with one wild leap springs into the abyss, where its waters, but just now sleeping so calmly in their cradle of densely-set willows, break into foam with the sound of thunder. During a part of the year, however, it is dried up.

The magnificent *Caduta della Marmore*, formed by the Velino near Terni, seems to have been partly created by the hand of man. The Roman consul, Curius Dentatus, first brought the waters of the river to this precipice in B.C. 274; but the bed prepared for them having become filled up with calcareous sediment, Pope Paul IV. (or, as some authorities assert, Clement VIII.) was compelled to excavate a new one.

[According to Calindri, the height of the fall is 1230 feet; but a more accurate measurement seems to be—the upper fall, 50 feet; the second, or perpendicular fall, from 500 to 600 feet; and the third or lowest fall, 240 feet. The bed of the river, above the falls, is about 50 feet in width, and the rapidity of the current is estimated at seven miles an hour.

The falls of Terni have been immortalized by Byron:—*

"The roar of waters!—from the headlong height
Velino cleaves the wave-worn precipice;
The fall of waters! rapid as the light
The flashing mass foams, shaking the abyss;
The hell of waters! where they howl and hiss,
And boil in endless torture; while the sweat
Of their great agony, wrung out from this
Their Phlegethon, curls round the rocks of jet
That gird the gulf around, in pitiless horror set,

"And mounts in spray the skies, and thence again
Returns in an unceasing shower, which round,
With its unemptied cloud of gentle rain,
Is an eternal April to the ground,
Making it all one emerald:—how profound
The gulf! and how the giant element
From rock to rock leaps with delirious bound,
Crushing the cliffs, which, downward worn and rent
With his fierce footsteps, yield in chasms a fearful vent.

"To the broad column which rolls on, and shows
More like the fountain of an infant sea,
Torn from the womb of mountains by the throes
Of a new world, than only thus to be

[* Byron, "Childe Harold," canto iv.]

Parent of rivers, which flow gushingly,
With many windings, through the vale :—Look back!
Lo! where it comes like an eternity,
As if to sweep down all things in its track,
Charming the eye with dread,—a matchless cataract!"

Not to be forgotten in this connection are the *Falls of Tivoli*, near Rome, which, like those of Terni, are artificial in character, being formed by the direction of the waters of the river Anio over a precipice of 320 feet. The works by which this noble cascade was created owe their existence to the genius of Folchi, the Roman engineer, and the liberal energy of Pope Gregory XVI.]

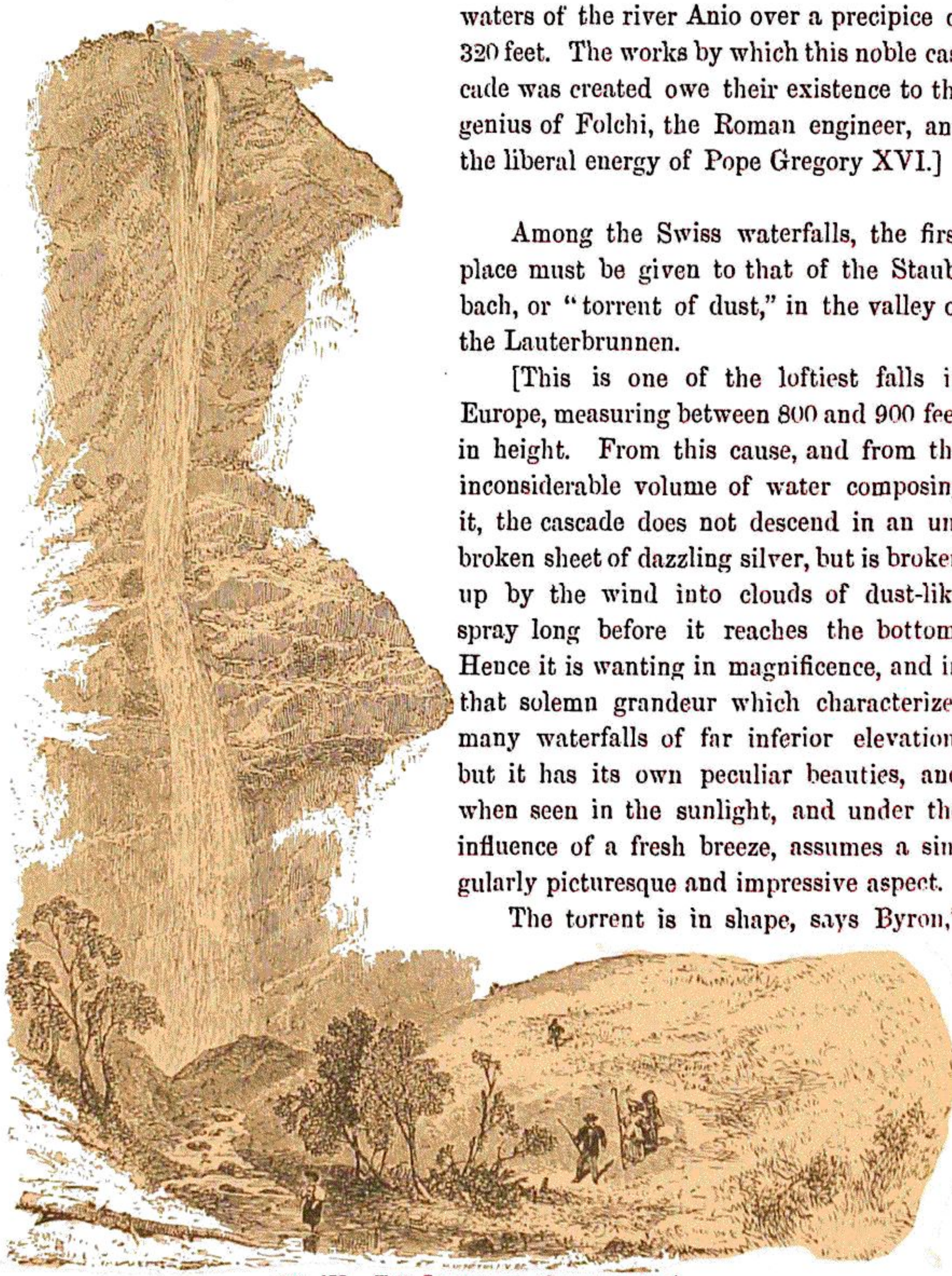


FIG. 178.—THE STAUBBACH (SWITZERLAND).

Among the Swiss waterfalls, the first place must be given to that of the Staubbach, or "torrent of dust," in the valley of the Lauterbrunnen.

[This is one of the loftiest falls in Europe, measuring between 800 and 900 feet in height. From this cause, and from the inconsiderable volume of water composing it, the cascade does not descend in an unbroken sheet of dazzling silver, but is broken up by the wind into clouds of dust-like spray long before it reaches the bottom. Hence it is wanting in magnificence, and in that solemn grandeur which characterizes many waterfalls of far inferior elevation, but it has its own peculiar beauties, and when seen in the sunlight, and under the influence of a fresh breeze, assumes a singularly picturesque and impressive aspect.

The torrent is in shape, says Byron,*

[* Byron, "Life and Letters," edited by Thomas Moore.]

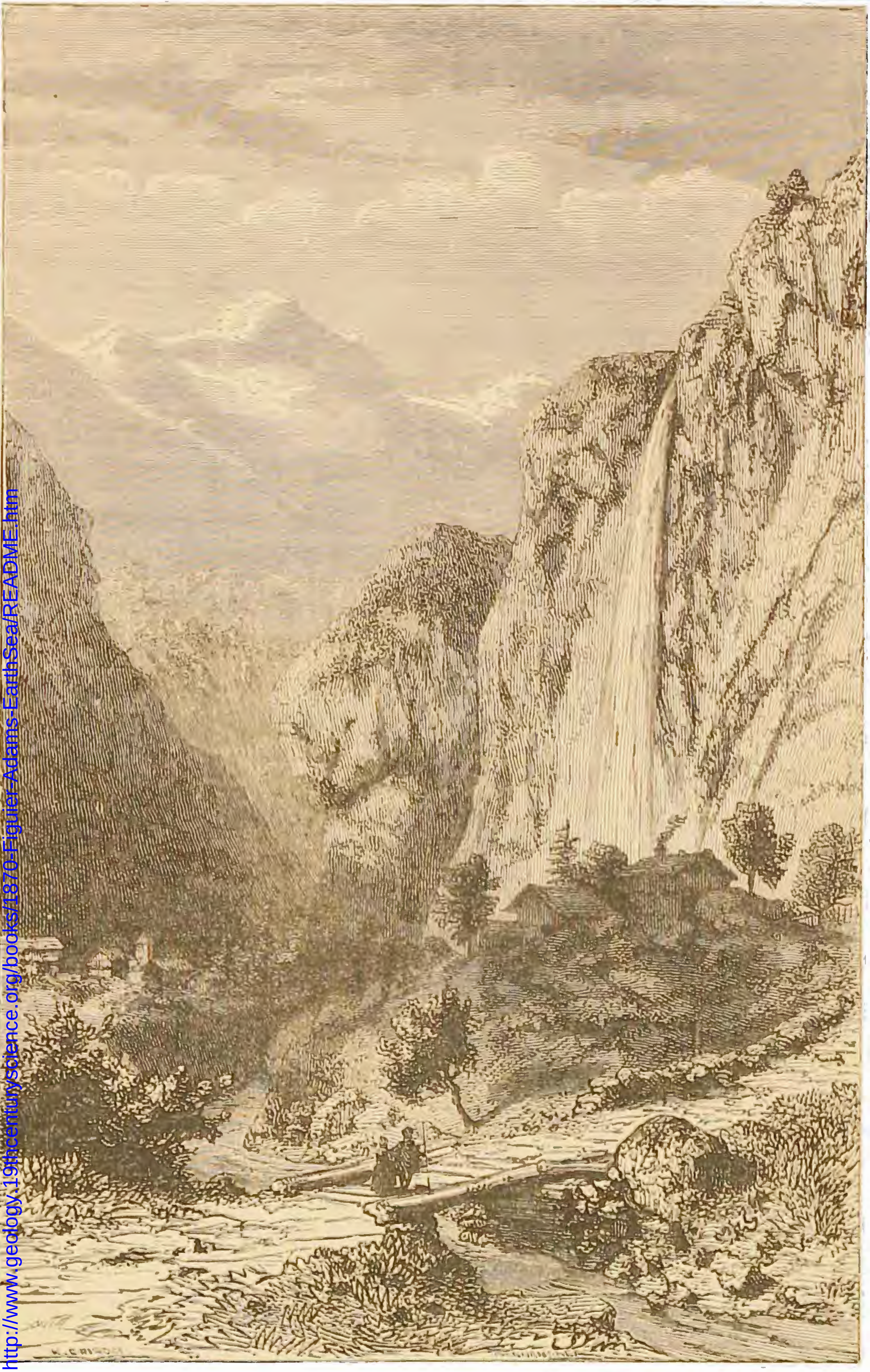


FIG. 179.—CASCADE OF THE STAUBBACH (FROM THE VALLEY OF LAUTERBRUNNEN).

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curving over the rock, like the *tail* of a white horse streaming in the wind—such as it might be conceived would be that of the "pale horse" on which Death is mounted in the Apocalypse. It is neither mist nor water, but a something between both: its immense height gives it a wave or curve—a spreading here, or condensation there—wonderful and indescribable.

Fair is the Valley of Lauterbrunnen, says Longfellow,* with its green meadows and overhanging cliffs. The ruined castle of Unspannen stands like an armed warder at the gate of the enchanted land. In calm serenity the snowy mountains rise beyond. Fairer than the rock of Balmarusa, yon frowning precipice looks down upon us; and, from the topmost cliff, the white pennon of the Brook of Dust shimmers and waves in the sunny air!—

"This bold, this bright, this sky-born waterfall."

The *Falls of the Aar*, at Handeck, have been celebrated by Wordsworth in a noble sonnet:—†

"From the fierce aspect of this river, throwing
His giant body o'er the steep rock's brink,
Back in astonishment and fear we shrink;
But, gradually a calmer look bestowing,
Flowers we espy beside the torrent growing;
Flowers that peep forth from many a cleft and chink,
And, from the whirlwind of his anger, drink
Hues ever fresh, in rocky fortress blowing:
They suck—from breath that, threatening to destroy,
Is more benignant than the dewy eve—
Beauty, and life, and motion, as of joy:
Nor doubt but He to whom yon pine-trees nod
Their heads in sign of worship, Nature's God,
Those humbler adorations will receive."

The Falls of the Aar, if not equal in beauty to the Staubbach, are its superior in magnificence. The rock over which the river rushes in a tremendous mass of dark swirling waters is upwards of 200 feet in perpendicular height, and the gorge which seems to swallow up the foam and thunder and headlong impetuosity is a very abyss of gloom. The quantity of water is so great, that it sweeps more than half-way down in one continuous, glancing, and apparently solid sheet, before the wind breaks it up into shivering foam.

Near the beautiful vale of Meyringen, the small but furious stream of the *Reichenbach* descends the rocky declivity in a succession of headlong leaps, extending in all over 2000 feet. Rock, and crag, and mossy boulder; pine-wood and roaring torrent; precipitous cliffs and ledges drooping with wild-flowers, combine in a picture of more than ordinary impressiveness.

The *Waterfall of the Sallenche* is situated near Montigny, in the Valais. The

* [Longfellow, Prose Works: "Hyperion."]

† [Wordsworth, Poems: "Memorials of a Tour on the Continent," xiii.]

stream here makes its way into the valley of the Rhone through a rugged ravine which has been excavated by its incessant agency. Its perpendicular descent may be estimated at about 280 feet, but the last bound of the cataract does not exceed 120 feet.

Scarcely less famous, and certainly not less picturesque, are the *Falls of the Linth*, particularly those of the Fätschbach and the Schreymbach, near Linthal; and the magnificent cascade of the Sandbach, which descends from an elevated plateau, lying west of the Lower Sand Alp. At the *Devil's Bridge*, near Wasen, the Reuss leaps down into the awful gorge of Schöttenin in a lofty cataract, which tumbles and roars, and howls among the huge fragments of granite that obstruct

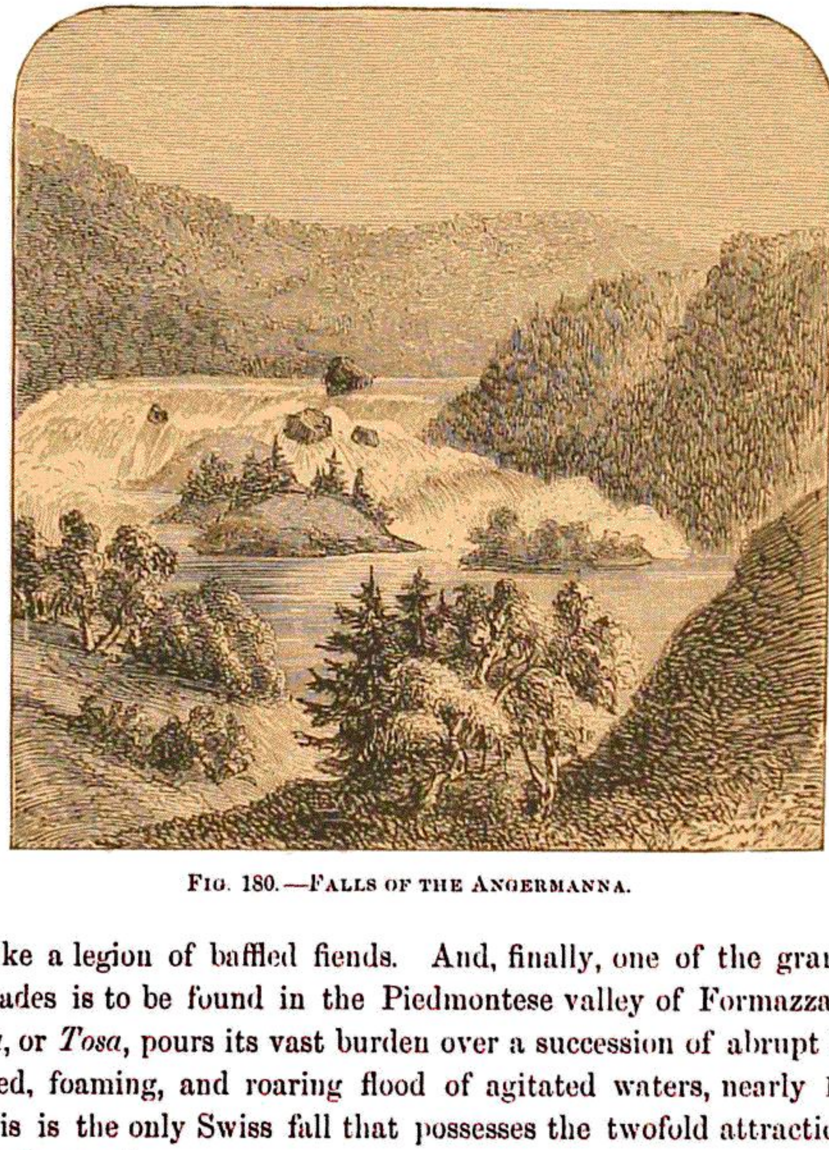

FIG. 180.—FALLS OF THE ANGERMANNA.

its course, like a legion of baffled fiends. And, finally, one of the grandest of the Alpine cascades is to be found in the Piedmontese valley of Formazza, where the river *Toccia*, or *Tosa*, pours its vast burden over a succession of abrupt ledges in an uninterrupted, foaming, and roaring flood of agitated waters, nearly 1000 feet in length. This is the only Swiss fall that possesses the twofold attraction of height and volume of water.]

Sweden and Norway are rich in magnificent waterfalls, many of which swirl furiously and thunderously through the deep shadows of leafy pine-woods. The most considerable is that of Trollhetta, or the *Gotha-Elf*, an offspring of the immense Wener, which is fed by twenty-four rivers. It precipitates itself into an abyss of more than 130 feet deep upon huge fragments of rock, which churn it into one wild sea of foam. The canal of Trollhetta was constructed that this tremendous cataract might be avoided.

We may also name, in Sweden, the cascade of Elfkaerleby; in Norway, that of Rjukandfoss, formed by the Maanelf, in the province of Tellemarken, and 1015 feet in height; that of the Feiomfoss; the Glommen, the Pursoronka, and the Utahanna; and finally, that of Opthun, in the Sognefield.

On the borders of Lapland, the Angermanna-Elf, a beautiful river, as broad as the Danube, and fringed with ancient forests, forms a noble cascade in the neighbourhood of Liden; its waters dash themselves in an excess of violence on an archipelago of little islets, as if they would hurry them onward in their own impetuous course.

Reference should also be made to the graceful cascade of the river Savannah in the Mauritius, which possesses this interesting characteristic: it falls on a basaltic wall composed of perfectly regular prisms, forming what is popularly known as the Giants' Causeway.

Among the Himalayan range numerous magnificent cascades have been discovered. In the Andes, the *quebradas* sometimes leap into chasms of a terrific depth, and pour their wild currents through a rocky defile, whose walls are upwards of 320 feet in height.

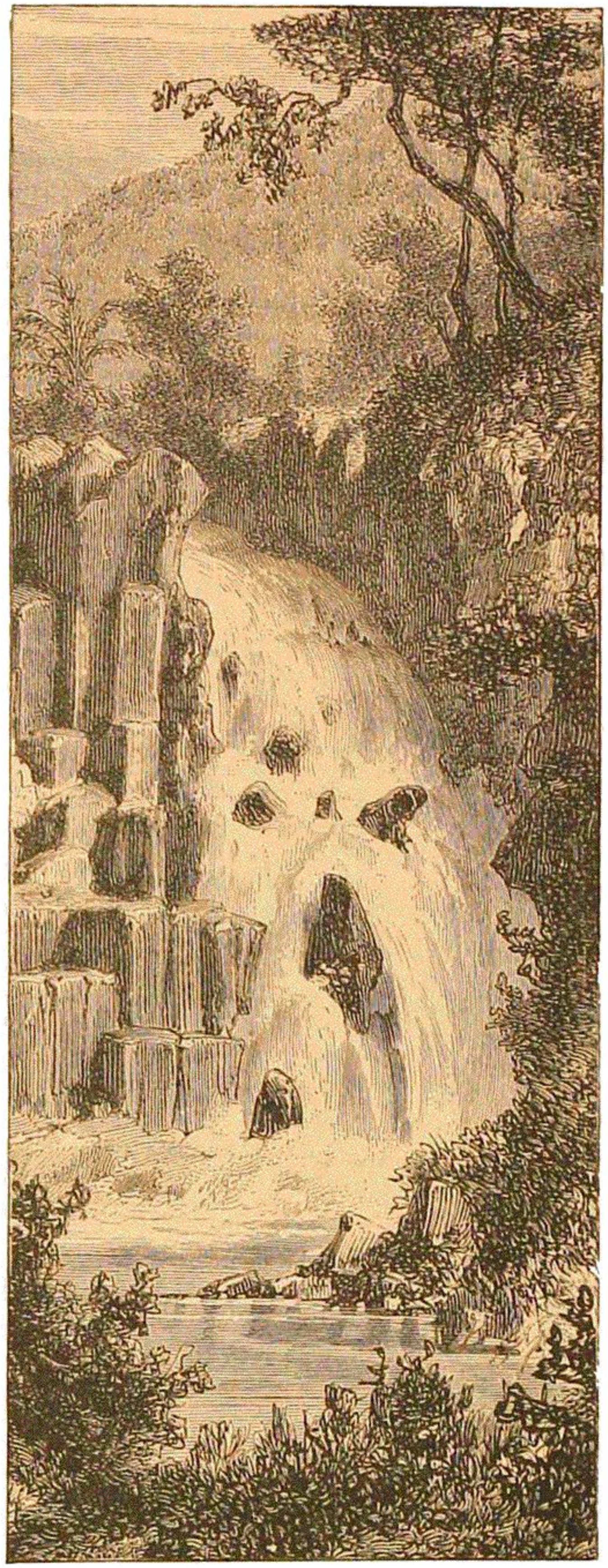

FIG. 181.—CASCADE OF THE SAVANNAH, IN THE ISLAND OF MAURITIUS (INDIAN OCEAN).

Nor must we forget, in the State of Virginia, the *Falling Spring*, a superb watery arch, which projects itself over a rampart of rock with so bold a curve that the traveller can pass beneath it dry-footed.

If the ground where a cascade takes its headlong leap is disposed in terraces, the water springs from stage to stage with a succession of short bounds or descents, sometimes presenting the appearance of a wavy sheet, sometimes of a liquid wall, until it finally arrives on a comparatively horizontal surface, and flows with greater moderation. It is these successive falls which are properly called *cataracts*, though the word is frequently applied in a very loose and indefinite manner.

Where the soil offers no abrupt "solution of continuity," but only a very sensible

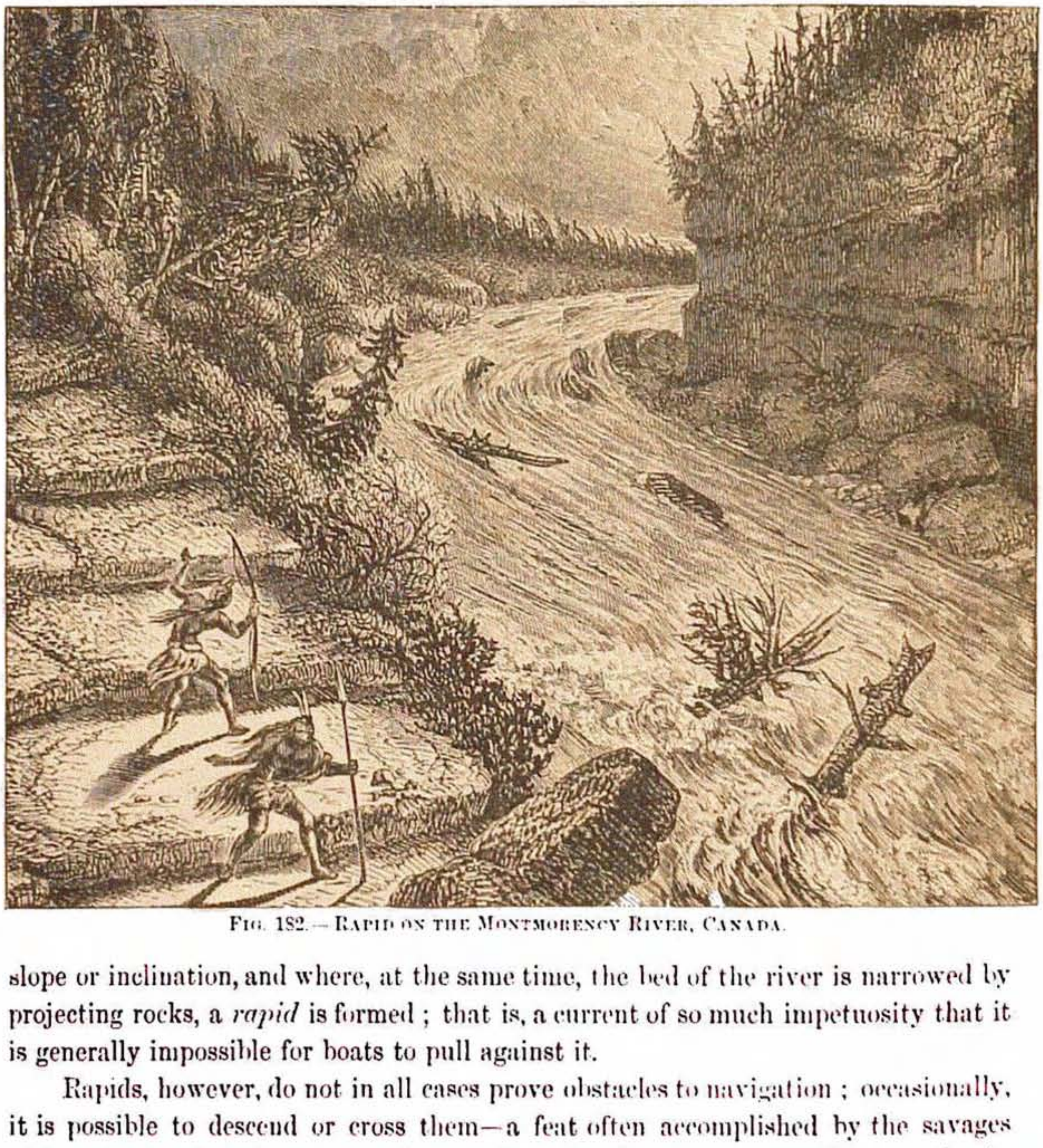

FIG. 182.—RAPID ON THE MONTMORENCY RIVER, CANADA.

slope or inclination, and where, at the same time, the bed of the river is narrowed by projecting rocks, a *rapid* is formed; that is, a current of so much impetuosity that it is generally impossible for boats to pull against it.

Rapids, however, do not in all cases prove obstacles to navigation; occasionally, it is possible to descend or cross them—a feat often accomplished by the savages of America in their boats of bark, as well as by the adventurous Creoles, who, in their light and graceful skiffs, fear not to brave the whirlpool and the eddying, swirling tide. Our illustration represents a rapid on the river Montmorency, in Canada, about eight miles above Quebec. One of the banks of this torrent consists of a succession of steps or stages, and has been not inappropriately named *the Giants'*

Staircase. The Montmorency Falls descend from an altitude of 260 feet into a kind of funnel-shaped ravine, bordered by sombre precipitous rocks, whose jagged edges and salient angles are known by the fiercely foaming eddies. A cloud of silvery vapour rises in the air, and in the sunshine glows with a thousand rainbows—arch upon arch of living light! The crest of the rocks is enriched with a bright fresh vegetation, and bright runlets wind beside the principal cascade.

The reader will be familiar, by description, with the *rapids* of the river Amazons at Pongo de Manserichi, where the mighty flood is pent up in a narrow defile, and struggles like a giant to break from its thralls. Those of the Connecticut River are also remarkable for their grandeur. In Europe we may refer to those of the Rhone at Pierre Encise,—

> "Where the swift Rhone cleaves his way between
> Heights which appear as lovers who have parted;"—

of the Rhine at Bingen; and of the Danube at Orsova.

[The defile at Orsova is the famous "Iron Gate"—a table-land of rugged rock, 4250 feet in width, over which the great river formerly swept with an infernal commotion and a thunderous noise. This rapid, which was followed up by a series of dangerous eddies, whirlpools, and shallows, was at one time an obstacle of insuperable difficulty to the upward progress of vessels, no craft being able to traverse it which drew more than two and a half feet of water. But by a series of successful blasting operations the terrors of the pass have been so far diminished, and the channel deepened, that it is now accessible to vessels of eight and even nine feet draught.]

Among the great *cataracts* of the world, those of *Maypures*, on the river Orinoco, have acquired a wide celebrity. They consist, in truth, not of one, but of many successive cascades or falls. The best point of view, according to Humboldt, is from the height of Manimi:—*

On reaching the summit of the rocks, says our great philosopher and traveller, the eye suddenly measures a sheet of foam more than a mile in extent, with enormous rocks, black as iron, emerging from its bosom; some are mamelons, grouped two by two, like hills of basalt; others may be compared to feudal towers, strong fortresses, and ruined edifices. Their gloomy colour vividly contrasts with the silvery splendour of the foaming waters; each rock and each islet is crowned with clumps of flourishing trees. From the foot of these mamelons, and as far as the view extends, a dense smoke is suspended above the river; through the white-gleaming mist spring the tops of the lofty palms.

The other great cataracts of America are those of the Potomac, the James River, the Missouri, the river Columbia, the Niagara, the Tequendama—not far from Santa Fè de Bogota—and that of the Yosemity, in California, which is 2600 feet in height. The Rio San Francisco, in Brazil, ceases to be navigable for a course of two-and-sixty miles, owing to a succession of cataracts which terminate in the Cachoeira-Grande, and are constantly enveloped in whirling masses of vapour.

* A. von Humboldt, "Voyage aux Régions Equinoxiales," tome vii., p. 170.

[The *Niagara* is that world-famous cataract which pours the waters of Lake Erie into Lake Ontario. More correctly may it be said to convey the superfluous waters of four great lakes—or, rather, inland seas—which, after gathering in a channel thirty-three miles long—a channel extending from Lake Erie to Lake Ontario—suddenly hurl themselves in one mighty flood, and with a roar like that of thunder among the mountains, over the brink of a huge precipice, falling beneath in a mass of foam and spray, irradiated with shifting iris-hues.

The cataract itself is divided into two unequal portions by the intervention of Goat Island, which has a façade nearly one thousand feet in breadth. The fall on the Canadian side of the river, called the *Horseshoe Fall* from its shape, is 2000 feet broad and 149 feet 9 inches high. The reader who has seen the Thames at Erith has to imagine, therefore, that it is suddenly precipitated over a wall of rock only fifty feet lower than the Monument, if he would form an idea of the magnitude of this astonishing cataract. The American fall is 1140 feet broad and 164 feet high. The former, however, altogether exceeds the latter in sublimity. With such impetuous fury does the boiling flood fling itself over the precipice, that, in striking the stream below, it forms an arch, whose span is several feet distant from the base of the rock; and, consequently, the traveller may pass between the rock and the curving waters as through a vaulted gallery of crystal!

The amount of water rolling over these falls has been estimated at 670,250 tons per minute.

We have spoken of the sublimity of the scene. A traveller, not wont to indulge in exaggeration of language, describes his impressions thus:—*

"So entirely," he says, "was I unprepared for the enormous volume of water, that, in the weakness of my comprehension and inability to grasp the scene, I was unwilling to turn my aching eyes from the glorious spectacle, apprehending it could only endure for a season, and that the overwhelming rush of water must speedily cease. But as I gazed with trembling anxiety, and marked no change beyond the masses of spray-clouds, swayed by the wind across the mighty sheet, which ever retained its sublime proportions, the truth began to force itself upon me, that for thousands of years the waters had been falling, by day and by night, at all times and seasons, ever sounding, in a voice which once heard can never be forgotten, the praise of Him who bade them flow. Here, indeed, may be felt the beauty of the words in our canticle, 'O ye seas and floods, bless ye the Lord; praise him, and magnify him for ever!' And it was probably with feelings of deep awe that the Indians of olden time, worshipping the Great Spirit, gave the peculiarly appropriate name of O-Ni-au-ga-rah, 'The Thunder of Waters,' to this matchless scene. It is indeed eloquent 'as with the voice of a great multitude, the voice of many waters, the voice of many thunderings, saying, Alleluia: for the Lord God omnipotent reigneth!'"

Mr. Charles Dickens's description does even fuller justice to the glories of Niagara:—†

* [C. R. Weld, "Vacation Tour in United States and Canada."]

† [Charles Dickens, "American Notes."]

FIG. 183. —THE FALLS OF NIAGARA.

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"When I felt how near to my Creator I was standing, the first effect, and the enduring one, instant and lasting, of the tremendous spectacle was peace;—peace of mind, tranquillity, calm recollections of the dead, great thoughts of eternal rest and happiness; nothing of gloom or terror. Niagara was at once stamped upon my heart as an image of beauty, to remain there, changeless and indelible, until its pulses cease to beat, for ever.

"I think in every quiet season now—Still do those waters roll and leap, and roar and tumble, all day long. Still are the rainbows spanning them a hundred feet below. Still, when the sun is on them, do they shine and glow like molten gold. Still, when the day is gloomy, do they fall like snow, or seem to crumble away like the front of a great chalk cliff, or roll down the rock like dense white smoke. But always does the mighty stream appear to die as it comes down, and always from its unfathomable grave arises that tremendous ghost of spray and mist which is never laid, which has haunted this place with the same dread solemnity since darkness brooded on the deep, and that first flood before the Deluge—light—came rushing on creation at the word of God!"

The roar of Niagara is sometimes audible at Toronto, a distance of six-and-forty miles. It is often the scene of fatal accidents and tragic catastrophes, even of suicides; though it is difficult, perhaps, to imagine that man should commit self-destruction in the presence of so overpowering a manifestation of the divine power.

A story is told of an Indian, whose canoe had through some unfortunate mischance been entangled in the vortex of the current, springing to his feet when he found his fate inevitable, brandishing his spear, and chanting aloud his death-song, as he swept on to death! A similar anecdote was recently recorded in the newspapers: the Indian, with the stoical composure of his race, threw himself down in his canoe, as if courting slumber, and so quietly passed away. Neither he nor his boat was ever seen again.

Chateaubriand's description of the cataract is characterized by his usual eloquence:—

"From Lake Erie to the Fall," he says, "the river continues its descent down a rapid slope, and, at the point of its descent, it is less a river than a sea, whose torrents force themselves into the yawning jaws of the gulf. The cataract divides itself into two branches, and curves like a horse-shoe. Between the falls an island projects, hollowed underneath, and impending, with all its trees, over the chaos of billows. The mass of the river which precipitates itself southward is rounded like a vast cylinder, then unrolls like a sheet of snow, and shines in the sun with all its colours; the volume which pours eastward descends in a horrible gloom; it may be compared to a column of water of the Deluge. A thousand rainbows curve and cross each other in the abyss. The wave striking the shattered rock is dashed back in whirling foam, which soars far above the forests, like the smoke-wreaths of a vast conflagration. Pines, wild walnut-trees, and rocks like phantoms, embellish the scene. Eagles, drawn down by the current of air, descend, revolving, to the bottom of the gulf; and carcajous suspend themselves by their long tails to the end of a drooping branch to snatch from the abyss the disfigured carcasses of the bears and elands."

During the present era of the world's history, the great cataract has but slightly modified its appearance; and though the eternal rush of the billows has been incessantly at work wearing away the rocky shelf over which they fall, the rate of retrocession was scarcely discernible in a lifetime. Of late, however, appearances have been observed which seem to indicate that, erelong, a sudden and entire change of the Canadian Falls may occur, and in such a manner as to diminish, if not entirely divert, the stream which now passes over the precipice on the American side of Goat Island. Within the past two years a peculiar motion of the rapids at a point about 800 yards above the curve in the Falls, over which the greatest volume of water descends, has attracted the attention of accurate observers, and led to a belief that the current has effected a breach in the soft shale stratum underlying the limestone ledge over which the main body of waters descends.

This shale stratum is visible under Table Rock, and in the banks of the river on either side below the Falls, while it ascends toward the south at a gradient that would reach the river-bed about 800 yards above the Canadian Falls.

The theory thus briefly described has recently [1868] become an undoubted fact. A marked and constant change in the motion of the rapids has been observed at the point indicated; and it is also said that symptoms are discernible of the outflow of a subterranean stream into the gulf below the Falls. The final result of this combined action must be to produce a sudden retrocession of the Falls, sooner or later, to the point where the limestone strata terminate, and, consequently, a total change in their appearance and character.

The *Kaaterskill Falls*, in the United States, form a very romantic and imposing spectacle. Their waters issue from two small lakes in the Catskill Mountains, on the west bank of the river Hudson. The upper fall descends 175 feet; the torrent then rushes along the level for some forty or fifty yards, to leap over a second precipice, 80 feet in height, and down into a deep, dark gorge, whose encircling rocks and woods tower aloft to an elevation of upwards of one thousand feet.

Several cataracts of singular beauty occur on the *Columbia River*. The current is strong and rapid; the bed of the river broken by immense crags and boulders; while the scenery on either bank is distinguished by all those features of savage grandeur which belong to the weird primeval forest.

In South America the *River Funza*, on escaping from the confined valley of Santa Fé de Bogota—a basin shut in on all sides by lofty mountains—sweeps over a precipice 574 feet in height and about 130 feet in breadth, throwing up a column of pearly vapour which is visible at Santa Fé, a distance of seventeen miles. At the summit and at the base of this precipice two different climates prevail; the character of the vegetation also is entirely different. Above, the traveller wanders in the pleasant shadow of leafy oaks and elms, or traverses a luxuriant tract of corn-fields; below, he makes his way through the palms and bananas of the tropical world. Above, the air is fresh and cool, and the breeze temperate; below, a sultry heat nourishes the luxuriance of bloom peculiar to a torrid clime.

Our British cataracts and waterfalls are greatly inferior in magnificence to those of Switzerland or the United States, but some of them possess a quiet picturesque beauty which is far more winning. The *Falls of the Clyde*, for instance, though only on a miniature scale, exhibit those sylvan charms which poet and painter know so well how to appreciate. They are three in number—the Stonebyres, Corra Linn, and Bonnington Falls; of these the Corra Linn is the grandest. Here the river rushes over a declivity, 84 feet high, into a sheltered basin hollowed out of the rock, whose sides are richly clothed with wood. As the bed of the stream is encumbered with crags, the waters now sweep through a narrow gulf with measureless violence—now dimple and circle in quiet glassy pools—now flash around and around in ceaseless eddies—everywhere presenting some fresh point of beauty.

Near Crathie, the stream of the *Garr-valt*, or Garrawalt, a tributary of the Dee, forms a noble waterfall, which cannot be seen without an emotion of admiration. The *Linn of Muick*, near Ballater, is a cascade with only 36 feet depth of fall, but the surrounding scenery gives it an imposing character. A streamlet which flows into Dhu Loch makes a bold and resplendent leap of fully 200 feet.

Near Moffat are the famous *Falls of Devon*, where the river tumbles and flashes through a rocky ravine, in a series of abrupt descents; the first of 34 feet, and the second of 44 feet; in addition to a confused whirl of eddies, and roaring rapids, and natural sluices, which bewilder the spectator with their incessant motion and strange wild noises.

Superior in grandeur, however, are the *Falls of the Foyers*, a tributary of Loch Ness. The stream runs chiefly along a deep and narrow glen, with wild mountainous barriers on either hand, until, within a mile and a half of its mouth, it forms two falls of a splendidly picturesque character, with romantic accompaniments of rock and wood, chasm and precipice. The upper fall is a leap of about 40 feet; from thence to the lower fall the river descends an incline of a quarter of a mile in length, with a gradient of 30 feet; the lower measures about 90 feet. Professor Wilson, no incompetent judge, speaks of these Falls as "the most magnificent cataract, out of all sight, in Britain;" and they have also been celebrated by the poet Burns:—*

"Among the heathy hills and ragged woods,
The roaring Foyers pours his mossy floods,
Till full he dashes on the rocky mounds,
Where, through a shapeless breach, his stream resounds.
As high in air the bursting torrents flow,
As deep-recoiling surges foam below,
Prone down the rock the whitening sheet descends,
And viewless Echo's ear, astonished, rends.
Dim-seen, through rising mists, and ceaseless showers,
The hoary cavern, wide-surrounding, lowers;
Still through the gap the struggling river toils,
And still below the horrid caldron boils."

At the *Rumbling Bridge*, near Dunkeld, the river Bran takes a sheer leap of about 85 feet into a gloomy and precipitous chasm, where the tortured waters seethe and boil with a wonderful commotion.

* [Burns, "Poetical Works:" *Lines Written with a Pencil at the Fall of Foyers.*]

Reference may also be made to the *Falls of Tummel.* The river itself is described by Mrs. Brunton as "of all rivers the most truly Highland—impetuous, melancholy, and romantic—foaming among the fragments that have fallen from mountains which seem to have been cleft for its course." The fall—which is, in truth, not one unbroken descending sheet of water, but a series of rapids and leaps terminating in a bold headlong bound of eighteen feet—has been accurately delineated by MacCulloch:*—"Its rare and peculiar merit is, that it is beautiful in itself, and almost without the aid of its accompaniments. Though the water breaks white almost throughout, the foams are so graceful, so varied, and so well marked, that we can look at it long without being wearied by monotony, and without attending to the surrounding landscape. Whether low or full—whether the river glides transparent over the rocks to burst in foam below, or whether it descends like a torrent of snow from the very edge—this fall is always various and always graceful. The immediate accompaniments are, however, no less beautiful and appropriate; and the general landscape is at the same time rich and romantic—nothing being left to desire to render this one of the most brilliant scenes which our country produces."

In truth, almost every Highland glen has its cascade, or waterfall, or "louping linn," filling its recesses with a grand or tender music, and lighting up the landscape with the sheen of rainbows and the glory of sparkling waters. Their general character has been finely described by Clough, in a poem which ought to be more widely known, for where it is known it cannot fail to charm. The reader will perhaps forgive us for breaking up our narrative with another quotation:—†

"Broad and fair the stream, with occasional falls and narrows;
But, where the glen of its course approaches the vale of the river,
Met and blocked by a huge interposing mass of granite,
Scarce by a channel deep cut, raging up, and raging onward,
Forces its flood through a passage so narrow a lady would step it.
There, across the great rocky wharves, a wooden bridge goes,
Carrying a path to the forest; below, three hundred yards, say,
Lower in level some twenty-five feet, through flats of shingle,
Stepping-stones and a cart-track cross in the open valley.
  But in the interval here the boiling pent-up water
Frees itself by a final descent, attaining a basin
Ten feet wide and eighteen long, with whiteness and fury
Occupied partly, but mostly pellucid, pure, a mirror;
Beautiful there for the colour derived from green rocks under;
Beautiful, most of all, where heads of foam uprising
Mingle their clouds of white with the delicate hue of the stillness.
Cliff over cliff for its sides, with rowan and pendent birch boughs."

Nor is England, though less plentifully endowed in this respect than her northern sister, without the beauty of the waterfall. In Devonshire and Derbyshire are many picturesque cascades; and the chines of the Isle of Wight are mostly occupied, as they were originally excavated, by leaping, tumbling, and flashing streams, which, at Shanklin and Blackgang, descend from a considerable elevation.

* [Dr. J. MacCulloch, "Highlands and Western Islands of Scotland" (ed. 1824).]
† [A. H. Clough, "The Bothie of Tober-na-Vuolich," p. 115 (ed. 1868).]

In the Lake District the waterfalls are numerous, and many of them are distinguished by their romantic and even magnificent character. The principal are Dungeon Gyll, Lodore, Stock Gyll, and Aira Force. These have been celebrated by Wordsworth and Southey, and it must be owned that they are not unworthy of a poet's praise.

In completing our rapid survey we must glance at Africa. Here the most remarkable cascades are those of the Nile, the Zambesi, the Zaire or Congo, and the Senegal.

The *Falls of Félou*, on the latter river, are situated about one hundred miles

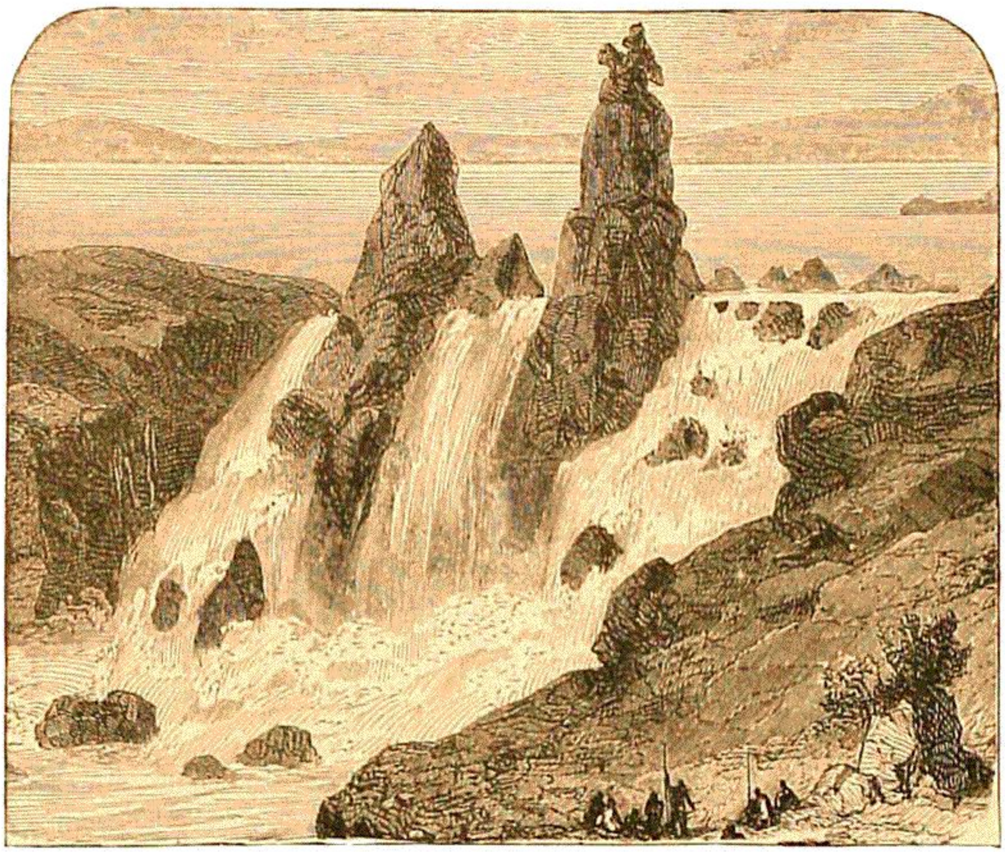

FIG. 184.—FALLS OF FÉLOU, ON THE SENEGAL RIVER.

above its confluence with the Falémé. The traveller reaches the spot from the village of Medina, by ascending a gentle incline to a very extensive table-land, whose surface is as polished as an asphalt pavement. After a walk of forty minutes, he finds himself in front of the river, and beneath the cataract. The difference of level is not more than ninety-five feet; the vertical plane on which the waters are distributed in falling is besprinkled with blocks of sandstone, incessantly assailed by their restless agency, and fashioned into the most fantastic designs. Observe the deep orifices which have been wrought by the infiltrations and minute fragments of quartz, as if by a chisel. The waters have undermined the rock from below, and it is the parts already weakened which cut the troughs or sluices in the wall of sandstone thrown across the river's course from north to south. The singular outline of the rocks environing the cataract has given rise, among the negroes, to a host of legends.

The *Victoria Falls*, on the river Zambesi, were first made known to the civilized world by the illustrious traveller and pioneer of geographical science, Dr. Livingstone.

He describes the surrounding scenery as very beautiful; the banks of the Zambesi, and the islands which, gem-like, stud its surface, being adorned with sylvan vegetation of great variety of form and colour. There flourish the mighty baobab, each of whose enormous arms would form the trunk of a large tree; the graceful palm, with its plume of emerald foliage; the silvery mohonou; and the

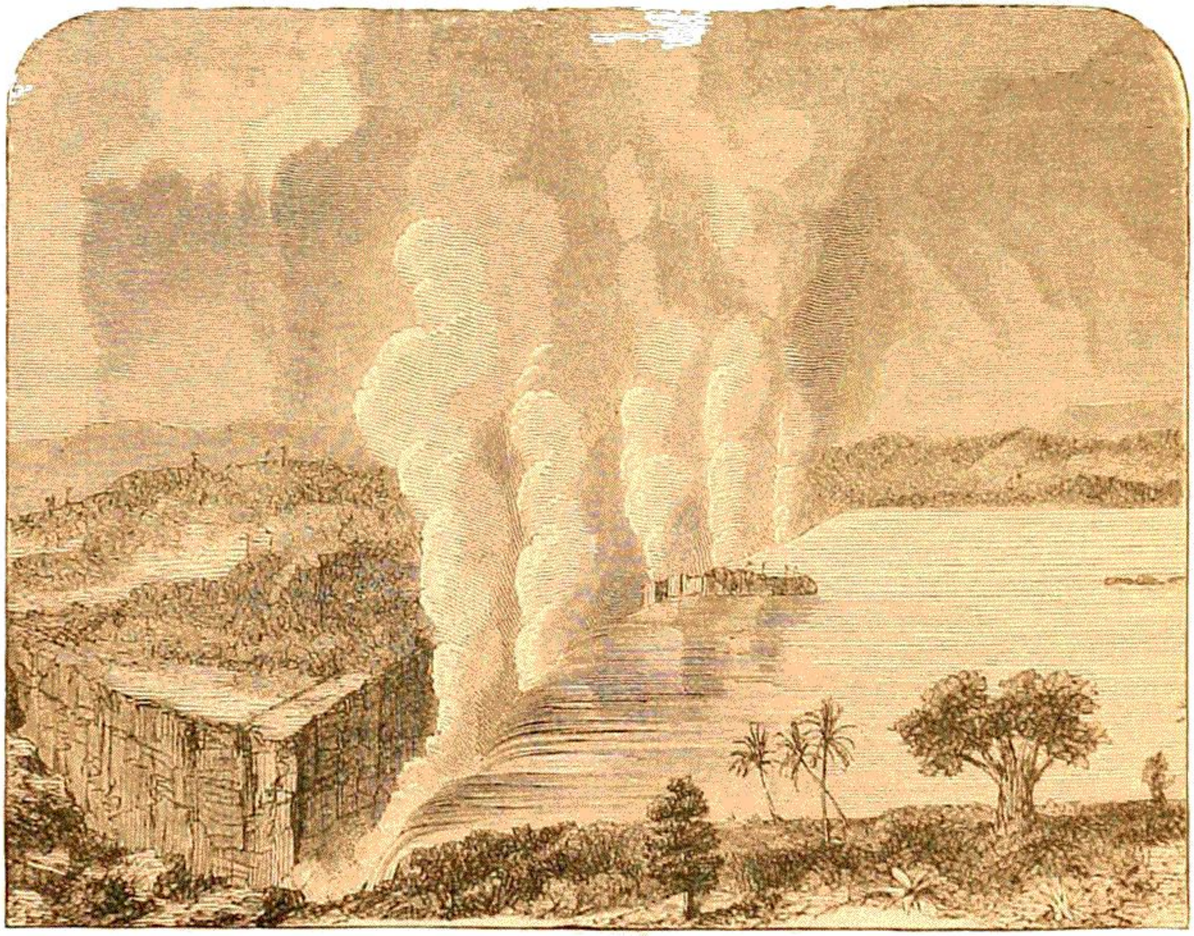

FIG. 185.—THE VICTORIA FALLS, ZAMBESI RIVER.

motsouri, rich in clusters of bright scarlet fruit. The Falls are bounded on three sides by densely-wooded ridges 300 or 400 feet in height, and may be likened to a flood of water, a thousand yards broad, hurled over a precipice of basaltic rock one hundred feet in depth, and then suddenly compressed into a narrow gully of fifteen or twenty yards.

"If one imagines," says Dr. Livingstone,* "the Thames filled with low tree-covered hills immediately below the Tunnel, extending as far as Gravesend, the bed of black basaltic rock instead of London mud, and a fissure made therein from one end of the Tunnel to the other, down through the keystones of the arch, and prolonged from the left end of the Tunnel through thirty miles of hills; then fancy

* [Dr. Livingstone, "Missionary Researches in South Africa."]

the Thames leaping boldly into the gulf, and there forced to change its direction, and flow from the right to the left bank, and then rush roaring and boiling through the hills, he may have some idea of what takes place at this the most wonderful sight I have witnessed in Africa."

In descending into the narrow abyss already spoken of, the cataract breaks into five separate streams, which send up, to an elevation of 200 or 300 feet, as many volumes of luminous vapour—shafts of shivering spray and foam, which in the sunlight are gloriously wreathed with the rare hues of Iris.

The natives call these falls, in allusion to their vaporous clouds and thunderous roar, Mosooatunya—that is, "*smoke* does *sound* there." They were anciently known by the appellation of Shongwe, which appears to have meant "a seething caldron." Its columns of smoke are visible at a distance of five to six miles, and might lead an American traveller to imagine himself in the vicinity of a burning prairie.

Celebrated in story will be the *Ripon Falls*—so named by Captain Speke*—which carry the infant stream of the Nile, in a channel 150 yards broad, over a barrier of igneous rocks 12 feet high.

Speaking of the Nile, we may add a few details in reference to the cataracts which occur on its course through Nubia into Egypt. They are six in number; but though called *cataracts*, are more properly *rapids*, in which no considerable descent is made, no sudden perpendicular plunge; but the river pours along an inclined plane, divided by rocks into several narrow passages, where the waters rush with great velocity, forming numerous eddies and whirlpools. From the violence of the current, the ascent of the river at these points is a matter of difficulty, and even of danger; and the native boats are frequently swamped in their efforts to pass the first and most formidable cataract.

> "The Nile! the Nile! I hear its gathering roar,
> No vision now, no dream of ancient years,—
> Throned on the rocks, amid the watery war,
> The king of floods, old Homer's Nile appears."—(LORD LINDSAY.)

The commencement of the cataract has been expressively described as a complete archipelago of granite rocks, some red, others black, and all shining in the sun, as though highly polished, with various torrents rushing between them in all directions. These rocks are of the most extraordinary forms; now awful, now grotesque; they look as ancient as the earth itself—the very skeletons of the antediluvian world. On the western bank the sands of the Great Desert, yellow as gold, and broken by the action of the wind into rolling waves, descend to the water's edge, interspersed with great masses of black basalt; on the east, crag rises above crag in such chaotic confusion that one can only suppose the scene to have resulted from some volcanic explosion.†

Mr. Eliot Warburton furnishes an amusing narrative of his adventures in effecting the passage of the first Cataract.‡

* [Captain Speke, "A Journey to the Sources of the Nile."]
† [Mrs. Romer, "Temples and Tombs of Egypt," etc.]
‡ [Eliot Warburton, "The Crescent and the Cross."]

The sheikh, he says, who had charge of the river at this particular point, placed himself on a commanding rock, and encouraged his men with shouts, and prayers, and objurgations to haul the boat up the watery acclivity. For this purpose, a stout English rope was made fast to the mainmast; the Nubians clung to it with a vice-like grasp; "Yallough! Wallah!"—a mighty shout—a long pull, a strong pull, and a pull all together—and away went the boat up the hill of water which forms the first stage of the cataract.

So much having been accomplished, the amphibious attendants, standing waist-deep in the river, took a quiet breathing pause. The sheikh gesticulated, and cried, "Yallough! Wallah!" and again they set to work. More shouting, more efforts, and the second fall or stage was safely passed. Then, over a tranquil reach of the

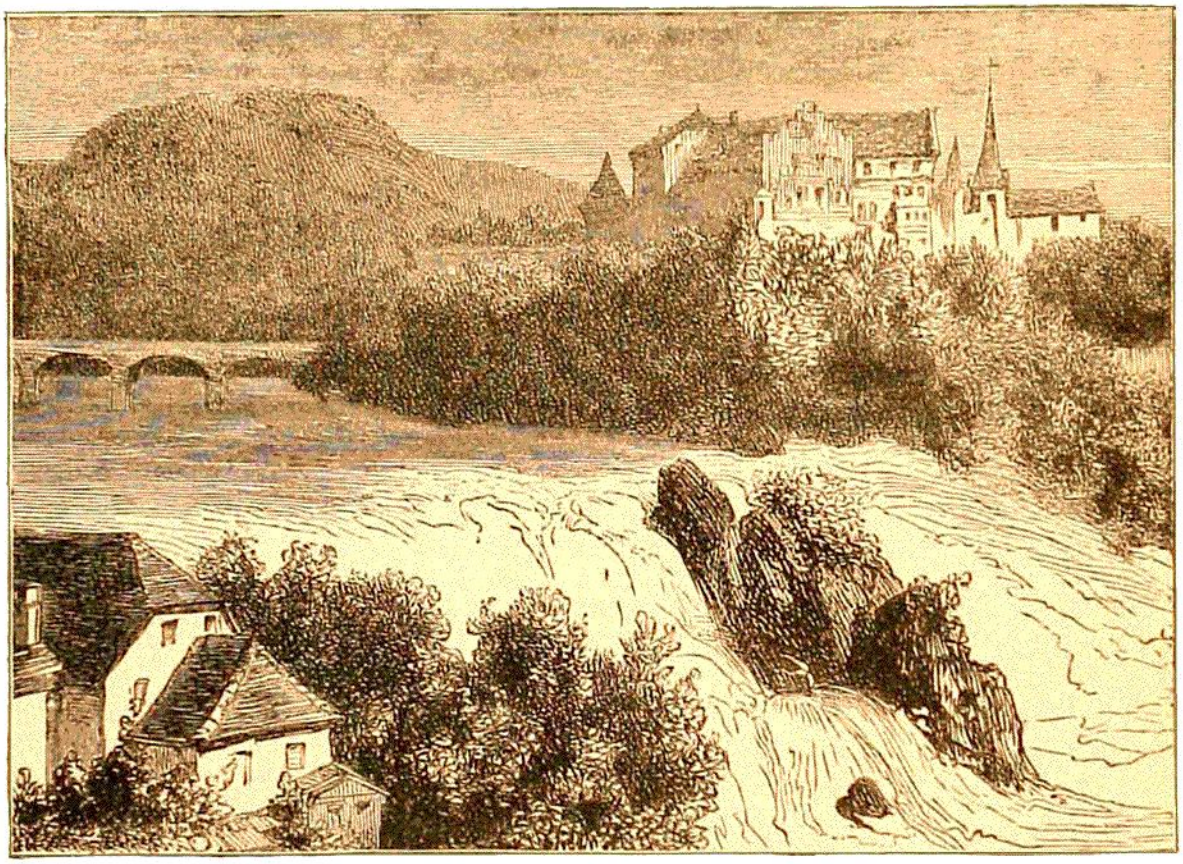

FIG. 186.—FALL OF THE RHINE, AT LAUFFEN, NEAR SHAUFFHAUSEN.

stream, Mr. Warburton moved on to the third and most difficult stage of the rapid, where the Nile hurls the whole volume of its waters between two towering cliffs.

The sheikh, however, proved fully equal to the responsibilities of "the situation." Flinging off the encumbrance of his long robes, he stood forth stripped of everything but his drawers; even his turban was thrown aside, and the long Mussulman tuft of hair that crowned his shaven head floated "like a horse-tail in the wind." His gestures and his ejaculations were violent and incessant. His followers seemed animated with supernatural vigour. They shouted and they strained; they darted hither and thither; they jumped upon the rocks; they leaped into the waters; now they fended off the quivering boat from some perilous crag; now they tugged lustily at the straining rope; the cries of "Yallough! Wallah!" were redoubled, and replied to from the shore by shouts of "Haybesah!" (God help you!)—a minute, and another—the boat was half-buried in sand and spray. Hurrah! the dreaded cataract was surmounted, and the boat rode triumphantly on the tranquil river.

The first Cataract is situated at Assouan (the ancient *Syene*), in lat. 24° 10′ N.: and the sixth, south-west of Mograb, in lat. 19° 30′ N.

We shall conclude this somewhat desultory chapter with a brief description of one of the most renowned falls in Europe; that of Schaffhausen, where the Rhine, in a volume of waters 450 feet in width, descends a precipice of 70 feet.

Figure to yourself, says Madame Roland, the river in all its majesty sweeping headlong like a sea of leaping foam; three rocks, crowned with verdure, interrupt the course of this vast sheet of water, this torrent of snow. The irritated river lashes its enclosing banks in furious wrath, undermines them, encroaches upon them, and multiplies its falls by the gaps it cleaves in them; it crashes down with a turmoil which spreads horror on every side—with which the whole valley re-echoes—and the shattered billows soar aloft in vapours gaily adorned by brilliant rainbows.

The Florentine Poggio, one of the most famous Italian authors of the tenth century, who officiated as the Pope's secretary at the Council of Constance, is the first writer to make mention of the Schaffhausen Cataract: "The river," he says, "precipitates itself among the rocks with so much fury and so terrible a roar, that one might almost say it bewailed its fall."

The scene deserves to be visited, and to be contemplated from both banks, and under all its various aspects: from the Château of Woerth, where there is now a hostelry; from the belvedere of the Château of Lauffen, beneath which a solid gallery of timber abuts in the very centre of the waters. Finally, the tourist should obtain a guide to the principal rock, which divides the cascade into two main parts; but one need have a firm head to attempt the ascent. It is at night, and in the soft radiance of the moon, that the magnificent spectacle produces the greatest impression. Once seen, it can never be forgotten, but will be treasured up in the memory among those precious things and those tender associations which the lover of nature will not willingly suffer to fade away.]

CHAPTER IV.

THE MID-COURSE OF THE RIVERS:—FLOODS AND INUNDATIONS.

ACCORDING to Ritter,—than whom there is no more eminent authority in geographical science,—cataracts and rapids are most numerous in the upper and mid-course of rivers. In the mid-course, however, the channel conspicuously assumes a more gradual development. The Volga, throughout the lower part of its flow, does not offer a bolder gradient than 1 in 2500; in other rivers the incline is even gentler. Accordingly the waters glide along, yielding to their own pressure. They corrode their banks in the direction where their waters meet with the least resistance; and change their course according to the nature of the opposed shores, executing the most capricious meanders. As a general rule, the windings of the mid-course of rivers follow the direction of the hydrographical *massifs*. It is then that they love to stud their surface with islands, of which so many begem the broad bosom of the Rhine. In the St. Lawrence (Canada), at the entrance of Lake Ontario, the islands form a veritable archipelago: they are called the *Thousand Isles*, but in reality they number one thousand six hundred and ninety-two.

The bed of a river sometimes cuts transversely a chain of mountains, which opens before it as if by enchantment, astonishing the voyager with the most agreeable surprises, and suddenly unfolding before him the most beautiful panoramas. These gaps or passes, which originate such picturesque effects, are very numerous on the noble Hudson river of North America.

Another cause of the retardation of the current is the ocean-tide, whose waves press back the stream towards its source, or, at least, arrest for awhile their onward flow. This stagnation increases the lateral pressure of the waters on their banks; so that human industry is often forced to guard against floods and inundations by the erection of embankments and other artificial defences. A natural consequence of this strong pressure on the sides, as well as of the shifting character of the soil in level plains, is the frequent displacement of the lower course, as we see in the Po, the Ganges, the Nile, the Rhine, and other important streams. Bifurcations, and manifold embouchures

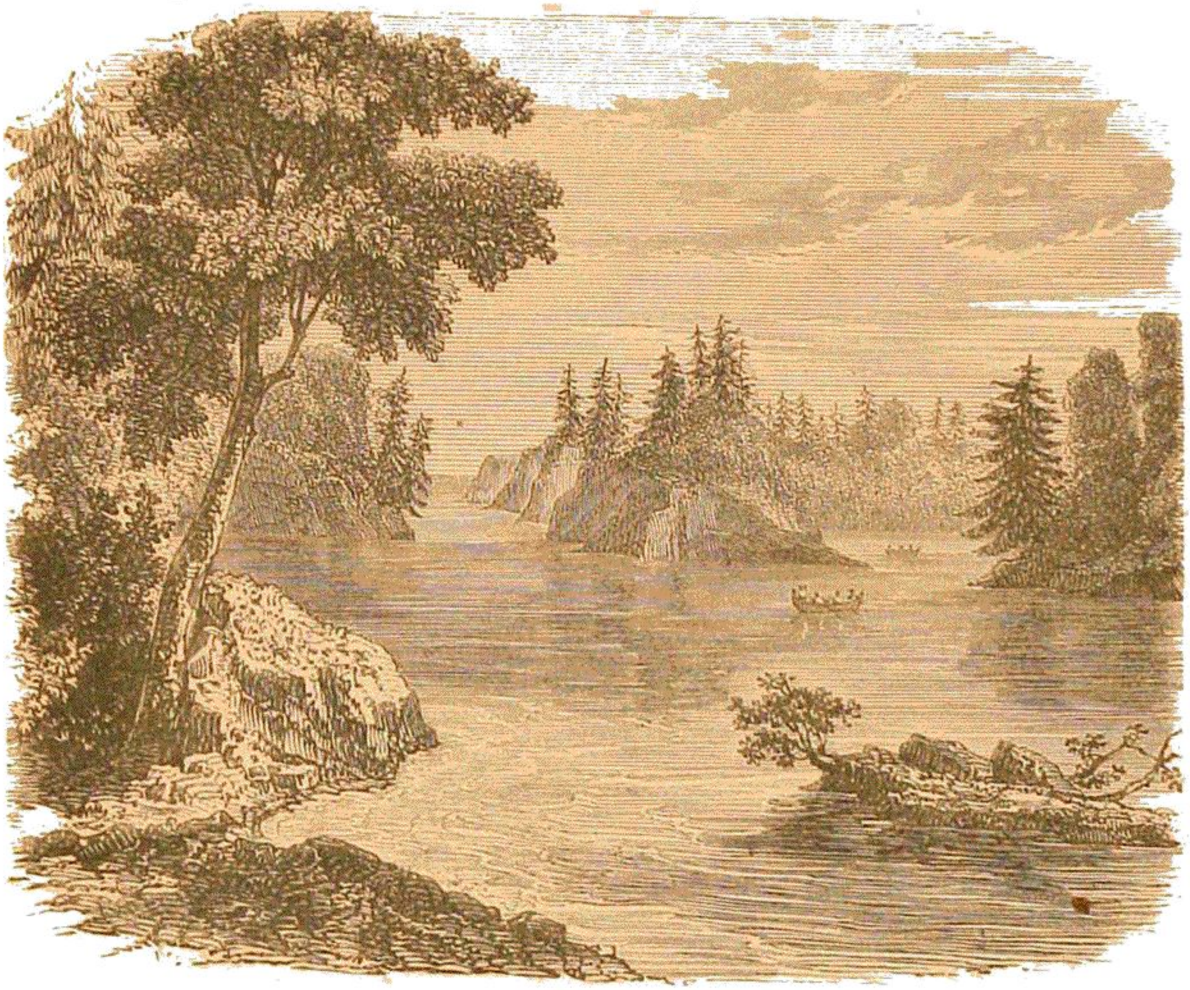

FIG. 187.—VIEW OF THE THOUSAND ISLES.

or mouths, also owe their origin to the tendency of the waters, choked up in their lower course, to seek expansion.

The injurious effects of this "choking-up"—this *engorgement*, as the French expressively call it—are particularly felt at the epoch of the yearly *floods*, to which many rivers are subject, and which proceed either from the melting of the snow and ice, or from continued storms of rain. In some districts these floods are only accidental, and occur after a heavy gale or incessant showers. The Arve, in Savoy, is the victim, so to speak, of sudden inundations. It swells to such a volume that, unable to make its way with sufficient swiftness between the hills enclosing it above its point of confluence with the Rhone, the waters of the torrent flow back in the river-bed, force it to re-ascend with them, and cause the mill-wheels erected on the bank of the Rhone to revolve in a contrary direction. These accidental and unforeseen floods give rise to the most disastrous inundations, which commit terrible havoc in the surrounding country.

In those rivers where they are of inferior magnitude, the floods are, nevertheless, recognized by the change they effect in the colour of their waters. Hence an interesting observation was made on the Seine. The waters of the Marne and the Seine, which unite in the vicinity of Charenton, possess different shades of colour, which are easily distinguishable under the Pont-Neuf, at the extremity of the Ile de la Cité. If there has been rain in Burgundy, but none in Champagne, the yellowish waters of the Seine present a perceptible line of demarcation between them and those of the Marne.

The high water of the Seine and the Loire, in their mid-course, rises from twenty to twenty-two feet; the rise of the Rhine is not nearly so great. These differences are wholly due to the nature of the tributaries which feed them.

The floods of the Rhone, sometimes so disastrous, are caused in the main by the pluvial waters descending from the two valleys of the Côte-d'Or and the Jura, which form the basin of the Saone. The rapid liquefaction of the glaciers of Switzerland occasionally produces, in the spring, the most terrible inundations in the basin of the Rhone. The awful scourge of waters which desolated Morayshire in 1829 was the result of a long season of wet weather, so that the porous and spongy soil had become thoroughly saturated and water-logged; and being unable to absorb the rain, accumulated it in various channels, which swelled and overflowed in a most extraordinary manner.*

* [Sir J. Herschell, "Physical Geography," p. 170.]

[Of the wide-spread desolation caused by these remarkable floods, Sir Thomas Dick Lauder published a very accurate and impressive description.* We shall quote but a single example—the effect of the inundation on the small parish of Knockando:—

"The Knockando burn, entering the River Spey from the left, is extremely small, but was swollen by the flood to a size equal to that of the Spey in its ordinary state. The high promontory on the neck of which the manse of Knockando stands shoots forwards towards the steep opposite banks of the burn, interrupting the continuity of its haughs by a narrow pass, leaving room only at the base of the precipice for two cottages, a small garden, and a road. Where the glen opens, a little way above, there stood a carding-mill, a meal-mill, and the houses of their occupants. Of the two cottages at the bottom of the promontory, one was inhabited by the old bellman, his wife and daughter, and a blind beggar-woman, who had that night sought quarters with them; the other was tenanted by a poor lame woman, who kept a school for girls and young children. After the flood, the prospect here was melancholy: the burn, that formerly wound through the beautiful haugh above the promontory, had cut a channel as broad as that of the Spey from one end of it to the other. The whole wood was gone; the carding-mill had disappeared; the miller's house was in ruins; and the banks below were strewed with pales, gates, bridges, rafts, engines, wool, yarn, and half-woven webs—all utterly destroyed."]

The annual thaw of the glaciers also gives rise to regular floods in the brooks or rivers which they feed.

Many of our European rivers, which are not very rapid, freeze during winter, and cover themselves with a crust of ice, often of great thickness. At the epoch of its breaking-up in spring, the ice gives way at those points where it possesses the least tenacity; the waters then sweep along with them large blocks and fragments which, on encountering an obstacle, accumulate, and gather one upon another,

* [Sir T. D. Lauder, Bart., "Account of the Floods in Morayshire."]

raising a barrier against the waves, which they force to spread themselves over the neighbouring fields, effecting terrible ravages. Such is the cause of the inundations annually occurring on the river Vistula, in spite of the embankments which have been raised to restrain its waters.

Water-courses in the Torrid Zone are subject to periodical floods in the rainy season, which result in the most extraordinary consequences.

[Egypt owes all its fertility to the periodical overflow of the Nile. This annual rise, which for ages has taken place every year within a few hours of the same time, and to within a few inches of the same height, is one of the curiosities of physical geography. Upon it depends the woe or welfare, the abundance or famine, of a nation. To its increasing waters the cultivable soil of Egypt is indebted for the irrigation that secures its fertility. They are conducted over the thirsty ground in hundreds of tiny channels. But for their beneficial influence, the valley would be a wilderness of leafless sand. They are charged with a rich black mud, which, deposited upon the soil, endows it with extraordinary fertilizing properties. Owing to this deposit, the surface of the land is annually increasing in elevation ; but it is a singular fact that the bed of the river is also proportionately rising.

The overflow of the Nile is caused by the periodical rains of eastern Abyssinia and the countries further south, and upon their greater or lesser quantity depends its height and extent. This height is carefully noted, as the area of land subjected to irrigation, and the length of time during which it will remain under water, are necessarily regulated by it, and hence the occurrence of a good or bad harvest may be predicted with certainty.

The ordinary rise at Cairo is about twenty-five to twenty-seven feet : less is insufficient ; more is dangerous, frequently overwhelming entire villages. A rise of only eighteen or twenty feet means—a famine.

The land, thus strangely fertilized and refreshed, will yield three crops annually : being first sown with wheat or barley ; a second time, after the spring equinox, with cotton, millet, indigo, or some similar produce ; and thirdly, about the summer solstice, with millet or maize. The river begins to rise about the end of June, and attains its maximum towards the end of September, after which it gradually subsides. At the time of its greatest height, the country wears a very singular aspect. On the elevated bank, you stand, as it were, between two seas ; on one side rolls a swollen turbid flood of a blood-red hue ; on the other lies an expanse of seemingly stagnant water, extending to the desert-boundary of the valley ; the isolated villages, circled with groves of palm, being scattered over it like floating islands, and the *gise*, or dike, affording the sole circuitous intercommunication between them. When the waters subside, the valley is suddenly covered with a mantle of the richest green, and the face of the land smiles in the traveller's eyes with all the splendour of a new-created beauty.*]

The Senegal and the Niger are subject to similar floods. In Asia, the Brahmapootra and the Ganges, which descend from the snowy heights of the Himalaya, and bathe its base, one on the south, the other on the north, to empty their waters afterwards in the Bay of Bengal, are celebrated for their inundations at fixed epochs. These overflowings, which unite the two rivers through the network of innumerable canals, lay all the lowlands under water.

The Brahmapootra alone inundates the province of Upper Assam, from the middle of June to the middle of September. The floods of the Hoang-ho and the Yan-tse-kiang, in China, extend over nearly as wide an area, and for nearly as long a period.

The American rivers very frequently produce diluvial inundations, which recall the celebrated verses of Ovid:—

> "Exspatiata ruunt per apertos flumina campos,
> Cumque satis arbusta simul, pecudesque virosque,
> Tectaque, cumque suis rapiunt penetralia sacris. . . . .
> Jamque mare et tellus nullum discrimen habebant,
> Omnia pontus erant, deerant quoque littora ponto."
>
> OVID, *Metamorphoses*, lib. i., c. 6.

Imitated:—

> [Through the broad fields, unchained, the rivers sweep
> And, raging, whirl adown their current deep
> The hanging woods, the crops, the homes, the shrine
> Of worshipped deities, and flocks, and kine:
> And see, now earth and water lurid blend,
> And all in one vast shoreless sea descend!]

Tropical rains swell the volume of the Paraguay, the Parana, and the Orinoco; and their waters, spreading afar over the Pampas, transform them into immense morasses, where whole herds of cattle perish. The augmentation of these rivers is proportional to the amount of water fallen, and for this reason we may look upon them as veritable *pluviometers*. It appears that upwards of eight feet of rain (ninety-eight inches) fall every year in the centre of the virgin forests of South America.

* [Eliot Warburton, "The Crescent and the Cross," p. 21, *et seq*.]

CHAPTER V.

THE LOWER COURSE OF THE RIVERS:—DELTAS—SAND-BARS—ESTUARIES—THE "TIDE RACE" OF RIVERS—"BORES," PROROROCAS, AND DOUBLE TIDES.

THE spoils which the rivers gather from the formations which they traverse are carried down into the plains, where their lower course, or third and final period, commences. This is known by the circumstance that their incline becomes less and less perceptible. The river Senegal, at its embouchure, has a descent of only an inch and a quarter in every thousand yards. Hence it results that the motion of a river grows much slower as it approaches its "resting-place," the ocean. Its waters accordingly deposit the sand and mud with which they are loaded; their bed is raised; and thus are produced those serious obstacles to navigation, variously known as sand-bars, shallows, deltas, and the like.

The deposits formed by important rivers at their embouchures frequently give birth to considerable tracts of land, which increase the superficial area of the continents. The soil of Holland is, in a great measure, the production of the deposits of the Rhine, the Scheldt, and the Meuse. These streams still deposit every day, during the calms which accompany high water, considerable earthy sediments, with the necessary consequence of gradually elevating their shores. By protecting them with solid dikes and embankments against the tides, the inhabitants ensure the preservation of the new lands thus formed,—lands which the Dutch call *polders*, and which are remarkable for their fertility.

The riverine deposits eventually effect a separation and division of the waters to which they owe their origin, and the surface assumes, between the two currents, a triangular form, which, from its resemblance to the Greek letter Δ, is called a Delta. The most celebrated is the Delta of the Nile, which is still increasing in area. The entire valley of the Nile is rising at the rate of six inches in a century; a fact which is proved by the gradual sinking of the monuments of ancient Egypt. Mr. Horner's excavations under the statue of Rameses at Memphis, professed to show that the deposit of the Nile is nearly 30 feet thick beneath its base, which of itself is 9 feet 9 inches beneath the present surface of the soil. From these imperfect data he boldly inferred that the Nile must have begun to inundate Egypt 10,000 years before the era of the great Rameses, or 13,500 years ago. At a depth of nearly 15 feet, a bed of pottery ware has been discovered. Are we then to conclude from this "treasure-trove" that the existence of man dates back to the remote antiquity of 14,000 years.

FIG. 188.—A SCENE ON THE NILE.

[After passing the hills of Gebel-el-Mokatem, and a little below Memphis, the Nile enters upon the great alluvial plain of the delta, and thence makes its way to the Mediterranean through two main arms, forming the sides of an isosceles triangle, and numerous branches; some of which discharge their waters into the sea, others into the two principal channels. These are now known, from the towns situated at their mouths, as the Damietta (E.) and Rosetta (W.) arms.

The deposit of the Nile has been ascertained to consist of—

Clay, ...	48	parts out of 100.
Carbon,...	9	"
Carbonate of lime, ...	18	"
Carbonate of magnesia, ...	4	"
Silica, / Oxide of iron, } in varying quantities;		

forming a compost of extraordinary richness.]

The Po forms at its embouchure a *delta* analagous to that of the Nile, but much more variable than the latter in configuration and extent. On the two sides of this embouchure lie the lagoons of Venice and Comacchio.

[The delta begins at about fifty miles from the Adriatic, and is formed by a northern and a southern branch—the *Po della Maestra* and the *Po di Primaro.* The *Valli di Comacchio*, a low and unhealthy tract of marsh and pool and canal, lies immediately to the north of the Primaro branch. The Po della Maestra is about 800 feet in breadth.]

The delta of the Rhone in France is very well known. It consists of a wide area of flat dull plains, intersected with swamps, here rendered fertile by the abundant muddy deposits of the river—there submerged by dreary, dank, and stagnant waters, and only adapted, as in the neighbourhood of Aigues-Mortes, for the growth of reeds and rushes.

[Near Beaucaire it bifurcates into two main streams, the Greater and the Lesser Rhone, which enclose the delta known as the Ile de la Camargue, and finally pour their turbid waters into those of the Mediterranean. Along the eastern branch extends the arid and stony plain of Crau ; the western district is less accursed, and produces excellent crops of corn and rice, besides affording pasture for large herds of cattle and flocks of sheep. There are numerous salt lakes communicating with the sea by natural or artificial ducts. The two arms of the Rhone are so obstructed with sand-banks, that navigation is principally confined to the canals, which open up a passage between the river at Ardos and the sea at Port-du-Bouc.]

In Asia, the Euphrates and the Tigris have created an extensive alluvial area. The Hoang-Ho, or Yellow River, conveys into the Yellow or Chinese Sea a quantity of mud which, in 24,000 years, would convert that sea into dry ground.

The Ganges and the Brahmapootra unite their deltas in such a manner as to assume the form of a M, whose points look inland. The surface of this double delta is threaded by a veritable labyrinth of canals and creeks of salt water. Despite their terrible unwholesomeness, these regions are inhabited by man, but a great portion of their extent, known as the *Sunderbunds,* is simply a desert abandoned to the alligator and the tiger. It is the very hot-bed of pestilence. From these fatal marshes issued forth, some fifty years ago, the awful plague of cholera, which rapidly spread over the Asiatic continent, and thence into our own hemisphere.

It must not be forgotten that the *deltas* effecting a combination of salt and fresh water, polluted by organic matter—such as the vegetable detritus which the rivers amass at their mouths—concentrate every condition capable of vitiating the air, and rendering it injurious and deadly to human life.

The reaction which takes place between the organic matter and the sulphates dissolved in the sea-water convert these salts into sulphurs; which in their turn are decomposed by the carbonic acid of the atmosphere; and the sulphuretted hydrogen resulting from this decomposition, diffused in the air, endows it with mephitic properties. Intermittent fevers, more or less severe, invariably ferment upon the coasts which present the conditions we have just enumerated; and when these conditions reach a certain excess, as in the Gangetic delta, they originate the most formidable epidemics.

[The delta of the Ganges begins at Seebgunge. From thence to the Bay of Bengal, the descent, along a line of 285 miles, averages not more than three inches in a mile. It now commences to throw off its various branches; the Bhagrutti at Seebgunge, and, about 70 miles lower down, the Jellinghi—which afterwards unite to form the Hooghly; below the starting-point of the Jellinghi, the Ganges gives birth, successively, to the Marabhanga, the Gorae, the Chundni, and the Kirtynassa; on the other hand, it receives numerous affluents from the Brahmapootra,—the entire area between the two great rivers forming a perfect network of watercourses, which eventually find their way into the Bay of Bengal, through fully twenty estuaries. Of these, the most available for navigation, at present—though fears are entertained of its filling up before any long period of time has elapsed—is the Hooghly, in lat. 21° 40′ N., and long. 88° E.

It has been computed that the Ganges delivers into the sea, on an average, a yearly total of 534,600,000 tons of solid matter. Towards the end of July, the delta is inundated over a breadth of nearly one hundred miles; presenting a broad waste of level and slowly-moving waters, studded by clumps of trees and villages, and navigated by every kind of craft. To reduce the inundation, extensive dams and embankments have been constructed, with a total length of one thousand miles.]

[There are several deltas on the American continent.

That of the mighty river Orinoco begins at about 130 miles from its mouth, where it throws off a branch which flows northward into the Atlantic. Several of its mouths are navigable; and the main stream, the Boca di Nuvios, is divided by a line of low green islands into two channels, each a couple of miles in width.

The Amazons enters the Atlantic by a mouth of about 150 miles in width. It is divided into two branches; one of which joins the Parà, south of the island of Das Joanes or Marajo, the other enters the ocean to the north of it. Most of its tributaries, at their point of junction, have also deltoid branches.

The delta of the Mississippi, traversed by its multiple creeks or bayous, is 150 miles broad, and includes an area of 14,000 square miles, protected from the frequent inundations which take place by a gigantic system of *levees* or embankments. The descent of the deltoid plain is 320 feet, or eight inches per mile. At high water the river is higher than the plain. The great floods rise forty feet above low-water mark, at the head of the delta, and twenty feet at New Orleans. The gigantic river is then changed into a vast muddy sea, which yearly carries away thousands of acres of soil, with all their vigorous growth of timber.]

Estuaries may not inaptly be termed negative deltas. They are lakes of fresh and salt water which form the mouths of certain rivers, and suddenly expand before reaching the sea. The *Rio de la Plata*, in South America, is, in truth, a gulf, which below Buenos Ayres is never less than 170 miles broad, and receives the ample tribute of the Uruguay and the Parana. Nearer home we may refer to the noble estuary of the Thames, below Cliffe; to that of the Forth, below Granton; and of the Clyde below Greenock. We know also the estuaries of the Gironde, in France; the Dneiper, in Russia; the Obi and Yeneseï, in Asia; the Columbia and St. Lawrence, in North America. They enable ships of the largest burthen to penetrate into the very heart of the continents. The Chinese poetically term these vast enlargements of the rivers, the "sons of ocean." The mouth of the river of the Amazons may perhaps be regarded as an estuary. In the rainy season, the river pours its waters into the South Atlantic with such impetuosity, that for a distance of 180 leagues, it is said,* they refuse to mingle with the ocean waves.† We recognize them by their greenish tint and rapid current. A similar

* Huot, "Manuel de Géographie Physique," p. 121.

† [The Amazons river, formerly called the *Orellana*, from the name of the Portuguese, Orellan, who first explored it, divides itself at its mouth into two branches: on the left, the Rio Marañon, or Amazons, properly so-called, about fifty miles wide; on the right, the Rio Para, some twenty-five miles in breadth. These two channels are separated by the island of Marajo, which is nearly as large as Sicily.

It is said that when Pinzon, the lieutenant of Columbus, discovered this great river, in 1498, he cried, "*Mare an non?*" ("Is it a sea or no?") Hence the Spanish and Portuguese names, *Maranon* and *Maranhao*.]

phenomenon is observable at the mouths of the Danube, and of the river Syra, in Norway.

Notwithstanding the enormous impulse given to these great masses of water, they cannot always flow freely into the ocean; the ascending tide crushes them back, and a gigantic struggle then takes place between the fresh-water floods pouring down from the inland plains and mountains, and the salt waves which the flow of the sea brings up. At the mouth of the Amazons river the tide penetrates into the interior for upwards of two hundred leagues, occupying several days in the journey. At the epochs of the strongest tides—that is, at new and full moon—the sea attains in two minutes an elevation which usually it does not attain in less than six hours. The spectator then beholds a wave of 13 to 16 feet in height advancing with incredible swiftness; it is speedily followed by a second; then by a third and a fourth, which spread themselves over the entire surface of the river. The collision of these masses of fresh and salt water makes the neighbouring islands tremble; the ships hurriedly make all sail from the scene of the terrible conflict, whose din may be heard at a distance of two leagues.

The waters of the Orellana, and those of the ocean, says Malte-Brun, precipitate themselves into the battle like two armies; with their foaming waves the shores are inundated; rocks, dragged along like so many tiny pebbles, dash against each other on the back of the billow which bears them; you might say that the genius of the river and the god of the ocean contended for the empire of the waves.

This description is somewhat too poetical; but the phenomenon of the *pororoca* is one of the most imposing scenes in nature.

In the Orinoco, the influence of the tide, in April, is felt for more than 75 leagues from the river's mouth; its elevation at the embouchure is 40 inches; it decreases gradually towards the interior.

In Asia, in the Indus and in the Hooghly, one of the arms of the Ganges, the waves ascend for upwards of 80 miles, at the rate of 18 miles per hour.

In the European rivers, this reflux of the ocean at their embouchures is less violent. The tide ascends the Thames to Teddington, a distance of 65 miles, but it is a slow and gradual movement, not exceeding 3 to 4 miles per hour. In the Seine and the Dordogne this "meeting of the waters" is known as the *mascaret*, equivalent to our English "bore." * In the latter river it consists simply of three or four very lofty and rapid waves, or swells, which follow on one another, and occupy the entire breadth of the river. They sweep up the channel at the rate of 13 to 16 feet per second, with boiling, foamy crests, which overwhelm everything they encounter.

FIG. 189.—EFFECT OF THE "BORE" AT LA BORVILLE, ON THE RIVER SEINE.

At the September equinox the Seine presents the phenomenon of the *mascaret ;* and it also occurs on the two little rivers of the Vire and the Aure.

The Chinese rivers sometimes swell 32 to 48 feet, owing to the impetuous influx of the tide, which is considerably increased in force when the wind blows from the sea. In the River Zaïre, in Africa, the waters in mid-channel continue their course to the sea, while along the two banks flow two contrary currents which roll and surge

* [In some parts of England it is also called the *eyer*.]

towards the source. It may be stated, as a general law, that the effect of the "bore" is more energetic on the margin than in the centre of rivers.

The three great rivers which pour their waters into inland seas—the Nile, the Danube, and the Volga—are not affected by this phenomenon, because the Mediterranean, the Euxine, and the Caspian have no perceptible tides. They may therefore be designated essentially *continental rivers.*

The reader will permit us, perhaps, to dwell a little more in detail on this curious phenomenon of the reflux of the tides at the embouchure of rivers, and particularly as it is manifested in the Seine.

The arrival of the ocean-tide in the lower Seine causes a tumult of waters which, picturesque as it appears to the spectator, is unfortunately attended with disastrous consequences to the farms and pastures along the river-banks, and to vessels lying at anchor where the reflux occurs. One may still see, between Quillebœuf and Villequier, the masts of numerous ships engulfed by the furious rush of the waters. To guard against these accidents, the French Government has constructed, below Quillebœuf, considerable works to check the action of the ocean-tide; but from this point to Caudebec it still exercises its ravages, although in a lesser degree than formerly. It is at Caudebec, or, better still, at Villequier, that this imposing phenomenon can now be most thoroughly investigated.

While the tides of ocean move forward by imperceptible degrees, and rise but slowly, you may see from your station on the bank the advanced-guard of the waters arrive in the bed of the Seine in the guise of a rolling wave, whose height frequently exceeds that of the dikes erected to confine it, and which instantaneously fills the vast basin of the river—a basin enlarged, at Quillebœuf, into a veritable arm of the sea. Deafening noises announce these grand crises. They are favoured by a moderate sea-breeze; but a violent wind, on the contrary, scatters abroad the billows, and diminishes their height.

The "mascaret" of the Seine was not described or studied until long after Condamine, by his impressive relation, had made known the *pororoca* of the Amazons. Bernardin de St. Pierre was the first to mention it. According to the mythological style which in his day was in vogue, he compares the Seine to a nymph pursued by Neptune.

It is at the epochs of the spring and autumnal equinoxes, and on the second day after new or full moon, that the "mascaret" displays the greatest energy. It is still more formidable a day or two before and after either of these epochs.

But what is the true cause of the extraordinary elevation of the waves which thus precipitate themselves into the basin of a river, and drive back the current towards its source? We must look for it in the law discovered by Lagrange, and recently confirmed by the experiments of Mr. Scott Russell, that the rate of propagation of a wave diminishes with the depth of water. The consequence of this mechanical law is, that the first waves of the flux, being retarded in their march on their entrance into comparatively shallow water, must necessarily accumulate and be overwhelmed by the following billows, which move in deeper water; that these, in their turn, will be driven forward by their successors; and that this process will continue until it forms a kind of mountain which rotates upon its own axis, and pours itself in a cataract over the deeper portions.

M. Partiot, an engineer charged with the superintendence of the navigation of the Seine, addressed a paper, in 1857, to the *Académie des Sciences*, which contained an elaborate account of this phenomenon, and of his observations extending over a long series of years.*

M. Partiot had carefully studied two "mascarets;" one in the bay of the Seine, at Saint-Jacques, the other in the embanked portion of the river, near the village of Vieux-Pont. At these two points he had fixed, close to the land, his metrical standards, and was thus enabled to measure the height of the billow which formed the "mascaret."

At Saint-Jacques he found it to be about 70 inches, and at Vieux-Pont 54 inches.

M. Partiot has also put on record a series of figures which represent the different aspects of the "bore" above and below Quillebœuf. At the points where the channel of the river is deep, the phenomenon is only perceptible on the borders along the dikes. This agrees with what has been observed by seamen navigating the Amazons river and the arms of the Ganges; and, in fact, ships sailing in deep water, in the mid-channel of the river, do not suffer from the *pororoca* or *bore*, though it overwhelms the vessels moored in shore or stationed in shallow water.

The ingenious writer concludes from his observations that, to remove the obstacle of the "mascaret" at the mouth of rivers, we must facilitate as much as possible the entrance of the rising tide, and clear away all the obstacles which oppose it. These are, in general, mud, sand-banks, and shoals; so that the works designed to improve the mouths of rivers and to ensure a sufficient depth, would necessarily have the effect also of diminishing the "mascaret" on their banks, and putting an end to the danger which this phenomenon presents for navigation.

However, it would be impossible to secure for a river the same depth of water from its mouth to its source. Indeed, it must not be supposed that by dredging the bed of a river at its mouth we *suppress* the "mascaret;" we only displace it, remove it to a higher point, and turn aside its violence. The great works which have enclosed the channel of the river, above and below Quillebœuf, prevent the obstruction of the waves in that locality, but the "mascaret" is carried onward to Villequier, Caudebec, Aizier, and Tancarville. The dikes erected at Villequier, by M. Emery, have defied until now the attacks of the flood, and it is hoped they will also suffice to protect the place from the ravages of the "mascaret," which had ended in sweeping away one-half the town.

Certain rivers have no mouths. They lose themselves in vast

* Figuier, *Année Scientifique et Industrielle*, 3· année, p. 121.

morasses, which, through their abundant evaporation, can receive without overflow the constant addition of the waters. Such is the Zenderoud, in Persia, which terminates its course in a swamp. Many of these all-devouring marshes are found in Africa and Central Asia.

Other rivers there are which disappear in subterranean cavities, though most frequently they rise again at a lower point.

[The Rhone is thus engulfed at a place called *La Perte du Rhone*, to the west of Geneva, and re-appears some distance further down. When the waters are tolerably low, the whole river is absorbed for about one hundred and twenty yards; but the Italian Government, to facilitate the passage of the timber-rafts, has blown up an extensive portion of the covering rocks, and opened up the channel.

A similar phenomenon is observable on the river Mole, near Boxhill, in Surrey. In very dry seasons it entirely disappears, from Burford Bridge to within a short distance of Leatherhead, nearly three miles of its course. The places where it is absorbed are locally called *swallows*, and through these crevices the water rushes with velocity. These phenomena, says Dr. Mantell, are referable to the cavernous nature of the subsoil over which the river flows. The vale of Boxhill, like the other transverse outlets of the chalk of the North Downs, has evidently resulted from an extensive fissure produced in the strata while they were being elevated from beneath the waters of the ocean by which they were once covered. A chasm of this kind must have been partially filled with loose blocks of the chalk rock, the interstices being more or less occupied by clay, marl, sand, and other drift brought down by the floods which traversed this gorge. and found their way to the vale of the Thames.

We may add that disappearing streams, dry in summer but full in winter, are common in Kent and Hampshire; in the former county they are called *nailbournes*, and in the latter *lavants*.]

The river De la Lys, in Belgium, precipitates itself into the grotto of Han, whence it emerges at a distance of 1650 feet.

The Meuse disappears near Bazoilles, and rises again at Noncourt, after a subterranean course of six miles.

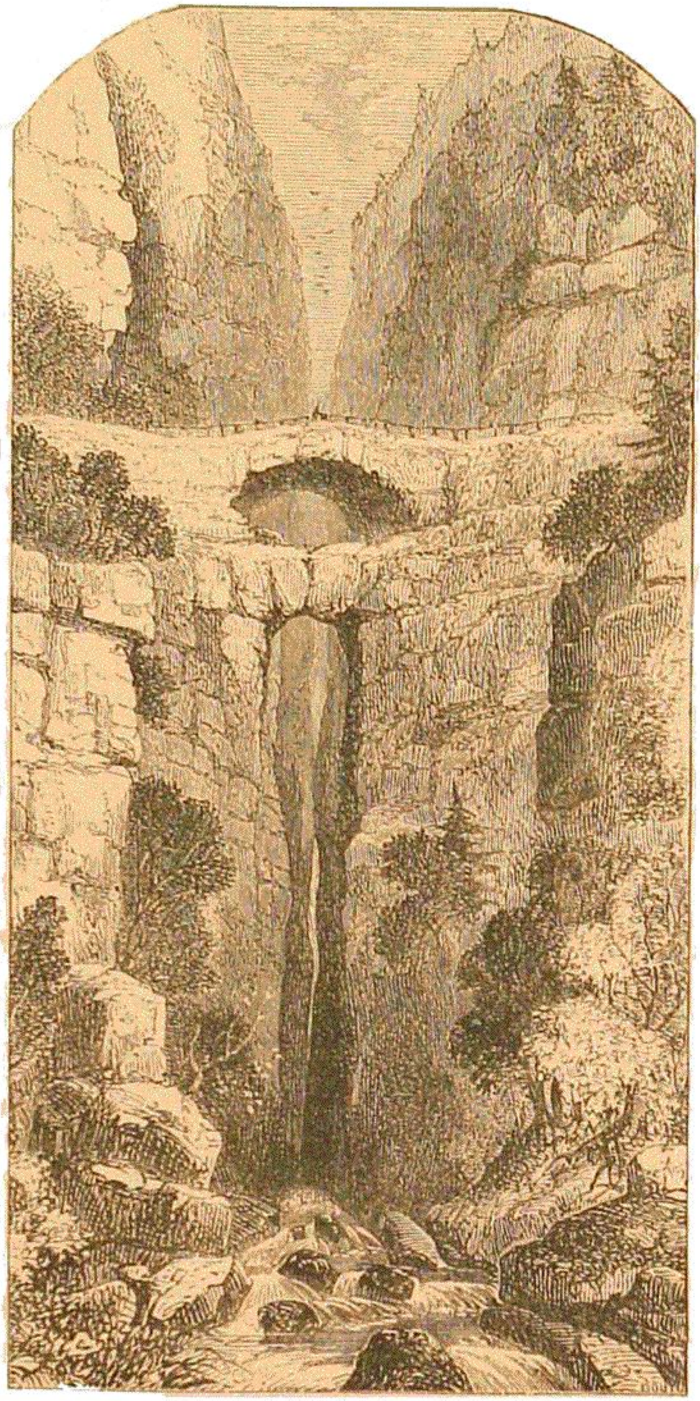

FIG. 190.—NATURAL BRIDGE IN THE VALLEY OF ICONONZO, IN MEXICO.

Analogous phenomena occur on the Tille, Suzon, Eure, and Aros. The Venelle, in the department of Côte-d'Or, and the Guadiana, in Spain, are absorbed in marshy meadows, whence they again issue forth with augmented volume. Hence the Spaniards speak of the "great bridge where they can pasture a hundred thousand horned cattle."*

The Dromme, which unites with the Aure in the department of the Calvados, empties itself, at some distance from the sea, into a cavity thirty-nine feet in diameter, known by the name of the *Fosse de Soucy*. Before arriving there, it loses a portion of its waters in the other hollows which exist in its bed. Certain springs on the sea-shore are supposed to be connected with its subterranean course.

If the caverns in which the waters disappear are of small extent, and open on both sides, they form *natural bridges*. These are also met with in localities where no watercourses now-a-days exist. One of the most remarkable of these curiosities is that of the valley of

* [Camden, in his "Britannia," observes of the tract of ground where the Mole disappears, that "its inhabitants, no less than the Spaniards, may boast of having a bridge that feeds several flocks of sheep."]

Icononzo or Pandi, in Mexico. It unites the edges of a chasm 325 feet deep, at whose bottom winds a small torrent, the *Rio de la Summa-Paz*, enclosed in an almost inaccessible bed. The principal bridge is forty-eight feet long by thirty-nine wide, with a thickness of six and a half feet. Sixty-five feet below this first bridge is found a second, composed of three blocks, which support themselves without any artificial aid; the central is pierced with a hole, through which may be seen the bottom of the abyss.

The Bridge of Arc, under which the stream of the Ardèche flows, is a natural arch, 98 feet high and 195 feet in span. The Bridge of

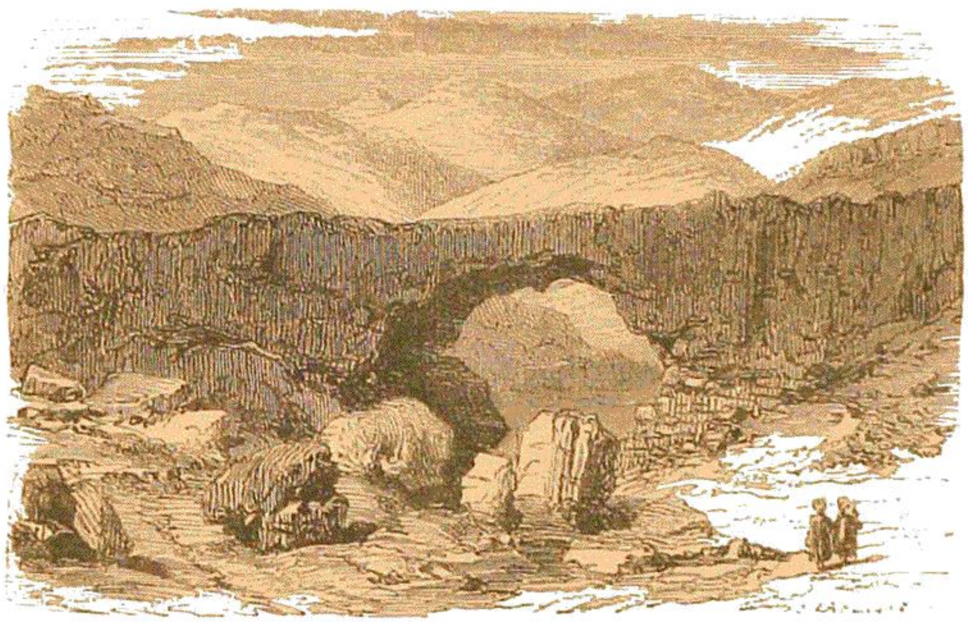

FIG. 191.—NATURAL BRIDGE OF AÏN-EL-LIBAN.

Veja, near Verona, is 125 feet high. The magnificent Rock Bridge of Virginia, in the United States, spans an abyss which separates two mountains; an abyss 225 feet deep, in whose deep obscurity flash the restless waters of Cedar Creek. This marvellous arch is nearly 100 feet in length and 42 feet thick; it is a natural curiosity, which none can behold without feelings of admiration.

In the Lebanon, a torrent which empties itself into the Beyrout river, passes under a natural arch of 215 feet in height, locally known as the *Aïn-el-Liban*.

[A similar natural bridge occurs near Tisr Kŭráone, over the Litany (the ancient Leontes), where the river has tunnelled through a rock more than ninety feet thick. The road from Wady et Teim to Nihah is carried over this lofty and amazing arch.

The arch over the Dog River, near the Niba el Liban, spans a tremendous ravine hollowed out in the solid rock. The arch is 90 feet thick; the span measures 157 feet; and the height on the lower side is nearly 200 feet.*]

We have now brought the reader acquainted with the principal phenomena connected with or originated by the rivers. It remains for us to bring under his notice a comparative table of their total length, calculated from the best authorities, as well as the bay, gulf, or sea into which they empty their waters.

THE PRINCIPAL RIVERS OF THE WORLD.

I. EUROPE.

Name.	Mouth.	Length in Miles.
Volga....	Caspian Sea,	1900
Danube.	Black Sea,	1750
Dnieper,	Black Sea,	1050
Don,	Black Sea,	900
Elbe,	German Ocean,	770
Rhine,	German Ocean,	695
Vistula,	Baltic,	680
Loire,	Bay of Biscay,	600
Rhone,	Mediterranean,	580
Oder,	Baltic,	550
Seine,	British Channel,	500
Douro,	Atlantic Ocean,	455
Po,	Adriatic Sea,	450
Ebro,	Mediterranean,	410
Thames,	German Ocean,	240
Severn,	Irish Sea,	210
Tay,	German Ocean,	160
Trent,	Humber Estuary,	144
Clyde,	St. George's Channel,	123

II. ASIA.

Name.	Mouth.	Length in Miles.
Yan-tse-Kiang.	Yellow Sea,	3000
Hoang-Ho,	Yellow Sea,	3000
Obi,	Arctic Ocean,	2800
Lena,	Arctic Ocean,	2400
Yeneseï,	Arctic Ocean,	2300
Amoor,	Sea of Japan,	2240
Indus,	Gulf of Oman,	1700
Brahmapootra,	Bay of Bengal,	1500
Ma-kiang or Cambodia,	Chinese Sea,	1500
Euphrates,	Persian Gulf,	1360
Ganges,	Bay of Bengal,	1350
Irrawaddi,	Bay of Bengal,	1200
Amü-Deryá (Gihon),	Sea of Aral,	1150

* [Dr. Thomson, "The Land and the Book," pp. 45, 46.]

III. AFRICA.

Name.	Mouth.	Length in Miles.
Nile, ...	Mediterranean, ...	3350
Niger, ...	Gulf of Guinea, ...	2300
Zambesi, ...	Mozambique Channel, ...	1200
Orange River, ...	Atlantic, ...	1050
Senegal, ...	Atlantic, ...	950
Gambia, ...	Atlantic, ...	700

IV. AMERICA.

Missouri, ...	Mississippi, ...	4500
Mississippi, ...	Gulf of Mexico, ...	2986
Ohio, ...	Mississippi, ...	2300
Amazons	South Atlantic, ...	2000
St. Lawrence, ...	North Atlantic, ...	1900
Paraguay, ...	La Plata, ...	1800
Mackenzie, ...	North Polar Sea, ...	1600
Orinoco, ...	Caribbean Sea, ...	1352
La Plata (estuary and river),	South Atlantic, ...	1300
Columbia, ...	North Pacific, ...	1090
Colorado, ...	Gulf of California, ...	1090
Uruguay (Tocantins), ...	South Atlantic, ...	800
Red River, ...	Lake Winnipeg, ...	340
Hudson River, ...	North Atlantic, ...	325
Rio Grande, ...	Gulf of Mexico, ...	270
San Francisco, ...	North Atlantic, ...	——

V. AUSTRALIA.

Murray, ...	South Pacific, ...	700
Darling, ...	The Murray, ...	600

We shall now cast a rapid glance at the most important of the world's great Rivers, commencing with those of EUROPE.

The most considerable European rivers are the *Danube* and the *Dnieper*, which empty their waters into the Black Sea; and the *Don*, which falls into the Sea of Azov.

The *Danube*, whose source is in the Black Forest, is speedily augmented by the confluence of the rapid Inn, which is not inferior to it in point of development, and has fully as just a claim as the Danube to give its name to the principal channel. This great and famous river, which so long separated Christendom from the Mohammedan empire, carries eastward the gathering waters of the Alpine basin, and those which descend from the southern slope of the Carpathians. It is navigable for vessels of 100 tons as high as Ulm. Before entering upon the plains of Wallachia, it traverses the rugged defile of the Balkan, historically celebrated as the *Iron Gates.** In its course it collects the tribute of sixty streams, and drains an area of 300,000 square miles.

The Carpathian Mountains enclose in their recesses the springs of the *Vistula*, which waters the broad Sarmatian plain, and renders itself to the Baltic Sea, after traversing a very marshy country. The

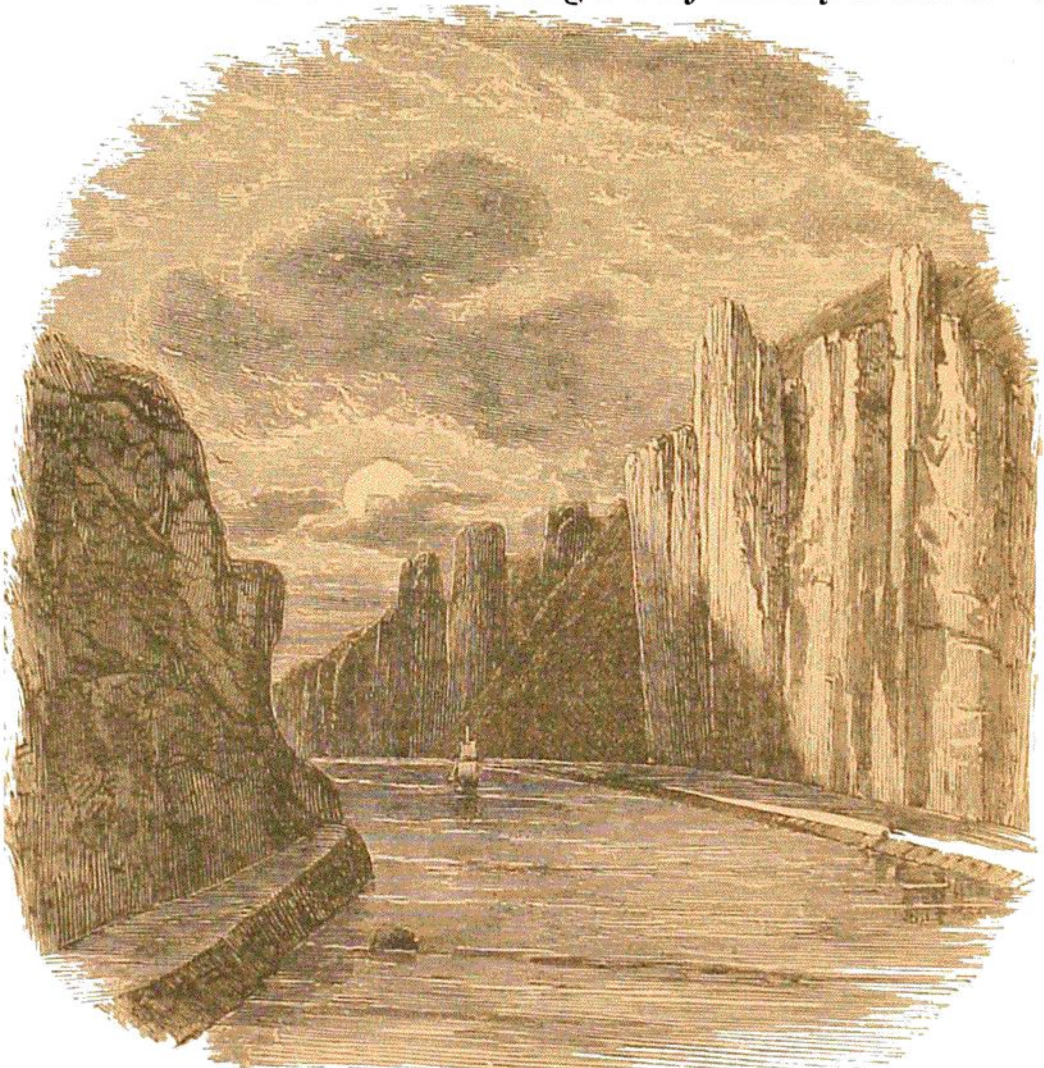

FIG. 192.—IRON GATES OF THE DANUBE.

river Bug, one of its principal affluents, comes from the swamps of Pripet, where also rises the Pripet river, a tributary of the Dnieper. It may therefore be said that the basins of the Vistula and the *Dnieper* touch one another and intermingle in this immense morass, without any conspicuous elevation of the soil to mark the line of partition of their waters. It is possible, therefore, through the canals

* [According to Adelung, the word *Danube* means "the lower water." The word *Dan* is found in the names of many rivers—as *Rho-dan-us.*]

of the Dnieper, to pass in a boat from the Black Sea to the Baltic—from the south-east of Europe to the north-west.

The *Oder* and the *Elbe* follow the same northward direction as the Vistula, but their basins are more diversified in surface.

The *Rhine* conveys into the North Sea the waters of the Alpine chain; the *Rhone* carries them into the Gulf of Lyons; the Po diverts them into the Adriatic. [A canal between the Rhone and the Rhine connects the North Sea with the Mediterranean. The whole area of Holland is a collection of "deltoid islands" formed by the Rhine, in conjunction with the Meuse and the Scheldt.]

The principal rivers of France are the *Seine*, the *Loire*, and the *Garonne;* all of which pour their waters into the Atlantic.

[The Spanish mountains give birth to many navigable streams, scarcely less famous in song and history than for natural beauty. Of these the *Tagus* has depth enough for large ships as high as Lisbon. Its actual course is 480 miles. In commercial importance it is superior to the *Ebro* and the *Douro*, though these rivers attain a greater development, and collect the waters of more extensive basins.

The drainage-area of the *Volga* exceeds 640,000 square miles, and the river is navigable throughout the greater part of its course, or for 1900 miles. It has its source in a small lake on the table-land of Valdai, 530 feet above the sea-level, and falls into the Caspian, which is 83 feet 7 inches below the level of the Black Sea; so that it has a fall of 633 feet in 2400 miles. It conveys to the Caspian one-seventh of all the river-water of Europe.

We now turn our attention to the most important rivers of ASIA.

Lake Aral, an inland sea like the Caspian, receives two twin-rivers, the *Amü-Deryá*, or *Gihon* * (the ancient Oxus), and the *Syr-Daria*, or *Sihon* (the ancient Jaxartes), which descend from the table-land of Pamir and the mountain-chain of the Belor-Tagh.

The general direction of the former is from south-east to north-west. It appears to have been of old "the great highway of the

* [The Turks call it the *Djihoun;* the natives who dwell on its banks the *Amü-Deryá*.]

nations," and to have afforded an easy access to the great Aralo-Caspian basin. Most geographers are of opinion that it formerly entered the Caspian at the south-east of the Bay of Balkan by two branches; and Von Humboldt, in his great work on Central Asia, elaborately discusses the physical changes which have broken up the communication.*

The *Syr-Daria*, or "yellow river," waters the barren steppes of the Kirghiz. Its course is north-west, and it flows into Lake Aral on its eastern shore, at the Gulf of Kamechlou-Bachi.]

The vast Siberian plain is watered by three great rivers which empty themselves into the Frozen Sea: the *Obi*, the *Yeneseï*, and the *Lena*.

[The basin of the *Lena* occupies 800,000 square miles. The river rises in the mountains north of the Lake of Baikal, and strikes in a north-easterly direction for upwards of half its total length to the bleak town of Yakutsk, the coldest inhabited locality on the face of the earth. North of Yakutsk, in lat. 63° N., it is augmented by its principal tributary, the Aldan: it then flows towards the Arctic Ocean, between banks of frozen mud; prodigious masses of which are borne along its turbid current by the summer floods, revealing to the curious eye "the bones of those huge animals of extinct species which at some remote period had found their nourishment in these desert plains." Its length is 2400 miles.

The *Yeneseï* is a considerably larger river than the Lena; its total course measuring 2300 miles, while it drains a basin of about 1,000,000 square miles. It is formed by the junction of the Great and Little Keru; receives numerous important tributaries; and at its embouchure in the Frozen Ocean forms a large gulf or estuary.

In the Lake of Tobskoi—*i.e.*, the "Lake of Gold"—in Great Tartary, rises the *Obi*, which receives the Irtish and the waters of the Lesser Altai range. The *Irtish* takes a westerly course to the north of Semipolatinsk; is joined by the Tobol, from the Ural Mountains;

* [Humboldt, "Asie Centrale," ii., pp. 162–197.]

and soon unites with the Obi, which, after a career of 2800 miles, flows into the Arctic Ocean in 67° N. lat.

"The bed of the Obi," says Mrs. Somerville,* "is very deep, and there are no soundings at its mouth; hence the largest vessels might ascend at least to its junction with the Irtish. Its many affluents also might admit ships, did not the climate form an insurmountable obstacle the greater part of the year. Indeed, all Siberian rivers are frozen annually for many months, and even the ocean along the Arctic coasts is rarely disencumbered from ice; therefore these vast rivers never can be important as navigable streams; but towards the mountain they afford water-communication from the Steppe of Issim to the Pacific. They abound in fish and water-fowl, for which the Siberian braves the extremest severity of the climate."]

The gigantic river *Amour*, which flows in an easterly direction, separates Siberia from China. It empties itself into the Pacific Ocean, between the Sea of Okhotsk and the Sea of Japan. Its banks afford an immense extent of rich pasturage. To the Englishman this river has a peculiar interest, as its course marks the rapid advance of Russian aggression in the direction of *India*.

China is traversed by the *Hoang-Ho*, or Yellow River, a tributary of the Yellow Sea; and by the *Kiang* (or Yan-tsi-Kiang), which flows into the Sea of Corea. These two streams, so to speak, are twins, like the Euphrates and Tigris; they bound the region which the Chinese call "the Flower of the Centre"—a kind of Mesopotamia separating the north and south of China—and then blend their waters in one common embouchure. The *Ma-Kiang*, or Cambodia, empties itself into the Chinese Sea, after traversing the kingdom of Siam, and Cochin-China. It passes Saïgon, and forms a delta in conjunction with the river bearing the name of that great city.

The same quarter of the world contributes to the Indian Ocean the *Martaban*, or Salouen, and the *Irrawaddi*, whose volume is multiplied tenfold during the rainy season. Ava, the capital of the Burman empire, is situated on the river Irrawaddi.

The three great rivers of Hindustan are the *Ganges*, the *Brahmapootra* and the *Indus*, all issuing from the inexhaustible bosom of the great Himalaya range.

The *Indus*, or *Sind*,† is formed by the confluence of five rivers which traverse the picturesque valleys of the Punjaub (Penta-potamia), the extreme limit of the conquests of Alexander the Great.‡ [The junction-point is about midway between

* [Mrs. Somerville, "Physical Geography," i. 400.]
† [In Sanscrit, *Sindhu*—probably from a root signifying "to flow."]
‡ [Alexander crossed the river at Attock, or Atak, the ancient *Taxila*.]

the city of Atak, on the main stream (which rises on the north side of Mount Kailas, in lat. 31° 20′ N., long. 81° 30′ E.), and its mouth; and from hence it is navigable. After a gradually diminishing course—its arid sandy bed absorbing its waters, which also spread into a multiplicity of insignificant channels—it reaches at Migani, eight miles north of Hyderabad, the commencement of its Delta. This low-lying and unwholesome tract measures 75 miles in length, and 130 miles in width, along the coast of the Indian Sea.

The total length of the Indus is 1700 miles; the area of its drainage has been computed at 488,000 square miles, or four times the superficial extent of the British Isles.

The *Ganges*, *Ganga*, or "sacred river," is upwards of 1500 miles in length. During the first half of its course it flows south-east; it then flows east for about 400 miles, through the rich plains of Bengal; and afterwards takes a south-easterly direction.

It rises from a mountain snow-field, 13,800 feet above the sea-level, in lat. 30° 54′ N., and long. 79° 7′ E. After a course of ten miles it reaches the famous temple of Gangoutri, at an elevation of 10,300 feet; about twenty miles lower down, breaks through the gigantic barrier of the Himalaya; rolls onward to Hurdwar (157 miles), on the frontier of the great Indian plain; then, with an average fall of 22 inches in a mile, strikes boldly to the south-east, and after a career of 488 miles reaches Allahabad; receives several important tributaries, flows 563 miles, with a fall of about five inches in a mile; and at Seebjunge, reaches the inland extremity of its delta—a grand labyrinth of waters, which, through various leading channels, flow into the Bay of Bengal.

The *Brahmapootra* is formed by the junction in Assam of two main branches, the Brahmapootra proper, and the Sanpoo. It then flows for upwards of 900 miles in a westerly direction to the Bay of Bengal, uniting with the Ganges to form its labyrinthine delta, and communicating with it through several channels. Its total length from the source of the Sanpoo is 1500 miles; from that of the Brahmapootra, 900 miles. The Sanpoo rises in the same marsh or swamp as the Indus and Sutlej.]

The ancients gave the name of Mesopotamia ("land between two rivers") to the region enclosed between the basins of the *Tigris* and the *Euphrates;* a rich and fertile country, which, of old, was the seat of the great Asiatic empires. All the waters of the two rivers flow from the Taurus chain; not a single tributary is furnished to them by the Syrian desert. Their courses are directly parallel, with an inclination from the north-west to the south-east, until they unite, at a point anciently called Digba, to form the *Shat-el-Arab*, which flows into the Persian Gulf; traversing a delta, whose existence, probably, does not date back more than three thousand years. It is even supposed that at a distant epoch the waters of the gulf poured far into the interior of Arabia, leaving only an isthmus between that country and Asia Minor. In the latitude of Bagdad the two rivers approach so closely, that the intervening land measures only 27 miles across. Anciently, in the palmy days of Nineveh and Babylon, a communication was maintained between the two rivers by means of canals. Near Dongly the Tigris flows for some distance underground; on the course of the Euphrates one cataract occurs, that of Nuchar.

The next branch of our subject is the rivers of AFRICA.

[The *Nile* is the great river of Africa, and from the mystery which long enshrouded its sources, one of the most interesting of the rivers of the world. Until solved by the labours of Speke, Grant, and Sir Samuel Baker, their actual position was a problem which stimulated the curiosity, and foiled the ingenuity of geographers.

The actual basin of the Nile, says Sir Samuel Baker,† is included between the 22nd and 39th degrees of east longitude, and the 3rd and 18th parallels of north latitude. The drainage of this vast area is monopolized by the Egyptian river. The Victoria and Albert Lakes, the two great reservoirs of the equatorial waters, are the recipients of all affluents south of the Equator; the Albert Lake being the grand reservoir in which are concentrated the entire waters from the south, in addition to tributaries from the Blue Mountains, from the north of the Equator. The Albert N'yanza is the great basin of the Nile: the distinction between that and the Victoria N'yanza (discovered by Speke and Grant) is, that the Victoria is a reservoir receiving the eastern affluents, and it becomes a starting-point, or the most elevated *source* at the point where the river issues from it at the Ripon Falls; the Albert is a reservoir, not only receiving the western and southern affluents direct from the Blue Mountains, but it also receives the supply from the Victoria and from the entire equatorial Nile basin. The Nile, as it issues from the Albert N'yanza, is the *entire* Nile; prior to its birth from the Albert Lake it is *not* the entire Nile.

The true Nile would seem to be the river which flows out of the lake discovered by Sir Samuel Baker, and named the Albert N'yanza, at a point called Mayungo. Thence, under the name of the Bahr-el-Abiad, or White Nile, it flows in a north-westerly direction, through a comparatively unknown country, to Gondokoro, which is 200 miles from Mayungo, and about 1900 feet above the sea-level (lat. 4° 55′ N., long. 31° 50′ E.) Across a level plain, with a comparatively inconsiderable descent, but with a remarkable sinuous course, it proceeds first north-west, and then north-east, for some four or five hundred miles, until in lat. 9° 15′, and long. 30° E., it receives

* [See Carl Ritter's "Erdkunde," vol. x., pp. 5, *et seq.*; Kinneir's "Memoir," pp. 59, *et seq.*; and Col. Chesney's "Expedition up the Euphrates," *passim.*]

† [Sir S. Baker, "The Albert N'yanza," &c., i. 304, 305.]

its first great affluent, the Bahr-el-Guzal, from the west. It then takes an easterly course for eighty, and a northern one for thirty miles, swollen by the tributary waters of the Giraffe and the Sobut. Afterwards, it runs for nearly 500 miles due north, to Khartoum, the capital of Nubia, where it is joined by the Bahr-el-Azrek, or Blue Nile; the united stream then flows north to its first rapid, or cataract, at Meroë; traverses the fertile country of the Berbers; descends into Egypt at Assouan, lat. 24° 10′ N.; and with an average fall of only two inches in 1800 yards, proceeds to form its famous Delta, and to pour its waters into the Mediterranean Sea.

The total length of this great river is about 3300 miles.]

Next to the Nile, the most important river in Africa is the *Zambesi*, which has been explored by Dr. Livingstone; it joins the Mozambique Channel in lat. 18° S.

The *Niger*, or *Joliba*, descends from the eastern slope of the mountain-chain whence flow, in a westerly direction, the Senegal, the Gambia, and the Falené. At first it strikes in a north-easterly direction to Timbuktu; then returns towards the south; and pours itself into the Atlantic through two-and-twenty mouths.

This river, whose course has only recently been made known to Europeans, was successively explored by Mungo Park and Laing, both of whom fell victims to their brave and adventurous spirit; then by the Frenchman Caillé, and Dr. Barth, who, more fortunate than their predecessors, returned from Timbuktu in safety. The latter traveller, who has published a valuable and interesting narrative of his discoveries, ascended the river as far as Say.

Further to the south—namely, in southern Guinea—we meet with the *Zaire*, or *Congo*, which also falls into the Atlantic Ocean.

The rivers of AUSTRALIA are, with few exceptions, inconsiderable; flowing, for the most part, through the ravines which intersect the table-lands. In the rainy season their volume is augmented in an extraordinary manner. The Hawkesbury, for example, rises 96 feet above its ordinary level. It is probable that in the interior of the island-continent exists a basin formed of salt-lakes, into which several streams empty their waters. [The best-known rivers are—in New South Wales: the Hunter, 200 miles; the Manning, the Hastings, the Darling, and the Murray, 700 miles. In Victoria: the Mitta Mitta, the Ovens, the Goulbourn, the Loddon (tributaries of the Murray), the Glenelg, the Latrobe, and the Yarra Yarra (or "flowing-flowing")—the latter is liable to sudden floods from the heavy rains and the melting of the snow. And in Tasmania: the Tamar and the Derwent.]

Nearly all the great rivers in SOUTH AMERICA have an easterly flow, and empty themselves into the Atlantic Ocean. The belt of ground between the Pacific and the western Cordilleras is too narrow to permit the formation of any important stream.

The estuary of *La Plata* receives the *Rio Parana*, which, like the *Paraguay*, comes down from the north. These two rivers unite at Corrientes, and then in a single channel repair to the Atlantic. Their tributaries, all of westerly origin, are the rivers Pilcomayo, Vernejo, and Salado (whose water is brackish). The *Uruguay* flows parallel to the Parana, and also falls at Buenos Ayres into the magnificent La Plata estuary—a vast bay of fresh water, with a width of 125 miles at its mouth; it penetrates inland upwards of 185 miles.

The *San Francisco* comes from the south, and skirts the littoral mountain-range of Brazil. It flows into the Atlantic. The *Rio de Para* is the common estuary of the Uruguay and the Tocantins, which traverse Brazil from south to north.

The island of Marajos separates this estuary from the mouth of the *Amazons* river, or the *Maranon*, the greatest river on the surface of the globe.

Its basin embraces 2,000,000 square miles. It is fed by the streams which descend from the eastern flank of the Peruvian Andes, and its banks are clothed with the luxurious and almost impenetrable growth of the virgin forests. Its mouth was discovered in 1500, by Pinzon, one of the comrades of Columbus. Francisco Orellana descended it from its source to its mouth. It has recently been explored, to a greater or lesser extent, by Messrs. Bates, Burton, Wallace, and Agassiz, who have greatly enlarged our knowledge respecting its characteristic features. At its mouth the Amazons is 170 miles broad; its length is 3000 miles; so that it separates the North American hemisphere from the Southern, like a liquid equator. Its channel is navigable inland for 2500 miles; is so deep that the sounding-lead touches no bottom; and so broad that its two banks are frequently indistinguishable by the voyager, who seems to be sailing in the open sea.

Its principal affluents are the Madeira, the Rio-Negro, by whose means it communicates with the basin of the Orinoco, the Tapajos, and the Xingu. They water immense tracts of fertile land and impassable forest.

"To give an idea," says a French writer,* "of the immense variety of trees and

* Elisée Reclus, "Revue des Deux-Mondes."

shrubs, stimulated by the inextinguishable vitality of Tropical Nature, you must penetrate into one of those winding canals which circulate among the islets of the thousand archipelagoes scattered over the bosom of the Amazons. Impending over the river the most various trees succeed each other—uplifting their crests—unfurling their fans—developing their leafy canopies—and balancing above the waves their garlands of snowy flowers."

To the same writer we are indebted for the following description of this Giant of the Rivers :—

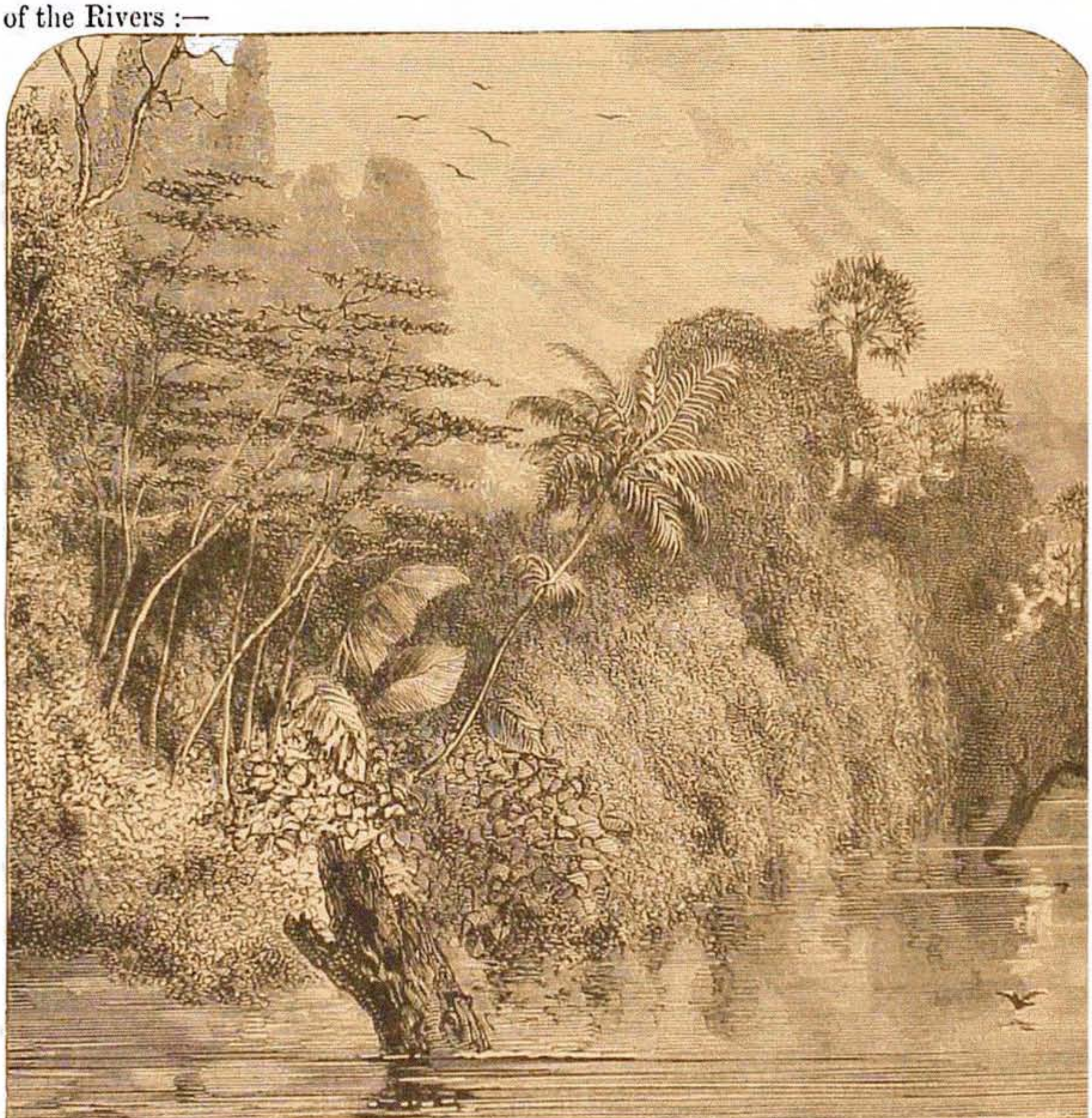

FIG. 193.—VIRGIN FOREST: BANKS OF THE LOWER AMAZONS.

"Terrible by its current, which flows at the rate of four to six miles an hour, the Brazilian river is not less formidable from the intensity of its periodical floods. Regular in its movements as the Nile, it begins to increase towards the month of February, when the sun, in its apparent northward march, melts the snow-masses of the Peruvian Andes, and guides above the basin of the Amazons its attendant trains of heavy showers and snow. Under the combined action of the thaw and the rain-deluges, the flood rises gradually to an extraordinary elevation of forty feet ; the low islands disappear, the banks are inundated, the scanty lagoons unite with the river, and swell into actual inland seas; the animals seek an asylum on the summits of the lofty trees; and the Indians who inhabit the shore encamp on floating rafts.

"Towards the eighth of July, when the river begins to sink, the natives have new dangers to contend with; the waters returning within their accustomed channel, undermine the long-flooded banks, slowly gnaw them away, and suddenly huge masses of earth, many hundreds and even thousands of yards in area, are carried away by the turbid tide, involving trees and animals in hopeless ruin.

"These landslips take place so frequently that the riverine trees have no time to attain their complete development, and the voyagers who navigate the Amazons river descry but a few of the colossal trunks they had hoped to see. The cultivation of a field on the river-bank is, accordingly, a perilous attempt; and if he would not behold his house, and his farmstead, and his crops swept away in some chaotic convulsion, the colonist will not establish himself in the vicinity of the river until he has thoroughly studied its formidable characteristics.

"The very islands are exposed to sudden destruction: when the rows of wrecked trunks which serve them as breakwaters have yielded to the fury of the headlong current, a few hours, or even minutes, will suffice for their disappearance, crumbling away before the flood; you see them melt away in the twinkling of an eye, and the Indians who had stationed themselves thereon to collect turtles' eggs, or dry the products of their fishing, are compelled to take refuge immediately in their canoes from a terrible death.

"Then in the swirl of the current pass along huge rafts of entangled trunks, which now twine together and now break loose, now accumulate round every headland now gather upon the shore in colossal piles. Around these immense trains of trees which, under the weight of the waters, roll and plunge heavily, like marine monsters or dismasted ships, float vast tracts of the *cannarana* herb, converting certain portions of the river-surface into flourishing and verdurous meadows. We may comprehend, then, the religious terror experienced by the travellers who make their way up the river of the Amazons, and behold at work these yellow whirlpools of sand, eating into the shores, overthrowing the trees, sweeping away the islets to reconstruct them anew, and dragging downwards to the ocean immense convoys of trunks and branches. 'The great river was terrible to contemplate,' says Herndon, the American traveller; 'it rolled through the solitudes with a solemn and majestic air. The waters seemed wrathful, malicious, pitiless, and the general aspect of the landscape awoke in the soul emotions of dread and horror similar to those which funeral solemnities produce, when, with the minute-gun firing, the tempest howling, or the waves wildly dashing, the crew assemble upon deck to bury the dead in a storm-tost sea.'"

The river-banks are incessantly attacked and transformed by the inundations of which we have elsewhere spoken, as well as by the *pororoca*.

The embouchure of the *Orinoco*—another shoreless lake—lies to the south of the West Indian Archipelago, on the coast of Guiana. In many respects this river is like the Nile. Like the great African stream, it has its cataracts, its periodical floods, and its crocodiles, and it has still, as the Nile once had, its unknown sources.

In North America, the western flank of the Rocky Mountains sends to the Pacific the river *Oregon* or *Columbia*, and the *Rio Colorado*, which falls into the Gulf of California. From their eastern declivity descend the *Mackenzie*, which falls into the Arctic Ocean, the *Churchill*, and the *Saskatchewan*, which flows into Hudson's Bay.

The Gulf of Mexico receives the *Rio Grande del Norte*, and the muddy but majestic *Mississippi*, whose basin occupies an area of 1,226,600 miles.

[The *Mississippi—i.e.*, *Miche Sepe*, "Father of Waters"—rises in the highlands of Minnesota, in lat. 47° 10′ N., and long. 94° 54′ W. Its sources consist of numerous small lakes, situated at an elevation of 1680 feet above the sea-level. It runs in a general southerly direction, with a total length—from its rise to its mouth—in lat. 29° N., and long. 98° W., of 2986 miles; but if we also trace the current of its principal tributary, the Missouri, of 4506 miles. It is navigable to the Falls of St. Anthony, 2200 miles; the Missouri may be ascended to a point 3950 miles distant from the Mexican river; and there are 1500 other navigable branches, of which it is only necessary to name the Red River, 340 miles; the Ohio, 2300; and the Arkansas, 700 miles.

The Mississippi forms the boundary-line of ten of the United States:—

Iowa, Missouri, Arkansas, Louisiana, and part of Minnesota, lying on the west bank;

Illinois, Kentucky, Wisconsin, Tennessee, and Mississippi, on the east bank.

It also waters the following important towns:—St. Paul, Galena, Quincy, St. Louis, Memphis, Vicksburg, Natchez, and New Orleans.

Its delta, where it pours its waters through a multiplicity of *bayous*, or channels, is 150 miles long, and occupies an area of 14,000 square miles. A great portion of the country traversed by this colossal river is a wide, grassy, alluvial plain, forming those "rolling prairies" which are so characteristic a feature of North American scenery, and which afford to innumerable herds of buffaloes and deer an apparently inexhaustible field of pasturage.

The *Missouri*, or "*Mud River*," rises in two forks, the Jefferson and Galatin, in the Rocky Mountains, lat. 45° N., and long. 112° W. After a northerly course of 500, and an easterly one of 1200 miles, it flows south-east to its junction with the Kansas, and then east to join the Mississippi. At high water it may be ascended as high as the Great Falls, 2540 miles from its point of confluence. Its principal tributaries are the Kansas, the Platte, the Yellowstone, and the Cheyenne. At the Great Falls it descends 357 feet in a series of imposing cascades, one of which is 87 feet high, extending over 16 miles.

The *St. Lawrence* collects the waters of five great lakes, Superior, Michigan, Huron, Erie, and Ontario, and flowing between Canada and the United States, carries its burden into the Atlantic.]

CHAPTER VI.

LAKES AND INLAND SEAS.

IT remains for us, before we enter upon a survey of the ocean-world, to speak of those basins of fresh or brackish water which we call *lakes* or *inland seas.*

A reservoir of water which is continuously fed by some unknown spring, is denominated a *lake.* If the water spreads over a considerable surface of ground, which it covers with difficulty, and if its borders are ill-defined, it is designated a *marsh, morass,* or *swamp.* When the water has been partially absorbed by the soil, we distinguish the locality as a *bog.* Lakes and morasses are met with, in greater or lesser number, at all elevations, in the lowest plains as among the loftiest mountains.

Veritable lakes—*lakes* properly so called—are very frequently mere expansions of the basin of the river which traverses them. It is thus that in Europe the Lake of Geneva is formed by the development of the Rhone, the Lake of Constance by the Rhine, the Lago Maggiore and the Lakes of Como and di Garda by the affluents of the Po. The romantic river Orbe traverses at first the Lake of Joux (in the Upper Jura), situated 1950 feet above the level of the Lake of Geneva; then it is engulfed in vast funnel-shaped cavities hollowed out in the limestone; after a subterranean course of upwards of 4000 yards, it emerges into daylight in a lower valley, 750 feet below its original point of disappearance, and traverses the Lakes of Neufchatel and Bienne. Lake Baikal, in Eastern Siberia, receives and again gives up the Angara; Lake Tzana, in Ethiopia, the Abbaye, or Blue River.

Occasionally we may observe successive contractions of the valley, and the lake will then be divided into several basins, like that of

Lucerne, traversed by the river Reuss, which fills three basins, without counting the two lateral lakes that also communicate with it. In America, the five grand lakes of Canada seem to be in reality the successive basins of the broad and extended channel of the river St. Lawrence. In Russia, Lakes Ladoga, Onega, Saïma, Bielo, and Ilmen, communicate, by rivers, with one another as well as with the Lake of Finland.

Lakes whence issue rivers are frequently fed only by subterranean springs. Such is the case with Lake Seligher, which gives

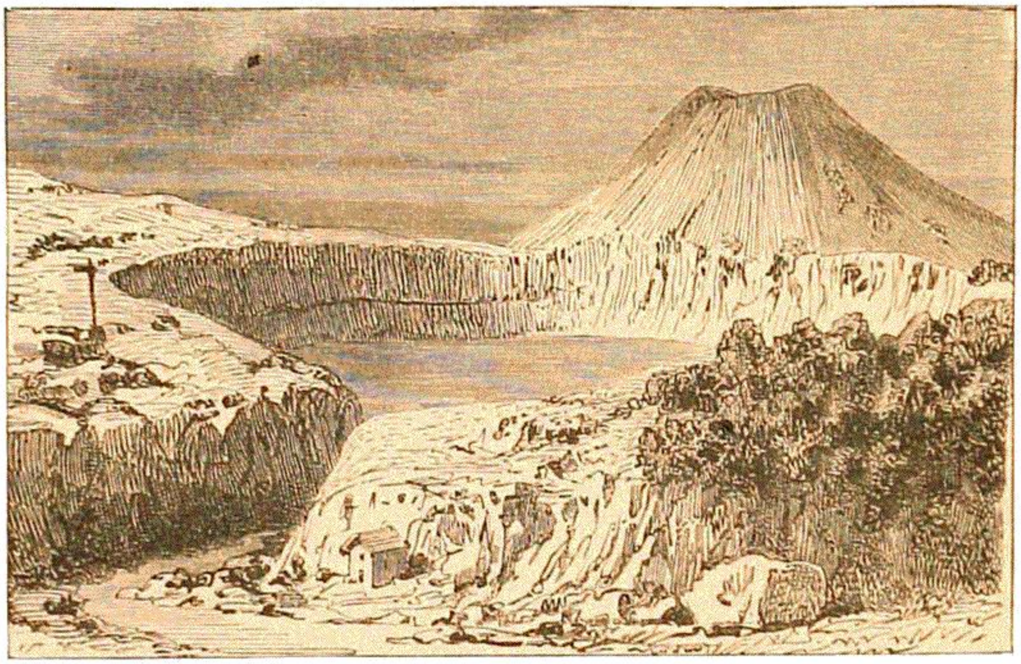

FIG. 194.—LAKE PAVIN, IN AUVERGNE.

birth to the Volga; the Koukou-Noor, at the foot of the mountain-range of the Thian-Chan, whence flows the Yellow River; and the Rawana-Hrada, on the northern slope of the Himalayas, the source of an affluent of the Indus. Usually, these lakes are of small dimensions and situated at a very lofty level, like that of Monte Rotondo, in Corsica, or the Cader-Idris, in Wales. But the contrary prevails when a lake receives a river without throwing off any stream of water. Then, of two things, one or the other must happen: either the waters pass away through subterranean ducts, or the evaporation is so great as to balance the quantity of water received. Sometimes both causes act together.

Lakes of this description are generally salt or brackish. In truth, they may more justly be described as *inland seas:* such are the Caspian Sea, the Aral Sea, and the Dead Sea. Lakes Balkh, Tchad, Titicaca, and Celano are fresh-water reservoirs.

Finally, there are lakes into which and out of which no river flows. Generally, they occupy the craters of extinct volcanoes, and originate in an accumulation of the rain-waters. The evaporation being compensated by the heavy rains, the level of these lakes does not sensibly alter. The most singular of the lakes formed in this manner is Lake Pavin, in Auvergne; but the Lakes of Albano and

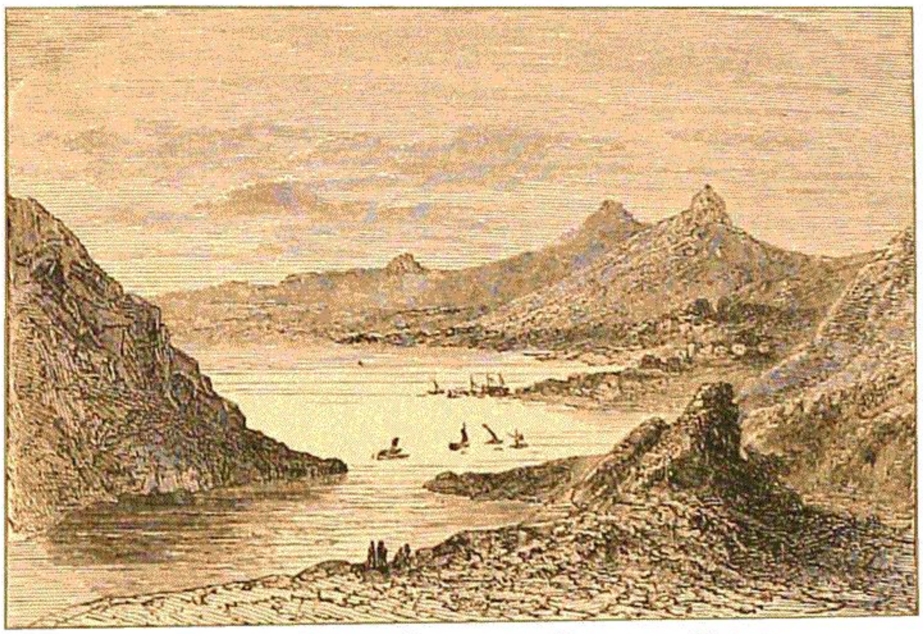

FIG. 195.—PONDS OF BERRE, NEAR MARSEILLES, FRANCE.

Avernus, in Italy, and numerous basins in the district of the Eifel, have a similar geological origin.

Lakes there are which communicate directly with the sea, and might, perhaps, be more justly designated gulfs. On the continent they are called *lagunes.* Sometimes they are formed by the sea; sometimes by the embouchure of a river. [To this category belong the romantic lochs that break the outline of the west coast of Scotland, as Loch Fyne, the Holy Loch, Loch Long, and the Gair Loch; and certain Irish *loughs*, as Lough Swilly.] We may also refer to the lagoons of Venice and Comacchio; the three Haffs of the Baltic; Lake Maelar in Sweden; the ponds of Berre, near Marseilles, and of Thau, near Cette, on the Mediterranean coast of France; and the *Grande Lagune*, in the Gulf of Mexico.

Perhaps we ought to include under this division the beautiful lagoons which sleep, encircled by a ring of coral, in the palm-fringed islands of the South Pacific.

Lakes occasionally present a very curious fact; namely, the blending of several reservoirs of fresh water with reservoirs of salt water. To the north of the Caspian, the traveller sees, in a wide and level plain, a throng of little lakes, some of which contain fresh water, and others water charged with marine salt or sulphate of magnesia, in quantities varying according to the season of the year. There are lakes in Tibet which hold in solution boracic acid, and this acid is only found in the same condition in certain lakes or *lagoni* of Tuscany. It is from these sources our chemists obtain their supplies of a substance which is of great usefulness in pharmacy and the arts.*

In Tuscany the name *lagoni* is given to small natural or artificial lakes, produced by the condensation of the jets of water and vapour which issue from the soil, in somewhat the same manner as the *geysers* of Iceland. They are projected into the air with great impetuosity, diffusing a sulphurous odour. In falling back, they form the lakelets already mentioned.

The saltness and density of the waters of the great salt lakes are frequently greater than those of the ocean, as may be observed in the Dead Sea and the Lake of Urimeyeh.

The phenomenon of lunar tides (though on a very small scale) has been ascertained to exist in Lake Michigan and other vast inland reservoirs.

The accidental tides called *seiches*, which affect the levels of the Lake of Geneva, Lake Wettern in Sweden, and many others, are

* [Boracic acid is also found in the crater of a mountain in the island *Vulcano*. The Tuscan supply, however, is the largest and most important. Native boracic acid is employed as a source of borax, and consists of about three-fourths of pure acid and one-fourth of water.]

better known and more sensible. They are sudden overflows, of brief duration, arising probably from differences of atmospheric pressure on the very extensive surface of the waters. *Seiches* occur in all seasons, but are generally most frequent in spring and autumn.

In Africa and America we meet with lakes which dry up at intervals, like the salt pools of the Sahara Desert, and the Lakes of Xarayes and Parià. Others present a phenomenon analogous to that of intermittent springs. Such is the Lake of Zirknitz, in Illyria. It is surrounded by limestone mountains. Its circumference varies

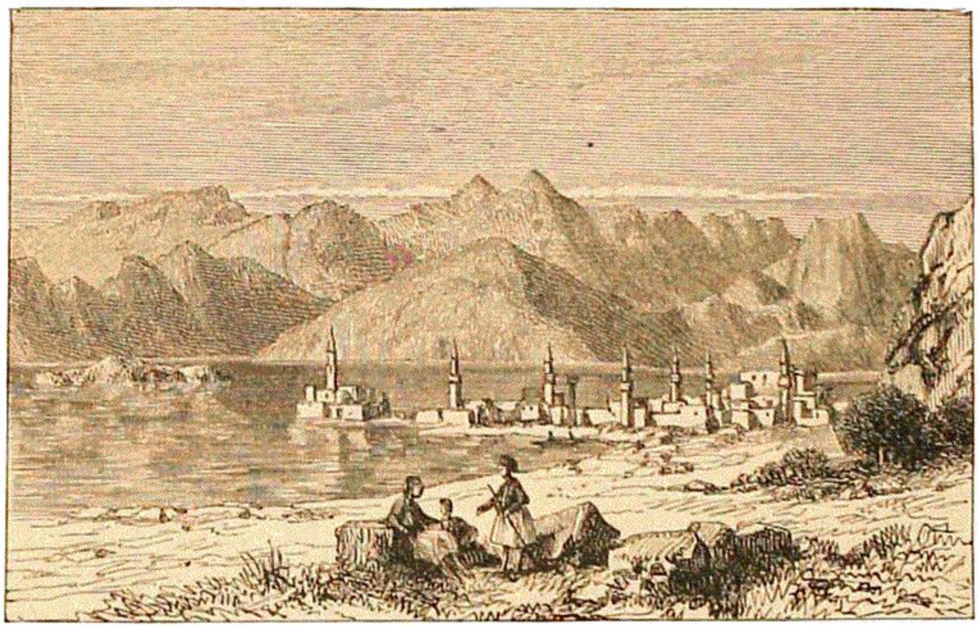

FIG. 196.—LAKE OF JOANNINA, IN GREECE.

from fifteen to thirty miles; it receives eight streams, and its surface is studded with four or five islands, on the largest of which is situated the village of Vorneck. At certain epochs, the waters flow through a great number of subterranean conduits, whose orifice opens in the bed of the lake, so that one may easily catch with the hand the fish which are not carried underground. The lake then remains dry for a considerable time, is overgrown with a rich vegetation, and, perhaps, tilled and planted. But beware of trusting to the calm impostor! The waters suddenly return through the channels by which they disappeared; the lake, with a formidable roar, fills itself anew, and swallows up the crops which covered its ancient bed.

The Lake of Joannina, in Greece, rendered celebrated by the adventures of Ali Pasha, communicates by a subterranean canal with the river Kalama, and in summer is reduced to a mere pond; maize is then sown in the dried-up soil.

[We shall close this chapter with an enumeration of the most remarkable lakes of the globe.

EUROPE.

The *Lakes of Switzerland* have been immortalized by poet and artist for their

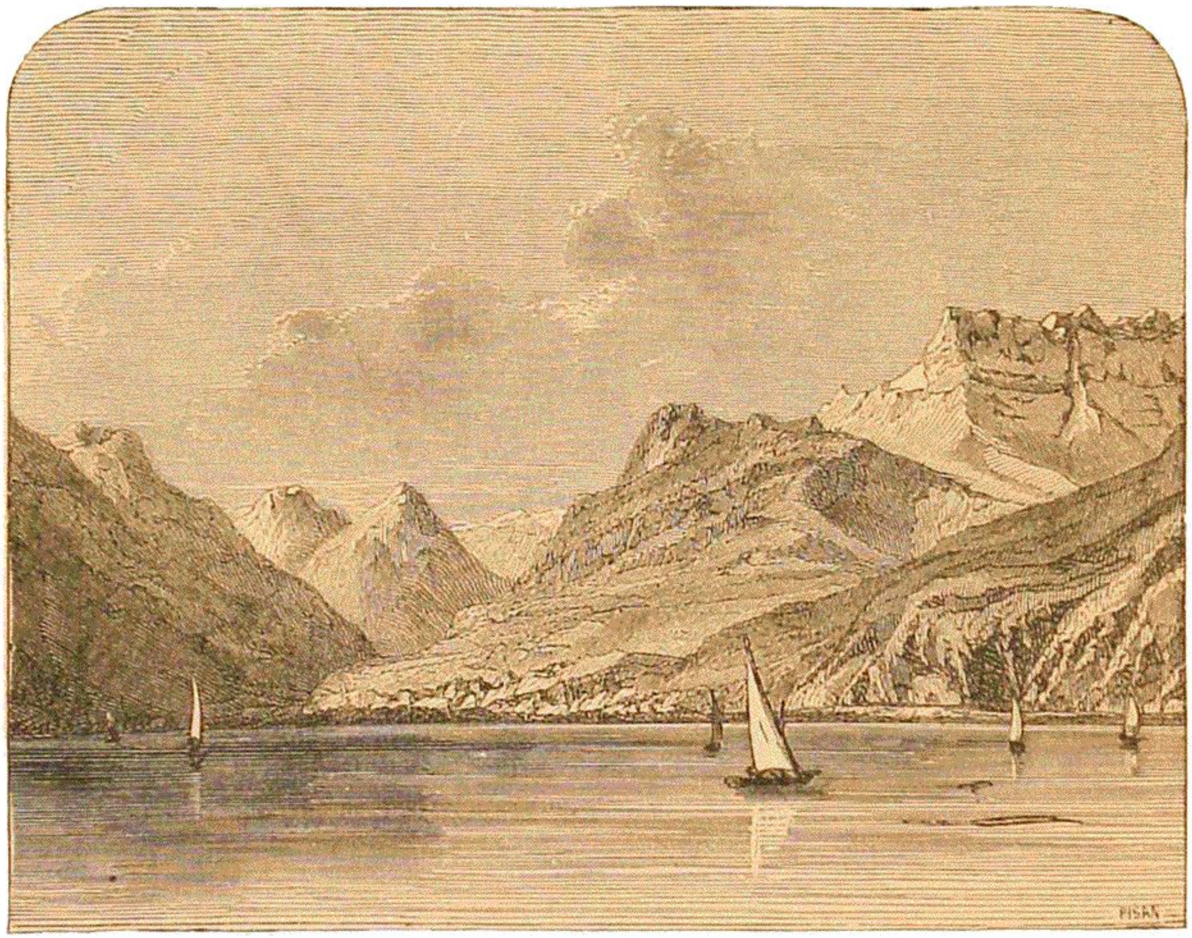

FIG. 197.—LAKE OF GENEVA (AT THE UPPER END).

picturesque beauty. Of those of Geneva, Lucerne, and Constance we have already spoken; but it is not they, perhaps, which most vividly influence the imagination or most powerfully charm the gaze. The tiny mountain-tarns, or lakelets—sleeping in the solitude of the lofty Alpine regions—on whose banks the chamois quenches its thirst, or whose glassy wave is darkened by the shadow of the lammergeyer—are invested with a wild, strange loveliness never seen in those large sheets of water whose shores are inhabited by man. We may mention as singularly romantic in scenery the little *Lake of Œschi*, near Kandersteg, in the canton of Berne, which gives birth to the Kander river. It occupies the bosom of the valley of Œschinen, is fenced round by glaciers and precipices, and mirrors on its surface the snow-crowned peaks of the Blumlis Alp.

Very beautiful, too, is the *Lake of Brienz*, near Interlachen—a glassy reservoir of deep, dark blue water, encircled by woody heights, and fed by numerous waterfalls and mountain-torrents. It measures 8 miles in length, exceeds 500 feet in depth, and is 1781 feet above the sea-level.

Lake Thun is another of the glories of the Bernese Oberland. It is 10 miles in length and 1775 feet above the sea. Its northern shore is rendered majestic by the frowning presence of two huge mountains; the sharp peak of the Stockhorn, and the pyramidal mass of the Niesen.

The *Lake of Wallenstadt* is about 12 miles long by 3 miles broad; its banks are embellished with a succession of glorious landscapes—in which glens, and gloomy precipices, and flashing streams, and "shadowy woods," sloping hills and gaunt bare mountain-heights are marvellously combined.

But "*Leman* with its crystal face" is, perhaps, the most beautiful—certainly the most interesting—of the Swiss lakes. "Its very name," says Lord Lytton,* "is a poem in itself. It conjures up the living and actual shapes of those who have been greater than their kind. As the thought of Troy brings before us at once the bright Scamander—the heaven-defended towers—the hum of the wide Grecian

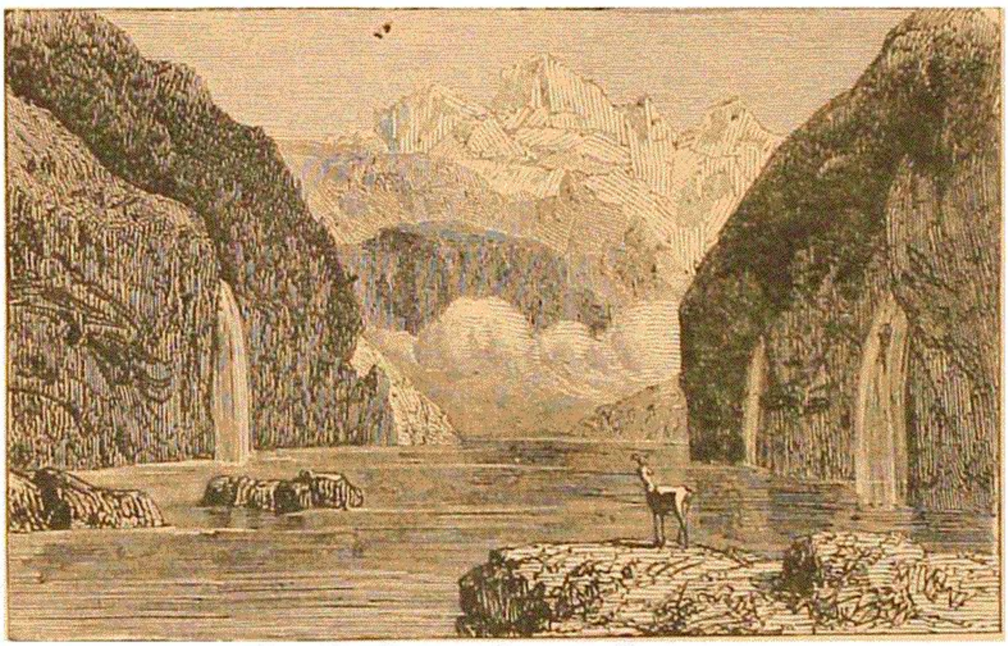

FIG. 198.—LAKE OF ŒSCHI, IN SWITZERLAND.

camp—with the lone tent of Achilles, sullen at his loss—and the last interview of Hector and her to whom he was 'father, mother, brethren'—so with the very name of Leman rise up the rocks of Meillerie—the white walls of Chillon—we see the boat of Byron, with the storm breaking over the Jura—the 'covered acacia walk' in which, at the dead of night, the Historian of Rome gazed upon the waters after he had finished the last page of his deathless work: Voltaire, Rousseau, Calvin—beings who were revolutions in themselves—are summoned before us. Yes; Leman is an epic: poetical in itself, it associates its name with the characters of poetry;—and all that is most beautiful in nature is linked with all that is most eloquent in genius."

* [Lord Lytton, "The Student."]

The *Lake of Geneva*—called by the Romans *Lacus Lemanus*—has nearly the shape of "Dian's crescent bow," its horns having a southward inclination. Along its northern shore it measures 55 miles, and along its southern, 40; its maximum breadth is 6 miles; its greatest depth, 900 feet. Its surface is about 1142 feet above the sea-level.

"Lake Leman woos me with its crystal face,
The mirror where the stars and mountains view
The stillness of their aspect in each trace
Its clear depth yields of their far height and hue."

In Northern Italy occur three lakes of great though tranquil beauty; smiling lakes, embowered among groves of olive, orange, and pomegranate, and not surrounded, like the waters of Switzerland, with rugged and gloomy precipices: the Lakes of *Como*, *Lugano*, and *Maggiore*.

Lago di Como is about 40 miles in length from north to south. It is fed by the Adda, and as it has no outlet, the Adda must also carry off its superfluous waters. The finest and most accurate description of it with which we are acquainted is given by Henry Taylor, the author of "Philip Van Artevelde":—

"Sublime, but neither bleak nor bare,
Nor misty are the mountains there,
Softly sublime—profusely fair,
Up to their summits clothed in green,
And fruitful as the vales between.
They lightly rise,
And scale the skies,
And groves and gardens still abound;
For where no shoot
Could else take root,
The peaks are shelved, and terraced round.
Earthward appear in mingled growth
The mulberry and maize; above
The trellised vine extends to both
The leafy shade they love.
Looks out the white-walled cottage here,
The lowly chapel rises near;
Far down the foot must roam to reach
The lovely lake and bending beach;
While chestnut green and olive gray
Chequer the steep and winding way."

Lago di Lugano (also called Ceresio) is of a very irregular outline; its shores making numerous sudden curves and abrupt bends, which enclose the most delightful recesses and shadowy coves. Its scenery is very varied; being at one point bare, bleak, rugged, and mountainous; at another, a series of vineyards, fig-groves, and walnut-copses, interspersed with white villas and blooming gardens. Its extreme length is 20 miles.

Lago Maggiore, or the Greater Lake—the *Lacus Verbanus* of the Romans—is about 54 miles in length and 3 miles in breadth. Its landscapes are exquisite, but the shores so precipitous that there is scarcely a path along their difficult steeps.

In Northern Russia and in the Scandinavian Peninsula are numerous lakes, some of them of very great extent. *Lake Ladoga*, which the river Neva connects with the Gulf of Finland, is the largest in Europe, being 120 miles long, 70 miles broad, and covering an area of 6804 square miles. Its depth varies from 12 to 2000 feet, and it receives the waters of seventy rivers.

Through the river Svir it also receives the tribute of *Lake Onega*, which is situated in the government of Olonetz, and measures 59 miles in breadth by about 150 in length. Its area is estimated at 4830 square miles. The depth varies from 550 to 700 feet. It abounds with fish, and is studded with numerous islands; but its navigation is difficult and dangerous.

Lake Wener is the largest lake in the Scandinavian Peninsula. It measures upwards of 90 miles in length, and varies from 15 to 48 miles in breadth ; its maximum depth is 309 feet ; its elevation above the sea-level, 150 feet. Total area, 2005 square miles.

Lake Wetter, in Sweden, has an area of 850 square miles. It is 70 miles long and 30 broad. Its clear, emerald, translucent waters are embosomed in the midst of scenery of the most romantic character. It frequently changes its level, and is subject to a remarkable undulation, which is so impetuous as to break up the thick sheet of ice that covers it in winter.]

A similar phenomenon is noticeable on the deep lake of Boleslaw, in Bohemia, which is frequently affected by an inexplicable movement.*

A lake near Beja, in Portugal, forebodes, by its strange howling noises, the coming storm. Lake Baikal, the sacred lake of the Russians, also announces to the fishermen the approach of a gale or tempest, an hour beforehand, by violent undulations called the *zyb*, which seem to come in the same direction as the wind. Only, its undulations are less violent before a storm than before a moderate breeze. Lake Baikal (in Turkish, *Bei-kal*, the "rich lake") is about 400 miles long, and its average breadth is 45 miles. Its area has been computed at 14,000 square miles. It is surrounded by the Baikal Mountains, an offshoot of the Altai range, and receives the myriad streams which roll down their rugged flanks. It finds an outlet in the river Angara, which flows through a narrow gap in the north-western barrier of rocks.

* In Lake Huron there is a bay where electric clouds are constantly accumulating; it is impossible to traverse it without hearing the roll of thunder. Sir Alexander Mackenzie records a singular phenomenon which he noticed on Lake Rose (North America):—"At the portage of Martres," he says, "the water is not above three feet deep, and has a muddy bottom; you can thrust poles into it to a depth of 13 feet as easily as into water. Yet this mud exercises a magnetic attraction on the boats, so that the rowers can with difficulty make progress. Loaded craft run the risk of sinking to the bottom where the water is shallow; but in the south, where the depth is very great, the effect ceases to be perceptible." Something analogous may be seen, according to the same author, at a certain point of Lake Saginaga.

[Our British lakes are not important from their size or commercial capabilities, but their peculiar beauties have endeared them to artist and poet.

In England, the Lake District includes the south of Cumberland and the north of Westmoreland; a region of limited area, but abounding in the most diversified and romantic landscapes. The Cumbrian lakes are Bassenthwaite, Buttermere, Crummock Water, Derwentwater, Ellerdale, Thirlmere, and Wast Water. Those of Westmoreland are Grasmere and Windermere. Ulleswater is partly in Cumberland and partly in Westmoreland.

Derwentwater is justly famous for its picturesque loveliness. It is 3 miles long, 1½ miles broad, 72 feet deep, and 222 feet above the sea. Rocky mountains closely encircle it, as if it were Diana's bathing-pool, which they would fain protect from the curious eye. Its surface is diversified by several richly-wooded islands.

Grasmere is also fenced round by lofty mountains. It is oval in form, like a cameo, and measures upwards of a mile in length and half a mile in breadth. At the head of the lake is the fair village of Grasmere, with its gray old church, in whose quiet "God's Acre" repose the remains of Wordsworth and Hartley Coleridge, and some members of Wordsworth's family.

It is almost impossible to name or think of this fairy ring of waters, without recalling the fine sonnet in which the great poet of the Lakes has done homage to its charms:—

> "Clouds, lingering yet, extend in solid bars
> Through the gray west; and lo! these waters, steeled
> By breezeless air to smoothest polish, yield
> A vivid repetition of the stars;
> Jove, Venus, and the ruddy crest of Mars
> Amid his fellows beauteously revealed
> At happy distance from earth's groaning field,
> Where ruthless mortals wage incessant wars.
> Is it a mirror?—or the nether sphere
> Opening to view the abyss in which she feeds
> Her own calm fires?—But list! a voice is near;
> Great Pan himself low-whispering through the reeds.
> 'Be thankful, thou; for, if unholy deeds
> Ravage the world, tranquillity is here!'" *

The Queen of the English Lakes, however, is *Windermere* (or *Winandermere*), which is partly in the county of Lancaster, and partly separates that county from Westmoreland. Its length is 11 miles, its extreme breadth 1 mile; it is fed by the united waters of the Brathay and Rothay, as well as by numerous rippling and flashing rills and brooklets; its surplus waters flow off through the channel of the Leven into Morecambe Bay. Its greatest depth is 240 feet.† Many of the isles which gem its liquid bosom are of a beauty which poets dream of in their dreams, and its finely-wooded shores open up at every step a landscape of Arcadian richness in form and colour. At the north end the gentle loveliness of its scenery gives place to an air of rugged and almost gloomy majesty; and the heights of Bowfell, Scafell,

* [Wordsworth, "Poems of the Imagination," sonnet vii.]

† [The deepest of the English lakes is Wast Water, 270 feet.]

Harrison Stickle, and Langdale Pikes, fling their heavy shadows upon the tranquil wave. At Rydal, on its banks, long lived William Wordsworth; Elleray was the residence of Professor Wilson ("Christopher North"); and Dove's Nest, the poet's home of Mrs. Hemans.

We pass to a brief survey of the inland lochs, or lakes, of Scotland, which are on a larger scale, though not more beautiful, than the mountain-bosomed waters of north-western England.

Loch Lomond, in Dumbartonshire, is 23 miles in length, with an average width of 1½ miles, and an extreme width of 5 miles. Its depth varies from 60 to 600 feet. A prominent feature in its scenery is the huge mass of Ben Lomond; but perhaps its peculiar attractiveness is chiefly due to the numerous islands which stud its sur-

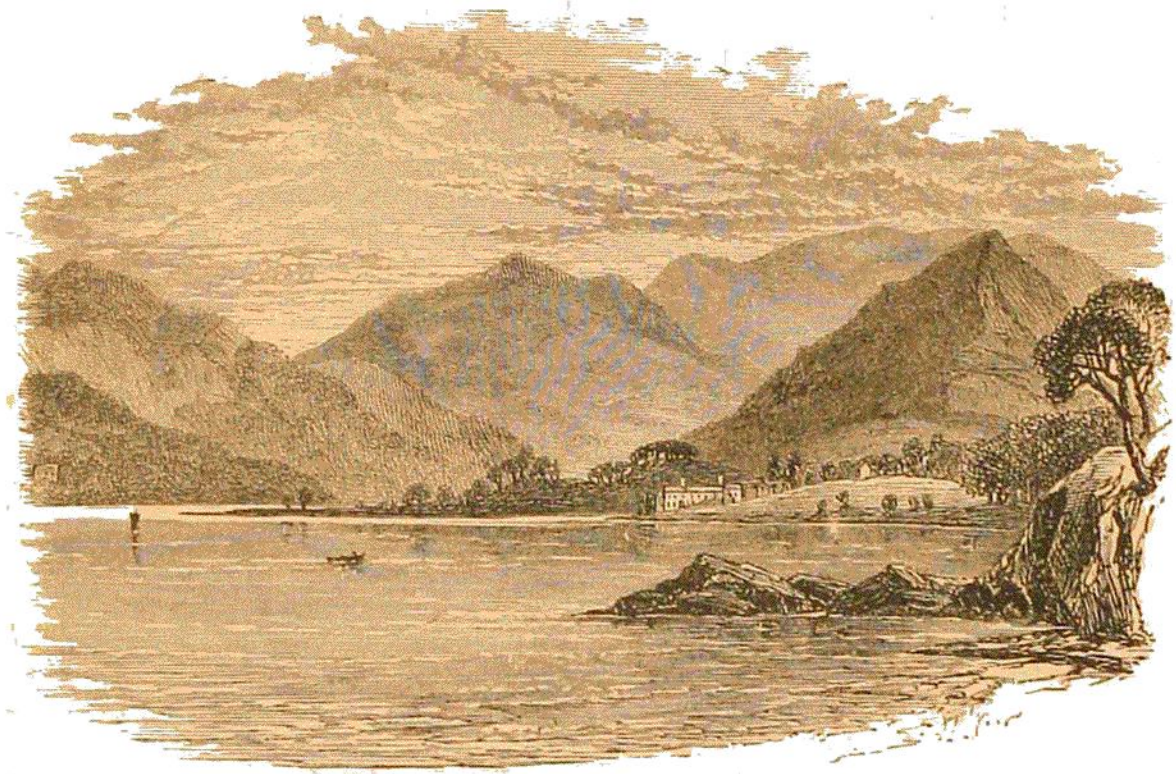

Fig. 199.—The Head of Lake Windermere.

face, and which are of the most diversified character—some rugged and bare, others low and grassy, others embowered in luxuriant wood, and all of different size and outline. The upper portion of the lake has a grandeur that almost approaches sublimity.

Loch Doon, in Ayrshire, though less visited by tourists, is, to our thinking, fully as deserving of praise and enthusiasm as the Lomond or Loch Katrine. Its length is 6 miles; its breadth, from 3 to 6 furlongs. The variety of landscapes along its shores cannot fail to enchant the most listless eye; green, sloping pastoral hills are succeeded by the boldest and wildest mountains; sylvan vales of exquisite loveliness are contrasted with glens so savage and eëry that one might think them the fitting haunt of "woman wailing for her demon-lover;" and the lake, at the lower end, pours its waters through a ravine so deep, so rugged, and so sombre that it seems to have been cleft in the everlasting hills by a giant hand.

St. Mary's Loch, in Selkirkshire, has been rendered famous by the genius of Wilson, Hogg, and Sir Walter Scott. It is separated at its head, by a narrow neck of land, from another and a smaller loch—the Loch of the Lowes; and at its lower extremity pours off its surplus into Yarrow Water—a wild, swift stream, of piscatorial repute, which winds through the well-known pastoral vale of Yarrow,—

"The silver current flows
With uncontrolled meanderings."

St. Mary's Loch is about 3½ miles long and from 4 to 7 furlongs wide. It lies in the heart of lofty, smooth, grassy, and leafless hills, with a singularly impressive air of silence and loneliness, which it is impossible for the most indifferent to disregard.

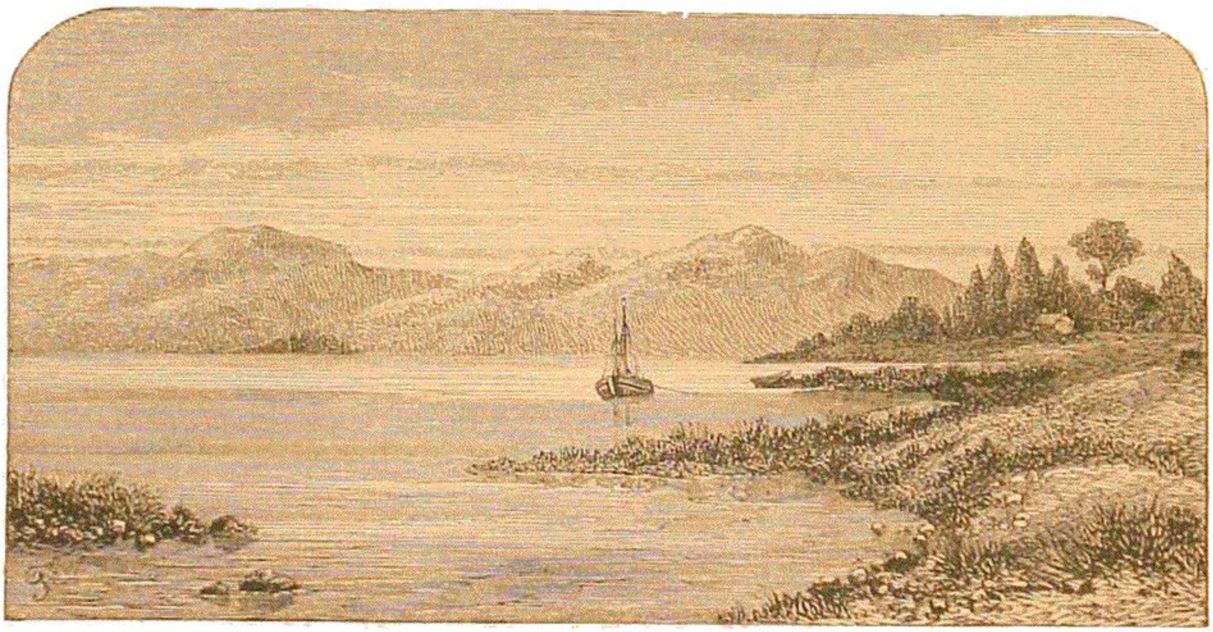

FIG. 200.—LOCH LOMOND.

Loch Katrine extends with many windings from north-west to south-east. It measures 8 miles in length and about three-quarters of a mile in breadth; its maximum depth is 468 feet; its elevation above the sea-level, 365 feet. Its scenery is not less remarkable for variety than grandeur; a noble effect being obtained by the bold promontories which jut forward into the lake's clear surface, and whose craggy foundations are whitened by foaming waves. The encircling mountains are intersected by numerous valleys and gorges, through whose deep shades tumbles many a "brawling stream," which, as it leaps from ledge to ledge, fills the air with its noisy music. Sometimes the shore rises into steep and lofty cliffs, like those of a sea-coast; but more frequently it spreads along the water's edge in a belt of heathery greensward. The mountains which guard the upper waters of the lake are not very lofty, but above them and against the distant horizon sweep the striking range of Ben Lomond and the granite peaks of Argyleshire. On the north side towers Benchoan to an altitude of 3000 feet; further south is the bare and bold Benledi; and near the lower end of the lake the characteristic and imposing mass of Benvenue, which has been described as "an immense heap of broken hillocks," with a total elevation of 2806 feet above the sea.

Near the head of the lake lie three picturesque islands: one, the loftiest, blooms with purple heath; another is embowered in vigorous leafy growth; the third is also wooded, and contains the ruins of an ancient fortalice. Near the lower extremity is "Ellen's Isle," so called from its connection with Scott's poem of "The Lady of the Lake." It is a beautiful and romantic spot, fenced round with crag and boulder, and richly clothed with wood.

A glen of great sublimity leads from Loch Katrine to Loch Achray, which is one mile and three-quarters long and half a mile broad. This glen is famous among the "beauties of Scotland" under the name of the Trossachs, and with its masses of curiously shaped rock and lofty precipitous heights is assuredly a most impressive scene.

The features which distinguish the scenery of Loch Katrine have been described by Sir Walter Scott in one of his most effective passages, which, it is believed, the reader will not object to reperuse:—*

"Boon nature scattered, free and wild,
Each plant or flower, the mountain's child.
Here eglantine embalmed the air,
Hawthorn and hazel mingled there;
The primrose pale and violet flower
Found in each cliff a narrow bower;
Foxglove and nightshade, side by side,
Emblems of punishment and pride,
Grouped their dark hues with every stain
The weather-beaten crags retain,
With boughs that quaked at every breath.
Gray birch and aspen wept beneath;
Aloft, the ash and warrior-oak
Cast anchor in the rifted rock;
And, higher yet, the pine-tree hung
His shattered trunk, and frequent flung,
Where seemed the cliffs to meet on high,
His boughs athwart the narrowed sky."

The traveller issuing through the glen now sees the smiling lake before him:—

"Gleaming with the setting sun,
One burnished sheet of living gold,
Loch Katrine lay beneath him rolled,
In all her length far-winding lay,
With promontory, creek, and bay,
And islands that, empurpled bright,
Floated amid the livelier light,
And mountains, that like giants stand,
To sentinel enchanted land.
High on the south, huge Benvenue
Down on the lake in masses threw

* [Sir W. Scott, "Lady of the Lake," canto i., stanzas 12–16.]

Crags, knolls, and mounds, confusedly hurled,
The fragments of an earlier world;
A wildering forest feathered o'er
His ruined sides and summit hoar,
While on the north, through middle air,
Ben-an heaved high his forehead bare."

We have thus glanced at the best-known of the Scottish lakes. There are half a hundred others, of different sizes and character, which are scarcely less beautiful, romantic, or sublime. Those in the Northern Highlands, however, have a strong "family likeness," and are deep, still sheets of water, closely encircled by bare, lofty, and precipitous mountains, whose brown shaggy sides are scored by many a flashing and noisy burn.]

ASIA.

The Hindus have their sacred lakes; as those of *Mano-Sarowar* and *Ravana-Bruda*, which are situated in the centre of the table-land that lies north of the Himalayas. In the immediate vicinity of these lakes are found the head-waters of the Indus, the Ganges, the Brahmapootra, and the Djuma. When speaking of the Himalaya, in an earlier chapter, we referred to the lakes that at great elevations sleep among the recesses of the giant mountains. We give here a representation of *Lake Kiouk-Kiol*, from the valuable and important work of the brothers Schlagintweit.

The great lakes of *Van* and *Urumiyah* are excessively salt. They lie within the mountainous region of Armenia. They receive numerous tributaries; but though they possess no apparent outlet, their volume diminishes rather than increases.

[Lake Van is 80 miles long and 50 broad (at its maximum). Its area is 1200 square miles. *Lake Urumiyah* or *Urmeyah*, Urumijah or Urmea—called also the Lake of Marugha and Lake of Tabríz—lies about thirty-five miles west from Tabriz, at an elevation of 4320 feet above the sea-level. Its length from north to south is about 80 miles; its average width, 25 miles; and it contains upwards of 1900 English square miles. Its water is remarkable for its specific gravity, and contains twenty-five per cent. of salt. They are rapidly disappearing, and their banks now present an immense tract of thick saline incrustation.

The *Dead Sea*, which receives the sacred waters of the Jordan, occupies a considerable depression in the soil of Palestine, and is probably of volcanic origin. The level of its waters is no less than 1300 feet *below* that of the Red Sea. They form two widely different basins; the northern one, very deep (1300 feet), being separated from the southern, which is very shallow (13 feet), by a long sandy peninsula, named El-Mesran.

The striking name which this remarkable reservoir of inland waters has borne for so many generations is justified by the gloomy and desolate aspect of its naked shores, as well as by the lugubrious scenery everywhere surrounding it. Almost the only vegetation is the *Osher* of the Arabs—a plant which bears a fruit with some resemblance to an apple. Attempt to eat it, however, and the mouth is filled with a disagreeable substance. This is the famous "Dead Sea fruit," which has so often been used by the moralist to point a moral, and by the poet to adorn a tale.

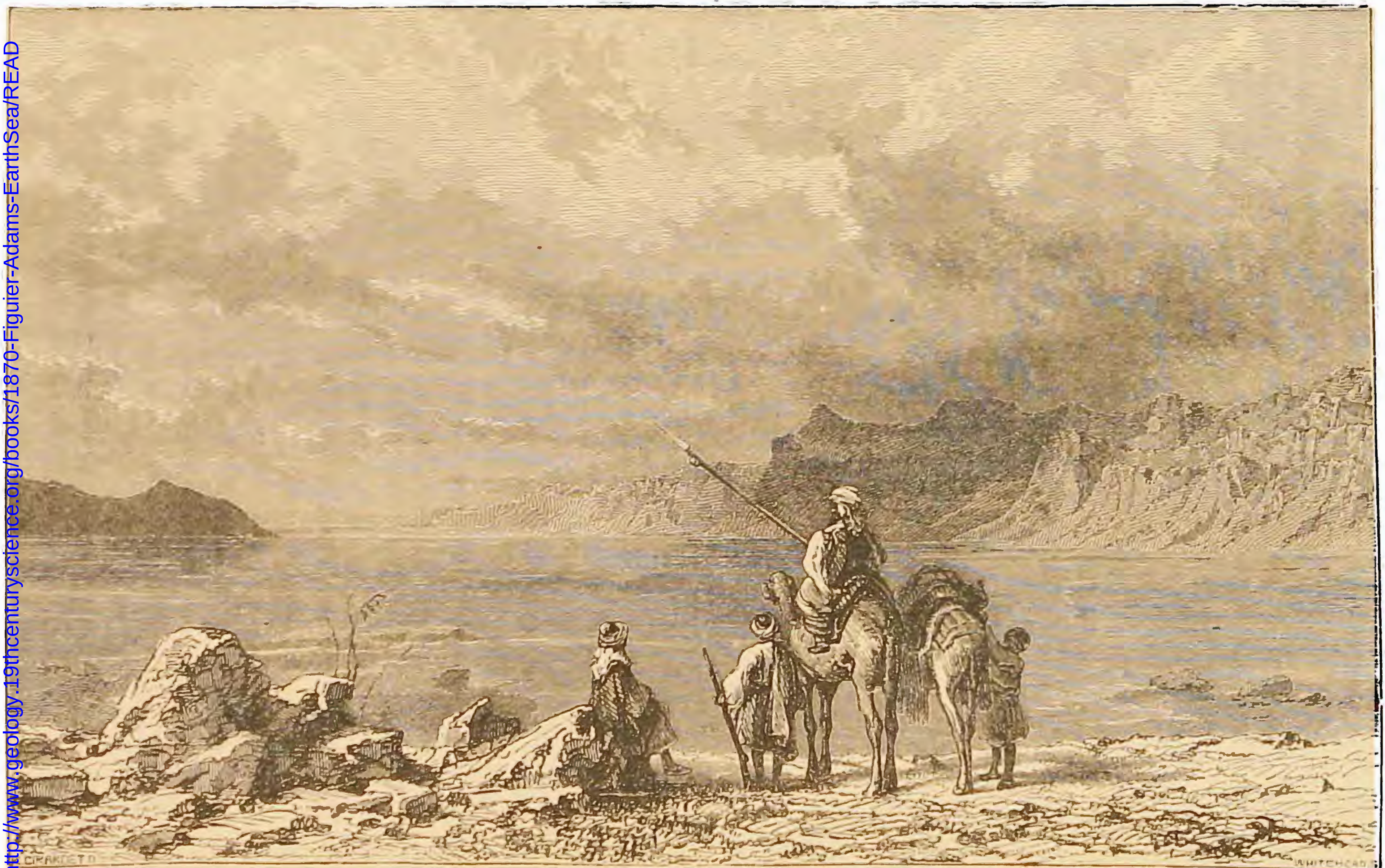

FIG. 202.—THE DEAD SEA.

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The peculiar character of the Dead Sea has given rise to a host of fables. It was anciently believed that no bird could fly across its expanse without being stricken dead by unwholesome vapours, and that its waters were of so great a density as to support a human body on their surface without difficulty. It does not require, however, the aid of fiction to produce a strong impression on the mind of the spectator.

In many respects, as Dean Stanley observes,* it is one of the most curious of inland seas. It lies, as already stated, 1300 feet below the level of the Mediterranean, and is thus the most depressed sheet of water in the world. Its basin is a steaming caldron—a bowl which, as it has been well described, from the peculiar temperature

FIG. 201.—LAKE OF KIOUK-KIOL, IN TIBET.

and deep cavity in which it is situated, can never be filled to overflowing. The river, itself exposed to the same withering influences, is not copious enough to furnish a supply equal to the demand made by the rapid evaporation.

The excessive saltness of the Dead Sea is, however, even more remarkable than its deep depression. This peculiarity, says Dean Stanley, is mainly occasioned by the huge barrier of fossil salt at its south-western corner, and heightened by the rapid evaporation of the fresh water poured into it. Along the desert shore, the white crust of salt indicates the cause of sterility. Thus the few living creatures

* [Dean Stanley, "Sinai and Palestine," pp. 290–293.]

which the Jordan washes down into the waters of the sea, are destroyed. Hence arises the unnatural buoyancy and the intolerable nausea to taste and touch, which raise to the highest pitch the contrast between its clear, bitter waves, and the soft, fresh, turbid stream of its parent river. Strewn along its desolate margin lie the most striking memorials of this last conflict of life and death; trunks and branches of trees, torn down from the thickets of the river-jungle by the violence of the Jordan, thrust out into the sea, and thrown up again by its waves, dead and barren as itself.

The specific gravity of the water of the Dead Sea ranges from 1172 to 1227. While sea-water only contains 30 parts of salt in the 1000 parts, that of the Dead Sea contains no less than 250.

The length of this curious inland basin is 40 miles; its average breadth 9 miles. It is situated in lat. 31° 10′ to 31° 47′ N., and long. 35° to 36° E.]

AFRICA.

On the African continent we notice first the great *Lake Tchad*, whose shores

FIG. 203.—LAKE TCHAD (AFRICA).

have been so thoroughly explored by Dr. Barth. It is an immense, marshy, and somewhat shallow lagoon, whose ill-defined shores change with the seasons of the year, according to their alternations of drought and heavy rains. Its waters are fresh, and it receives the tribute of numerous great rivers. In the midst of this vast shining expanse rise some verdurous islands; its shores are fertile and well cultivated. Cotton, cereals, and beans yield abundant crops, and ample pasturage is found for herds of cattle. Hippopotami, crocodiles, and elephants are included in the fauna of the Lake Tchad region.

Lake Tanganyika, which is situated in long. 27° E., and between the 3rd and

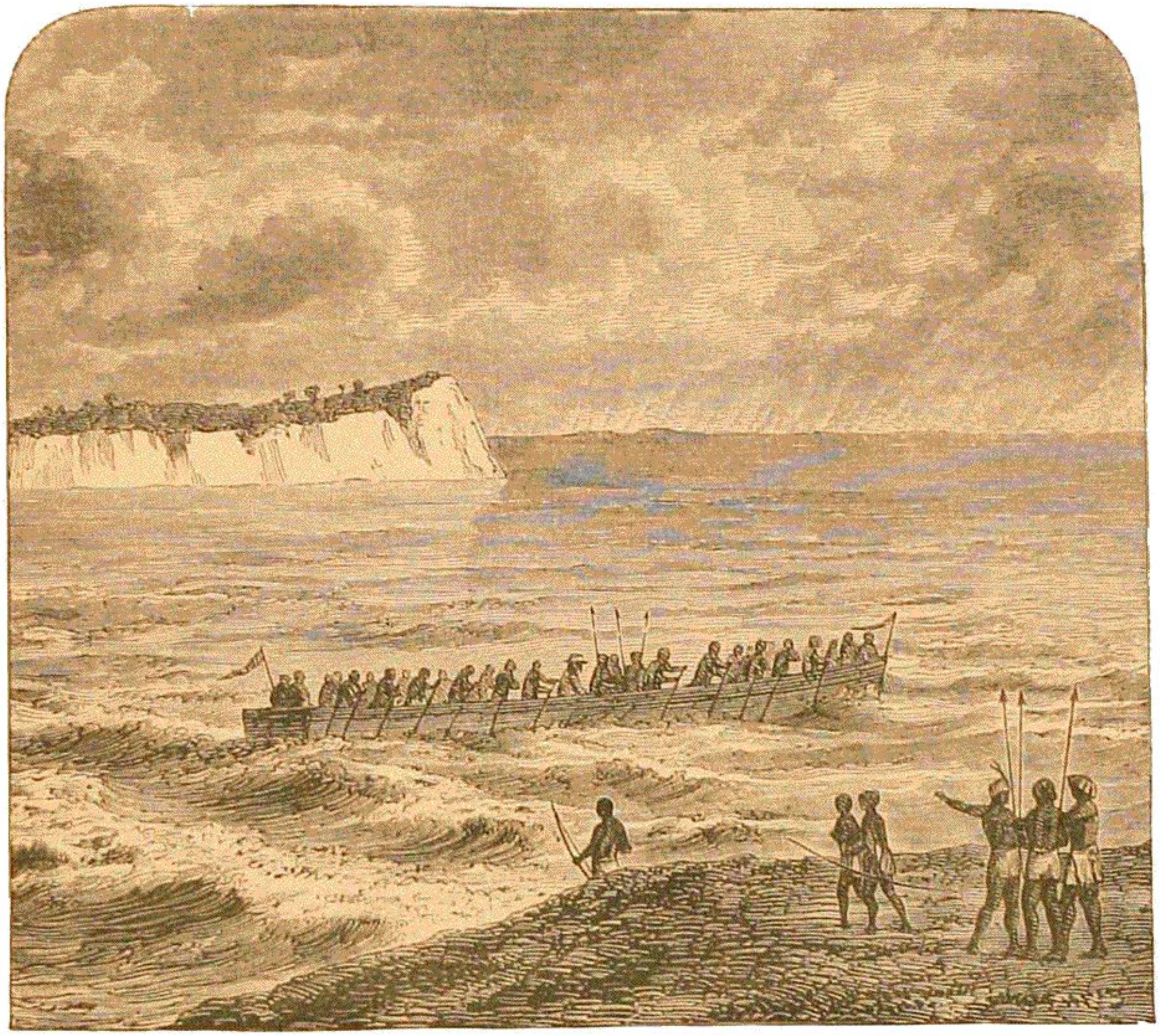

FIG. 204.—LAKE TANGANYIKA (AFRICA).

8th parallels of south latitude, was discovered in 1853 by Captain Burton. It is of an oval form, and measures 320 miles in length; breadth, from 15 to 60 miles. The water is fresh and deep, and its basin a volcanic crater, hollowed in the granite, which receives several streams, but has no apparent outlet. It is plentifully stored with fish.*

To the south of Lake Tanganyika Dr. Livingstone has discovered three important but less extensive lakes: *Shirwa*, *N'yassa*, or *N'yinyesi* ("lake of stars"), and *N'gami*.†

* Burton, "Lake Regions of Central Africa."

† Livingstone, "Missionary Researches in Southern Africa." &c.

Shirwa, or Tamandua, is of an oval shape; 60 miles long, 10 to 23 miles broad, and 1800 feet above the sea-level. Its shores are elevated and picturesque.

The contrary may be said of the marshy environs of the N'yassa, or Star Lake, which lies 350 miles inland from the Mozambique coast, measures 210 miles by 26, is 1300 feet above the sea, and, according to Dr. Livingstone, "has something of the boot shape of Italy."]

To the north of Lake Tanganyika, and immediately under the Equator, lies the *Victoria N'yanza*, whose surface is 3740 feet above the sea-level. It is one of the reservoirs of the Nile, and was discovered by Speke in 1858, and more fully explored by Speke and Grant in 1862. It is supposed to be 220 miles in length, and about the same in breadth. To the north-west lies another reservoir of the Nile, to which we have already referred, the *Albert N'yanza*, or Luta N'zigé. It seems to be a remarkably narrow basin, about 230 miles in length.

AMERICA.

In the territory of Utah, in North America, lies the *Great Salt Lake*, whose

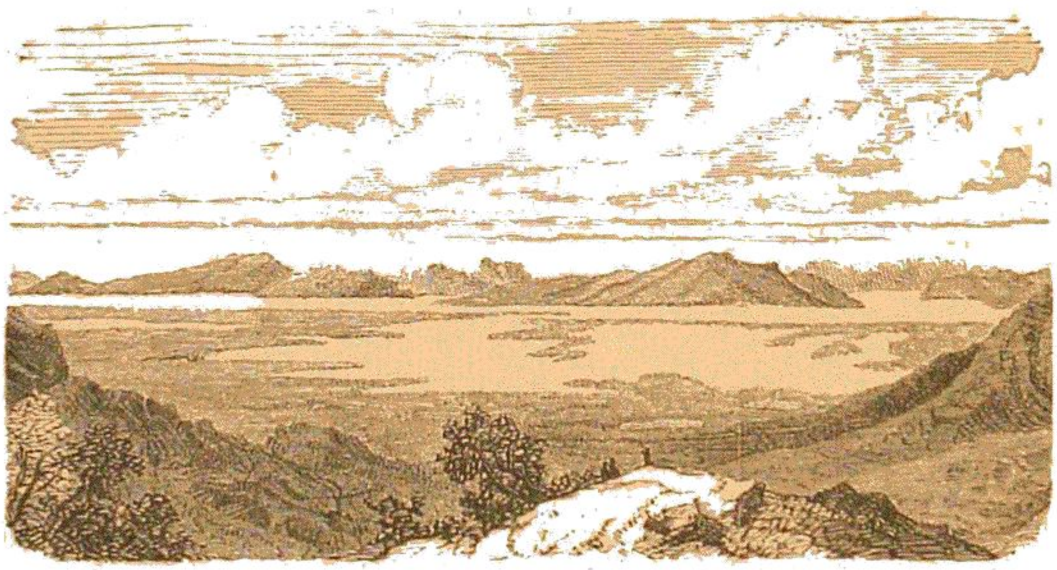

FIG. 205.—THE GREAT SALT LAKE OF UTAH, U. S.

waters are fatal to organic life. In its neighbourhood the Mormons have erected their "City of the Saints," on the bank of a river named the Jordan, which falls into this Dead Sea of the Far West. Captain Burton, after bathing in the Salt Lake, says that his hair when he emerged from the water was literally powdered as with hoar-frost, and his skin encrusted with a saline efflorescence. The Salt Lake is situated at an elevation of 4200 feet above the sea-level.

In the northern regions of the New World are numerous lakes of immense extent. Five, which might more justly be designated inland seas, are found in Canada. As our limits do not admit of our describing them, we subjoin a few figures in illustration of their enormous dimensions.

CANADIAN LAKES.

	AREA.	ELEVATION ABOVE THE SEA-LEVEL.	LENGTH.	MEAN BREADTH.	DEPTH
	Sq. miles.	Feet.	Miles.	Miles.	Feet.
Lake Superior	32,000	596	355	80	900
Lake Michigan	20,000	578	240	80	1000
Lake Huron	24,000	578	220	70	1000
Lake Erie	9600	565	240	40	200
Lake Ontario	6300	234	180	35	600

Only inferior to these in importance are *Lakes Winnipeg, Wollaston*, and *Athabasca ;* the *Bear Lake*, and *Slave Lake*, whose shores are chiefly tenanted by wild animals.

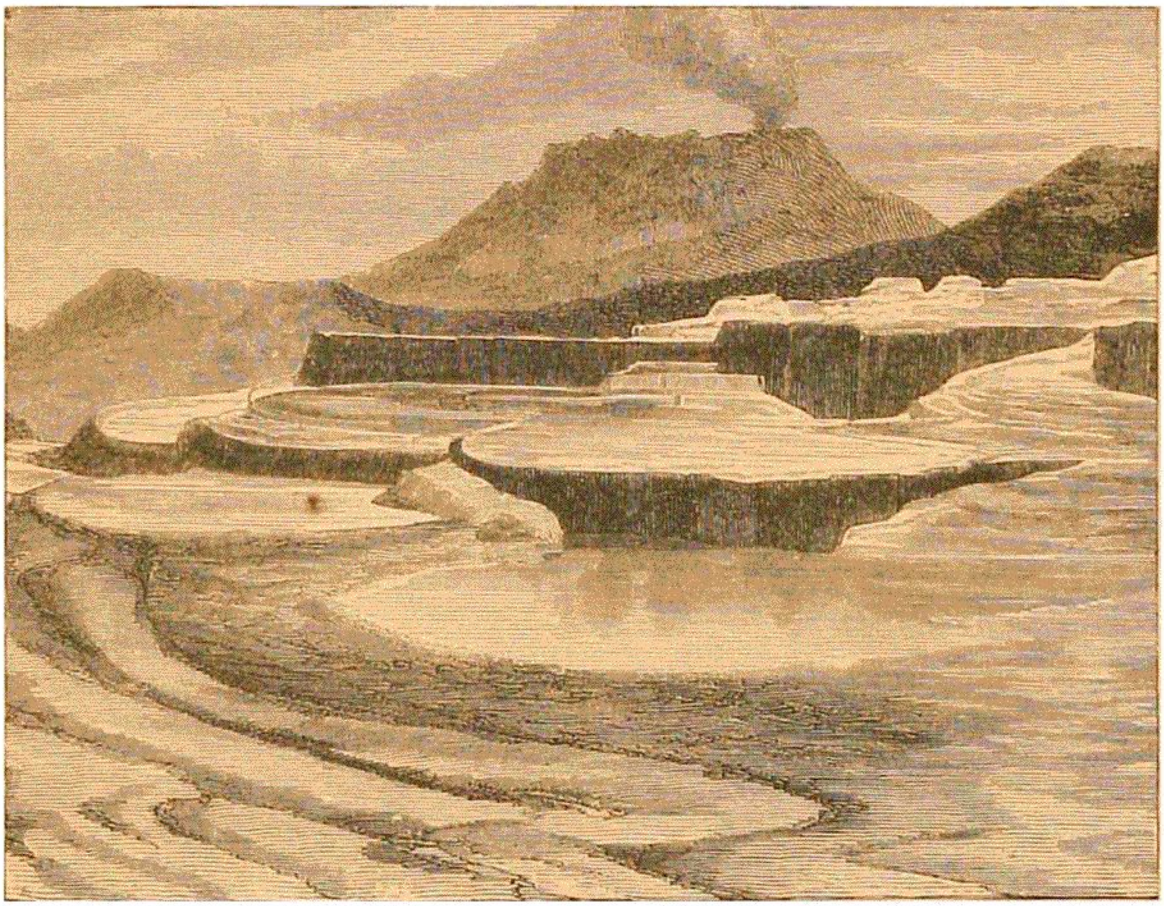

FIG. 206.—THE ROTHO-MAHANA LAKE, NEW ZEALAND.

In South America, the most remarkable lake is that of *Titicaca*, between two chains of the Bolivian Cordilleras ; it communicates with the neighbouring lake of *Ullagas* by a river which is, in truth, nothing more than a conduit or natural canal (in Spanish, *desaguadero*).

In New Zealand occurs a lake of boiling waters, the *Rotho-Mahana*, already described in our account of the volcanic phenomena of that colony.

[We shall close this chapter with a table of figures in reference to the extent and altitude of the most famous lakes of the world, which the reader can compare with the data already furnished of the five great Canadian fresh-water seas.

LAKES OF THE WORLD.

	Area.	Elevation above the Sea-Level.	Length.	Mean Breadth.	Depth.
	Sq. miles.	Feet.	Miles.	Miles.	Feet.
Sea of Aral	...	...	265	125	...
Lake Baikal	14,000	...	400	45	...
Lake Balkash	...	...	150	75	...
Caspian Sea	140,000	38½ ft. below Black Sea	700	200	600 to 3000
Lake of Celano, or Fucino	85	2176	10	7	*
Dead Sea	1900	1300 ft. below.	80	25	...
Lake of Geneva	...	1150	50	8	920
Lake Ladoga	6804	...	120	70	12 to 1000
Lake Onega	4830	...	150	59	550 to 700
Slave Lake	...	...	...	...	...
Lake Tanganyika	1844	...	320	15 to 60	...
Lake Titicaca	...	12,846	115	30 to 60	70 to 180
Lake Tchad	800	...	200	170	...
Lake Wener	2005	150	90	15 to 48	309
Lake Winnipeg	9000	628	264	85	...
Lake Van	1200	...	80	80	...

* [This lake is being completely drained. It was remarkable as the only one in the Central Apennines.]

BOOK VI.

THE WORLD'S SEAS.

O thou vast Ocean! ever-sounding Sea!
Thou symbol of a drear immensity!
Thou thing that windest round the solid world
Like a huge animal.

BARRY CORNWALL.

It is the unpastured sea hungering for calm.

SHELLEY.

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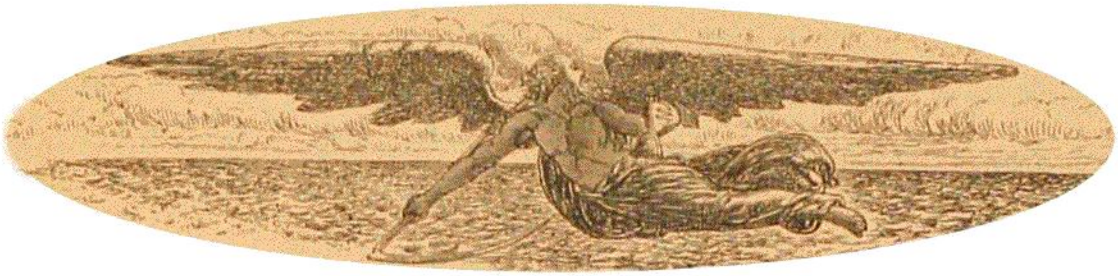

BOOK VI.

THE WORLD'S SEAS.

CHAPTER I.

THE SEAS:—THEIR EXTENT—COLOUR OF THE SEA—ITS PHOSPHORESCENCE—COMPOSITION OF SEA-WATER—THE ATOLLS, OR CORAL ISLANDS—GEOLOGICAL ORIGIN OF THE SALTNESS OF THE OCEAN.

OCEAN, that immense sheet of water which covers nearly three-fourths of the surface of the globe, and whose name awakens in the brain so many memories of joy and sorrow, of hope and fear, plays a very important part in the grand economy of nature. Swept by the incessant winds, its vast surface continually inspires the injurious gases which load the atmosphere; in its enormous mass it engulfs the débris carried down to it by the rivers and streams which have washed the continents and islands, and restores to the atmosphere, in the form of vapour, those purified waters which descend upon the earth in the shape of rain, or snow, or dew. These waters again flow back into the ocean through the streams, the brooks, and the rivers; and thus an eternal circle is established, an unending voyage, which makes the same waters serve for the support and renewal of the world's organic life.

The ocean, says Malte-Brun, by its exhalations which refresh and moisten the air, nourishes vegetable life, and furnishes the necessary aliment for those admirable channels of running water that are ever flowing, and yet never empty. But for the beneficent influence of the vapours which every moment escape from the surface of the sea, the whole earth would sicken and wither into an inanimate desert; and if the ocean slowly or suddenly dried up, all organized nature would probably be annihilated.

Nevertheless, the immense and profound seas offer no obstacles to the commercial intercourse of nations, whom they only separate in appearance; the maritime highways now traversed by such long processions of ships are freer and broader than those of earth; their maintenance lays no burden upon human communities, for they are kept up by nature.

One of the most remarkable features of the sea is its continuity. With the exception of some inland reservoirs which the ocean long ages ago abandoned in the heart of the continents—such as the Dead Sea and the Caspian—it is "one and indivisible." As the poet says, it embraces the whole earth with uninterrupted wave.

Περὶ πᾶσαν ἑλισσόμενος χθὸν' ἀκοιμήτῳ ῥεύματι.

The average depth of the sea has not been accurately ascertained; but it is impossible to explain certain tidal phenomena without allowing it to be at least 22,000 feet (7 kilomètres). It is true that a great number of soundings, taken out at sea, have invariably given lesser results; but, on the other hand, several have overpassed this limit; and cases are recorded * in which 39,340 feet to 49,180 feet of line has been paid out without touching the bottom. But admitting that 21,300 feet represent the mean depth of the ocean, Sir John Herschel computes that the volume of its waters will exceed 32,808,000,000 of cubic yards, and their total weight three millions of trillions of tons = 3,000,000,000,000,000,000. This would equal one two-thousandth of the whole terrestrial mass.

We shall return hereafter to the subject of soundings, by means of which we ascertain the depth of the ocean, and the configuration of its bed. We must now treat of the colour and composition of its waters.

The colour of the sea varies greatly, at least in appearance. According to the evidence of a host of observers, the ocean, when seen by reflection, presents a tint of ultramarine blue, or lively azure. When the air is pure, the tranquil surface of the waters seems of a brighter and more radiant blue than the skies. In cloudy weather this passes into a sombre green; which becomes darkly or luridly

* [This is doubted by Captain Maury in his "Physical Geography of the Sea."]

brown when the sea is agitated. At sunset the waves are kindled with glowing hues of purple and emerald. Or, as Byron sings,—

> " O'er the hushed deep the yellow beam he throws,
> Gilds the green wave that trembles as it grows."

A variety of local circumstances also influence the colour of the ocean-waters and tom

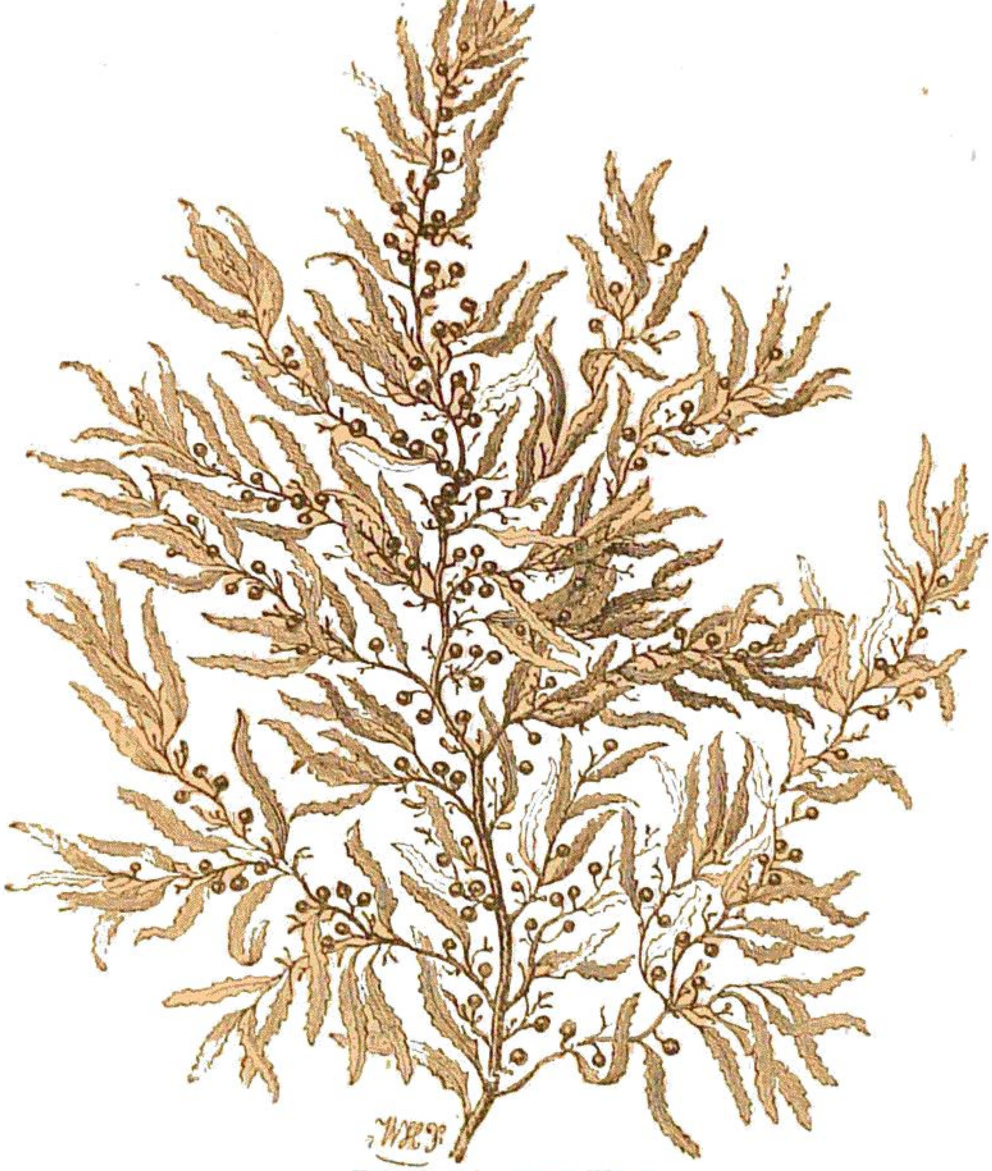

FIG. 207.—SARGASSO WEED.

be of white sand, and the water not very deep, its tint will be grayish or apple-green ; if the sand be yellow, the green is deepened and darkened. The neighbourhood of reefs is frequently indicated by the " pronounced colour " of the surrounding sea. In the Bay of Loango the waters seem of a burning red, because such is the natural colour of its bed.

At other times a peculiar tint is given to the waters by coloured animalcules. The Red Sea owes its colouring to a microscopic alga, the *Trichodesmium erythræum.* The sea-waters—condensed by the spontaneous action of the solar rays—in the salt-marshes of Southern France assume, when they have arrived at a certain stage of condensation, a beautiful red colour, which is owing to some animalcules with a reddish shell (*carapace*) that live in sea-water under this condition, and die (a strange and curious fact !) as soon as the water becomes more highly condensed, or is diluted by the effect of rain.

Navigators frequently traverse long green, red, white, or yellow belts of water, whose tints are derived from certain microscopic crustacea, medusas, zoophytes, and marine plants. Such is the case with the "Sargasso Sea" of the Atlantic, which lies midway between the Azores, the Canaries, and the Cape de Verde islands, occupying a space equal in extent to the whole valley of the Mississippi. Another Sargasso Sea is found in the Indian Ocean ; and a third just outside the Antarctic Circle.*

It is to a similar cause we must refer the magnificent phenomenon of the phosphorescence of the sea, which delights and astonishes the voyager in the Indian Ocean, the Baltic, the Arabian Gulf, and elsewhere. In the Indian Ocean, Captain Kingman traversed a zone fully twenty-four miles in width which was so full of phosphorescent animalcules as to present, at nightfall, the appearance of an immense field of snow. These animals, nearly two inches long (15 centimètres), were formed of a transparent gelatinous matter. The reflection of the solar light upon this viscous substance gave to the surface of the water a milky appearance.

The phosphorescence of the sea is an imposing and magnificent spectacle. The ship, when cleaving "the liquid plain," seems to advance in the midst of golden and vermilion flames, which flash off from the keel like electric lightnings. Myriads of stars seem to float and play on the rippling tide ; they multiply—they unite—they swell into one vast field of fire. The scene is one which in its fantastic and almost weird character may well remind the spectator of the sight that dazzled the Ancient Mariner :—†

"They moved in tracks of shining white,
And when they reared, the elfish light
Fell off in hoary flakes.

"Within the shadow of the ship
I watched their rich attire ;
Blue, glossy green, and velvet black,
They coiled and swam ; and every track
Was a flash of golden fire."

* [See "The Mysteries of the Ocean," pp. 120–123, edited by the compiler of the present work, and published by Messrs. T. Nelson and Sons.]

† [Coleridge, "The Ancient Mariner," part iv.]

In stormy weather the rolling billows are all lighted up, and swell and break in silver-flashing foam. Glittering bodies, which might be mistaken for fiery snakes, seem to pursue each other, to overtake each other, to disappear, and again to flash forth in living lustre!

Known from time immemorial, the phenomenon of the phosphorescence of the sea has been observed by all navigators. It is of frequent occurrence in certain regions of the ocean, especially in the

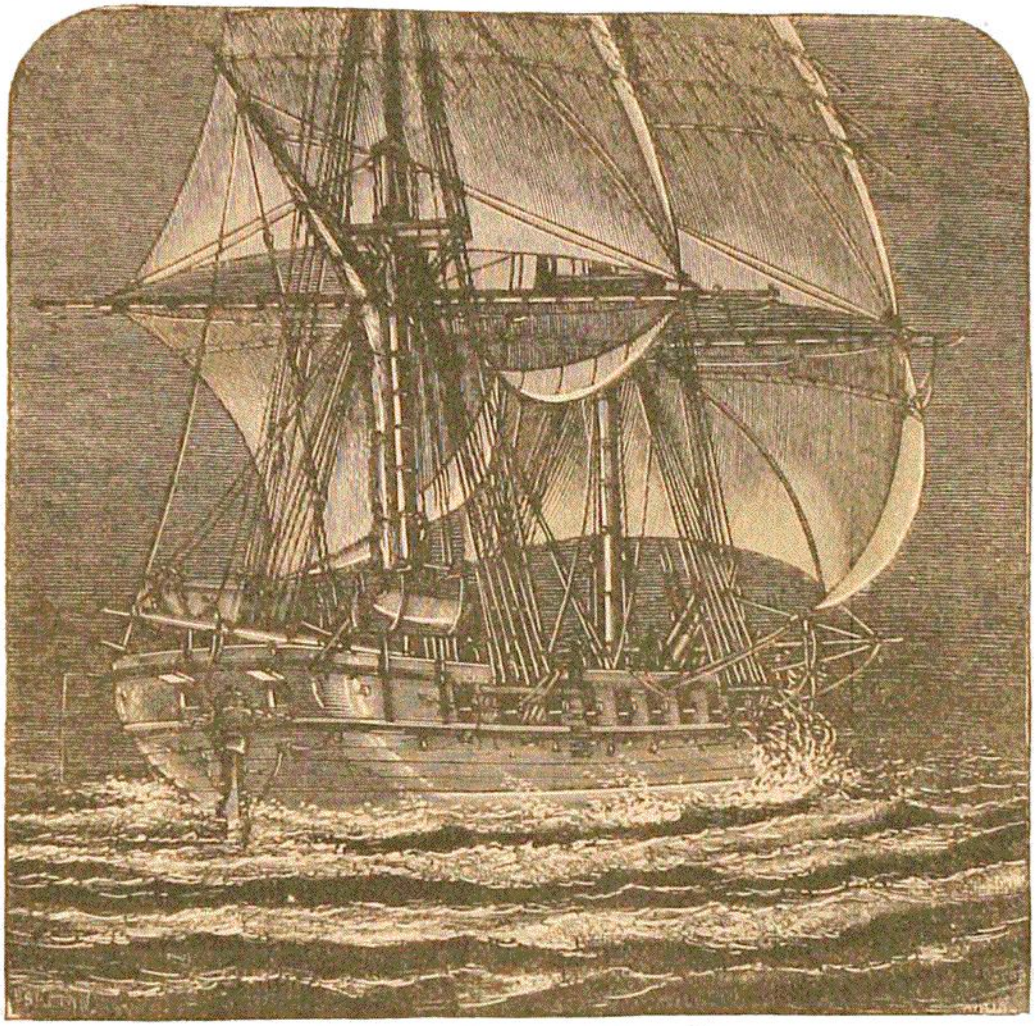

FIG. 208.—THE PHOSPHORESCENT SEA.

Indian Sea and under the Tropics. The radiance lights up the crest of the waves which, as they fall back, scatter it abroad in every direction; it clings also to the helm, and seems to escape from the waves tossed off the vessel's bow; it plays also about the weedy rock and billow-beaten reef. In the still, shadowless nights of the Tropic World the effect produced by this phenomenon is truly magical.

This phosphorescent lustre originates in the presence of a multitude of molluscs and zoophytes which glitter with a radiance originated by themselves. They emit a fluid so susceptible of expansion that, when swimming zigzag, they describe upon the water a series of brilliant tracks which extend with singular rapidity.

One of the most remarkable is a species of *Pyrosoma*, which we may describe as a kind of viscous pouch, about an inch in length: if thrown on a vessel's deck, it gives forth as much light as iron heated to a white heat. Sir John Herschel has remarked on the surface of very tranquil waters a curious form of this phosphorescence; polygons with rectilineal outlines, several feet square superficially, intermittently illuminating themselves with a vivid light which swiftly passes through them.

The phosphorescence of the sea may also result from another cause. When animal matters putrify, they sometimes become phosphorescent. The bodies of certain fishes, when decomposed, emit a light of tolerable intensity. Messrs. Becquerel and Breschet have observed some fine effects of phosphorescence produced by this cause in the waters of the Brenta, at Venice.

Animal matter in a state of decomposition—such as dead fish—floating on the surface of ponds and pools, sometimes produces large oily spots which, shining upon the liquid, communicate to it, over a considerable space, the phosphorescent aspect.

Whatever may be the local cause, the colouring of the waters has procured for numerous rivers designations in allusion to it. The *Guaïnia*, or Rio Negro, is of a deep dark brown, which, however, does not in the least affect the limpidity of its wave. The Orinoco and the Cassiquiare have also a brown colour; the Ganges is of a turbid brown, while the Jumna, which flows into it, is green or blue. A milky hue belongs to the Rio Blanco, or *White River*, and to a host of other streams. The Ohio in America, the Torjedala, the Goetha, and most of the Norwegian rivers, the Traun at Ischl, the Forth at Aberdour, are of a beautiful transparent green. The Yellow and Blue Rivers of China are distinguished by the characteristic tint of their waters. The Arkansas, the Red River, the Llobregat in Catalonia, are remarkable for their redness, which they owe to the clay held in suspension in their waters.

Sea-water is essentially *salt;* that is, it contains a great number of mineral and other salts, which give it a disagreeable taste, and render it unfit for economic purposes. We find in it nearly all the soluble matters existing on the globe, but principally chloride of sodium, or sea-salt, and the sulphate of magnesia, potassa, and lime. Sea-water contains more than 30.0 of its own weight of dissolved matter. We proceed to furnish the reader with some accurate analyses of its composition.

The first is an analysis made by M. Figuier, of water obtained at Havre, a few leagues out at sea. For one gallon of water it gave the following result :—

	PARTS.
Chloride of sodium, ...	25,704
Chloride of magnesia, ...	2,905
Sulphate of magnesia, ...	2,462
Sulphate of lime, ...	1,210
Sulphate of potassa, ...	0,094
Carbonate of lime, ...	0,132
Silicate of soda, ...	0,017
Bromide of sodium, ...	0,103
Bromide of magnesium, ...	0,030
Oxide of iron, carbonate and phosphate of magnesia, oxide of manganese, etc., ...	traces
	32,657

The water of the Mediterranean is more charged with salts than that of the ocean. The subjoined analysis was made by M. Usiglio, a chemist engaged in the superintendence of the salterns of the south of France :—

	PARTS.
Chloride of sodium, ...	29,524
Chloride of potassium, ...	0,405
Chloride of magnesium, ...	3,219
Sulphate of magnesia, ...	2,477
Chloride of calcium, ...	6,080
Sulphate of lime, ...	1,557
Carbonate of lime, ...	0,114
Bromide of sodium, ...	0,356
Peroxide of iron, ...	0,003
	43,735

We may conclude, from the quantity of marine salt contained in a gallon of sea water, that the mass existing in the entire ocean would form, if spread over the globe, a stratum upwards of thirty-two feet in thickness.

[Many new facts in reference to the composition of sea water have been collected by Professor Forchhammer * of Copenhagen. We shall summarise the more important as briefly as possible.

* [Forchhammer, in "Transactions of British Association," year 1844.]

(1.) The elements which it involves are now known to be :—

Chlorine.	Potassium.	Silica.	Nickel.
Iodine.	Calcium.	Boracic acid.	Manganese.
Bromine.	Iron.	Silver.	Alumina.
Sulphur.	Fluorine.*	Copper.	Strontia.
Carbon.	Phosphate of lime.	Lead.	Baryta.
Sodium.	Ammonia.	Zinc.	
Magnesium.		Cobalt.	

(2.) The mean saltness of the Atlantic, between 0° and 30° north latitude, is 36.169 in 1000 parts of sea water; the maximum, 37.908; the minimum, 34.283.

(3.) The mean saltness of the Atlantic between 30° and 55° north latitude is 35.946; the diminution being due to the quantity of fresh water poured in by the St. Lawrence.

(4.) In Baffin's Bay and Davis' Strait it is 33.281, and increases as we proceed northwards, being 33.598 in 69°.

(5.) The mean saltness of the Mediterranean is 37.936, as compared with 34.388, the mean saltness of ocean.

(6.) In the Black Sea the mean saltness is about 15.0, the saltness varying at different points from 11.880 to 18.146.

(7.) In the Indian Ocean the mean saltness is 38,868.

(8.) Excepting certain regions—namely, the North Sea, Kattegat, Sound, and Baltic, the Mediterranean and Black Sea, the Caribbean Sea, and the Red Sea—the mean numbers for the great ocean are as follow :—

Sea water.	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Co-efficient.
1000 parts,	18.999	2.258	0.556	2.096	34.404	1.812
"	100	11.88	2.93	11.03	...	...
Equivalents,	429	45	16	82	...	...

It is evident, therefore, that sea water, as a whole, is no more of a chemical compound than is the atmospheric air; that it consists of solutions of different chemical compounds; that it is neutral, because it everywhere in the atmosphere finds carbonic acid to neutralize its bases, and everywhere on its bottom and shores finds carbonate of lime to neutralize any prevailing strong acid; that, lastly, the great stability of its composition depends upon its enormous mass and its constant motion, which is the reason that any local variation is evanescent compared to the whole quantity of salt.

It only remains to be added that the specific gravity of sea water *decreases* as its depth *increases.*]

Owing to its saltness, the density of sea water is greater than that of fresh water. Its specific gravity, on an average, is represented by 1.027. That of the Mediterranean, according to Usiglio, is 1.025 at a temperature of 69° 30′ F. The salinity of ocean, however, varies

* Discovered by the late Dr. George Wilson, of Edinburgh.

greatly under the influence of a host of local circumstances; among which we must include its currents, the winds which favour its evaporation, and the rivers which pour into it the fresh waters of the continents.

It has been remarked that this saltness is less towards the poles than under the equator; that it increases generally with the depth of the water and the distance from the coast; that the inland seas, such as the Baltic, the Black Sea, the White Sea, the Sea of Marmora, the Yellow Sea, are not so salt as the ocean. To this last rule the Mediterranean is an exception; as we have seen, it is *salter* than the ocean. This difference may be explained by admitting that the quantity of fresh water contributed to its reservoir by the rivers is inferior to that which it loses by evaporation. The saltness of the Mediterranean would, therefore, increase yearly, if it did not discharge itself into the ocean by a counter-current flowing from east to west, which prevails under the current that flows from west to east through the Straits of Gibraltar.

The Black Sea—the specific gravity of whose waters is 1.013—receives, on the contrary, through its tributary rivers, more fresh water than it loses in the shape of vapour. Its saltness, as we have shown, is less than that of ocean by more than one-half.

The Sea of Azov and the Caspian are still fresher than the Black Sea.

In the following table is shown the composition of the water of these three inland seas :—

In a Litre* of Water.	Black Sea.	Sea of Azov.	Caspian.
	Sp. g. = 1.013.	Sp. g. = 1.009.	Sp. g. = 1.005.
Chloride of sodium,...........	14.0195	9.6583	3.6731
Chloride of potassium,........	9.1892	0.1279	0.0761
Chloride of magnesium,....	1.3045	0.8870	0.6324
Sulphate of magnesia,........	1.4700	0.7642	1.2389
Sulphate of lime,.............	0.1047	0.2879	0.4903
Bicarbonate of magnesia, ...	0.2086	0.1286	0.0129
Bicarbonate of lime,.........	0.3646	0.0221	0.1705
Bromide of magnesium, ...	0.0052	0.0035	Traces.
	17.6663	11.8795	6.2942

* A litre is equal to 0.2200967 British imperial gallon, or rather less than a quart.

In the pent-up lakes which have no apparent outlet—such as the Dead Sea and the Lake of Aral—the degree of saltness has considerably increased. Numerous experiments have shown that the waters of the Dead Sea are salter than those of Ocean. Messrs. Boutron and Henry analyzed them, after the rainy season in April 1850, at about two leagues from the mouth of the Jordan; their specific gravity was then 1.10. A kilogramme* of the water contained:

Chloride of sodium,	110.03	grammes.
Chloride of potassium,	1.06	"
Chloride of magnesium,	16.96	"
Chloride of calcium,	6.80	"
Sulphate of soda, magnesia, and anhydrous lime,	2.33	"
Earthy carbonates,	9.53	"
Silica and organic matter,	2.00	"
Bromide, azotate, and oxide of iron,	Traces.	
	149.31	"

Specimens of the same water, add Boutron and Henry, have given on analysis much higher numbers for the quantity of saline residuum left by evaporation. Thus, out of 1000 parts Klaproth obtained a residuum of 426 parts; Marcet, 245.8; Lavoisier, Macquer, and Sage, 433.75; Gay-Lussac, 462.4; Lieutenant Lynch, 264.187. These results are easily understood if we remember that the saltness of the Dead Sea must necessarily diminish after the rainy season, during which it receives a great quantity of fresh water from the Jordan and other streams.

Some analyses of water of the Dead Sea, taken up in April 1862 near the mouth of the Jordan, were made in 1863 by M. Roux, and gave the result of 200 grammes of salt to a litre. No mineral water, if we except that of the Utah lake, is so impregnated with saline substances. The quantity of bromide of magnesium is 0.35 grammes per litre. According to these figures, the water of the Dead Sea must be the richest natural reservoir of the bromides, and can furnish an abundant supply of these medicinally useful salts.

The waters of the great lake of Utah, and those of Lake Urumiyah in Persia, also possess a remarkable salinity. In Lake Urumiyah, as in the Dead Sea, the proportion of salts is six times greater than that of ocean: a man may float on its surface without making the slightest auxiliary movement.

It is probable that many of our fresh-water lakes were originally salt, but have gradually lost their saltness through the mixture of their waters with those of the

* Equal to 2.20462 lbs. avoirdupois. A gramme is equal to .00220462 lbs. avoirdupois.

rivers that traverse them. As examples we may cite the great lakes of Canada, and the sea or lake of Baikal, where seals and other marine animals are still residing, having become acclimatized as the water gradually threw off its salinity. Even the sea is less salt at the mouth of the great rivers; and, as we have already stated, in the vicinity of the polar ice, which, when it melts, furnishes an immense volume of fresh water.

Its saltness renders the sea water more fit for the flotation of ships, since its density is increased by the salts which it holds in solution. In addition, these salts must assist in preventing what is known as the *corruption of the water;* which is, in truth, nothing more than the putrid decomposition of the organic matters it may contain.

From the table representing the composition of the water of the ocean and the Mediterranean, the reader will see that the salts of lime and potash, iodine and silica, figure therein in proportions virtually infinitesimal. Nevertheless, the lime and the silica play a part of the highest importance; for the quantities which seem to us so trivial in the chemical analysis of a litre of water, become enormous in the entire mass of the ocean. Marine plants absorb the lime, the silica, the potash, and the iodines dissolved in the sea water; they take up into their very texture these mineral matters. It is at the expense of the silica and the carbonate of lime that the marine animals form their solid shield, their carapace, or their shell. For the same purpose the infusoriæ seize upon the lime, silica, and potash; and it is through the laborious lives of these polypes that the Coral Islands are built up in the bosom of the waves, to fill the mind of the observer with emotions of wonder, awe, and admiration.

CORAL ISLANDS.

The Pacific Ocean and the Indian Sea are sown with islands, still in course of formation, which owe their origin to the polypes and corallines. From the waters of the ocean these zoophytes extract the lime and silicas which they find there in the shape of soluble salts. That they may increase and develop, it is necessary they should be constantly bathed by the waves. Without pause or rest they produce their calcareous deposits, which rapidly accumulate, and eventually rise to the very surface of the water. Then the wrack and débris of every kind which the sea carries to and fro, arrested in their wayward undulations by these submerged masses—retained upon these new-born islands—form on their surface a stratum of fertile soil. Here the rich growth of a tropical vegetation is duly developed, thanks to the seeds transported by the waves and the ocean-birds. Thus are formed in the Pacific Ocean the beautiful ring-like Islands of Coral.

Generally they are thickly wooded.

It almost always happens that the summits of the coral islands which emerge simultaneously around another submarine summit,

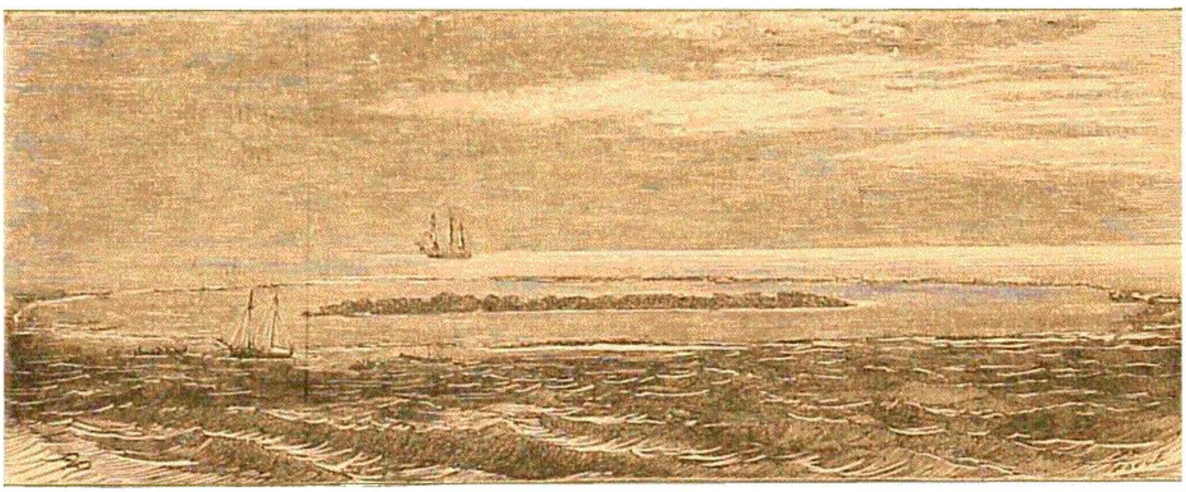

FIG. 209.—CORAL ISLAND OF OENO.

unite in an almost perfect circle, whose centre is occupied by a small clear lake. The waters of this lagoon contain a great number of shells, which produce pearls and nacre. Such are the islands of Oeno and Whitsunday, in the archipelago of Pomotou, visited by Captain Beechey. In due time this cincture enlarges laterally; the openings which gave access to its interior basin are closed; and when that basin has been filled up or run dry, the "fairy-ring of ocean" assumes very nearly the aspect of ordinary islands. The archipelagoes of the Maldives, the Chagoes, and the Laccadives, to the south of the great Indian peninsula, are of madreporic origin. Among the coral islets distinguished as *atolls** some are of such recent date that their birth was witnessed by our fathers.

Accumulations of coral masses form in the waters of Oceania an incredible number of reefs.

The great islands of that newly-formed archipelago are surrounded, through the slow labour of the polypes, by a barrier of reefs, rising at a certain distance from the coast, and rendering the approach both difficult and dangerous. The eastern coast of New Holland is fenced, between the 9th and 25th parallels of south latitude, by a cincture

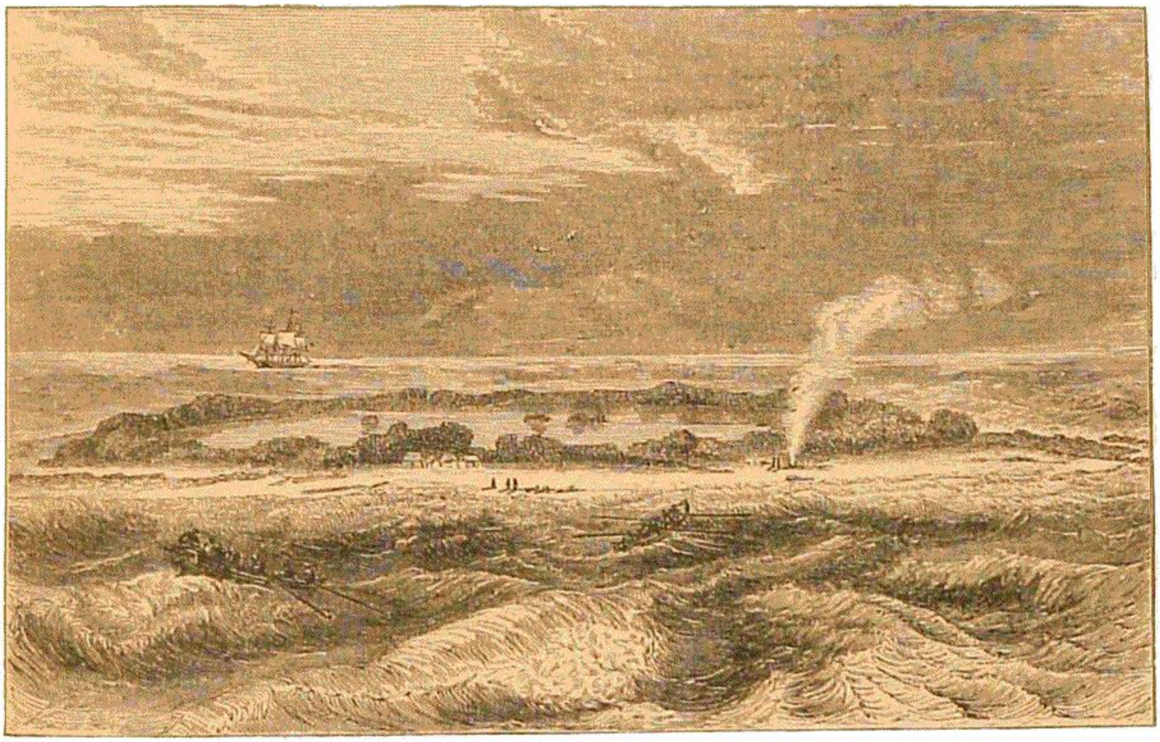

FIG. 210.—WHITSUNDAY ISLAND.—(*After Beechey.*)

of this description. The coral bank known as the *Great Barrier Reef* is 1200 miles in length, with a breadth varying from 200 yards to a mile, and at an average distance of from 20 to 30 miles from the shore, increasing at some points to 60 and even 70 miles.

[The roll of the billows against this formidable rampart offers a magnificent spectacle. The long ocean-swell, says Mr. Jukes, lifts itself in one great continuous ridge of deep blue water, which, curling over, falls on the edge of the reef in an unbroken cataract of dazzling white foam. Each line of breaker runs often one or two miles in

* Alfred Maury, "La Terre et L'Homme," p. 118.

length, with not a perceptible gap in its continuity. There is a simple grandeur and display of power and beauty in this scene that rises even to sublimity. The unbroken thunder of the surf, with its regular peal as each succeeding billow fell first on the outer edge of the great coral rampart, almost deafens the spectator; yet such is its depth of tone that it does not interfere with any nearer and sharper sound.

Both sight and sound are such as to impress the mind with an overwhelming consciousness of the Divine majesty and power.]

The walls constructed by the polypes are always precipitous, and the sea in their immediate neighbourhood frequently attains a remarkable depth. It occasionally happens that the first plateau is destroyed or lowered by the action of the billows; the corallines patiently recommence their labour on this new basis. The island of Tahiti reposes on a volcanic nucleus whose summit rises 6590 feet above the level of the sea.

Dr. Darwin has furnished a very interesting description of the *atolls* of the Sonda; from the great naturalist's narrative we borrow some details in reference to their formation.

It was formerly believed that the circular structure of the coral reefs was determined by that of ancient volcanic craters, on whose edge or rim the polypes raised their surprising structures. But this theory is not in harmony with the facts, and it seems in general difficult to believe in the existence of a volcanic upheaval of the soil as the foundation of madreporic foundations; for the polypes cannot live beyond a comparatively inconsiderable depth of water, and one knows not how to admit that the sea-bed has everywhere been raised to this uniform level. It is more probable, then, that the foundations of the coral islands are simply natural elevations of the ocean-bottom —mountains submerged at no great distance from the surface—of which the polypes take possession as colonizers, and build thereupon their fairy edifices.

It is a very singular circumstance that the coral reefs which edge or fringe the coasts are always separated from them by a broad channel, analogous to the lagoon of the *atoll*, and varying from one thousand to twenty thousand yards in width. One of these reefs encloses a dozen rocky islets. At the island of Borabora, the barrier is transformed into earth; but the white line of enormous breakers, sown here and there with numerous low and little islands, which the palm-tree enriches and adorns, separates the gloomy ocean from the placid surface of the inner channel, whose limpid waters bathe alluvial shores embellished with all the luxuriant bloom of a tropical vegetation. This gorgeous belt of verdure extends to the foot of the wild abrupt mountains of the interior.

Dr. Darwin, in 1858, explored with peculiar care Keeling Island, or Cocoa Island, which lies to the south of Sumatra. It is no more than a circular reef, crowned with a garland of very narrow islets, which leave open on the north a passage for vessels. In the central basin—a spacious and secure natural harbour—the water is calm and transparent, with a smooth white sandy bottom; it measures several miles across. Dr. Darwin accompanied Captain (afterwards Rear-Admiral) Fitzroy* to an island in the recess of this basin, to see, on the windward side, the dash of the breakers on the encircling reef. The cocoa-nut trees formed gay emerald festoons which stood out in strong relief against the azure vault of heaven; the level calcareous margin, besprinkled with scattered blocks, was washed by foamy billows.

In the sea water the chemist also discovers, though, it is true, in infinitesimal proportions, sundry metals, such as iron, copper, lead, and silver. The old copper arising from the sheathing of ships sometimes contains so much silver that it has been thought worthy of extraction. A curious calculation, based on the age of vessels, and on the route they have traversed during their voyages, shows that the waters of the ocean must hold in solution two million tons of silver.†

There is a question often propounded by the common people, to which they can obtain no satisfactory reply, and which, indeed, the most eminent physicists find

* [For fuller details the reader should consult the late lamented Admiral Fitzroy's narrative of the "Exploring Voyage of the *Beagle*;" Dr. Charles Darwin's "Journal of a Naturalist;" and Mr. Wallace's "Malay Archipelago."]

† [The grounds of this somewhat fanciful computation are set forth by Sir John Herschel, in his "Physical Geography," p. 22, *et seq.*]

it difficult to answer with any degree of certainty. Whence comes the salt dissolved in such great quantities in the water of ocean? In other words, what is the cause of the saltness of the sea?

We sometimes amuse ourselves, but very wrongly, by satisfying the eager questions of childhood with idle answers. Born near the shore of the Mediterranean, with its glorious mirror shining incessantly before my eyes, I put, in my young days, this question to my friends and attendants. Persons of reputed good sense found it entertaining—and thought it witty—to tell me that the sea was salt because ships were engaged to cast into it at regular intervals huge pyramids of salt, similar to those which lie heaped upon the border of our salterns. There is no irreverence in saying that the theories put forward by some scientific authorities to account for the ocean's saltness are worth no more than the absurd explanation which puzzled my childish brain. Some assert that the salt is spontaneously engendered in the bosom of the seas; others that it is furnished by tributary rivers. Let us dismiss these puerile hypotheses, and take a more scientific view of the difficulty.

In the early ages of our planet, before the aqueous vapours contained in the primeval atmosphere were condensed, and had begun to descend in boiling rains on the terrestrial surface, the earth's crust contained an infinite variety of heterogeneous mineral matters, some soluble in water and others insoluble. When for the first time the showers fell on our burning globe, they absorbed all the soluble substances; then they flowed together, and collected in vast basins or depressions of the soil. In this manner were created the seas of the primeval earth; they were simply accumulations of the pluvial waters in capacious reservoirs, which held in solution everything that the strata they had washed were able to yield up to them. Marine salt, the sulphates of soda, magnesia, potash, and lime, of silica in the condition of soluble silicate—in a word, all the soluble matters which our planet can furnish—formed the mineral contingent of these waters. If we now reflect that, from the geological ages down to our own day, no change has taken place in the general laws of nature; if we consider that the soluble substances contained in the waters of the primeval seas have remained therein because not endowed with volatility; and that the fresh water of the rivers constantly replaces the water which is evaporated from the bosom of ocean; we obtain an explanation of the sea's salinity. The theory is very simple, but, for ourselves, we have not formulated any part of it, and accordingly disclaim its responsibility. Chloride of sodium is not, in fact, the only substance in the ocean-waters. There are, besides, numerous mineral substances, and the saltness of the sea is not due to common salt alone, but to all the soluble salts of the globe. And in addition to these the metals are, as we have said, also found therein, though in very minute proportions. Such, indeed, must be the case if we consider the saline substances of the sea as the product of the general lixiviation of the globe which took place in the geological period.

If the pedagogue Jacotot could say: "All is in all," we may assert, after a more concrete fashion, that "everything which is soluble may be found in ocean."

CHAPTER II.

ON THE DEPTH OF THE SEA, AND THE CONFIGURATION OF ITS BED—ITS TEMPERATURE.

THE configuration of the ocean is not as yet well known to us; but it is reasonable to suppose that it does not essentially differ from that of the continents; that it is, in truth, a vast submerged continent; its basin presenting a succession of valleys, table-lands, and lofty mountains, whose summits form the islands.

If the ocean waters were gradually to retire, we should see, in the first place, the number of these islands greatly augmented, and their area continually enlarging; then isthmuses would arise to connect them with each other; by degrees new continents would make their appearance, whose depressions would retain a portion of the waters under the form of lakes. All the northern hemisphere, with its countless lakes, which are now deprived of the saline elements, gives us the impression, and presents the appearance, of a land abandoned by the waters, which have withdrawn towards the south. This hypothesis is confirmed by the enormous depth of the austral seas; it is in the southern hemisphere is accumulated the great mass of the world's waters.

The soundings hitherto made not being numerous enough to furnish an exact idea of the depth of the sea, the late M. Adhémar,—a physicist of well-merited renown,—attempted to arrive at it by way of induction; starting from the sufficiently plausible hypothesis that the broader a sheet of water the greater its depth. Assuming as unity (= 1) the length of the different parallels, Adhémar endeavoured to ascertain what might be the fraction of those circles which correspond to the liquid surface. His calculations gave the following results:—

N. Latitude.	Liquid Fraction.	S. Latitude.	Liquid Fraction.
60°	0.353	0°	0.771
50°	0.407	10°	0.786
40°	0.527	20°	0.777
30°	0.536	30°	0.791
20°	0.677	40°	0.951
10°	0.710	50°	0.972
0°	0.771	60°	1.000

The extreme terms, from 60° to 50°, are doubtful on account of the polar ice; but the table, as a whole, shows the regular expansion of the liquid surface from north to south. If, then, the depth of the waters increased with the increase of their area, it would be very perceptibly augmented towards the southern pole. There should exist, moreover, a *thalweg*, or line of greatest depression, in the basin of each of the three great gulfs formed by the Atlantic Ocean, the Pacific, and the Indian Sea, and these three lines, which M. Adhémar supposes situated at equal distances from the two shores of each ocean, would reunite at a point within the great ice-desert of the southern world.

Everything, then, leads us to believe that the depth of the sea is prodigious in the regions contiguous to the Antarctic Pole. Captain Sir James Ross paid out 4000 fathoms of sounding-line in 68° south latitude, without reaching the bottom. Captain Denham, of the *Herald*, struck the ground at 45,800 feet in the South Atlantic; but Lieutenant Parker, of the American frigate *Congress*, having sounded in the same locality, got rid of 50,000 feet of rope, without obtaining any indication of having reached the bottom.

These experiments have been made with the sounding-apparatus uniformly adopted in the American marine. Every vessel of the United States receives, on demand, a quantity of rope, 10,000 fathoms long, marked at every hundred fathoms. To these are attached leaden balls weighing 32 to 38 pounds, which are heaved overboard from a boat, the rope being left to unroll itself, and the pulley revolving with facility. Experiments conducted in this fashion had met with so many difficulties, that it became evident these must be conquered before any reliable deep-sea soundings could be taken. Spite of all the precautions adopted by Captains Denham and Parker, it was impossible for scientific men to accept their results, because it was known that the rope continued to uncoil, under the action of submarine currents, even after the bullet had reached the bottom.

At present the ordinary sounding-line is employed with some success, its indications being corrected by the law of the rapidities of descent. From 400 to 500 fathoms the line begins to descend on an average in 2 minutes 21 seconds; from 1000 to 1100, in 3 minutes 26 seconds; from 1800 to 1900 fathoms, 4 minutes 29 seconds. The ratio *decreases*, therefore, in a sufficiently regular manner so long as the rope is dragged downward by the lead. When it suddenly becomes *uniform*, we may conclude that the lead has struck the bottom, and that the line continues to run out through the effect of a current. We cannot rely on the shock of the bullet against the sea-bed, for at great depths this shock is not transmitted. The uniform movement of the sounding-line is, then, the only certain indication that the bottom

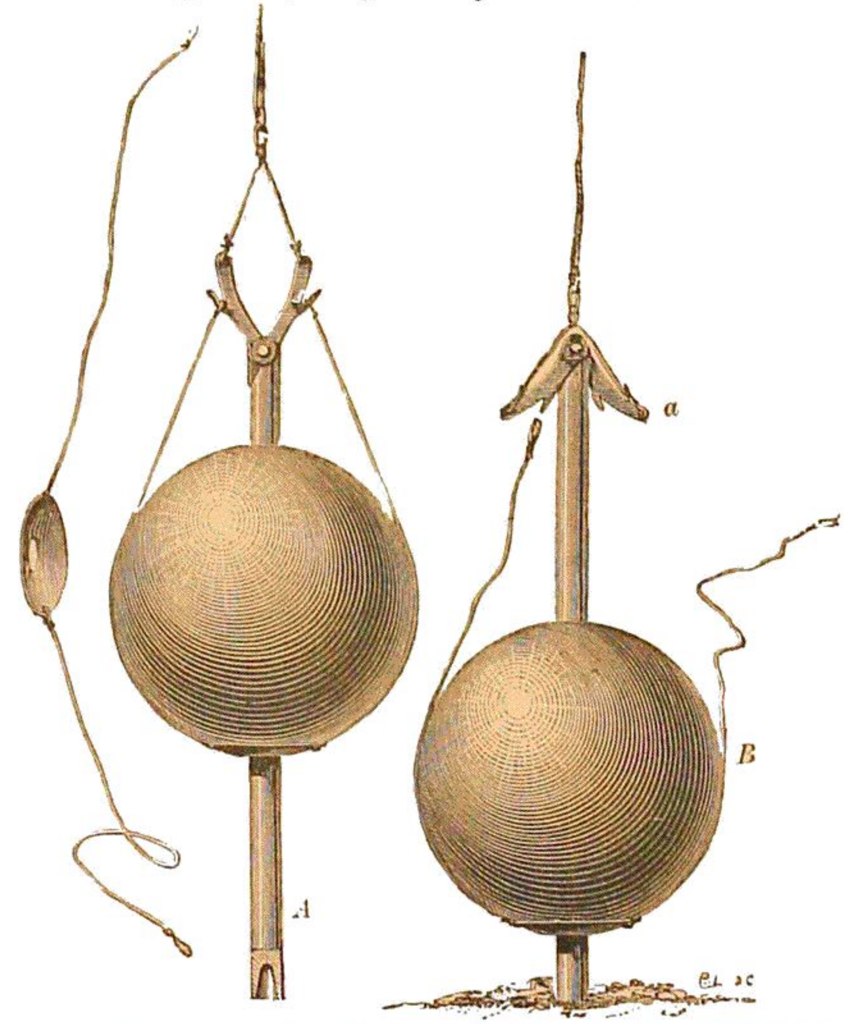

FIG. 211.—BROOKE'S SOUNDING-APPARATUS.—(*From Maury's "Physical Geography of the Sea."*)

has been reached; and, more, the ordinary sounding-apparatus cannot be recovered from any considerable depth.

But we now possess a far more perfect apparatus in the ingenious invention of Lieutenant Brooke, of the U.S. Navy, which enables us to bring to the surface specimens of the bottom of the sea. The sounding-line is attached to a heavy rod, whose extremity is hollow and covered with grease, so as to retain and bring away some fragments of the soil. The rod passes through a perforated cannon-ball, the hole being large enough to permit of the easy movement of the rod. As soon as the latter touches the bottom, the bullet disengages itself by a spring, and the sounding-line may be withdrawn with facility. We represent the apparatus in Fig. 211.

A represents the apparatus before it has touched the bottom ;

B the bullet falling through the shock of the apparatus against the ocean-bed, which causes the disengagement of the rope, owing to the change of position of the lever *a*.

Brooke's deep-sea sounding-apparatus has already furnished the investigator with some remarkable results ; and enabled Captain Maury, formerly the director of the Washington Observatory, to construct his beautiful orographical chart of the basin of the Atlantic, which, in accuracy, is probably not inferior to the best executed maps of Africa or Australia.

In the direction of its length, the basin of the Atlantic is, it seems, a kind of trench, or immense furrow, separating the Old World from the New. From the summit of Chimborazo to the bottom of this great valley the vertical distance is between 42,000 and 44,000 feet. The lowest point is probably to be found between the Bermudas and the Great Bank of Newfoundland, but its exact depth is still to be determined.

If the waters retired, says Maury, from this deep gulf, the skeleton of *terra firma* would be to a certain extent laid bare, and among the tossed and twisted sinuosities of the ocean-bed we should perhaps discover the remains of innumerable wrecks. Then would be revealed that terrible mixture of human bones, débris of all kinds, heavy anchors and precious pearls, whose fantastic image has perturbed so many dreams.

[The reader will remember Shakspeare's appalling picture of the weird scene :—*

"Methought I saw a thousand fearful wrecks ;
Ten thousand men that fishes gnawed upon ;
Wedges of gold, great anchors, heaps of pearl,
Inestimable stones, unvalued jewels,
All scattered in the bottom of the sea :
Some lay in dead men's skulls ; and, in those holes
Where eyes did once inhabit, there were crept,
As 'twere in scorn of eyes, reflecting gems,
That wooed the slimy bottom of the deep,
And mocked the dead bones that lay scattered by."]

The question is sometimes asked, Of what use are these deep-sea soundings ? We can only reply as Franklin did, in reference to the first aerostatic discoveries : Of what use is the infant when just born ? Every physical fact is interesting in itself ; it forms a link destined to unite sooner or later with other links, and conduct us to some useful truth. The importance of these soundings has already been justified by the indications they have furnished for the laying of submarine cables.

At the bottom of the Atlantic exists a remarkable plateau, or table-land, which extends from Cape Race, in Newfoundland, to Cape Clear, in Ireland, over a distance of 1800 miles and a breadth of 420 miles. Its depth, throughout its whole extent, is computed at 3200 to 4300 yards on an average. Upon this telegraphic table-land, as it has been called, rests the great Atlantic cable. Its surface has been frequently

* [Shakspeare, *Richard III.*, act i., scene 4.]

investigated by means of Brooke's sounding-apparatus; and thus it is proved that the bottom of the sea is there composed, in the main, of microscopic calcareous shells (*Foraminifera*) and of a small number of Diatoms. These frail and delicate shells which, in thick layers, strew the still ocean-bed, were brought up by the sounding-lead in a state of complete preservation; a proof that at a great depth the water is singularly tranquil.

The first exploration of the telegraphic plateau was undertaken, in 1853, by the American brig *Dolphin*, which made its soundings at every hundred miles up to the Scottish coast. Afterwards it directed its course towards the Azores, to the north of which the bottom (lime and yellow sand) was found at 6500 feet; to the south of Newfoundland the depth exceeded 16,350 feet. In 1856, Lieutenant Berryman, in the American steamboat *Arctic*, completed a series of soundings between St. John's, in Newfoundland, and Valentia, in Ireland; and, in 1857, Lieutenant Dayman, of the English steamer *Cyclops*, repeated the same operations.

[In the Gulf of Mexico the depth does not appear to reach 6300 feet. The Baltic Sea is one of the shallowest on the face of the earth; its maximum does not go beyond 1100 feet. Lieutenant Brooke's soundings in the Pacific give a depth of 2½ and even of 3 miles; in the Indian Ocean, of about 8 miles—a result, however, which Captain Maury considers erroneous. Nothing is known of the depth of the Antarctic Ocean, nor, accurately, of that of the North Polar Sea, except that it is assuredly very shallow. To the north of Siberia the line gives only 14 to 15 fathoms at 150 miles from the shore. As far as investigations have gone, the maximum depth of the North Atlantic would seem to be 25,000 feet.

The depth of the Mediterranean varies greatly. De Saussure obtained the bottom, off Nice, at 3000 feet. Between the Dalmatian coast and the mouth of the Po, it does not exceed 145 feet. Admiral Smyth has found from 975 to 2900 feet in the Straits of Gibraltar, and 5850 feet between Gibraltar and Ceuta, where the channel is only 14 miles wide. Between Rhodes and Alexandria the depth is 9750 feet; between Alexandria and Candia, 11,000 feet; and at 100 miles east of Malta, 15,000 feet. The Mediterranean, therefore, forms a kind of gigantic funnel.]

In the *Coral Sea* (lat. 13° S., long. 160° E.) Lieutenant Brooke obtained soundings of nearly 13,100 feet. Another sounding of 7040 fathoms (42,240 feet), in the Indian Ocean, was not successful in bringing up any specimens of the bottom. In the débris of the bed of the Coral Sea, conspicuous was the absence of calcareous shells, while the flinty *spiculæ* of the sponges were found in great numbers. Other soundings, made in the Pacific Ocean at depths varying from 16,300 to 19,600 feet, have been microscopically examined by M. Ehrenberg, who discovered in them one hundred and thirty-five different species, among which were twenty-two previously unknown to naturalists.* As a general rule, the composition of the infusoriæ of the Atlantic bed is chiefly calcareous; of the Pacific bed, principally siliceous. From the sea-water these animalcules extract the mineral matters—that is, the lime and silicic which form their shells; and when the organisms perish, their shells are deposited on the surface of the ocean-bed, where they accumulate in myriads upon myriads, covering the plains, and rising up in mountain-masses. It is thus, we may remark, that a great portion of our present continents was created in the geological period, consisting of horizontal strata formed of marine deposits—sedimentary earths, as they are called—among which an important place is occupied by the chalks and the calcareous beds of the Jurassic and Tertiary eras.

The *level of the seas* is, in general, everywhere uniform. It represents the spherical surface of our planet, and serves as a standard and basis for the computation of all terrestrial heights. However, the gulfs and mediterraneans opening eastward are exceptions to this rule; the accumulation of waters propelled into these receptacles by the general movement of the sea from east to west may determine a greater elevation of their level.

It was long supposed, on the faith of inaccurate measurements, that the level of the Red Sea was higher than that of the Mediterranean. It was also asserted that the level of the Pacific at Panama is 3¼ feet higher than the mean level of the Atlantic at Chagres, and that at the time of high water this difference rises to 13 feet, while at low water it is 6½ feet, and takes place inversely. The error has been satisfactorily demonstrated so far as concerns the levels of the Red Sea and the Mediterranean, and the approaching completion of the Suez Canal will furnish an incontestable proof. It is probable that a similar miscalculation has been made respecting the levels of the two great oceans.

The mean temperature of the ocean-surface differs but slightly from that of the atmosphere, so long as it remains unaffected by the disturbing influence of warm currents. In Tropical regions, it appears that the "liquid plain" is somewhat warmer than the ambient air.

[It has been ascertained, however, that below a certain limit of depth the temperature of the ocean remains constant at about 39° F. This depth varies under

* [Very interesting results may be expected from Dr. Carpenter's deep-sea soundings, which have, indeed, already made known some new forms of marine life.]

different latitudes, just as the line of perpetual snow varies upon the flanks of the mountains. Under the Equator it is $1\frac{3}{8}$ths of a mile: thence the limit gradually rises, approaching nearer and nearer to the surface as we ascend towards the Poles, until it reaches the surface in lat. 56° 25′ S. on the one hand, and in lat. 48° 20′ to 67° 30′ N., and descending again as the latitude increases to $\frac{5}{8}$ths of a mile in lat. 70°.

From the Equator to the isotherm of 39° the water *above* this line is warmer, and between 39° and the Pole is colder, than it is *below* the line; the temperature varying from the line to the surface.

The line of *maximum* surface-temperature, however, does not coincide with the Equator, owing to the influence exercised by disturbing currents; but occurs in lat. 10° N. in the Atlantic, lat. 12° N. in the Indian Ocean, and lat. 8° S. in the Pacific.]

We have already explained why the temperature of the ocean is much more uniform than that of the atmosphere.

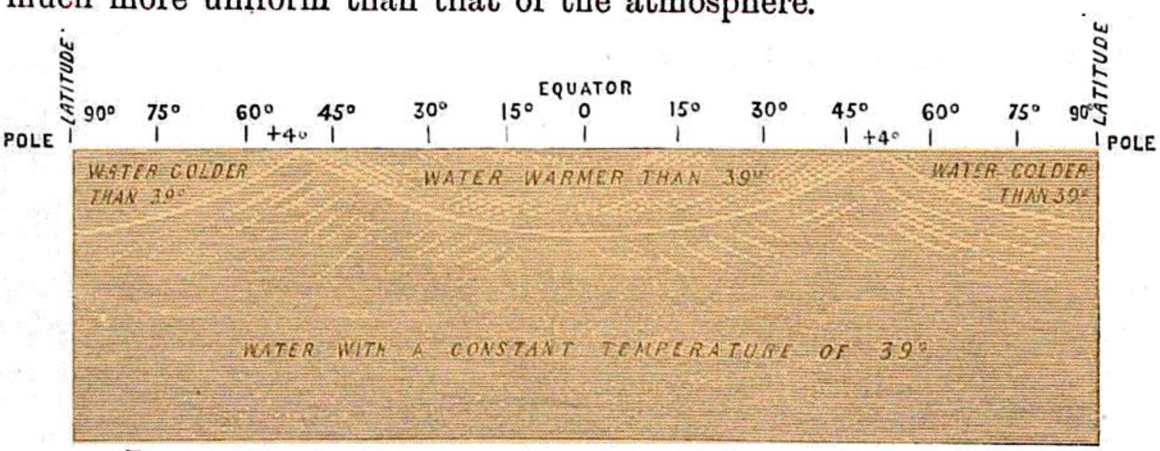

FIG. 212.—DIAGRAM, SHOWING AT WHAT DEPTH AN INVARIABLE TEMPERATURE OF 39° F. IS FOUND IN THE OCEAN.

A peculiarity worthy of being remembered is, that water is colder over shallows and reefs, and near the coast, than in the open sea; a fact of which advantage may be taken to render navigation more secure. Alexander von Humboldt explains this phenomenon by supposing that the deep waters re-ascend the slopes of the reefs and sand-banks, and mingle with the upper or superficial strata. Above these shallows thick mists are almost continually hovering, because the cold water which covers them determines a local precipitation of the atmospheric vapours. The outlines of the fogs are clearly marked; seen from a distance, they reproduce the exact form of the shallows and the accidents of the submarine soil. Nay, more; the clouds are often arrested at these points, and tower against the distant horizon like mountain-peaks.

CHAPTER III.

THE CURRENTS OF THE OCEAN.

THE oceanic currents depend on the combination of a great number of more or less active causes. Among these may be named,—the duration and force of the winds; the successive propagation of the tide around the globe; the density of the waters varying according to temperature; the depth, and degree of saltness; and, lastly, the variations of barometric pressure.

The currents which plough the sea present a striking contrast to the immobility of the contiguous waters; they are rivers of a fixed breadth, whose banks are formed by waters in a state of repose, and whose channel and course are often plainly visible, owing to the long tracks of weeds and other aquatic plants which they carry onward in their imposing march.

Clearly to understand the origin of these "ocean-rivers," it is indispensable, in the first place, to take into consideration the laws which regulate the atmospheric currents, and, in particular, those of the Trade Winds.

The difference of temperature between the equinoctial and the polar regions engenders two adverse or opposing currents—one, superficial, flowing from the Equator to the Poles; the other, beneath the former, flowing from the Poles to the Equator. On arriving at the Equator, the cold air of the Pole grows warm, and ascends into the upper strata of the atmosphere, whence it returns towards its original starting-point; there it again becomes cold, and, with the lower current, passes back towards the tropical regions. This process is incessantly taking place.

But the rotatory motion of the earth modifies the direction of these atmospheric currents. The swiftness with which the air is swept from west to east being almost null at the Poles, but very great at the Equator, it follows that the cold air, in proportion as it advances Tropic-wards, ought, at each step, to remain a little more in the rear at the west, or, which amounts to the same thing, ought to incline in that direction.

The cold Polar current, then, bends westward; and it is this circumstance which gives birth to the *North-east Trade Wind*, the prevailing wind of the northern hemisphere, and the *South-east Trade Wind*, the autocrat of the southern hemisphere. Even so the upper currents, which flow back to the Poles with equatorial speed, must more and more outstrip those atmospheric strata, endowed with an inferior swiftness of rotation, which they encounter in the polar regions, and, consequently, must incline eastward: thus arise the counter south-west and north-west Trade Winds, which reign *above* the north-east and south-east Trades, and frequently weigh them down to the surface of the sea in the latitudes of the temperate zones.

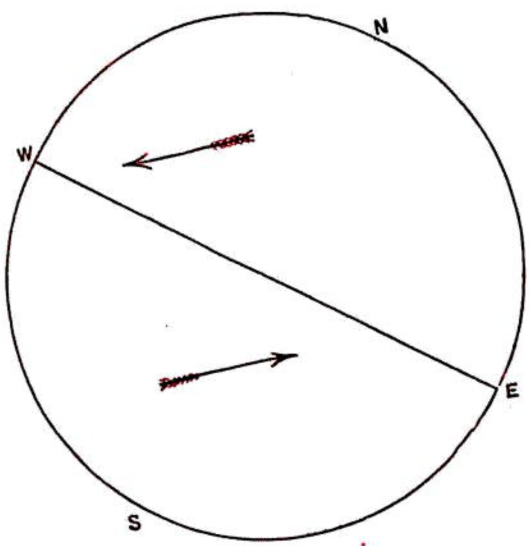

FIG. 213.—DIRECTION OF THE TRADE WINDS.

The two Trades are separated from one another by a belt of unequal width, where their collision with the surface of the ocean eventually neutralizes their westerly impulse; in general, the aerial current is there directed only from *below* to *above*. This belt, which does not coincide exactly with the Equator, is called the *Zone of Calms;* but the navigator frequently encounters therein those aerial tempests and rotatory winds which are known as *cyclones* or *tornadoes.*

The Trade Winds, whose westward movement is retarded by the frictional resistance of the ocean waves, communicates to the latter, by re-action, a tendency which impels *them* towards the west, or, more accurately speaking, towards the *south*-west in the northern hemisphere, and towards the *north*-west in the southern. The currents thus created on the surface of the water unite under the Equator to form the *great equinoctial current*, which moves from east to west. The motion, or rate of speed, is greater on the edges than in the middle of the current, because its creative force there displays an excess of energy; it results that the current easily bifurcates when it meets with any obstacle to its advance.

In the Atlantic, the bifurcation takes place a little to the south of the Equator; the southern branch descends along the Brazilian coast, and probably returns along the western coast of Africa.

The northern branch follows the coasts of Brazil and Guiana, enters the Caribbean Sea, and, reinforced by the current which comes up from the north-east, in the Bay of Honduras, traverses the Yucatan channel, and pours into the Gulf of Mexico; whence it debouches by the Florida channel, under the well-known name of the *Gulf Stream*.

It is thus eloquently described by Maury:—*

"There is a river in the ocean.

"In the severest droughts it never fails, and in the mightiest floods it never overflows. Its banks and its bottoms are of cold water, while its current is of warm. The Gulf of Mexico is its fountain, and its mouth is in the Arctic seas.

"It is the *Gulf Stream*.

"There is in the world no other such majestic flow of waters. Its current is more rapid than the Mississippi or the Amazon, and its volume more than a thousand times greater.

"Its waters as far out from the Gulf as the Carolina coasts, are of an indigo blue. They are so distinctly marked that their line of junction with the common sea water may be traced by the eye. Often one half of the vessel may be perceived floating in Gulf Stream water, while the other half is in common water of the sea; so sharp is the line, and such the want of affinity between those waters, and such, too, the reluctance, so to speak, on the part of those of the Gulf Stream to mingle with the common water of the sea."

The *Gulf Stream*, on its emergence from the Florida Channel, is about 14 leagues in breadth, 2200 feet in depth, and flows at the

* [Maury, "Physical Geography of the Sea," sec. 1, 2, 3.]

rate of nearly four and a half miles per hour. The temperature of its waters is about 86° F. From the American shores it directs itself to the north-east, towards Spitzbergen, its speed and its depth diminishing while it increases in width. Towards the 43rd parallel of north latitude, it divides into two branches, one of which strikes against the coasts of Ireland and Norway—whither it frequently conveys the vegetable seeds and grains it has borne from far Tropical regions—and warms the glacial waters of the Arctic Sea. The other inflects in the neighbourhood of the Azores towards the south, and makes for the African coast, whence it returns to the Caribbean Sea. In the midst of this vast circuit it collects the plants, and driftwood, and floating wreck, and the débris whirled hither and thither by a restless ocean. Thus originates the *Sargasso*, or *Weedy Sea*, that immense bank of marine plants (*Fucus natans*) which so powerfully affected the imagination of Columbus. These ever-verdant masses serve as an asylum for a multitude of molluscs and crustaceans. The waters occupy three years in traversing the oceanic current which embraces *the Weedy Sea*.

[The Gulf Stream led to the discovery of the New World by the quantities of bamboo tubes, fragments of carved wood, and trunks of trees which it flung upon the shores of the islands of Fayal, Flores, and Corvo, thus confirming Columbus in his idea that on the other side of the great ocean lay the Lands of Gold—the auriferous Indies. And during the perilous prolongation of his adventurous voyage, they cheered the sinking hearts of his followers with hopes of eventual success. The poet, therefore, represents them as inquiring of one another,—*

"Oh, whence, as wafted from Elysium, whence
These perfumes, strangers to the raptured sense?
These boughs of gold, and fruits of heavenly hue,
Tinging with vermeil light the billows blue?
And (thrice, thrice blessèd is the eye that spied,
The hand that snatched it in the sparkling tide)
Whose cunning carved this vegetable bowl,
Symbol of social rites, and intercourse of soul!"

In the economy of the Atlantic the Gulf Stream plays an important part. It carries the genial waters of the equinoctial regions into the high latitudes. Beyond the 40th parallel it possesses a temperature of 75° F. Propelled by the south-western winds which prevail in this zone, they mingle with the cold waves of the Northern Sea, and in its bleak regions mitigate the rigour of an unfriendly climate.

* Rogers, "Poetical Works:"—*Voyage of Columbus.*

South of the Great Bank of Newfoundland it encounters the cold currents that descend from the Arctic Pole by Baffin's Bay and the Greenland Sea; then a portion of these waters ascends towards the pole, skirting the western coast of Greenland. To the conflict of the polar and the equatorial waters is attributed the formation of the Newfoundland bank, both having incessantly deposited at this point the débris which they carry—mineral substances, and dead animal organisms—so that Newfoundland, to adopt the expressive phrase of Michelet, is nothing more than "a vast ossuary."]

The difference of temperature between the Gulf Stream and the waters which it traverses must inevitably produce the most terrible

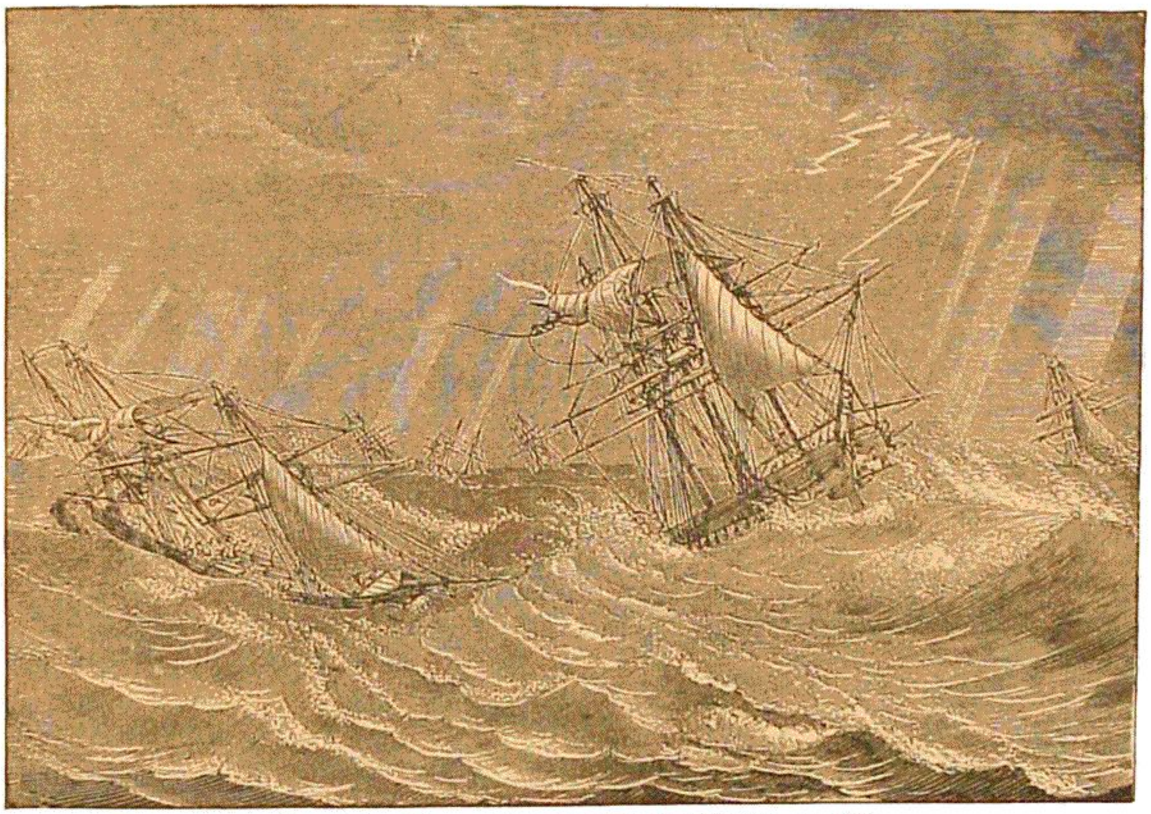

Fig. 214.—Hurricane in the West Indies, in 1780.

tempests and cyclonic storms. Modern discoveries, which have so clearly demonstrated the route of this grand warm river across the ocean's liquid plain, have enabled the mariner to shorten in a remarkable degree his westward voyages, and to avoid many of the dangers which formerly threatened and annihilated the labouring ships.

In 1780 a frightful hurricane devastated the West Indies, and caused the death of nearly 20,000 persons. Ocean forsook its bed, and inundated the towns; the bark of trees, mingled with human limbs, whirled round and round in the air. The fatally numerous catastrophes of this kind gave to the Gulf Stream the name of "King of the Tempest." But owing to the manifold nautical documents collected of late years at the Washington Observatory, by Mr. Redfield and Captain Maury, scientific men have learned how to define the direction and track of these formidable cyclones, so that their disastrous influence may to a certain extent be avoided.

We proceed to furnish an example of the usefulness of Maury's labours, which will speak more powerfully than pages of elaborate description.

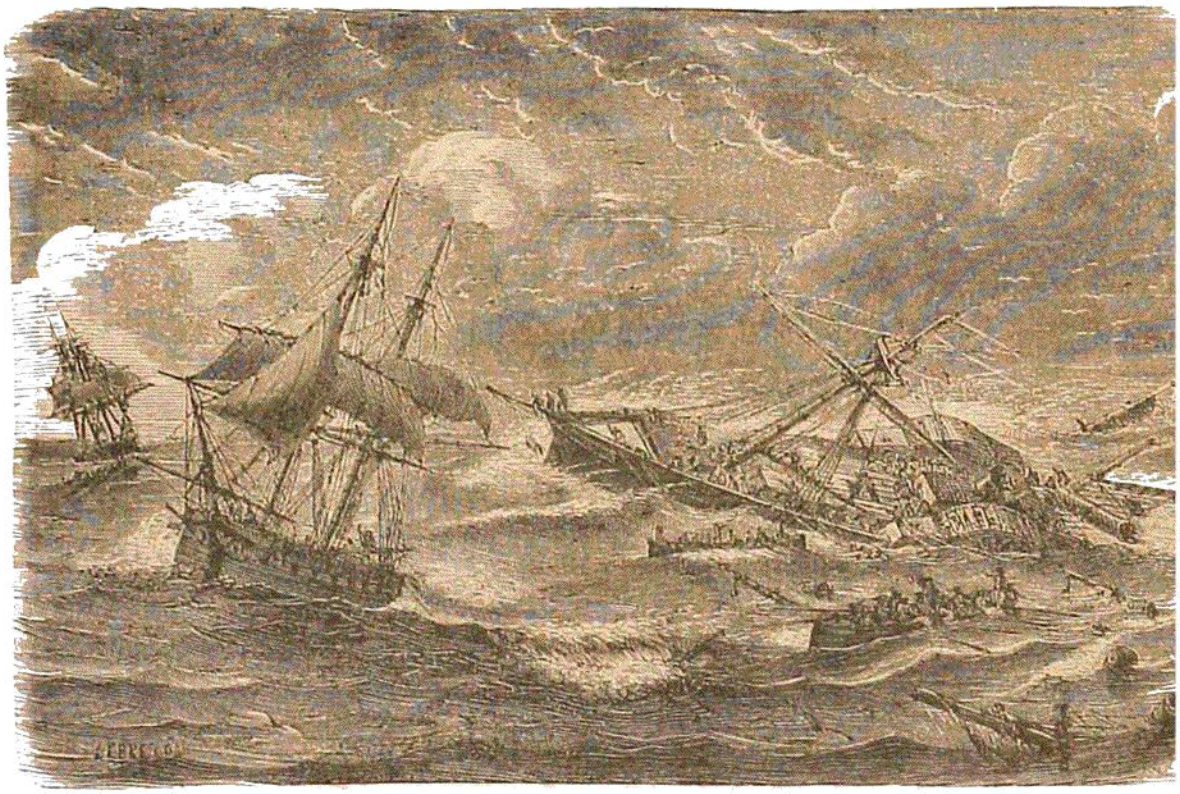

FIG. 215.—RESCUE OF THE "SAN FRANCISCO" BY THE "KILBY," IN 1853.

In the month of December 1853, the American packet-boat *San Francisco*, having on board a regiment of soldiers for California, was encountered, in the Gulf Stream, by a gale which speedily reduced her to a most lamentable condition. A single wave, sweeping the deck from stem to stern, carried away the masts, destroyed the machinery, and hurried into a premature death 199 officers and soldiers. The unhappy vessel lay upon the waters a miserable wreck, drifting in whatever direction the wind and the billows carried it. On the following day it was seen in this lamentable condition by a ship bound for New York; a few days later another vessel fell in with it; but neither could lend it any assistance, for they were occupied in endeavouring to ensure their own safety.

As soon as news of the calamity reached New York, two steam-tugs were ordered to the assistance of the *San Francisco*. But in what direction should they steer? What part of the sea should they explore? Application was then made to the conductors of the Washington Observatory for instructions what route to follow. The hope founded on the scientific lore of Captain Maury was not deceived. After examining all the data he possessed in reference to the direction and limits of the Gulf Stream at that time of the year, the celebrated hydrographer drew a chart of the region in which the dismasted steamer would probably be carried by the current, and defined the route to be followed by the two steam-tugs despatched to her assistance.

The crew of the *San Francisco* were saved by three ships, which had descried her in the open sea, before the New York steam-tugs arrived. But the point where they saw the steamer founder, shortly after the rescue of her crew, was precisely that which Captain Maury had laid down. Had but the tugs set out in time from New York, his triumph would have been complete. We may note, moreover, that the *Kilby*, which had caught sight of the drifting ship by day, and had lost it during the following night, succeeded in recovering it by a course of reasoning analogous to Captain Maury's, and was thus enabled, in conjunction with two other vessels, to save those on board.

We shall now continue our survey of the Ocean-Currents.

The equinoctial current of the Pacific traverses the great ocean throughout its entire extent, and then bifurcates off the Asiatic coast. Its feebler branch wheels to the north, where it encounters the polar current descending through Behring's Strait, and then returns along the coast of California. Its more considerable branch inflects towards the south, and sweeps around Australia. But here we meet with one or more counter-currents coming from the Indian Sea—the complicated and dangerous currents described by La Perouse and Cook.

The cold waters of the Antarctic pole are carried towards the equator by three great oceanic "rivers."

The first divides in lat. 45° S.; one arm doubles Cape Horn; the other (known as *Humboldt's Current*) ascends the coast of Chili as far as the equator; it tempers the climate both of Chili and Peru.

The second great current sweeps towards the Cape of Good Hope, where it separates into two arms, and embraces the east and west coasts of Africa.

And, third, the polar current of the Indian Ocean skirts the shore of Australia, turns, first, towards the west, then wheels to the south, in the direction of Madagascar; further to the south, it is driven back eastward by the polar current from Cape Horn. It is in this wise the warm waters of the Bay of Bengal, impelled by the Indian polar current, circulate between Africa and New Holland, whose southern coast, we may add, is washed by a lateral branch of this last-named current.

The *Monsoons* prevailing in the Indian Ocean serve to complicate still further the already intertangled and involved economy of the currents, by creating certain *periodical* currents, to which we must now direct the reader's attention.

In the preceding chapter, when dwelling upon the excessive salinity of the Mediterranean, we have spoken of a submarine current, whose function it is to convey the waters of the great inland sea into the "vexed Atlantic." Its existence may, to a certain extent, be proved by a calculation which shows that the quantity of salt water furnished by the *upper* current of the Strait of Gibraltar equals 170,000 cubic yards per annum—the quantity of fresh water contributed by the rivers, 16,000—and that which is lost by evaporation, 32,000; so that we should have an annual excess of 120,000, if the equilibrium were not re-established by a submarine outflow. This hypothesis is apparently confirmed by a very curious fact.

Towards the close of the seventeenth century, a Dutch brig, pursued and attacked between Tangier and Tarifa by the French corsair *Phœnix*, was sunk by a single broadside. But instead of settling down on the spot, the brig, owing to its cargo of oil and alcohol, floated in mid-water, drifted towards the west, and, after two or three days, eventually went ashore in the neighbourhood of Tangier, about twelve miles from the point where it had disappeared under the surface. It had, then, traversed this distance by the agency and under the influence of an *under* current, because the course taken was in direct opposition to that of the *upper* or surface-current.

This historical fact, in addition to some recent experiments, may be accepted as confirming the modern theory of a current flowing westward through the Strait of Gibraltar.

Captain Maury is also of *opinion** that a submarine counter-current prevails to the south of Cape Horn, and carries into the Pacific the superfluous waters of the Atlantic. In truth, the Atlantic is incessantly fed and nourished by copious rivers, while the Pacific, receiving no important tributary, must, on the contrary, undergo an enormous loss through the great evaporation which takes place on its surface.

Lieutenants Walsh and Lee, of the American Navy, have made some interesting experiments on the under-currents. They weighted a piece of wood so as to make it sink, but retained command of it with a fishing-line, to whose other extremity they attached an empty barrel, sufficiently large to support the apparatus; then they allowed the whole to go free. It was a truly extraordinary spectacle to see the barrel moving against wind and tide, at the rate of more than a knot an hour. The crew uttered exclamations of surprise on seeing it speed ahead as if dragged by some marine monster; many of the sailors even manifested a degree of alarm. The velocity of the barrel was evidently equal to the difference of velocity between the upper and under currents.

In 1773, the vessel of one Captain Deslandes was lying at anchor in the Gulf of Guinea; a strong current pouring into the bay prevented it from going more to the south. Deslandes then remarked that there existed an under counter-current, at a depth of fifteen fathoms, and took advantage of it in a very ingenious manner. A machine, offering a considerable extent of surface, was lowered to the depth of the counter-current, by which it was drawn forward with so much impetuosity as to tow the ship at the rate of a mile and a half per hour.

In the Caribbean Sea, a vessel may sometimes moor herself, by the same means, in the very centre of a current.

In the Sound, a double upper and under current was long ago proved to exist.

* [The subject of ocean-currents is fully investigated by Captain Maury in his admirable work on "The Physical Geography of the Sea."]

CHAPTER IV.

THE TIDES.

THE *tides* are periodical movements of the sea provoked by the attractive action of the moon and the sun—an action which is exercised over the entire mass of the earth, and manifested by the swelling motion of the waters. The force of the moon is about threefold that of the sun, because "Dian's bright sphere" is infinitely nearer the earth than the "radiant orb of day."

In discussing the theory of the tides, we shall first consider the *lunar tides*, ignoring, for the present, the solar influence.

The attraction which the moon exercises on any point of the earth is in the inverse ratio of the square of her distance. If we draw a right line from the moon passing through the centre of our globe, that line will strike the surface of the waters at two diametrically opposite points, Z and N; one of these points will have the moon at the *zenith*, the other at the *nadir*. The points of the sea which have the moon at the zenith—that is to say, those which the moon illuminates perpendicularly—will be nearer that planet, and, consequently, more strongly attracted than the centre of the globe; and the points diametrically opposite, those which have the moon at the nadir, will be more distant and less strongly attracted than the centre of the globe. Consequently, the waters situated directly under the moon will rise towards that sphere, and form a bulging—so to speak—or a swelling on the surface of the ocean; the waters situated at the antipodes being less strongly attracted towards the moon than the centre of the globe, will remain in arrear, and thus form a second promontory on the surface of the sea. Hence results a *double high tide*, under the moon, and on the opposite side of our earth. Throughout all the intermediate extent, where the waters are not subjected to the direct attraction of the moon, there will be *low tide*. (See Figure 216.)

The earth, in its rotatory movement, presents to the moon, in the space of twenty-four hours, all its meridians, which, consequently, find themselves each in due succession, and at an interval of six hours, now under the moon, and now at an inclination of 90° from that star. It results that in the space of a lunar day—that is, in the time which elapses between two consecutive passages of the moon over the same meridian—the waters of ocean will twice rise and twice sink over all the terrestrial globe. But the effect of the attrac-

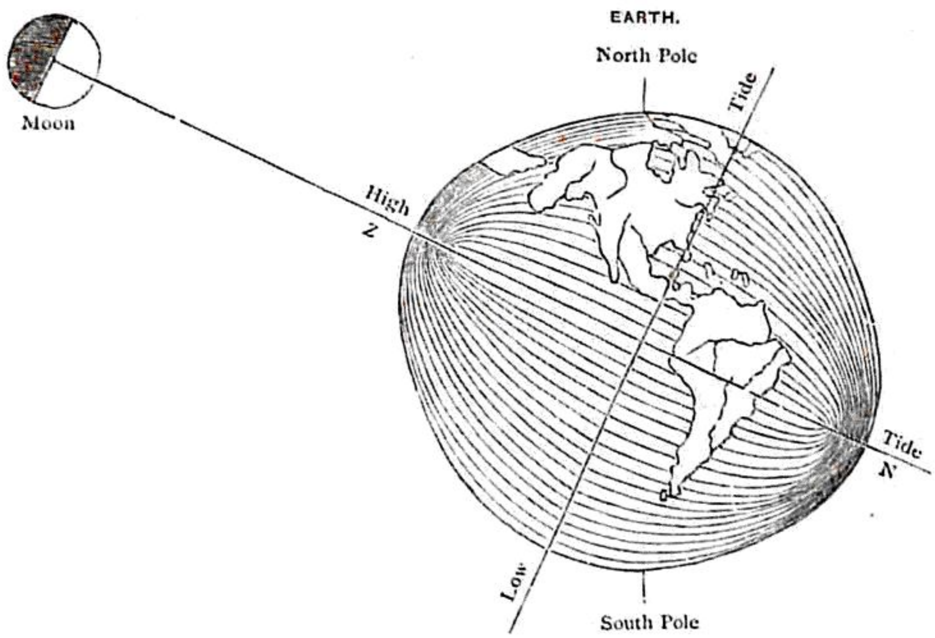

Fig. 216.—Lunar Tide.

tion is not instantaneously exercised, and the moon departs from the meridian before the elevation of the waters is complete; this is the reason the *flow*, or *flux*, does not attain its maximum until three hours after the culmination of the moon. The summit of the watery mountain upheaved by the flood follows the moon all round the globe, from east to west.

It is obvious, however, that the great inequalities of the ocean-bed, the presence of the continents, and the more or less rapid incline of their coasts beneath the waters—the different span of the channels and straits—finally, the winds, the ocean-currents, and a host of other local circumstances, will profoundly modify the regularity of the great tidal march.

Moreover, the moon is not the only celestial body which acts upon the waters of the sea. We have already said that the sun has a share in this phenomenon, although it is only 38-hundredths of that of our lunar satellite, on account of its vast and almost inconceivable distance from our earth. The inequality existing between the solar and lunar days (the latter are fifty-four minutes longer than the former) results from the joint or alternately contradictory action of the two others. When the sun and moon are in *conjunction*, or

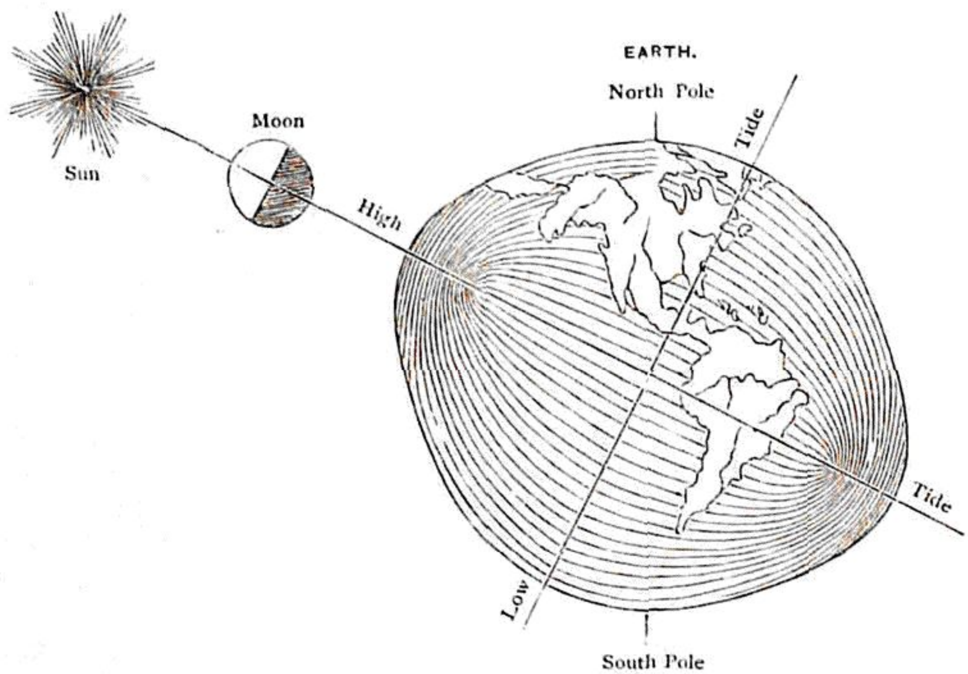

FIG. 217.—LUNI-SOLAR TIDE.

in opposition—that is, situated on the same straight line—their attraction upon the sea combines, and produces a very strong tide; this occurs at the epochs of the *syzigies* (the new and full moon). At the epochs of the *quadratures* (the first and last quarter) the solar action tends to produce a low tide wherever the moon wishes to raise the waters, and reciprocally: the result, accordingly, is a lunar tide perceptibly weakened.

All these effects are not instantaneously obtained, but the impulsion given continues to act, and is not fully spent for one or two days afterwards. The highest tide is as to the lowest in the proportion of 138 to 62, or of 7 to 3. The highest tides occur at the equinoxes, when the moon is in *perigee;* the lowest at the solstices, when she is in *apogee*. And the higher the sea rises when she is full, the lower it sinks when she becomes low. In our sea-ports the sea accordingly advances, or flows inland, twice daily; it is then said to be high water, and the phenomenon is called the *flood* or *flux:* it recoils twice, and subsides to low water; this is the *ebb* or *reflux*.

The tide is later by the clock about fifty minutes every day, because the lunar day is on the average twenty-four hours fifty minutes long. If, for example, it is high water at 2 o'clock this morning, to-morrow the tide will be up at 2.50. The low intermediary sea does not hold the mid-place between these two high waters. It is known that the tide rises much more quickly than it falls. At Havre and at Boulogne it occupies more than two hours and eight minutes in subsiding; at Brest, the difference is only sixteen minutes.

The retardation of high water on the passage of the moon to the meridian (at the epochs of the equinoxes) is always the same for any one locality, and ought to be determined by direct observation. This is called "the establishment" or "settlement" of the port; and is a fixed standard by which we may calculate the hour of high water for every day in the year.

The height of the tides varies in different regions of the globe, according to local circumstances. The eastern coasts of Asia and the western of Europe are exposed to extremely high and furious tides, while in the islands of the South Sea, where they are very regular, they do not rise more than 20 inches. On the west coast of South America the tides rarely attain 10 feet; on the west coast of Hindustan, they rise 18 to 22 feet; and in the Gulf of Cambaye upwards of 32 feet. This great difference is also felt in countries situated close to one another. Thus: a tide which, at Cherbourg, attains 19 to 22 feet, mounts, in the harbour of St. Malo, to 42½ feet. [According to Professor Airy, the rise at the entrance of the Bristol Channel, when spring-tides occur, is about 18 feet; at Swansea it is 30 feet; and at Chepstow, 50 feet. It may be taken, as a general rule, that the tide rises much higher *up* a gulf or tidal river than at its mouth; the *reason why* is obvious.*]

The highest known tide is said to take place in the Bay of Fundy, which opens to the south of the isthmus connecting Nova Scotia and New Brunswick; here the

* [See Professor Airy, "On Tides and Waves," *Encyclop. Metropol.*]

tide rises 120 feet, though in Green Bay, on the north side of the same isthmus, it attains only 7 feet. A story is told of a ship which, during the night, was deposited by the rising tide of the Bay of Fundy on a rock of some considerable elevation; judge you, O reader, of the dismay of her crew when they found themselves at daybreak suspended high in air, like an aerial vessel!

In those island seas which communicate with the ocean through a narrow channel only, tidal phenomena are scarcely perceptible, and for this reason. The moon's influence simultaneously extends over all the parts of these seas, and their waters are not copious enough to gather in a convexity or protuberance through the attraction of

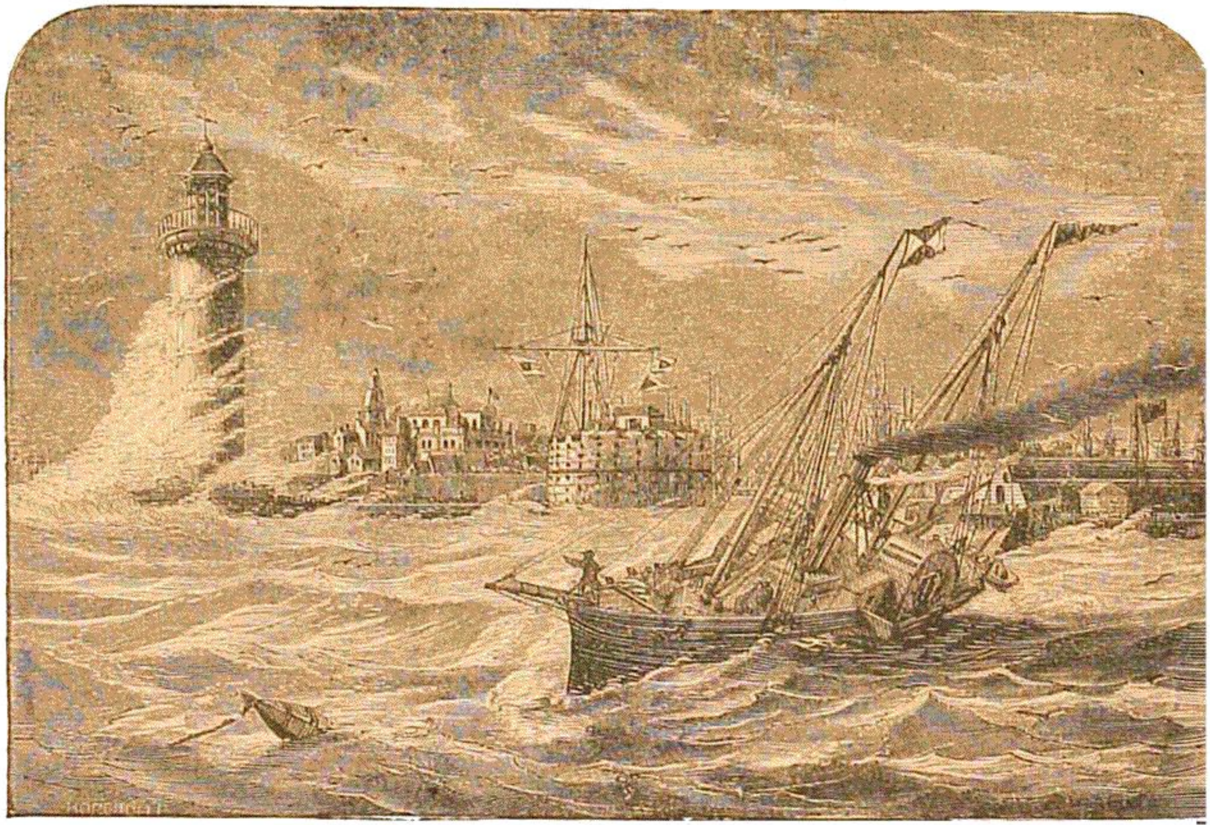

FIG. 218.—GREAT EQUINOCTIAL TIDE AT HAVRE, ON THE WEST COAST OF FRANCE.

our satellite. The intumescence, therefore, is quite inconsiderable. Hence there are no tides observable in the White and Black Seas, and they are very insignificant in the Mediterranean. At Alexandria they do not rise above twenty inches; at Venice, however, they sometimes attain six to seven feet. We have already recorded that a feeble lunar tide has been noticed in Lake Michigan; and have spoken at some length of the tidal march at the embouchures of the rivers, where it produces the well-known phenomena of the *mascaret* and *bore*.

The late Dr. Whewell laid down on some ably-constructed charts the onward movement of the great tidal wave through the seas of the globe. It is there shown that the colossal billow traverses the Atlantic from the 50th parallel of north latitude to the 50th parallel of south latitude in twelve hours, and at the rate of upwards of 56 miles an hour. The rate of advance, however, is less in the shallower parts of ocean; as, for example, in the vicinity of St. Helena. In the North Sea its velocity does not exceed 20 miles.

The tidal wave, after wheeling round the northern coast of Scotland, and

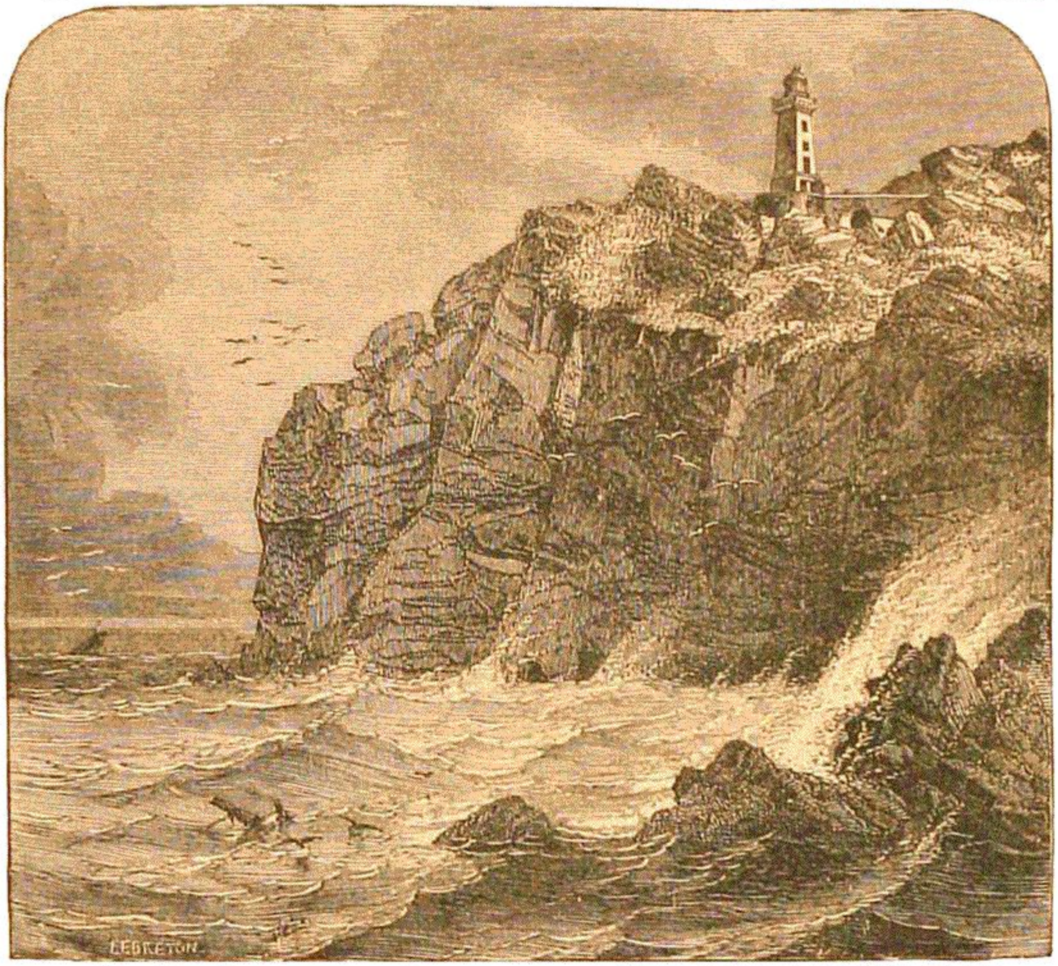

FIG. 219.—EFFECT OF THE BREAKERS ON THE PROMONTORY OF THE RAZ, ON THE COAST OF FINISTERRE.

occupying 3 hours and 38 minutes in flowing from Lerwick harbour to Dundee, traverses the German Ocean, washes the English coast, and between England and Ireland, in St. George's Channel, encounters the wave of the following tide; the collision of these two adverse currents produces some remarkable and complicated phenomena; there is even a point where the tidal movement is completely annihilated.

Upon the height of the tides a marked influence is exercised by the winds. When they add to the impulse given by the attracting star, they considerably augment the normal elevation of high water; if they blow in a contrary direction, they will entirely neutralize the flow. This occurs in the Gulf of Vera Cruz, where, at times, a tide occurs only once in three days, if the wind rises to a gale. An analogous phenomenon occurs on the coast of Tasmania.

The rising tide sometimes strikes upon the shore in a continuous manner, and with an incredible force. This violent shock is called the *ressac.* The surf then forms in the sea a mass of impetuous billows, stretching over an area of one thousand yards. The *ressac* increases as it advances towards the coast; when it attains the height of 20 to 22 feet, it may be likened to a mountain of water rolling over and over on its own axis. But this movement is not, in reality, a progressive one; it does not carry forward any floating bodies. The *ressac* is very potent at the island of Fogo (one of the Cape Verde group), and in India and Sumatra. To our English mariners it is known by the name of *surf.* It renders the approach to many coasts a very dangerous, and even impossible enterprise.

Sudden gales add to its terrors, creating huge waves or billows on the surface of the sea, which continually enlarge, and gradually swell into foam-crested mountains, rolling, bounding, and breaking one against another.

At one moment, says Malte-Brun, the waves seem to bear onward the goddesses of the sea, who come to amuse themselves with dance and pastime; at the next, a tempest bursts upon them, and maddens them with its fury; they seem to swell with wrath—you might almost believe they were ocean-monsters engaged in deadly battle. A strong, constant, and uniform wind, produces in the sea a succession of *waves*, or long wrinkles of water, which rise as it were on the same level, march with a regular movement, and hasten, one after the other, to precipitate themselves upon the shore. Sometimes the billows, suspended by a gust of wind, or arrested by a current, form, as it were, a liquid wall. Woe to the rash navigator who shall dare to approach it!

The highest waves known are those which prevail, at the epoch of the great tides, off the Cape of Good Hope, under the influence of a strong north-westerly breeze, which, traversing the broad sweep of the South Atlantic, drives the waters towards the African coast. These waves attain the height of 40 feet. A mountain like this, towering upwards between two vessels, hides each from the other's sight. In our accompanying illustration we represent the effect of the raging billows off the Cape, discovered by Bartolomeo Diaz.

Off Cape Horn, in South America, the waves are 32 feet high; in our European seas they rarely exceed 10, or, on extraordinary occasions, 18 feet.

A wave created by the influence of a violent wind exercises a pressure of 3,000,000 yards on the square yard. When the British Channel is vexed by a storm, the waves frequently tower above the very lantern of the Eddystone Lighthouse, which is 85 feet in

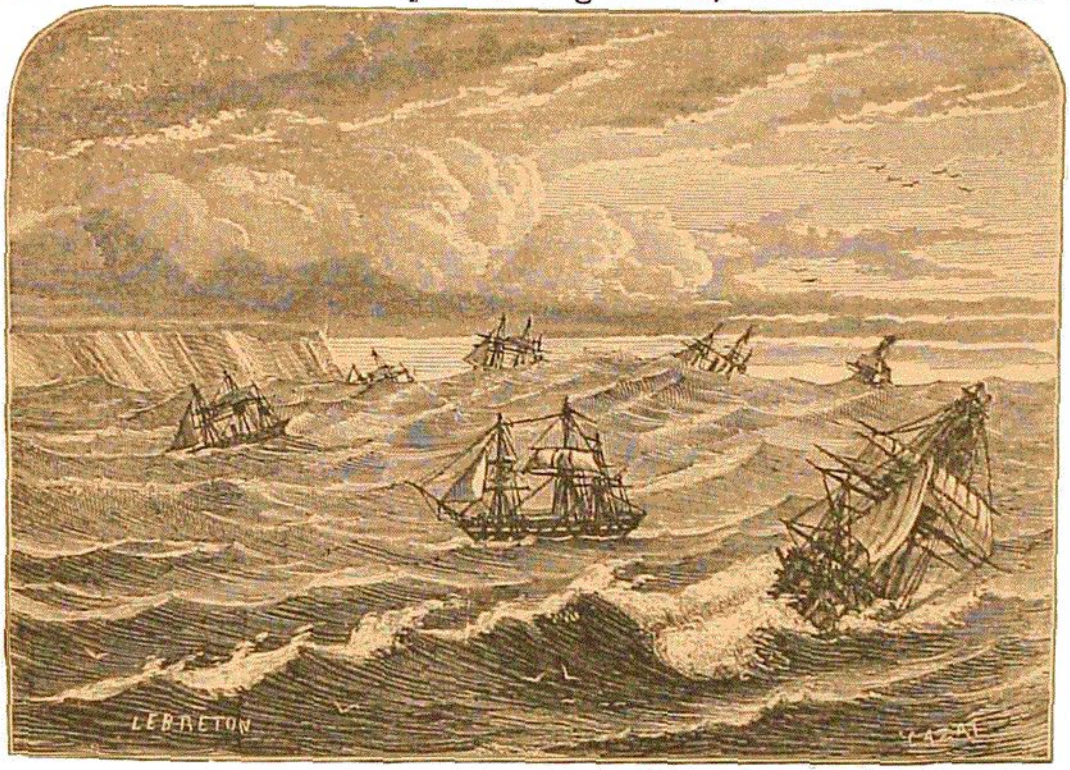

FIG. 229.—HEIGHT OF A WAVE AT THE CAPE OF GOOD HOPE.

height, and fall upon its roof in a cataract of foam and spray. After the hurricane which desolated Barbadoes in 1780, a couple of ancient guns were found upon the beach, having been transported thither from the ocean-bed by the rolling and surging waters.

If the ebbing waves encounter any obstacle in their receding movement, they form into eddies and whirlpools—the terror of the seaman. As an example we may name the whirlpool in the Strait of Messina, which rages over the rocks of Charybdis and Scylla; those rocks so celebrated in the traditions of antiquity, and rendered famous by the poetical exaggerations of Homer, Ovid, and Virgil. [The latter poet thus describes the scene :—*

* [Virgil, Æneid, bk. 3, transl. by Professor Conington, p. 95.]

"We hear the sea's stupendous roar,
And broken voices on the shore;
The waters from the deep upboil,
And surf and sand the depth turmoil.
'Charybdis!' cries my sire, 'behold
The rocks that Helĕnus foretold!
Haste, haste, my friends, together ply
Your oars, and from destruction fly.'
So said, so done: each heeds and hears:
First Palinure to southward steers,
And southward, southward all the rest
With sail and oar their flight addressed.
Now to the sky mounts up the ship,
Now to the very shades we dip.
Thrice in the depth we feel the shock
Of billows thundering on the rock;
Thrice see the spray upheaved in mist,
And dewy stars by foam-drops kissed.
At last, bereft of wind and sun,
Upon the Cyclops' shore we run."

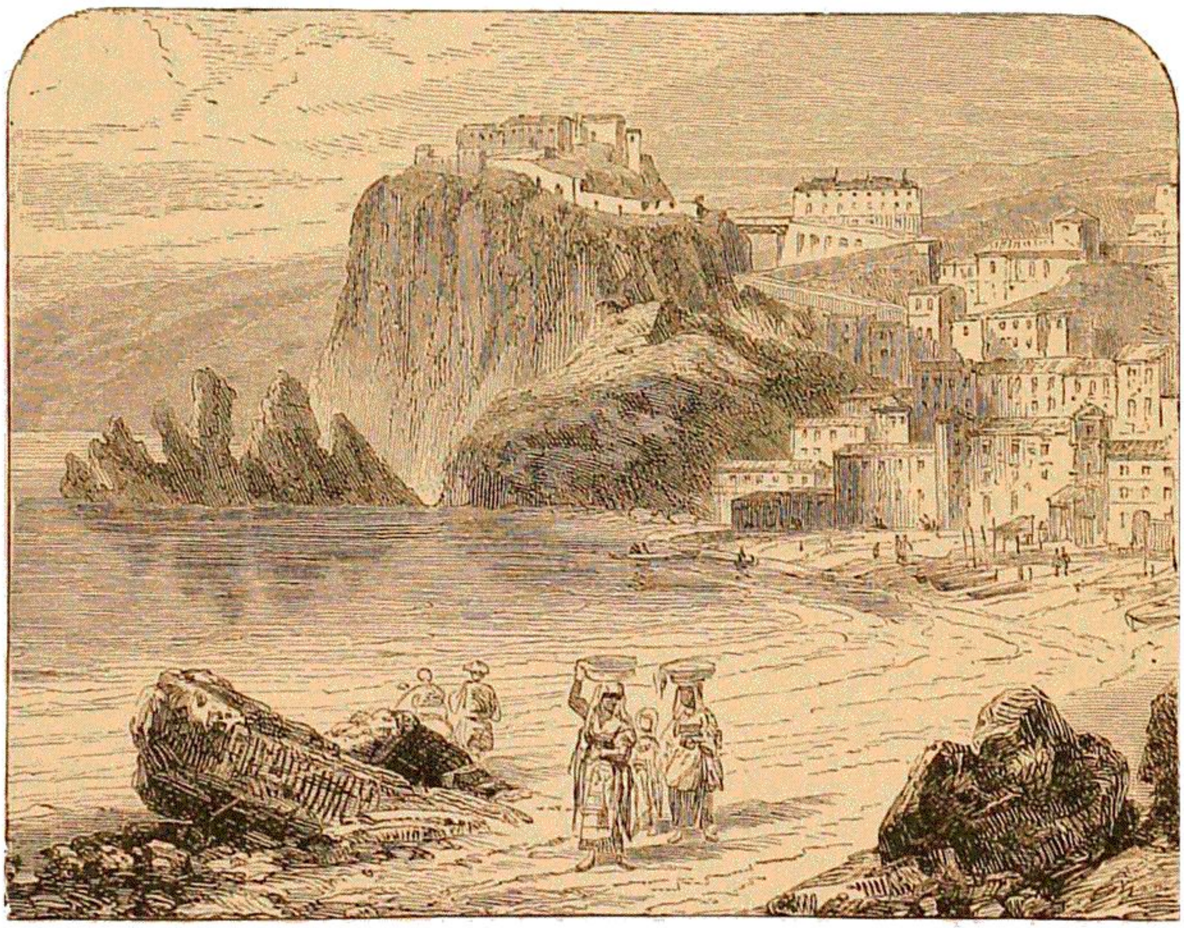

FIG. 221.—VIEW OF SCYLLA, IN THE STRAIT OF MESSINA.

A modern poet, Dante, also makes reference to it:—

"Come fa l'onda là sovra Cariddie,
Che si frange con quella in ciu s'intoppa,
Cosè convien che qui la gente riddi."*

* [Dante, "Inferno." vii. 22.]

Charybdis is situated outside the harbour of Messina, about two miles from the Rock of Scylla; it is now known as the *Galofaro.* It has long ceased to be formidable; and we must either conclude that its dangers were greatly over-coloured by the ancients, or that the navigation has been rendered safer by some change in the set of the currents; a change not improbable or impossible in a region so subject to the action of earthquakes. According to ancient geographers, it lay immediately opposite the Rock of Scylla; whence the old adage—

"Incidit in Scyllam, cupiens vitare Charybdim."
Seeking to avoid Charybdis, he falls upon Scylla.

FIG. 222.—TIDE-RACE OFF BOURBON ISLAND IN 1846.

Numerous eddies and whirlpools, though none of a dangerous character, exist in the Straits of Messina.]

Another celebrated European whirlpool is situated near the island of Eubœa. The *tornadoes* which occur in the seas of China and Japan, and which are frequently of such violence as to engulf the largest ships, belong to the same category. They have also been observed in the Gulf of Bothnia.

The Norwegian coast is indented by numerous salt-water creeks, or little gulfs, called *fjords*, and it also bristles with rocks, against which the northern billows dash with a constant swirl and fury. Here is the celebrated whirlpool of the Malström; its waters have a gyratory movement, which changes its direction every six hours. [At one time this whirlpool was described as swallowing in its vortex the largest ships and whales; the truth seems to be, that in ordinary weather it may be traversed without danger. When a violent wind is blowing, however, a vessel swept into the current would undoubtedly founder, or be dashed against the rocks.

The depth of the Malström, or Mosköestrom, is about twenty fathoms. It is situated between Mosköe and Moskenöes, two of the Loffoden islands; is greatest at high or low water; and when the wind blows *against* its current, agitates the sea for miles around. In the neighbourhood are some less considerable vortices, as the Napström and Galström.]

The terrible phenomenon of the *Tide-Race*, so much and so justly dreaded by navigators, originates in the combined effect of the tides and the whirlpools. In the calmest weather, and without a breath of air, you will sometimes see propagated upon the coast a series of deep and whirling waves, which seem, as it were, to *up-root* the ships, for they seize them by the keel, wheel them round upon their axis, and completely capsize them. We give a representation, in the accompanying cut, of a tide-race which wrecked, in 1846, the ships lying at anchor off the island of Bourbon.

[During heavy gales on the coast of Madras, the surf breaks in nine fathoms water at the distance of four, and even four and a half miles from the shore. At such times it is impossible for the stoutest boat to live in it, and the largest vessels are compelled to cut their cables and run out to sea. So awful is, at times, the violence of the gale, as actually to dominate over the upheaval of the billows, and scatter the levelled surface in a heavy shower of spray, called by sailors "spoon-drift." Its saline particles frequently impregnate the air to the distance of 50 miles inland. Even in fair weather the surf rises to a height of three feet at a distance of one hundred yards from the shore, and the natives pilot the voyager through it in boats called *catamarans*, which are specially constructed for the purpose.]

CHAPTER V.

THE POLAR SEAS.

THE Pillars of Hercules of the modern world are the Parry Mountains, situated within eight degrees of the North Pole, and the Ross Mountains, within twelve degrees of the South. Beyond these limits our maps and charts are blank; a *terra incognita* marks the area of each extremity of the terrestrial axis. Will man ever succeed in crossing these icy boundaries? Will he justify the prediction of the Latin poet, Seneca?—*

"Venient annis
Sæcula seris quibus Oceanus
Vincula rerum laxit, et ingens
Pateat tellus, Tethysque novos
Detegat orbes, nec sit terris
Ultima Thule."

Imitated:—

[The day will come, though yet 'tis far remote,
When Ocean shall its fixèd thrall unloose,
When all the wide Earth's space shall be revealed,
And Tethys to man's wondering gaze lay bare
Orbs long unknown, nor frozen Thule be
The Earth's extremest limit.]

To these questions we can offer no reply. Each step that man has made in the direction of the Poles has cost him dear; and it is not without reason that navigators have bestowed on the southern point of inhospitable Greenland the melancholy name of *Cape Farewell.*

The number of expeditions, for the most part English, which have explored the Frozen Seas, is estimated at one hundred and thirty. About twenty of these had for their special object the discovery of the fate of Sir John Franklin, in which they were finally successful.

* Seneca, Tragedy of "Medea," Act ii., line 376.

We now proceed to trace very rapidly and concisely a picture of the principal geographical data collected, at different epochs, in the bleak and barren regions of the two poles.

The first navigator who penetrated into Arctic America was Sebastian Cabot, who, in 1498, endeavoured to search out a North-West Passage from Europe to China and the Indies. Considering the epoch at which it was made, and the imperfect condition of the science of navigation, it was an enterprise of almost sublime audacity. A Scandinavian tradition attributes the same grand feat to a son of King Rodian, who flourished in the seventh century, to the Norwegian Osher (in 873), and to the Princes Harold and Magnus (in 1150).

Sebastian Cabot succeeded in reaching Hudson's Bay, but was then compelled by the insubordination of his crew to retrace his adventurous steps.

In 1500, Gaspard de Cortereal discovered Labrador; in 1553, Sir Hugh Willoughby Nova Zembla, and Chancellor the White Sea. The able and persevering Davis visited, in 1585, the western coast of Greenland; and, two years later, sailed up the strait which bears his name. Barentz discovered, in 1596, the frozen shores of Spitzbergen, which were surveyed in 1607 by Henry Hudson, as far north as the 82nd parallel. Three years afterwards, Hudson gave his name to the great bay or sea of Labrador, but here his progress was checked. His crew having revolted, he, his son, and eight sailors who remained faithful to him, were abandoned in a small boat without stores or provisions. Thus perished one of the greatest of the early navigators.

Jan Mayen's Island was discovered in 1611; the strait which Baffin mistook for a bay, and which still bears his name, was discovered in 1616. In his first voyage, in 1727, Behring caught sight of the strait which separates Asiatic Siberia from America; he traversed it in 1741, but his ship was wrecked, and he himself died of scurvy on its inhospitable coast.

Discovered in 1771, by a fur-trader, named Hearne, the Polar Sea was explored, some years later, by Mackenzie.

FIG. 223.—ICE-FIELD OF THE ARCTIC POLE.

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Since 1810, when Sir John Ross, Sir John Franklin, and Sir John Parry resumed the exploration of a North-West Passage, Arctic expeditions have succeeded one another with great rapidity. In 1827, Parry sailed as far north as 82°. Sir John Franklin, who set out in 1841, with the ships *Erebus* and *Terror*, perished miserably with his crew, after having solved the long-vexed problem, and found the open channel which Captain Sir Roderick MacClure discovered, in his turn, in 1850, but in an opposite direction. In 1855, Doctor Kane's expedition sighted the navigable waters of the Arctic Pole.

For the Antarctic Pole we give a similar resumé of its geographical history.

In 1772, Kerguelen, a Dutch captain, discovered a large and icebound island, which he supposed to be a portion of the great Southern continent. In 1774, Captain Cook explored these regions up to the 71st parallel of south latitude. In 1831, Bristow discovered Enderby's Land; in 1838, the French navigator, Dumont d'Urville, *la Terre Adélie* (or Adelia Land). Finally, in 1841, Sir James Clark Ross, a nephew of the Arctic explorer, Sir John Ross, penetrated with the *Erebus* and the *Terror* to the 78th parallel of south latitude. There he saw two lofty and ever-burning volcanoes, which he named after his two ships, and surveyed a new extent of frozen coast, which he called *Victoria Land.*

We shall return hereafter to these various voyages; but it is first needful that we should cast a glance at the general phenomena of the frozen seas, both in the north and the south.

General View of the Polar Seas.—It may be asserted that the Polar regions form a transition between the sea and the continents, for water is always found there in a solid state: for its surface, during the greater part of the year, being always at a very low temperature, the snow which falls does not melt, and the sea is consequently covered either with a continuous expanse of ice, or with enormous floating icebergs, drifting along at the mercy of the currents.

It is the risk of coming into collision with these colossal masses that makes the principal danger of the Polar Seas.

Captain (afterwards Dr.) Scoresby has given a very minute description of the different kinds of ice the navigator encounters in these parts. An extent of congealed water, whose limits cannot be recognized by the eye, is termed an *ice-field* (in French, *banquise*, or *champ de glace*). Ice-fields have been seen measuring thirty-five

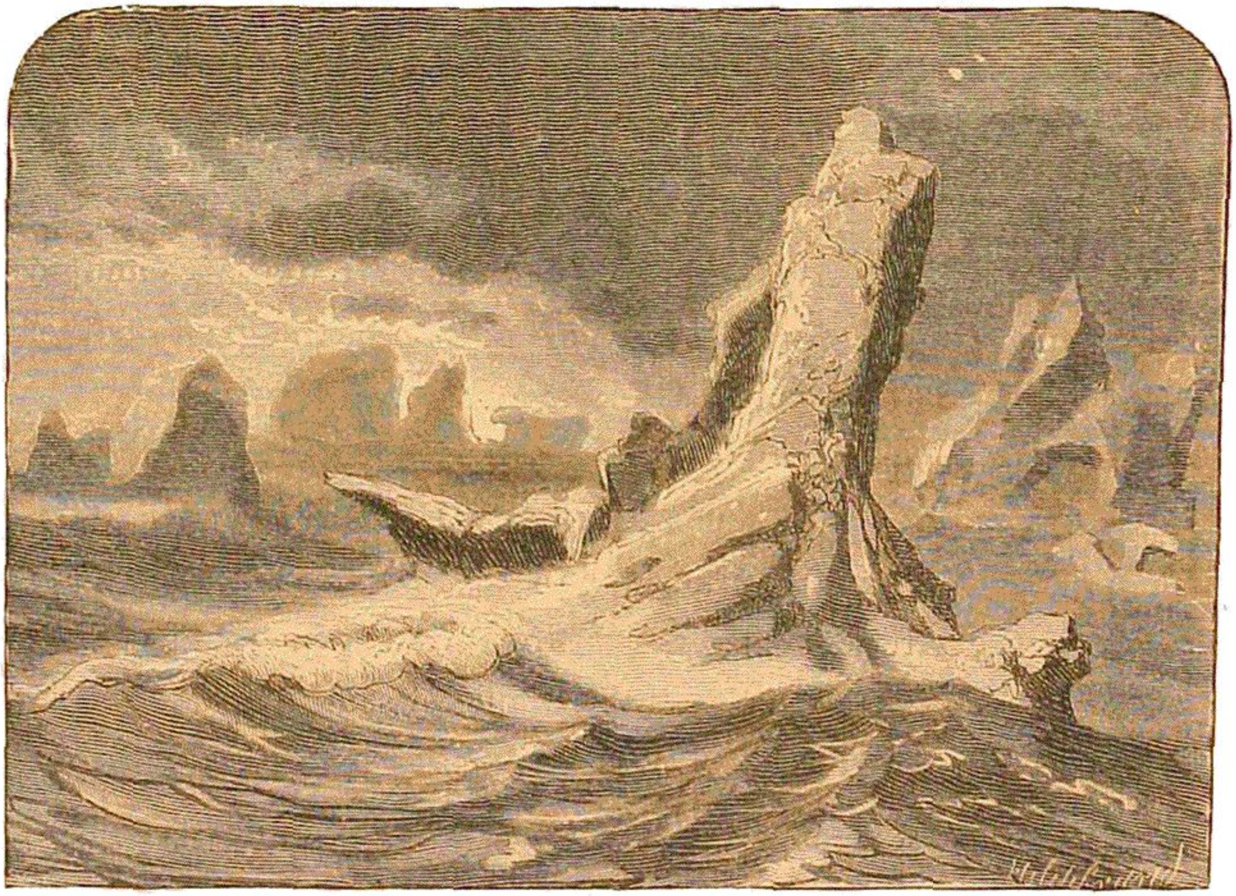

FIG. 224.—FLOATING ICE.

leagues in length by ten in breadth, and with a thickness of forty-five feet. But, generally, they do not rise more than three to seven feet above the surface of the water, and sink about twenty feet beneath.

Scoresby describes the formation of the ice-field in the open sea. When the first crystals appear, the surface of the ocean resembles that of water sufficiently cold to prevent the thaw of the snow falling upon it. As the freezing process continues, the sea suddenly grows calm, as if covered with oil. The small blocks of ice, as they form, dash against one another, round off their angles and inequalities, and eventually fuse together into a vast icy plain, whose thickness afterwards increases by its lower surface.

The water proceeding from melted ice is fresh. This is the natural consequence of a well-known physical phenomenon. When a saline solution, like that of sea water, is congealed by the cold, the pure water alone passes into a state of solidity; the more concentrated saline solution remains liquid. Water fit both for drinking and

FIG. 225.—A FIELD OF ICE.

domestic purposes may, therefore, be obtained by melting a block of Arctic ice, which has been well cleansed in fresh water.

Salt blocks of ice, however, are found in the ice-fields, and may be distinguished from the fresh-water ice by their opacity and by a peculiar dazzling whiteness. Fresh-water ice is transparent, and denser than salt-water ice. The saltness of the latter is wholly due to the sea water retained in its interstices. The so-called fresh-water ice is easily recognized by its limpidity and beautiful emerald tint. Dr. Scoresby sometimes amused himself by fashioning matches of ice, with which he ignited gunpowder, or his sailors' tobacco-pipes, greatly to the astonishment of his crew, who were not familiar with physical laws.

The ice-fields which form in the highest latitudes are driven southward by the winds and currents; but sooner or later the action of the waves shatters and breaks them up. The edges of the fractured blocks often rise up and are soldered anew; hence results that curious mass of protuberances or asperities which our sailors call *hummocks*, and which give to the icy seas of the north so irregular and fantastic an appearance. Hummocks are formed when the wrecks of the shattered ice-field approach each other's edges so closely as to re-cement their union, and are frequently 300 feet in length.

When the masses of ice leave between them an open space wide enough to admit of a vessel's passage, the ice is said to be "open." But frequently we also meet with mountains of ice only partially

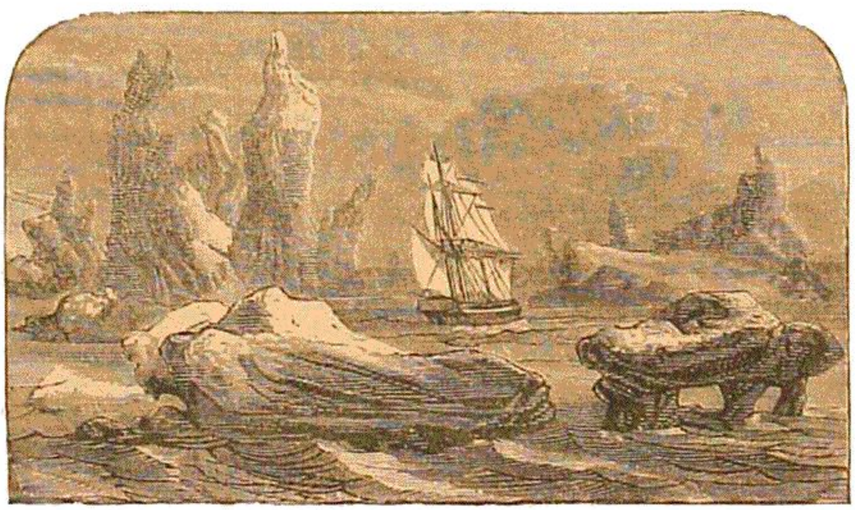

FIG. 226.—ESCAPING FROM AN ICE-FIELD.

submerged, one side of which is held down under the principal mass, while the other towers above the water. Scoresby once sailed above a *calf* (as our English seamen designate these icy eminences); but trembled at the thought that it might recover its erect position, and hurl his vessel into the air.

The aspect of the *ice-fields* varies in a thousand manners. Here it is an incoherent chaos, resembling a volcanic region, torn with crevasses in every direction, and bristling with shapeless blocks, scattered hither and thither, as if they were a giant's playthings; there it becomes a broken and irregular plain, an immense mosaic of ice-tables of all ages and dimensions, whose divisions are marked by long rugged ridges of the most fantastic form, resembling sometimes walls of rectangular blocks piled up in courses, and sometimes chains of rounded hills.

In spring, when the thaw occurs and the break-up commences, the pieces of light ice which solder together the large blocks and form them into a single mass are the first to melt; then the ice-masses split and separate, and the moving waters scatter them rapidly abroad, so that the vessels suddenly find a free passage opened up to them. However, a day of repose sometimes suffices to bring together these

FIG. 227.—SHIP CAUGHT AMONG THE ICE-FIELDS OF THE ARCTIC SEA.

floating fragments, which oscillate and dash against each other with sinister groans and strange noises, compared by the seamen to the yelping of young dogs.

When a ship finds herself imprisoned in the midst of a field of floating ice inexplicable changes are occasionally observed in these vast incoherent aggregations. A ship which seemed to be held immovably is found in a few hours to have made a complete revolution on its own axis. Two vessels, imprisoned at a short distance from each other, separated for several leagues without their crews being able to discover any alteration in the ice surrounding them. On other occasions the ships are dragged along with the floating ice, like so many white bears, which make long sea-voyages on these monstrous vehicles. In 1777, the Dutch whaler *Wilhelmina* was carried, with nine of her comrades, from the 80th to the 62nd degree of latitude, in sight of the coast of Iceland. During this terrible traject, the ships were dashed against one another; more than 200 persons perished, the remainder succeeded in gaining the land.

Lieutenant de Haven, sailing in search of Sir John Franklin, was caught in the ice in the middle of Wellington Sound. During his nine months' captivity, he drifted some 125 miles towards the south. The ship *Resolute*, which Captain Kellet was compelled to abandon in an ice-field of immense extent, was carried southward, with this enormous drifting mass, as far as De Haven.

The ice-fields and floating icebergs do not originate exclusively in the congelation of the sea water; a portion descends from the glaciers that line the shore.

On the borders of the circumpolar seas rise huge masses of ice,

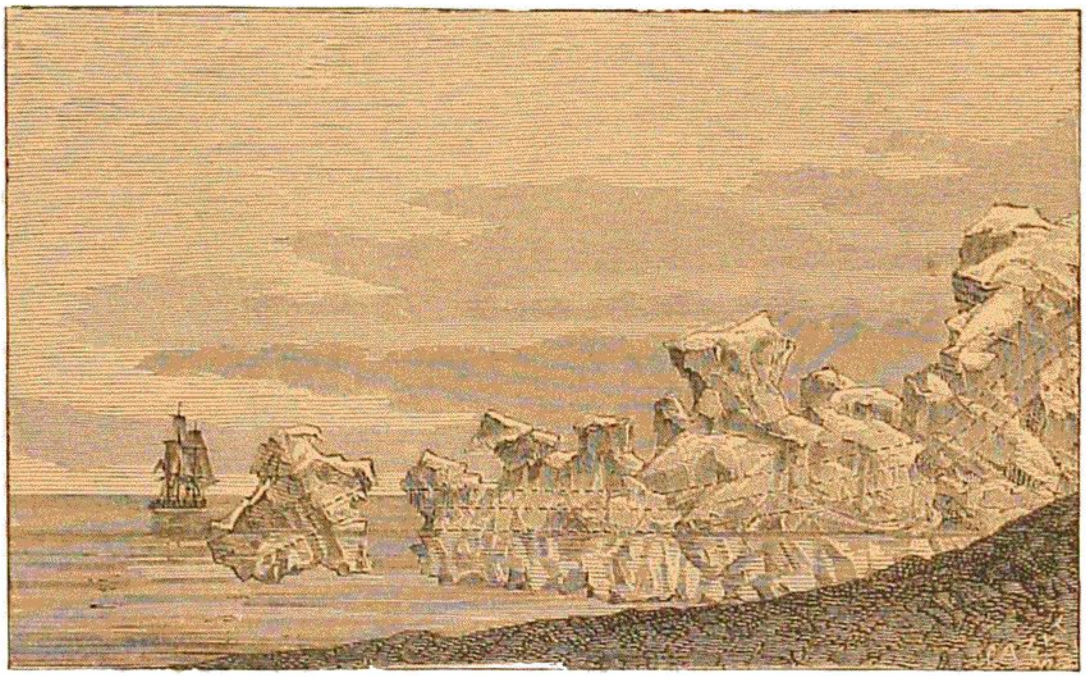

FIG. 228. — ORIGIN OF ICEBERGS, SHOWING HOW THEY ARISE FROM THE PROGRESSION OF THE POLAR GLACIERS.

and protect the coast with a glittering, impenetrable wall. When it accumulates to a certain elevation, it is broken up into glaciers, which, in their mode of formation, are analogous to those of temperate lands. In the accompanying illustration we represent one of the polar glaciers which has been most frequently surveyed — English Bay, Spitzbergen.

The polar glaciers, like those of temperate countries, are gifted with a slow progressive movement. The ice composing them gradually descends until it arrives at the base of the glacier; that is, on the edge of the sea. The action of the waves detaches them in time from the principal mass: they fall into the sea, sometimes with a formidable detonation. These icy Anakim encumber the shores, or are carried out to sea by the currents: in the latter case they constitute either ice-fields or icebergs.

Dr. Scoresby maintains that the icebergs which obstruct the navigation of Baffin's Bay do but partially originate in the congelation of the sea; that the majority are formed on the shore, in regions protected from winds and currents by the accumulation of the snows

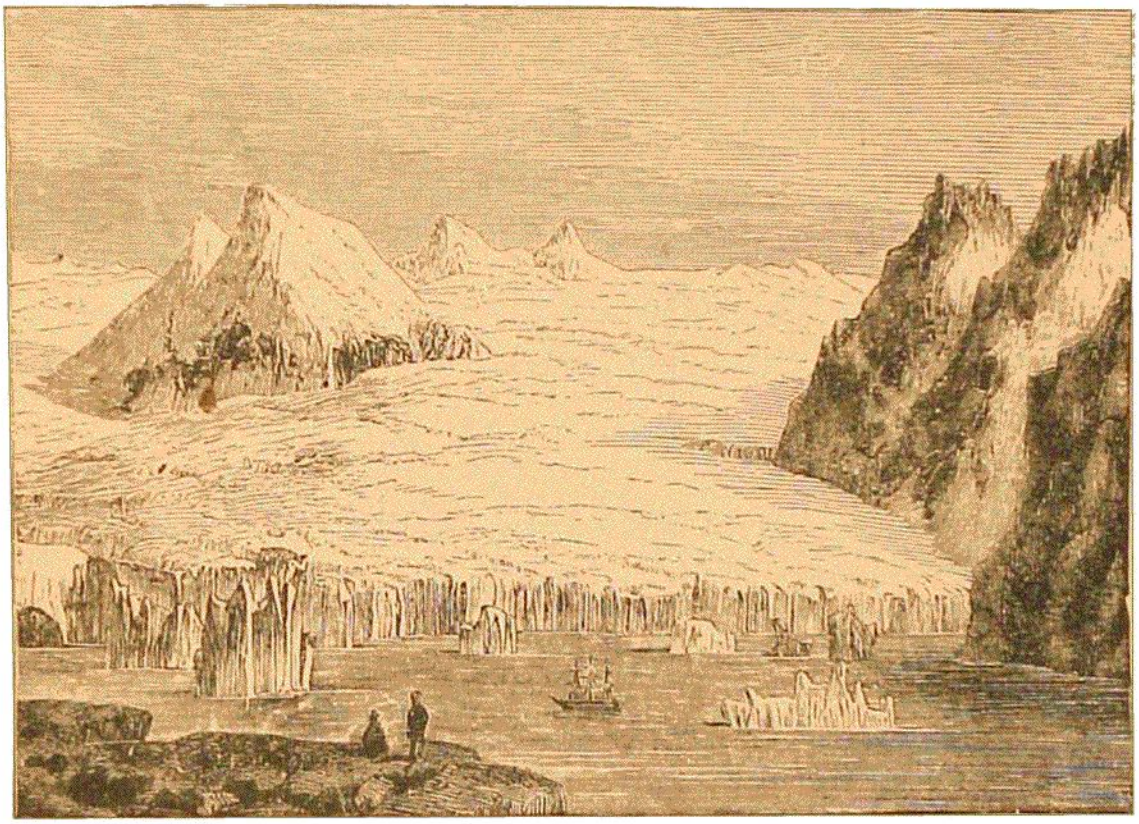

FIG. 229.—ENGLISH BAY, SPITZBERGEN.

of many years, alternately thawed and re-frozen. Of late years this observation has been more universally applied; and it has even been asserted that all icebergs are offshoots of the glaciers which bristle along the polar coast. There is a certain amount of exaggeration in this idea; and it is more scientific to admit that the floating ice of the Arctic seas originates both in the break-up of the great glaciers and the congelation of the dreary waters.

In the vicinity of Spitzbergen icebergs are few, and not of any considerable dimensions; but in Davis's Straits some have been seen measuring 3200 yards in length by 500 yards in breadth, their frosty summits towering more than 160 feet above the surface of the water; whence it follows that *beneath* the surface they are submerged upwards of 650 feet, for the proportion between the exposed and the submerged parts is as 1 to 4.

These giants of ice, incessantly corroded and gnawed by the waves that wash them, offer the most varied and fantastic outlines. Sometimes the spectator thinks he sees a floating island, indented

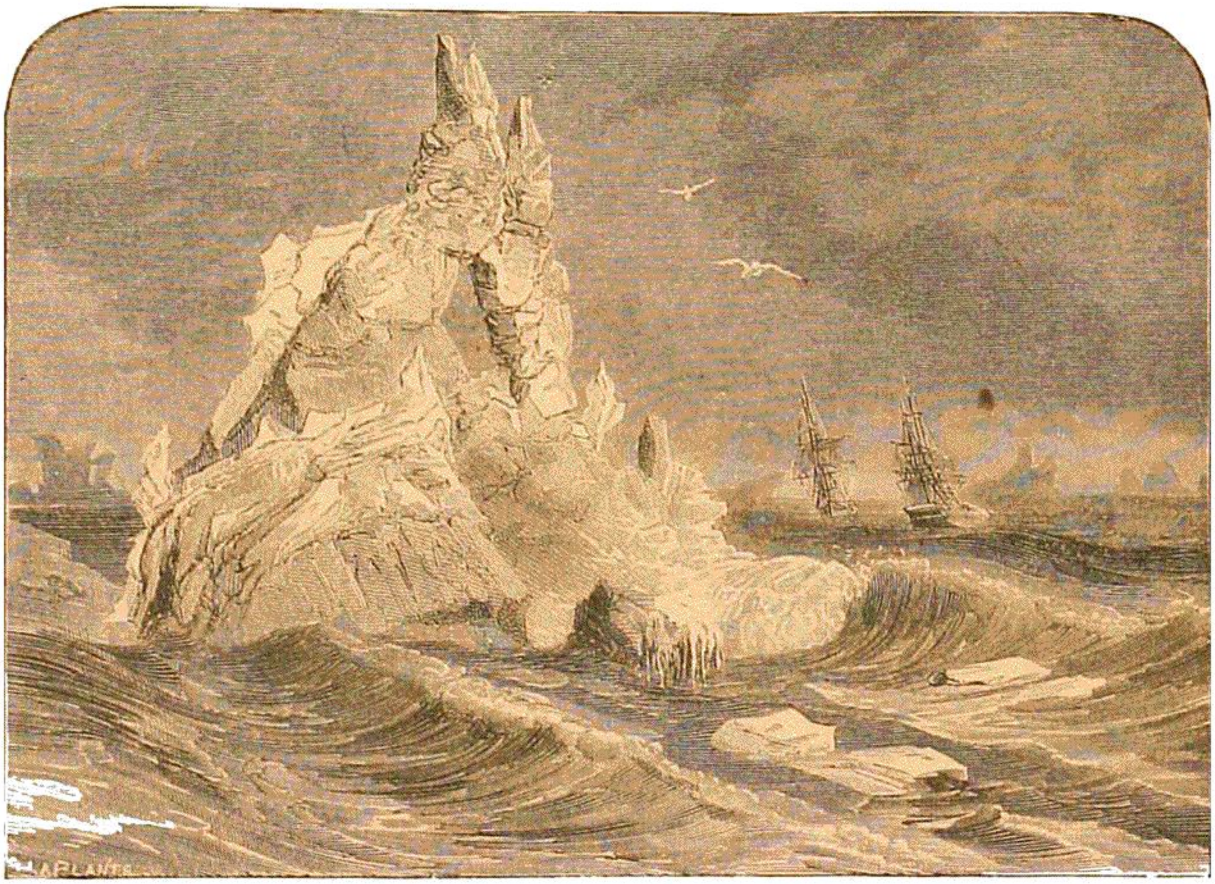

FIG. 230. — AN ICE-MOUNTAIN.

with bays and beset with promontories; sometimes a precipitous and inaccessible rampart, surmounted by crenelated towers, which overhang the abyss, and threaten to crush any unwary intruder; and sometimes tapering and graceful pyramids or spires, bright rounded cones, or smooth, circular plateaux.

We represent in the subjoined illustration a floating mountain. It was tunnelled by a long and lofty gallery, like a crystal arcade, which the sailors amused themselves by traversing.

It is easy to determine the age of these giants from the degree of erosion and degradation they have undergone. Detached, or split asunder after awhile, they resemble immense tabular plateaux, whose sides still inclose the débris of the *erratic blocks* torn from the littoral glacier; but occasionally they are greatly inclined, and present a more or less gentle slope, which can be easily ascended to the very summit. In time the restless waters work out profound cavities at the base, and horizontal channellings, which mark the successive lines of flotation of the decomposing masses. Then, as the degradation continues to increase, columns spring up, and natural bridges, and bristling shafts; stalactites and stalagmites, and yawning apertures, which pierce the huge colossus from side to side, especially when they are clothed in the purple light of the setting sun. More and more worn away by the combined

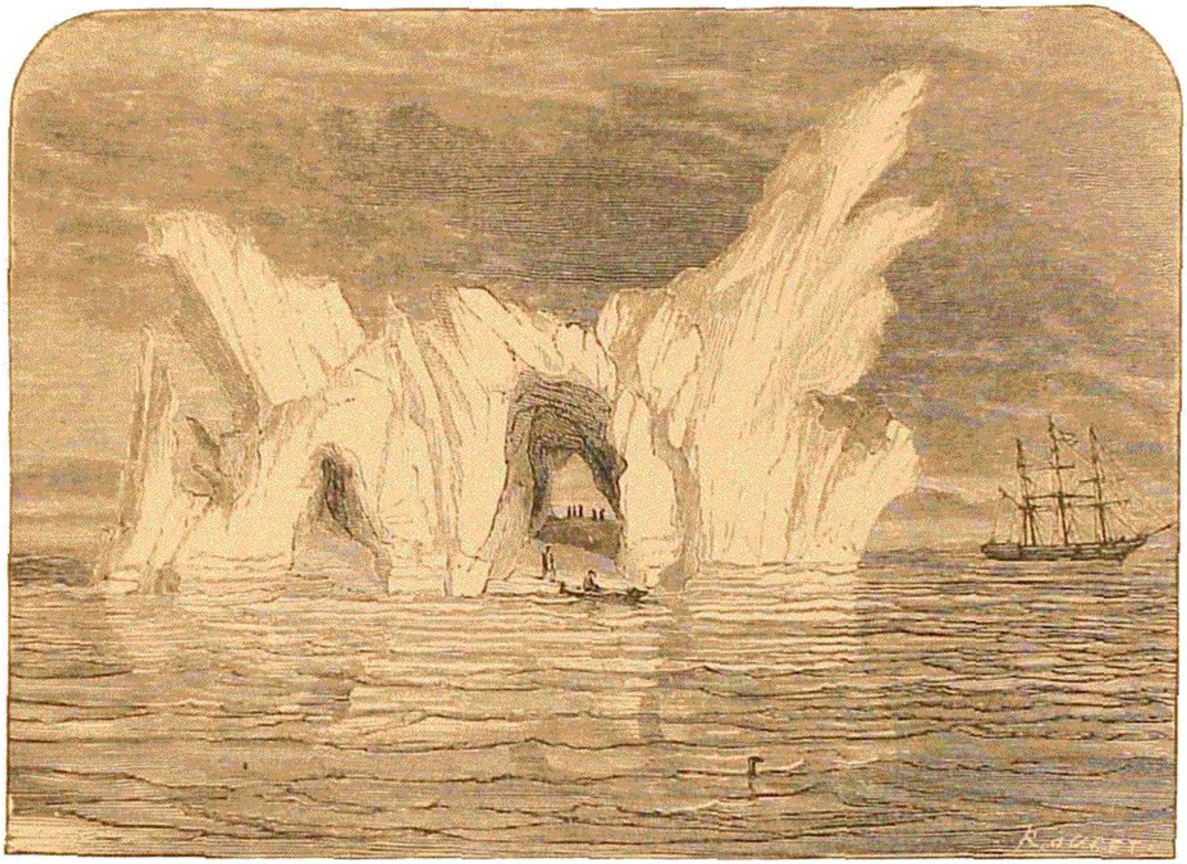

FIG. 231.—ARCHED ICEBERG, DISCOVERED BY SIR JOHN ROSS, OFF THE GREENLAND COAST.

action of the water and the atmosphere, they float southward, swept along the track of the rushing currents, sometimes even against the wind. When they arrive off the south of Greenland, the warm waters of the Gulf Stream complete their disintegration.

Not unfrequently the navigator falls in with a complete archipelago of these islands and islets of ice. The mass of blocks produces the effect of a city of giants which some geological catastrophe has overwhelmed, and whose ruins drift hither and thither at the will of the unchained elements. A myriad reflections of light play about its palaces of silver and crystal. When the human voice resounds in the mournful deadly solitude, unnumbered echoes repeat it on every side, as if the spirits of the unseen world gloomily responded to the rash intruder upon their sacred silence.

Nevertheless, nothing is so full of peril to the navigator as these dazzling islands, these fields of ice.

He must have a heart of brass, says Malte-Brun, who dares to penetrate into the inhospitable seas of the pole; for if the navigator has nought to apprehend from cyclone or tempest, he incurs other dangers which are far more capable of terrifying the most adventurous spirits. Sometimes enormous blocks of ice, loosed by the waters and driven by the winds, dash against his feeble vessel; neither rock nor shoal is so difficult to shun. Sometimes these floating mountains perfidiously surround the voyager, and block up every issue: his ship is arrested, is fixed. In vain, with powerless hatchet, he seeks to hew a path through the gigantic mass; in vain his flapping sails invite the breeze. His vessel is, as it were, wedged and welded into the ice; and the mariner, separated from the world of the living, remains alone with Nothingness.

When the *ice-master* catches sight of an ice-field coming down from the recesses of the north, the ship must set all her canvas to avoid a certain destruction. The rapidity of movement of these colossal masses is, in fact, prodigious. They may sometimes be seen rotating on their own axis at the rate of several miles an hour.

The shock of two ice-fields dashing one against another surpasses all that the imagination can conceive or invent. Figure to yourself the effect of a mass of eighteen millions of tons abruptly arrested in its career! If two masses of equal dimensions encounter with equal swiftness, from an opposite direction, what must become of a frail bark involved in the fearful collision! Thus each succeeding year sees multiplied, in the circumpolar seas, these sad disasters, and vessels perish by scores.

I have seen a ship, says Dr. Scoresby, crushed between two meeting walls of ice, and instantaneously annihilated in their formidable shock: only the summit of her mainmast remained erect above the floating tomb, like a funereal signal. Another was reared erect on its poop, like a startled horse. Two other noble three-masters have, in my very sight, been pierced through and through by keen blocks of ice upwards of one hundred feet in length.

In ill-omened Melville Bay more than two hundred ships have already perished in this manner.

The ice-mountains are often almost immovable. In such a case they provide the whalers with a convenient mooring-place if the winds are violent or contrary, if stability is necessary for a proper prosecution of the fishery, or if they seek shelter from the icebergs which drift downwards in the storm-vexed currents. It is dangerous, nevertheless, to moor beneath very lofty mountains of ice, for often their equilibrium is so unstable that the touch of a finger will make them tremble. If they encounter any obstacle when floating upon the sea, they break up into fragments like a gigantic obelisk, and shatter everything into ruin.

Ice whose surface has been levelled by the thaw becomes fragile and friable. Mountains of ice have been known to split in twain from summit to base when only smitten with a hatchet by a sailor engaged in anchoring his boat. The crevasse swallowed up the unfortunate man, and the blocks projected on every side sank his skiff. In Prince Napoleon's expedition to the north of Europe in 1856, his followers amused themselves by firing loaded guns at the mountains of ice and snow to break them into pieces.

The snow accumulated on these floating islands melts in the spring time, and forms in the hollows basins of fresh water, which prove a welcome resource to the whalers.

The winds of the Arctic Seas are remarkable for their variability. Their force diminishes greatly when they pass over a field of ice: sometimes the ice seems even to repel the breeze, and turn it in a contrary direction. The warm southern winds grow cool as they sweep over the frosty expanse, and give up their humidity in the form of snow. In these chill bleak regions clouds cannot form: the atmospheric vapours are condensed into snow, without passing through any intermediate condition.

Whirlwinds of frozen snow are justly dreaded by the seaman who is forced to traverse the ice on foot, or in sledges drawn by Eskimo dogs. Dense showers lash the unfortunate traveller's face, penetrate his mouth and nostrils, freeze together his eyelids, and blind him. The cold wind changes his skin to blue, and lashes him in the face like the thongs of a knout. In these regions the temperature sometimes sinks more than 18° below freezing-point, and is never more than half a degree above it. The lustre of the white mantle which everywhere covers the soil is so great that in polar regions one is forced to wear blue spectacles, or vizors, covered with iron-wire, when one wishes to traverse their plains of eternal ice.

A very frequent optical illusion in the polar regions makes objects appear of much greater dimensions than they really possess. A fox assumes the proportions of a bear; low banks of ice soar into radiant mountains. The eyes seemingly rest on the horizon of lands which are never approached. Just as in the sandy desert of Sahara, the distances of real objects are apparently diminished; the navigator advances, and still advances, but never reaches his goal.

Another source of error is the mirage, which represents as suspended in air the image of remote objects, and in this wise originates the wildest, strangest scenes. Scoresby one day perceived in the sky the reversed representation of a vessel which he recognized as the *Fame*, commanded by his father; he afterwards discovered that it had been lying moored in a creek about ten leagues from the point where the mirage had sported with his imagination.

In approaching a field of ice or snow, we invariably catch sight of a belt of resplendent white immediately above the horizon: this is called the *ice-blink;* a phenomenon which reveals to us beforehand the character of the ice we are approaching.

The great distinction between the polar countries and the other regions of the globe, is their long day and long night. Describing an immense spiral around the horizon, the sun gradually mounts to the highest point of his course, or 30°; then, in the same manner, it returns towards the horizon, and bids farewell to earth, slowly dying away in a gloomy and ghastly twilight. And, for six months, the Arctic wildernesses know it not.

When the navigator, says Captain Parry, finds himself buried for the first time in the silent shadows of the polar night, he cannot conquer an involuntary emotion of dread; he feels transported out of the sphere of ordinary existence. These deadly and sombre deserts seem like those uncreated voids which Milton has placed between the realms of life and death.

The very animals are affected by the melancholy which veils the face of nature. Under the influence of the almost perpetual gloominess Dr. Kane's Newfoundland dogs went mad, and died.

But if the sun for six months of the year deprives the circumpolar countries of the splendour of its fires, an imposing phenomenon frequently illuminates the long nights with dazzling radiance, as if Nature sought to compensate for the absence of the orb of day by the most impressive of all her optical wonders. The polar nights

Fig. 232. Aurora Borealis in the Arctic Seas.

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are nearly always lighted up by the gorgeous lustre of the Aurora; called Borealis or Australis, according to the pole at which it is produced. The gradation of the phenomenon is nearly in this wise:—the sky assumes a tint of brown, on which, as a background, is soon developed a nebulous segment, bordered by a more spacious arc of blinding whiteness, which seems agitated by a kind of effervescence. From this arc shafts and rays of light shoot upwards to the zenith. These luminous sheaves pass through all the colours of the rainbow; from violet and sapphire to green and purple-red. Sometimes the columns of light issue from the resplendent arch mixed with blackish rays; sometimes they rise simultaneously at different points of the horizon, and unite to form a sea of flame pervaded by rapid undulations. On other occasions, fiery dazzling standards are unfurled, to float lightly in the air. A kind of canopy, of soft and tranquil light, which is known as the *corona*, announces the close of the phenomenon. Thereupon the luminous shafts begin to wane in splendour, the richly coloured arcs dissolve, die out, and soon of all the magnificent spectacle nothing remains but a whitish cloudy haze at those points of the heaven which, but a few minutes ago, blazed with the mysterious fires of the Aurora Borealis.

[The *arch* of the Aurora is only part of a ring of light, which is elevated considerably above the surface of our globe, and whose centre is situated in the vicinity of the pole. It is easy, then, to account for the different aspects it presents to observers placed at different angles to it. A person some degrees *south* of the ring would necessarily see only a very small arc of it towards the north, from the interposition of the earth between him and the observer; if he stood nearer the north, the arch would appear larger and higher; if immediately below it, he would see it apparently traversing the zenith; or if within the ring, and still further north, he would suppose it to culminate in the south. It is supposed that the centre of the ring corresponds with the magnetic north pole, in the island of Boothia Felix.

The phenomenon generally lasts several hours, and is frequently diversified by peculiar features; so that sometimes it seems to present the hemispherical segment of a gigantic wheel; sometimes it waves and droops like a rich tapestry of coloured light, in a thousand prismatic folds; and, at other times, it may be compared to a succession of resplendent banners, or streamers, waving in the dark and intense sky.

The arch varies in elevation, but is seldom found more than ninety miles above the terrestrial surface. Its diameter must be enormous, for it has been known to extend from Italy to the polar regions, and has been simultaneously visible in Sardinia, Connecticut, and New Orleans.

According to some authorities, the phenomenon is accompanied by noises which resemble the discharge of fireworks, or the crackling of silk when one piece is rolled over another; but this statement is not confirmed by the experience of our ablest Arctic voyagers.

Of the magneto-electric origin of the Aurora no doubt can be entertained. When it occurs, the magnetic needle is invariably affected, the perturbation being greatest at the climax of the auroral brilliancy. The vertex of the arch is almost always in or near the magnetic meridian. The lights would seem to result from a discharge at or around the magnetic poles of electricity which has gradually accumulated round the magnetic poles.]

In the polar regions, the duration of daylight is about six months. Throughout this long interval the sun never ceases to shine; and at midnight it is only a little lower in the sky than at noon. [The long days act like the long nights upon certain animals. An amusing anecdote, in illustration of this fact, is recorded by Lord Dufferin:—*

"I had observed for some days past," he writes, "that the cock we had on board, as we proceeded north, and the nights became shorter,

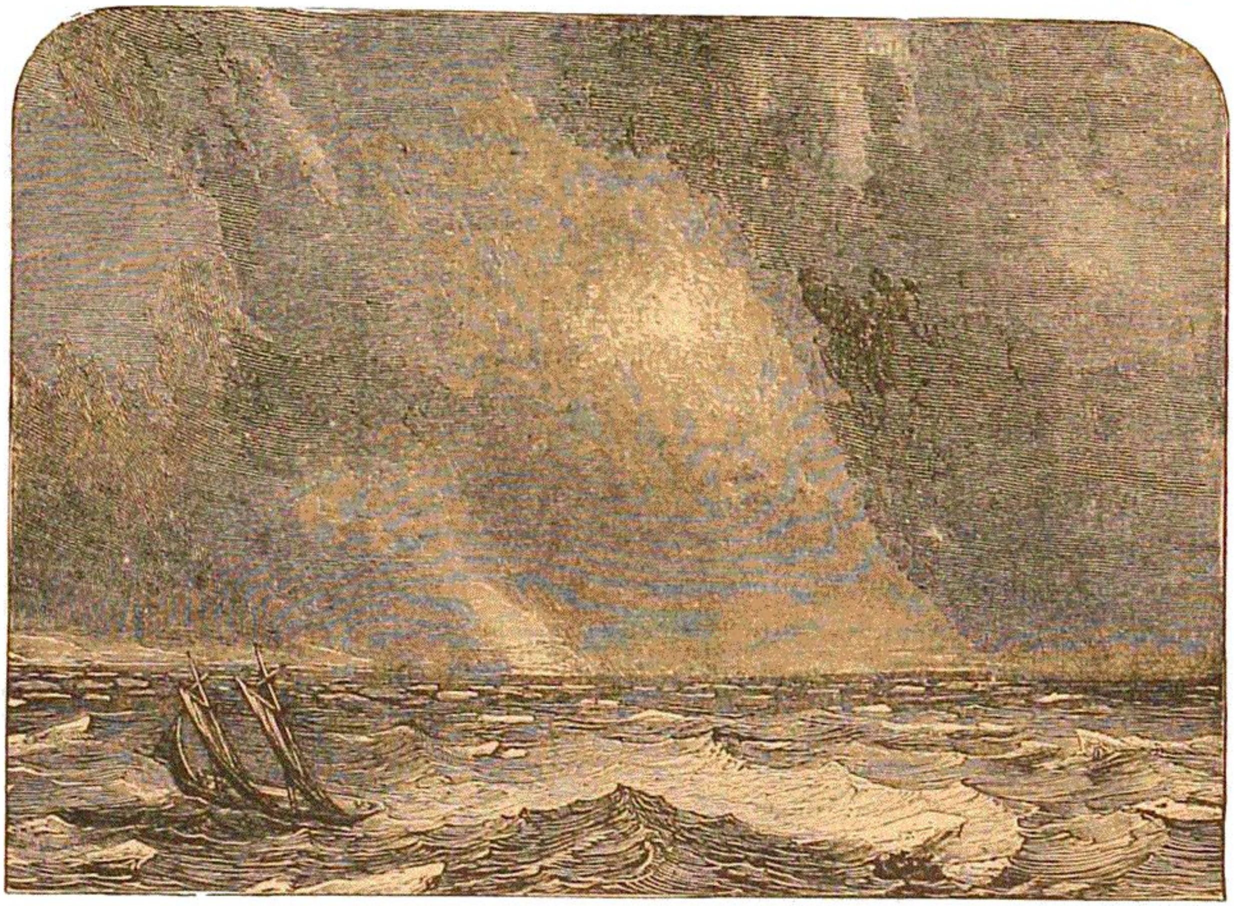


FIG. 233.—MIDNIGHT SUN AT SPITZBERGEN.

had become quite bewildered on the subject of that meteorological phenomenon, the Dawn of Day. In fact, I doubt whether he ever slept for more than five minutes at a stretch, without waking up in a state of nervous agitation lest it should be cock-crow. At last, when night ceased altogether, his constitution could no longer stand the shock. He crowed once or twice sarcastically, then went melancholy mad; finally, taking a calenture, he cackled lowly (probably of green fields), and leaping overboard, drowned himself."

To the same able and entertaining authority we are indebted for

* [Lord Dufferin, "Letters from High Latitudes," p. 31.]

a description of the sublime spectacle presented by the Midnight Sun at Spitzbergen.*

He speaks of the stillness, the deadness, and impassability of the scene as its most striking feature. Ice, and rock, and water were everywhere around him; not a sound of any kind interrupted the silence; the sea did not break upon the shore; no bird or any living thing was visible; the midnight sun—by this time muffled in a transparent mist—shed an awful, mysterious lustre on glacier and mountain; no atom of vegetation gave token of the earth's vitality; a universal numbness and dumbness seemed to pervade the solitude.

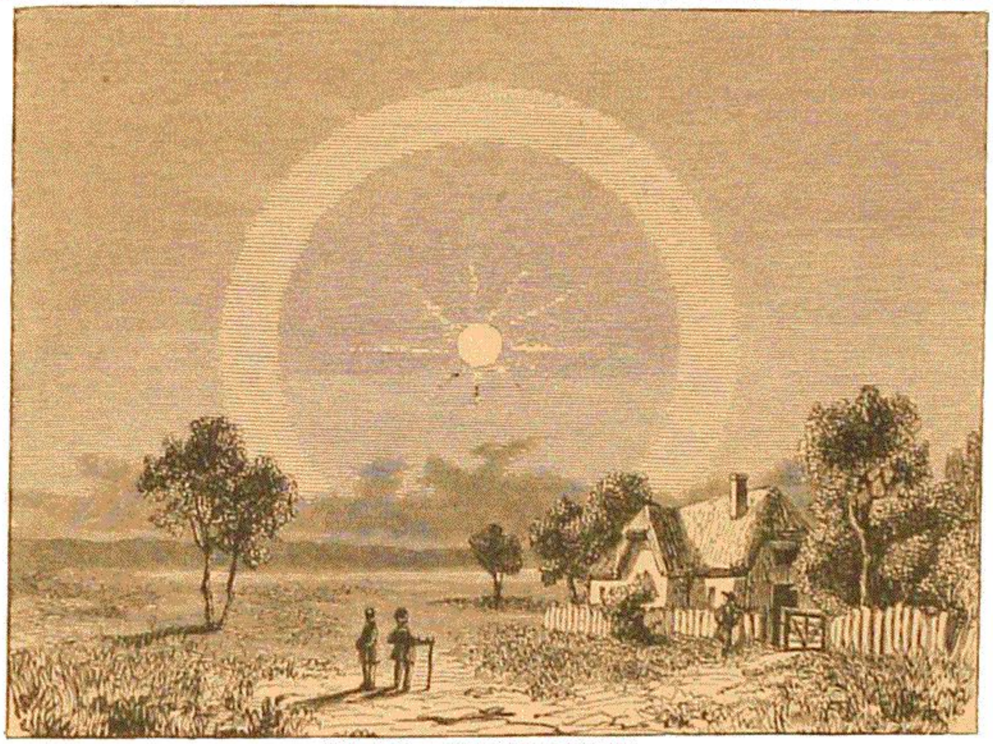


FIG. 234.—HALO IN NORWAY.

In scarcely any other part of the world is this appearance of deadness so strikingly exhibited.]

When the sun or moon is visible in the polar regions, the sphere very frequently appears surrounded by *halos*, or accompanied by the phenomena of *parhelia*, *anthelia*, and the like. Often a host of these meteors will simultaneously illuminate the heavens, as if the gods of the old Norsemen were holding high festival.

Such is a general view of the wonders of the Polar Seas. Let us now consider those which are peculiar to either pole.

* [Lord Dufferin, "Letters from High Latitudes," p. 192.]

THE ARCTIC POLE.

The Arctic, or North Pole, is the only one which has been carefully explored by man; for his commercial interests have led him to prosecute his investigations in this direction with unquailing ardour, while the Antarctic Seas present no attractions to human enterprise.

And yet, despite the numerous expeditions which for two centuries have traversed the ocean of the North, in search of a free passage by the north-west to the golden lands of India, the Arctic regions are far from being accurately known to geographers. Many navigators have been led into error by the mist and fog which cover them. In his first voyage, in 1818, Sir John Ross thought he saw

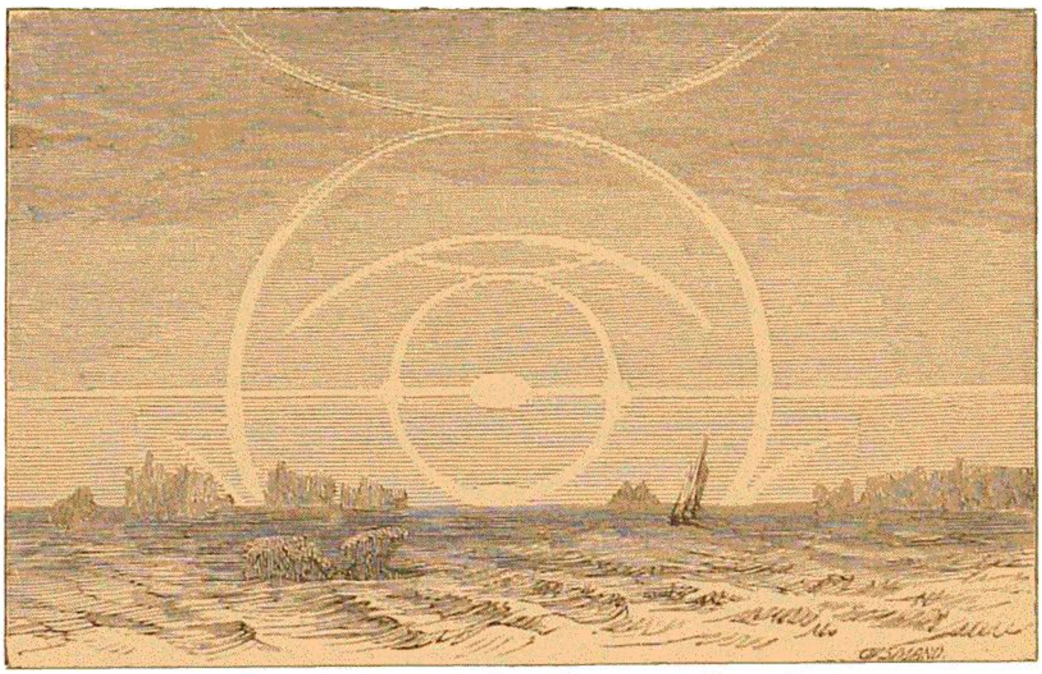


FIG. 235.—PARHELION, OR MOCK-SUN, IN THE POLAR SEAS.

Lancaster's Sound blocked up by a chain of mountains, which he named Croker Mountains. But in the following year Captain Parry discovered the mistake, and Ross was withdrawn from active service. It was due to the generosity of Sir Felix Booth, the opulent distiller, that, eleven years afterwards, he made a second exploring voyage in these regions. Of Parry's highly important voyage to the North Pole we shall give a few particulars.

He sailed from England, in 1819, with two ships, the *Hecla* and the *Griper*. He discovered Barrow's Straits, Wellington and Prince

Regent's Sounds, Cornwallis, Byam-Martin, and Melville islands, to which has been given the name of *Parry Archipelago*. In this short voyage he collected as many novel results as his successors have done in the last half-century. He, indeed, was the true pioneer of geographical enterprise and discovery in polar waters.

On Byam Island he ascertained the existence of some ruins of the ancient habitations of the Eskimos.

FIG. 236.—TRACK OF THE SHIPS "HECLA" AND "GRIPER," CUT THROUGH THE ICE BY THEIR CREWS, IN THE NEIGHBOURHOOD OF MELVILLE ISLAND.

Parry passed the winter on Melville Island. To reach the anchorage he had selected in Winter Bay, his men were compelled to saw through the ice a channel of a league in length; a task which, for three days, occupied all hands. Scarcely were the two ships moored in their commodious haven, before the thermometer sank to 18° below zero. The boats, cables, and sails, were carried ashore. The topmasts and yards were struck; and over the decks was built a roof of timber, which, being covered with thick felt, afforded an excellent shelter against the wind and snow. Every precaution that scientific intelligence could suggest was adopted against cold and damp. An endurable temperature was maintained on board the vessels by hot-air stoves. In each sleeping compartment an awning of waterproof cloth prevented the vapours from condensing on the wooden bulk-heads and partitions. Each crew was divided into companies, placed under the immediate superintendence of an officer, charged with the daily inspection of their clothes and physical condition; for nothing is so

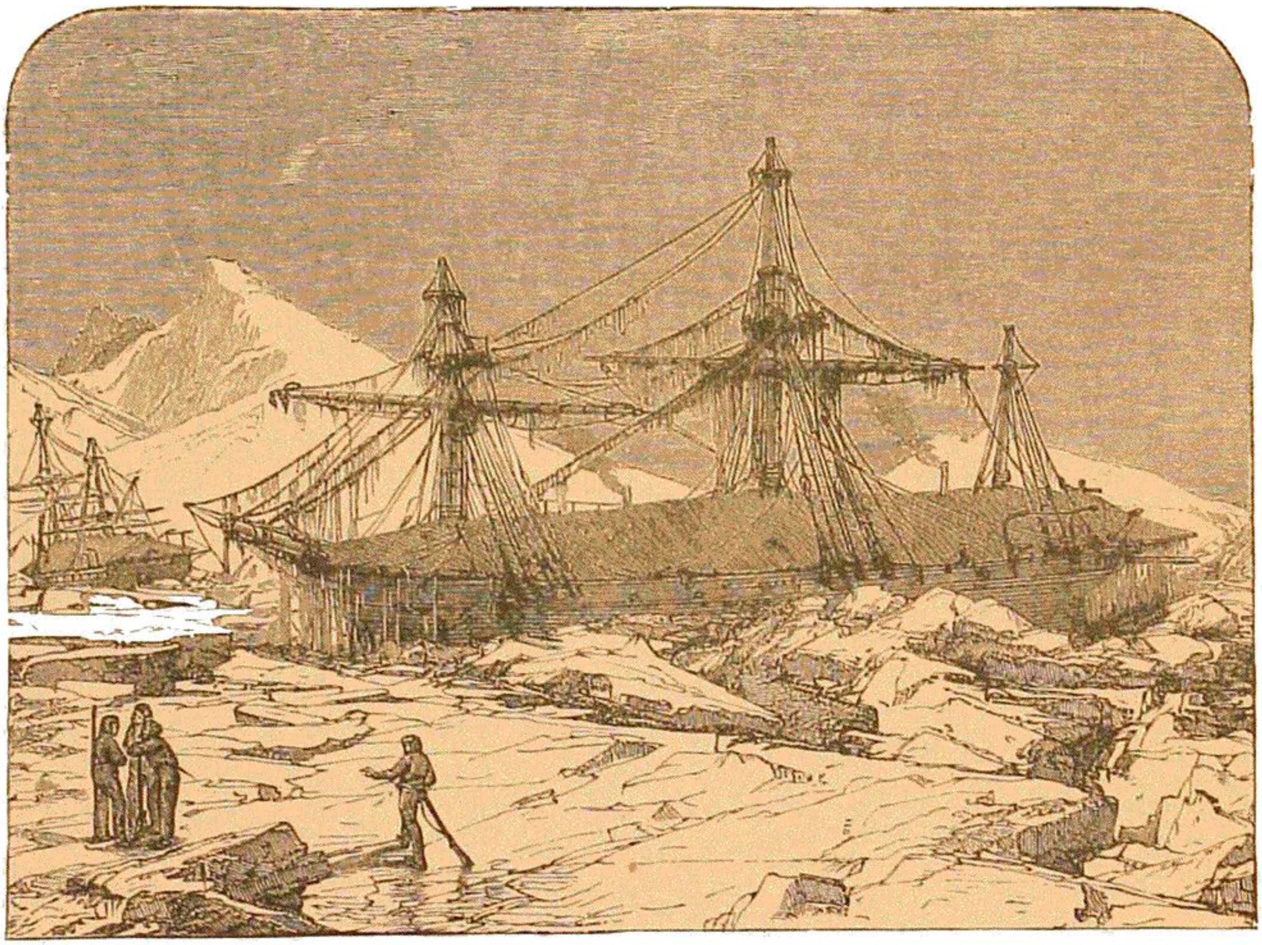


FIG. 237.—THE SHIPS "HECLA" AND "GRIPER" WINTERING AT MELVILLE ISLAND.

indispensable as scrupulous cleanliness in countries where the voyager is constantly menaced with scurvy.

To guard against the eventualities of the future, Captain Parry reduced the daily ration of bread by one-third. Beer and wine were substituted for grog. Every day the sailors were supplied with lemonade. Their repasts, worthy of Spartans, were occasionally varied with game. As a remedy against ennui, dramatic representations were given at frequent intervals. For these performances Parry composed a vaudeville, entitled, *The North-west Passage; or, The*

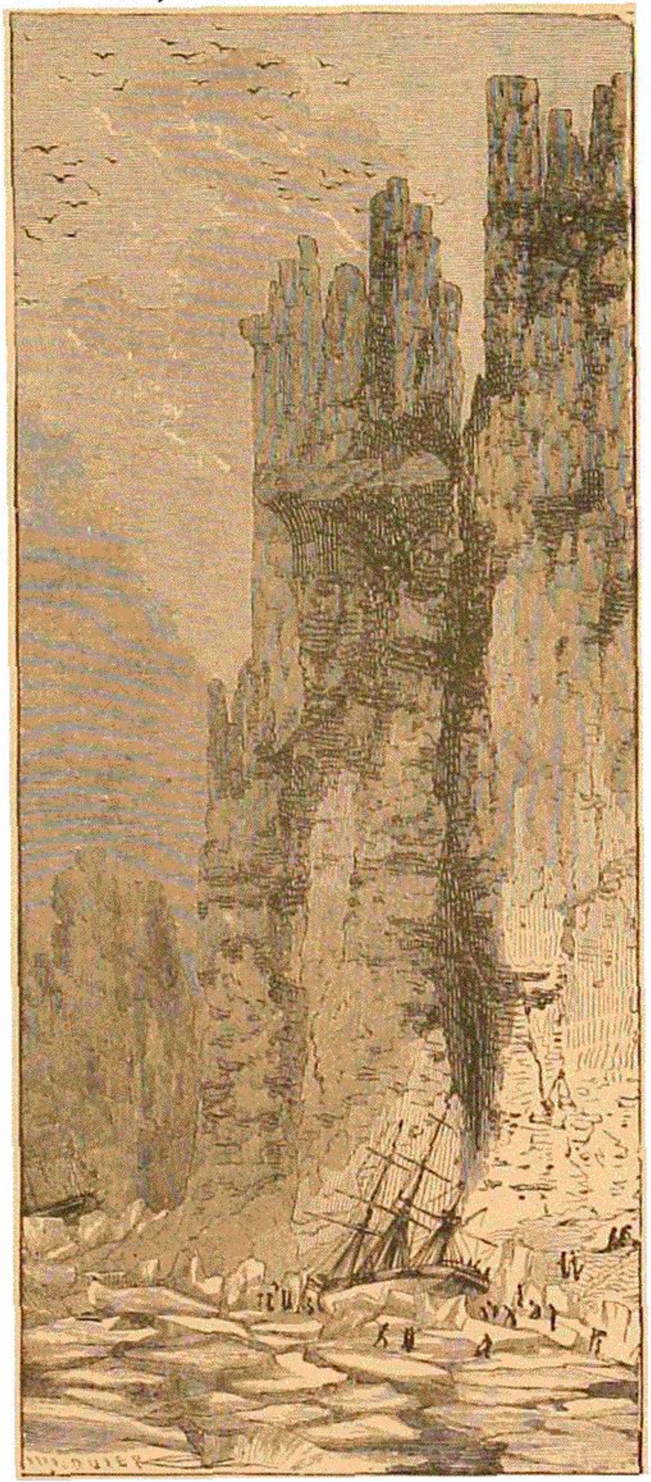
End of the Voyage. During the time occupied by them the thermometer stood, outside, at three degrees below freezing-point; and in the "theatre," at four degrees below. The footlights had, probably, never before been kindled at so low a temperature. During this eternal night of 84 days, the thermometer once sunk to fifteen degrees below freezing-point!

Some of the sailors had their limbs frozen, and were never completely cured. One day, the hut made use of as an observatory having caught fire, a seaman who sought to rescue a very valuable instrument lost both his hands; they were stricken by the mortal cold.

At length the month of June arrived, and some excursions were undertaken. In Melville Island the earth was found to be embellished with moss, and turf, and saxifrages. Reindeer had collected there, and musk-oxen, hares, Arctic geese, plovers, and other Arctic birds. Wolves and foxes prowled around this booty, whose possession the English seamen successfully disputed with them.

Captain Parry did not venture to spend a second winter in this terrible region. He returned to England as soon as the summer thaw opened up a free passage.

[In 1821, this able and successful explorer undertook a second voyage with the *Hecla* and the *Fury*. They sailed from the Nore on the 8th of May; they returned to the Shetland Islands on the 10th of October 1823. In the interval of seven-and-twenty months Captain Parry discovered the Duke of York's Bay; a vast number of inlets on the north-eastern coast of the American continent; Winter Island; the islands of Arnatoke and Voglet; the Fury and Hecla Strait; Melville Peninsula, and Cockburn Island. While wintering, in 1822, on Winter Island, the explorers were pleasantly surprised by a visit from a party of Eskimos; a visit which they duly returned. "They found," says Captain Parry, "an establishment of five huts, with canoes, sledges, dogs, and above sixty men, women, and children, as regularly, and, to all appearance, as permanently fixed as if they had occupied the same spot the whole winter." If the first view of its exterior created astonishment, that feeling was greatly enhanced when our adventurers entered one of the huts, and found that no materials were used in its construction but snow and ice. After creeping through two low passages, each with an arched doorway, the visitor came to a small circular apartment, whose roof was a perfect arched dome. Three doorways opened out of it upon as many inhabited rooms. In these the women were seated on beds ranged around the wall, each with her little fire-place or lamp, and with all her domestic utensils about her. The construction of these chambers resembled that of the outer apartment; being a dome, formed by separate blocks of snow laid in regular courses, and artistically fashioned into the shape requisite to form a substantial arch, from seven to eight feet high in the centre. The light was admitted through a circular window of ice, exactly fitted into the roof of each apartment.



PRINCE REGENT'S SOUND, IN 1824.

In 1824–25 a third voyage was undertaken by Parry, but it did not prove successful. He was surprised by the ice in Prince Regent's Sound, and compelled to pass the winter there. The *Fury* was so damaged by the floating ice that it was found necessary to remove her crew and stores to the *Hecla*, and abandon her.

Parry's fourth and last voyage was commenced in April 1826, when he was accompanied by Sir James Ross. On leaving Table Island, north of Spitzbergen, he placed his crew in a couple of boat-sledges, the *Enterprise* and *Endeavour*; one commanded by himself, the other by Ross. It required, we are told,* a zeal little short of enthusiasm to undergo, voluntarily, the toil of this expedition. When the adventurers arrived at a pool of water in the ice, they were then obliged to launch their boats, and embark. On reaching the opposite side, their boats were then to be hauled up the steep and dangerous cliffs of ice, their lading having first been removed.

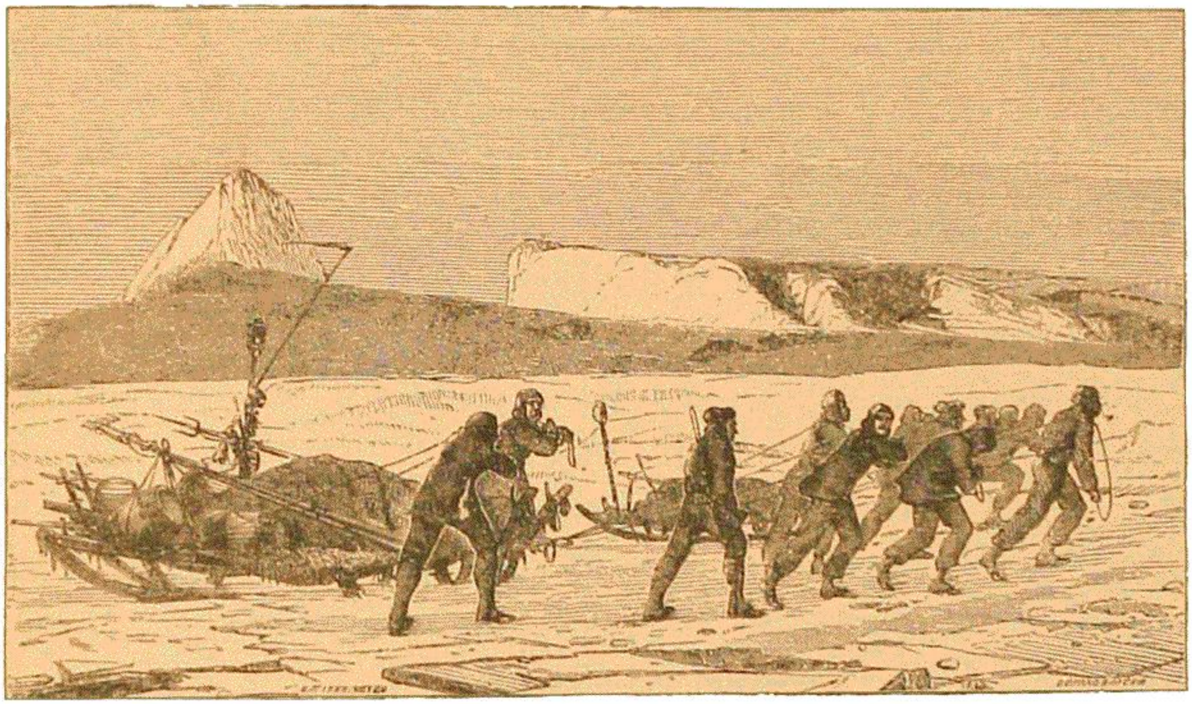


FIG. 239.—PARRY'S BOAT-SLEDGES, TO THE NORTH OF SPITZBERGEN.

By this most toilsome process, which was seldom interrupted by an interval of comparative repose, they contrived to accomplish eight miles in five days. They travelled only during the night, as a precaution against snow-blindness, and because the ice was then firmer and more consistent; they had also the great advantage of lying down to sleep during the warmer portion of the twenty-four hours. Soon after sunset they breakfasted; then worked for a few hours before taking their principal meal. Towards sunrise they halted, as if for the night; smoked their pipes; looked across the icy desert in

* [Cooley, "History of Maritime Discovery."—See also Parry's Narrative.]

the direction they were about to travel; and, wrapping themselves in their furs, laid down to rest.

After advancing as far as 82° 40′ north latitude, they were compelled by the drifting of the snow-fields to retrace their steps. They regained their ship on the 21st of August, and sailed for England.

In May 1829, Sir John Ross, accompanied by his nephew, James Clarke Ross, resumed the great task of Arctic exploration. Entering Prince Regent Sound, he found there the *Fury*—the dismantled ship abandoned by Parry five years before. The provisions on board of her proved a welcome resource for Ross and his followers.

On this voyage the Boothia peninsula was explored; and the explorers spent four consecutive winters in Felix Harbour, without being able to release their ship, the *Victory*. They availed themselves of the unwelcome detention to familiarize themselves with the manners and habits of the Eskimos, of whom Sir John Ross, in his narrative, has recorded numerous interesting particulars.

On the south-west coast of Boothia Felix, Ross discovered the magnetic North Pole. But his health, and that of his men, now rapidly declined, and compelled them to make an effort to escape from their icy prison. In their boats they contrived to reach Prince Regent's Sound; and after enduring the most terrible hardships were eventually sighted by a whaling-vessel. They were immediately received on board, when they learned that they had been saved by the *Isabella*, a ship formerly commanded by Captain Ross.

"I am Captain Ross," said the rescued explorer.

"Captain Ross," replied the crew of the *Isabella*, who had never seen him, "has been dead these two years."

Satisfactory explanations, however, were speedily exchanged; and it is unnecessary for us to state that Ross and his companions, on their escape from the horrors of a Polar grave, were most enthusiastically received in England.

We now come to Franklin's last and melancholy voyage.

His first expedition was made in the same year that Parry first ventured into the frozen seas. He then explored the Arctic coast of North America, and discovered the source of the Coppermine River, which he descended to its junction with the Polar waters. He proceeded as far north as latitude 68½°, to Point Turnagain. In his return journey, overland, he and his party suffered the severest hardships, and were reduced to gaunt and miserable spectres when they finally gained the welcome asylum of an English settlement.

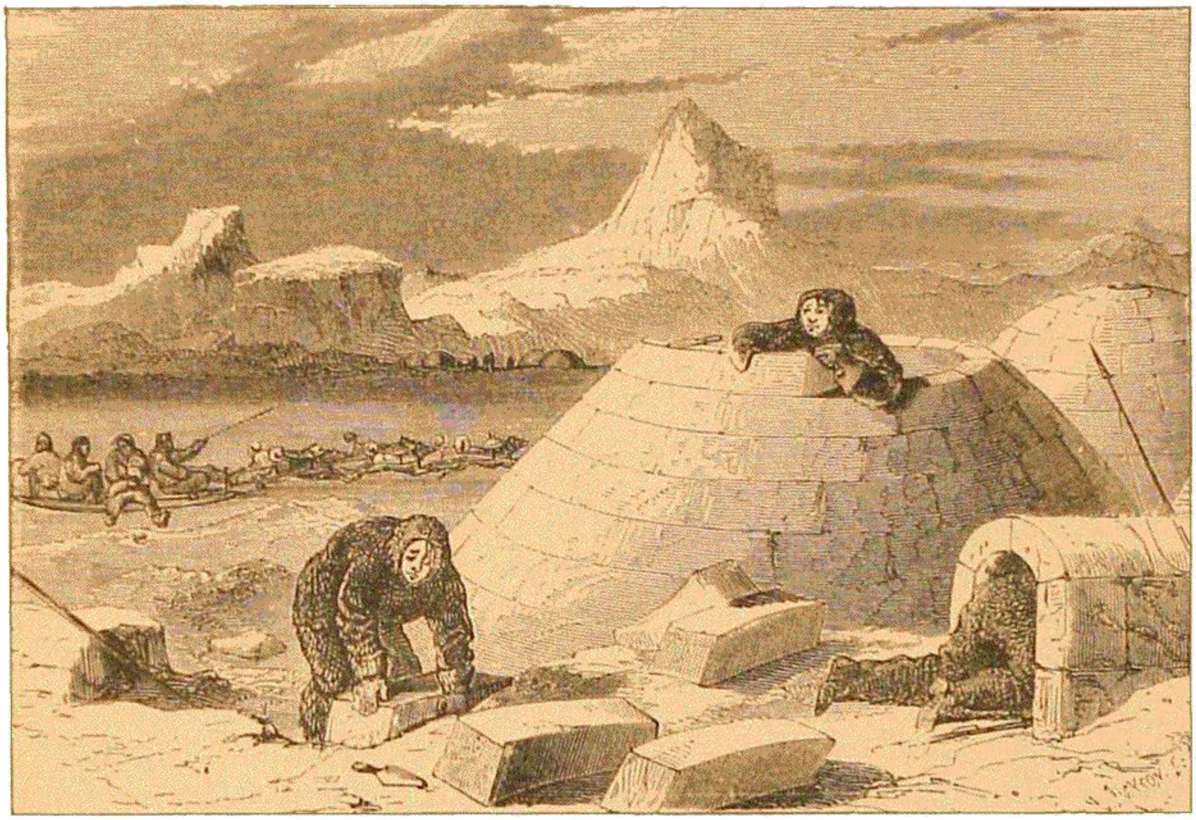


FIG. 240.—AN ESKIMO VILLAGE OF SNOW-HUTS.

In 1825 Franklin undertook a second expedition, and surveyed the Arctic coast for an extent of 500 leagues.

It was not until 1845 that he sailed on his third voyage, in the ships *Erebus* and *Terror*, with an able lieutenant in the person of Captain F. R. M. Crozier, and two crews consisting of one hundred and thirty-seven picked seamen. Both vessels were fitted with the screw-propeller, and supplied with three years' provisions, as well as every appliance which science could suggest.

Franklin and his followers were last seen alive by some whalers in Baffin's Bay, in the month of July 1845.

Three years passed away, and no tidings of the expedition reached England. The public mind began to grow disquieted. As an American writer observes, expectation darkened into anxiety, and anxiety into dread. It was at length resolved to dispatch an expedition in search of the missing adventurers. One set out under Sir James Ross, but returned unsuccessful. Another was led by Sir John Richardson, but obtained no clue to their fate. Were they alive, and imprisoned in some ice-bound recess? Or had they fallen victims to the terrors of an Arctic winter? No kind of answer to these questions could be given, until, in 1850, a ray of light was thrown upon the dark sad story by the discovery of some vestiges of the explorers in a bay at the eastern entrance of Wellington Channel. These vestiges consisted of "the ground-plan of a tent, scraps of canvas and rope, a quantity of birds' bones and feathers, and a long-handled dredging-rake." On Beechey Island Captain Penny also discovered a carefully constructed cairn, of a pyramidical form, whose summit was mounted with the remnant of a broken boarding-pike, and close at hand lay three graves, on whose rude memorial-tablets were inscribed the words, "*Erebus* and *Terror*."

It was now concluded that Franklin had penetrated into the remote wilds of the extreme north, and in this direction the searching expeditions proceeded, instead of exploring southward, as they should have done. In 1854, some information which Dr. Rae obtained from a party of Eskimos exposed the error that had been committed. These men asserted that, some years before, they had seen a company of about forty men, very feeble and sickly, passing to the south of Boothia, and evidently making towards the Great Fish River. At a later period, they had found their dead bodies; they had perished of cold and hunger. Dr. Rae brought home a number of relics from the Eskimos, bearing the private marks of various officers belonging to the two ships.

The recovery of these eloquent memorials of the missing navigators inspired Lady Franklin, who from the first had been heroically active in stimulating the search after her husband, with fresh energy and heart. She exhausted the remains of her private fortune in the purchase of a strong-built screw schooner, the *Fox*, and called for volunteers to second her efforts. Funds were liberally contributed by a sympathizing public, and numerous gallant men proffered their free services. The command was given to an experienced Arctic voyager, Captain M'Clintock, and with a first-rate crew of twenty-five able seamen, the little *Fox* sailed from England in the summer of 1857.

The following winter was spent in Baffin's Bay, and on the 27th of July 1858, the *Fox* made Lancaster's Sound. On the 11th of August she made Beechey Island, where she replenished her scanty stores from the depôts left by former expeditions. Then she steered westward, past Cape Hotham and Griffin's Island, and southward down Sir Robert Peel's Channel, until arrested by a barrier of fixed ice. Captain M'Clintock then resolved to retrace a portion of his course, and endeavour to force a passage through Bellot's Channel, which leads from Regent's Inlet into the great western sea whose waters wash the American coast from the Great Fish River to Behring's Straits. From the 20th of August to the 6th of September 1858, he watched his opportunity to make the projected "dash." On the last-named day the channel, which is eighteen miles long and one mile wide, was sufficiently free of ice for the *Fox* to attempt the passage. She ran through it merrily, but at its western extremity was repulsed by a belt of fixed ice, some miles in width, beyond which the open sea was rolling majestically.

Nothing could be done but prepare for another winter in the Arctic solitudes. It was enlivened by the well-directed efforts of Captain M'Clintock and Captain Young, his second in command, to amuse the crew, and glided by with sufficient rapidity. On February 17th, 1859, the two captains left the ship to establish depôts for their contemplated long journeys. Young struck westward for Prince of Wales Land; while M'Clintock proceeded in a southerly direction towards the magnetic Pole. These excursions were very brief; the cold was so intense that mercury remained frozen during the greater part of the time the men were absent from the *Fox*. But they sufficed to show that they were on the right track; for at Cape Victoria, on the west coast of Boothia, Captain M'Clintock was informed by the natives that, several years previously, a ship had been wrecked on King William's Land, but that all her people landed safely, and made their way to Great Fish River, where they died.

Accordingly, on the 2nd of April, the searching parties set out from Bellot's Straits. Captain Young proceeded northward and westward, but without making any discovery. Lieutenant Hobson and Captain M'Clintock, however, were more fortunate. Both made for King William's Land, where they parted: the former surveying the western, and the other the eastern shore. Captain M'Clintock rapidly completed his circuit across to Montreal Island, round the estuary of the Great Fish River, visiting Point Ogle and Barrow Island.

During this outward journey no wreck was found, and no bones of the lost crews discovered, but the few natives whom M'Clintock encountered readily gave him all the information they possessed, and bartered their relics of the *Erebus* and *Terror*.

The commander now turned to the north-west to complete the survey of King William's Land. Making a descent on the north side of Simpson's Strait, he made for the cairn erected by that discoverer, in 1839, on Point Herschel; and within ten miles of it, came upon a bleached skeleton. The poor fellow—probably a steward in Franklin's expedition—would seem to have dropped behind the retreating party, and in silence to have perished. At Point Herschel the cairn had been disturbed; and Captain M'Clintock conjectured that Franklin had placed there some memorial or record which the natives had subsequently removed.

From Point Herschel to the western extremity of King William's Land, the traces of the natives were so numerous as completely to have effaced those of the unfortunate castaways; but from the extreme western point to Cape Felix the beach was thickly strewn with signs of their miserable condition, like a rocky shore after some disastrous wreck. The whole of this melancholy Golgotha was carefully investigated by Captain M'Clintock from the south, and Lieutenant Hobson from the north, and the following were the principal results obtained:—

The *Erebus* and *Terror*, it is now known, spent their first winter at Beechey Island, after having explored Wellington Channel to lat. 77° N., and passed down again into Barrow's Straits, between Cornwallis and Bathurst Land.*

In 1846, the two ships seem to have successfully traversed Peel Channel, until imprisoned in the ice off King William's Land, on the 12th of September. Their position was about fifteen miles from the shore.

In May 1847, Lieutenant Graham Gore and Mr. Des Vaux landed and erected a cairn a few miles south of Point Victory, in which was deposited a document to the effect that on that day all the members of the expedition under Franklin were well and in safety.

In less than a month afterwards, however, the gallant Franklin was stricken down by disease and privation—a happy doom, as it spared him the long agony endured by his unfortunate followers.

The ice still continuing firmly set, they were unable to release the two vessels, and compelled to brave the perils of another winter.

Before the month of April 1848, nine officers and fifteen men "fell asleep." The *Erebus* and *Terror* were then abandoned, and the survivors of their crews, 105 in number, under the leadership of Captains Crozier and Fitzjames, started across the plain of ice for the Great Fish River. At and around the cairn were scattered a vast number of articles, which the wanderers had been unable, from want of strength, to carry away.

From this spot to a point about mid-way between Point Victory and Point Herschel nothing of an important character was discovered, and the skeletons as well as the relics were deeply imbedded in snow. At this mid-station, however, the searchers came upon the top of a piece of wood projecting above the snow, and on digging round it discovered a boat. She was resting on a very heavy sledge, and inside of her were two skeletons. The one in the bottom of the stern-sheets was covered with a great quantity of cast-off clothing, as if some friendly hand had endeavoured to protect the body, while still alive, from the mortal cold; the other, in the bows, seemed to have been that of an unfortunate seaman, who had crept thither to gaze wistfully around for the succour that came not, and in that position had yielded up his soul.

A couple of guns, loaded and ready cocked, stood close at hand, having probably been disposed for immediate use against wild animals.

Another pile of cast-off clothes lay near this boat; and it was Captain

* [These particulars are known from a record deposited in the cairn constructed by Sir John Franklin on Point Victory.]

M'Clintock's belief that the party who had brought her there were returning to the ships, having found their strength unequal to the painful and dangerous journey that lay before them; while, probably, the stronger portion of the crews pushed on with another boat-sledge, and ascended the Great Fish River.

We must remember, says Captain Sherard Osborne,—of whose admirable summary we have freely availed ourselves,—that some Eskimos met by Dr. Rae in 1854 spoke of seeing forty men dragging a boat near the Fish River; and said that the officer of that party was a tall, stout, middle-aged man, a description which agrees well with the appearance of Captain Fitzjames. The probabilities are, therefore, that the strongest under Fitzjames pushed on to perish in the wilds of the Hudson Bay Territory (relics have been found on the Fish River fifty miles above Montreal Island); whilst the weak, if they ever reached the ships again, only did so in time to see them wrecked by the disruption of the ice in the autumn of 1848. One ship went down, we are told by the Eskimos, and the other was forced on shore, and in her there was one dead person, "a tall, large-boned man." These wrecks, however, could not have taken place on the coast between Capes Victory and Herschel, for in that case the natives would have swept away the relics discovered by M'Clintock and Hobson. It may, therefore, be concluded that the wrecked ship was driven by the ice upon some spot within the range of the Fish River Eskimos; and that in the year 1857-58, the ice had in all probability again swept her away and engulfed her.

The point at which the fatal imprisonment of the *Erebus* and *Terror* in 1846 took place, was only ninety miles from the limit reached by the explorers Dease and Simpson, in their boats, in 1838-39. Ninety miles more of open water, and Franklin and his heroic followers would not only have won the prize for which they had so bravely struggled, but have gained their homes to enjoy their well-merited honours. Such, however, was not to be the case. "They were to discover the great highway between the Pacific and the Atlantic. It was given them to win for their country a discovery for which she had risked her sons and lavishly spent her wealth through many centuries; but they were to die in accomplishing their last great earthly task; and, still more strange, but for the energy and devotion of the wife of their chief and leader, it would in all probability never have been known that they were indeed the First Discoverers of the North-West Passage."*]

We have now to say a few words respecting the later voyages undertaken in the Polar Seas.

Before the return to England of Captain M'Clintock (in September 1859), Captain (now Sir Roderick) M'Clure, starting from Behring's Strait, discovered in 1850 the famous northern passage, fruitlessly sought after for so many centuries, between Melville and Baring Islands. On one occasion during his prolonged exploration he

* [Captain Sherard Osborne, C.B., "Narrative of the Search after Sir John Franklin."]

saw the thermometer descend to 13° below freezing-point. In the month of October 1854, M'Clure returned to England. A few years later, as we have seen, certain information was obtained that Franklin, before death overtook him, had succeeded in discovering the other

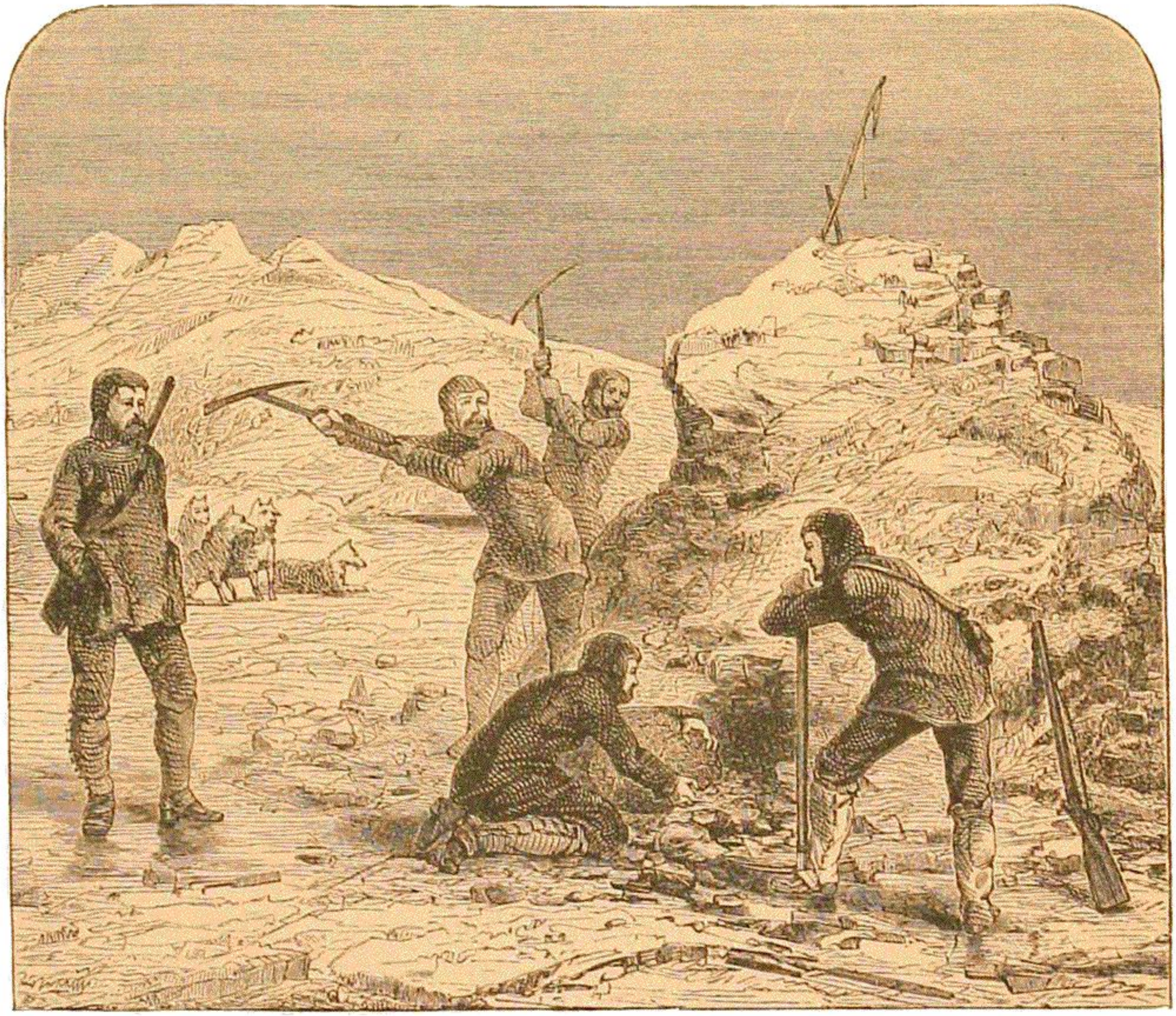


FIG. 241.—DISCOVERY OF THE CAIRN CONTAINING SIR JOHN FRANKLIN'S PAPERS.

open passage in the frozen North, to the south of Victoria and Wellington Lands.

In 1853, Dr. Elisha Kane's expedition penetrated into Smith's Strait, and advanced northward upon sledges drawn by dogs. The temperature, which had varied, on an average, from 2° to 12° below freezing-point, sank as low as 22°. At 11° from the pole, Kane fell in with Eskimo villages, called Etah and Peterovik, and he also discovered a colossal and majestic glacier, which he named after the philosopher Humboldt, and which he describes as connecting the two continents of Europe and America. A portion of his followers, led by Lieutenant Morton, discovered, beyond the 80th parallel, a channel of open water, tenanted by innumerable birds; sea-swallows, ducks, and gulls filled the air with their shrill cries. Seals disported on the floating ice. Ascending its shores, Morton encountered several genera of flowering plants: lychnis, hesperis, joubarbes (?), and the like. On the 24th of June, he planted upon Cape Independence, above the 81st parallel of north latitude, the flag of the *Antarctic*, which had previously seen the icebergs of the southern pole. To the north, an open sea extended far beyond the range of sight; to the left, the western shore of Kennedy Sound apparently terminated in a chain of mountains, whose loftiest peak, 9700 feet in height, received the appellation of Mount Parry. The expedition then returned to the south,

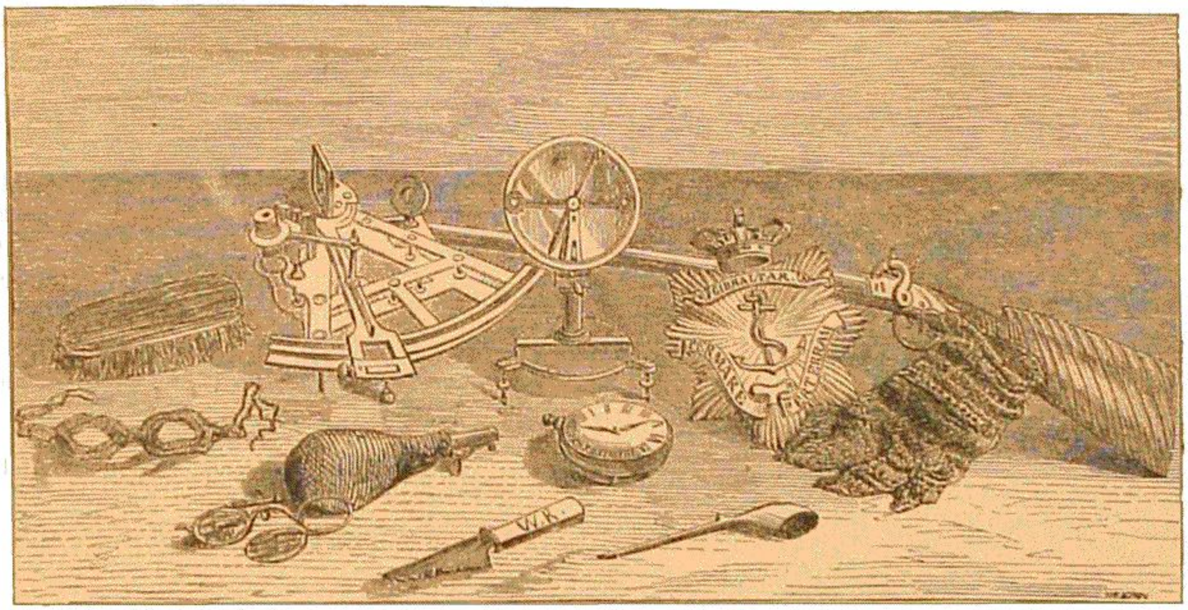


FIG. 242.—RELICS OF FRANKLIN'S EXPEDITION, BROUGHT BACK TO ENGLAND IN 1859.

and arrived, in a most feeble and wretched condition, at the port of Uppernavick, where its members were received on board an American vessel. Kane, exhausted by the sufferings he had undergone, died in 1857.

[Since the discovery of Franklin's fate, and the solution of the long-vexed problem of a North-West Passage, the interest felt by England in Arctic exploration has died out. Some interesting information respecting the manners and habits of the Eskimos, and the nature of the regions they inhabit, we owe, however, to the perseverance and energy of Captain Hall. The task abandoned by us has been taken up on the Continent, but with very small success. A German expedition, equipped in 1868, has added little, if anything, to the knowledge we already possess of the Arctic shores and seas. A French expedition is projected, and the question has also been raised of a new English venture; but it does not seem to have called forth the public support.]

This rapid survey we shall terminate with a few remarks upon a geological fact of great interest.

As far as we have been able to explore the nature of the soils of the countries adjacent to the North Pole, we have found them belonging, in the main, to the carboniferous formations. Such is the case, for instance, in Prince Patrick's Island and Melville Island. Under the crust of ice which covers them the coal-measures exist, with all the débris of fossil vegetables by which they are usually characterized. In the geological age, then, the Arctic regions of our earth must have been clothed with a rich and abundant vegetation, whose remains now constitute the carboniferous strata; a fact which clearly proves that their climate must formerly have been one of burning heat, and fiercer than that which now prevails in the Tropic zone. What a prodigious fall in temperature our globe must have undergone since that remote geological epoch!

It is a strange contrast which is afforded by the presence of vast coal-beds under a dense crust of snow and ice! If human industry ever planted itself in these apparently inhospitable lands, it could draw from the earth the combustible needful to warm its habitations, and thus nature herself would furnish the means of combating the rigorous conditions of an Arctic climate.

THE ANTARCTIC POLE.

The Southern Pole is probably surrounded by an enormous belt of ice, 250 miles in diameter; though there is every reason to believe that its dimensions have somewhat decreased since the voyage of Captain Cook, in 1774.

This formidable and impenetrable barrier can only be approached during the months of summer; that is, during December, January, and February.

The first navigator who penetrated into these deserts was the Dutch captain, Theodoric de Gheritk, whose ship formed part of the squadron of Simon de Cordes, destined for the East Indies. In January 1600, a storm having dispersed the vessels of this squadron, Captain Gheritk's was driven as far south as 64°, and sighted a coast resembling that of Norway, mountainous, and covered with snow, and extending from the Solomon Islands.

The narrative of Simon de Cordes was received with general incredulity, which was not entirely dissipated until the shores of New South Shetland were definitively recognized.

The idea of an Antarctic continent is, however, one of the most ancient conceptions of speculative geography—one of those which science finds it most difficult to drive from the imaginations of theorists and mariners. The existence of a southern continent seems necessary as a counterpoise to the Arctic regions. The *Terra Australis Incognita* is laid down, under this designation, on Mercator's charts, as extending around the South Pole; and when Kerguelen discovered, in 1772, the island which bears his name, he put forward Mercator's hypothesis as having suggested to him his voyage of exploration.

In 1774, the illustrious Captain Cook penetrated beyond the 76th parallel of latitude, under the 109th degree of west longitude. He traversed one hundred and eighty leagues between the 50th and 60th parallels of south latitude, without discovering the land of which some navigators had spoken; hence he was led to suppose that they had mistaken fog-banks or icebergs for a continent. Cook, nevertheless, does not reject the notion that one actually existed. In the narrative of his voyage, he asserts his belief that there lies near the pole an extensive area of land, where is formed the greater part of the floating ice of the vast southern ocean; that the ice would not spread so far were there not a tract of considerable magnitude situated to the south. He admits, however, that the greater part of the supposed austral continent would lie within the Antarctic Circle, where the sea is so encumbered with ice that it would be inaccessible. The dense fogs, the terribly severe cold, and the frequent whirlwinds of snow would also combine to increase the perils of the navigator. The aspect of these coasts is more horrible than any one can imagine. They seem condemned by nature to remain deprived of the cheerful sunshine, and buried under eternal ice and snow.

These desolate regions to which the great seaman applied the words of Pliny—"Pars mundi à natura damnata, et denso mersa caligine"—have not daunted the courage of Cook's successors; and, in our own days, several expeditions have been directed towards the realm of desolation, silence, and death.

In 1823 a free passage opened up into the Antarctic seas, of which a Scotch whaler, Captain James Weddell, took advantage to penetrate as far south as lat. 74° (in long. 34°), but the season being too far advanced, he found himself compelled to retrace his steps.

Weddell's voyage caused a great sensation, and led men to believe in the possibility of more serious explorations. Fifteen years later, the expeditions of the French navigator, Dumont d'Urville—of the American, Wilkes—and of the Englishman, Sir James Clark Ross, were dispatched towards the South Pole.

Dumont d'Urville, who was fated to perish miserably, in 1842, by an accident on the Versailles Railway, sailed, on the 9th of January 1838, from Magellan's Strait, with the two corvettes *Astrolabe* and *Zélée*. After having passed beyond the first barrier of ice, he expected to find, like Weddell, an open sea; but was soon constrained to renounce his sanguine hope. The icebergs became more numerous and more dangerous. In the South Polar Seas, they do not circulate in straits, or well-defined channels, like those of the North Pole. Detached from the enormous ice-fields which block up the shore, or, sometimes, only rest upon the shallows, their blocks accumulate in belts parallel to the face of the cliffs, intersected by a few narrow and sinuous channels. These icy cliffs are the more worn and broken up as they are the more remote from their original cradle; a circumstance which enables the seaman to judge approximatively of the distance of the ice-fields. The blocks of ice form, in the first place, huge prisms, or tabular masses, regular in form, and of a dull white colour; but by degrees they wear away, split up, are rounded or divided by the action of the waves which bear them onwards; their colour grows more transparent, and of a purer white. Then they float freely in a northerly direction, at the mercy of the winds and currents. From year to year they accumulate, but under different conditions, so that it is only a fortunate chance which clears a free passage among them, such as Weddell discovered. They have been discovered as high as 35° south latitude, and in the parallel of Cape Horn.

The two French vessels found themselves several times entangled in the ice collected by a northerly wind; and before they could effect their escape were compelled to wait the return of southerly breezes, which dispersed the enormous masses. In not a few instances, Dumont d'Urville was compelled to drive his ship against the ice-field that imprisoned it, and to open up by sheer force a passage, using his corvette as a battering-ram.

In 1838 he discovered, to the south of the Orkney Islands, a coast-line of about fifty leagues in length, which he named Louis Philippe Land and Joinville Land. It was crowned by enormous glaciers, which towered to an elevation of 2700 feet. Ross afterwards discovered here some very lofty peaks, such as Mount Penny and Mount Haddington, 7200 feet; he also ascertained that the supposed mainland was only a large island.

D'Urville's crew being much fatigued and stricken with disease, he returned to Valparaiso; resuming his explorations in the beginning of the following year (January 1839).

This time he advanced from a diametrically opposite point. He soon found himself in the midst of the ice, under the Antarctic Circle, and discovered Adélia Land (*la Terre Adélie*). Its long line of lofty cliff was surrounded by a belt of numerous threatening islands of ice. Dumont d'Urville, without hesitation, pushed forward into the perilous labyrinth, where, at times, his ships were so enclosed by icebergs, that he incessantly dreaded a terrible and fatal shock. Around these floating reefs the sea raged in formidable breakers, which would have instantly capsized any vessel drawn within their violence. It

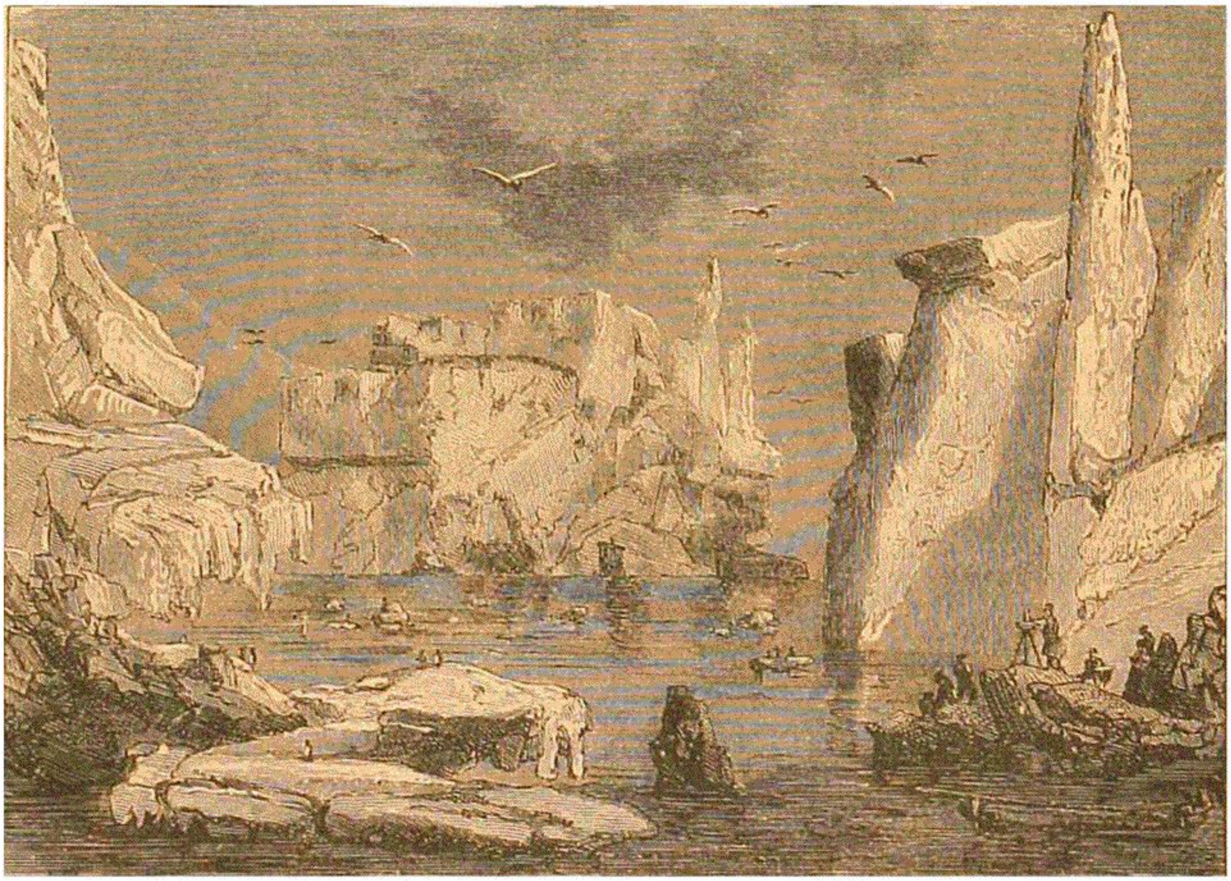


FIG. 243.—DISCOVERY OF LA TERRE ADÉLIE BY DUMONT D'URVILLE, IN 1839.

was in passing below the icy cliffs he was enabled to judge of their altitude.

They rose high above our masts, he says, and impended over our barks, whose dimensions seemed ridiculously dwarfed by the contrast. They might, in truth, have been taken for narrow streets in a city of giants. At their foot yawned tremendous caverns, excavated by the waves which raged within them thunderously. On the immense walls of ice, which shone like crystals, the sun darted its oblique rays, producing truly magical and enchanting effects of light and shade. From their summits leaped headlong into the sea a host of rills, fed by the snows which melted under the sun of January, the summer of the Antarctic regions.

Sometimes the glaciers and icebergs were situated so close to one another as completely to obscure all view of the snow-mantled land; the eye then rested on two threatening walls of ice, whose sonorous echoes repeated again and again the orders of the officers and the shouts of the seamen. The corvette which followed the *Astrolabe* appeared of such insignificant dimensions, and her masts so frail, that the crew were seized with a panic of terror. For nearly an hour the ships sailed between vertical ramparts of ice, and then passed into a vast basin, formed on the one side by the chain of floating islands they had just traversed, and on the other by a coast between 3400 and 4000 feet in elevation, with a broken undulating surface, which was everywhere encrusted in a thick layer of ice, glittering in the sun like a world of crystal. D'Urville and his officers pushed forwards in their boats, through a maze of icebergs, until they reached a small islet opposite the shore. Here they landed, and hoisted the French flag, as formally taking possession of the new continent. Then they carried away with them some fragments, detached from the bare precipitous cliffs.

These rocks are composed of quartz and gneiss. The Southern continent, therefore, belongs to the primary strata, while the Arctic belongs, in the main, to the transition.

Dumont d'Urville traced the chart of Adelia Land for some thirty leagues. It is a dead and desolate country, without a sign of vegetation.

A little further north, the French navigator vaguely discerned, in the white lines of the horizon, another coast, which he named *Clarie Coast*, and whose existence was soon afterwards confirmed by the American expedition under Wilkes.*

That skilful officer pushed to a great extent his researches in the

* [It is now well known that Wilkes was mistaken in many of his so-called Antarctic discoveries, and that he laid down as land, in his maps, what was simply a bank of clouds.]

Antarctic world, yet added little that was certain or important to our knowledge respecting it.

In 1841 Sir James Ross penetrated into a gulf which breaks up the great austral glacier. In 76° south latitude, he discovered a volcanic mountain, and at a short distance, another cone, of equal height, which proved to be an extinct, or, at all events, an inactive volcano. To these two peaks, as stated in an earlier chapter, he gave the names of his two vessels, *Erebus* and *Terror;* names in admirable harmony with the aspect and character of the surrounding country.

Ross penetrated as far south as the 79th parallel; thus carrying his explorations beyond the limit attained by preceding navigators.

Here we fitly conclude our survey of the EARTH AND SEA.

Appendix.

Page 16.—Geography of Homer.

AN interesting chapter on this subject will be found in the Right Hon. W. E. Gladstone's recent valuable contribution to Homeric literature, the "Juventus Mundi," from which we extract the following conclusions (pp. 488, 489):—

"The general arrangements of Homer show that he thought the Earth and Sea had a great extension northwards, but gave no idea of great distances in the longitudinal line, or from east to west. How far he carried it to the south, we have no means of judging. We know that the shield of Achilles represented the form of the earth, with the river Okeanos for its rim. Now a shield in general is sometimes compared with the moon by Homer, but he does not say the full moon; and the prevailing epithets for the shield would tend to show an oval form, or one adapted to cover the entire figure; the same form as that indicated in the formula of the Spartan mother for a soldier son—'Bring it, or be brought upon it.' The natural shape of the hide, of which the name is often applied to a shield, likewise seems to favour this belief. And such a form of the shield apparently agrees with the figure which the descriptions of the Outer Geography tend to give to the earth, in conjunction with the representation of the shield of Achilles.

"The noble conception of a great circumfluent river was probably founded on a combination of a double set of reports; the one, of great currents setting into the Thalassa, or Mediterranean Sea, and seeming to feed it, such as those of Yenikalè, the Bosphorus, Gibraltar; the other, of outer waters, such as the Caspian, the Persian Gulf, and probably the Red Sea."

Page 27.—The Earth's Distance from the Sun.

The transit of Venus across the sun's disc in 1874 will afford our astronomers an opportunity of solving what Professor Airy has called "the noblest problem in astronomy," the sun's distance from the earth. In what way it will enable to attain so desirable a result has been so clearly explained by a writer in the "Saturday Review" (Aug. 14, 1869) that we cannot do better than reproduce his observations:—

"It is well known," he says, "that to find the distance of any object on the earth from us, it is not at all necessary to walk over and actually measure the interval; it suffices to mark out a much smaller distance, called a base line, and then from either end of this base line to observe the angle between the distant object and the other end. Only one condition is necessary, and for instrumental reasons—the base line must be of appreciable length with regard to the distance of the object. Such a mode of measurement even may be applied to the moon, which is roughly a quarter of a million miles off, the observations being made, say, at Greenwich and the Cape of Good Hope, since the distance between those places—the base line—is appreciable when compared with the moon's distance. But when we come to the sun the case is different. If we could place two observers on the equator, one in longitude 0°, and the other in longitude 180°, we should then have the largest diameter of the planet as the base line; but, compared with the sun's distance, 7900 miles (the earth's largest diameter, and, consequently, the greatest distance between any two places on it), it is instrumentally *nil*—our base line is inappreciable—and this, the most obvious and direct method, therefore fails.

"It is generally supposed that Halley was the astronomer who first pointed out the flank attack on the sun's distance rendered possible by the transits of Venus over the sun's disc; but this is not the case. The suggestion is due to James Gregory, who suggested in 1663 that observations of Venus or Mercury, when they come between us and the sun, and are seen to pass over his disc, may give us the required information. An attempt to explain this will require a little attention. The method is really founded on one of Kepler's laws, by which mankind became acquainted with the *relative* distances of the planets from the sun long before they could determine their *absolute* distances. The thing to be done, therefore, is to measure the distance of the nearest planet from us, and then something like a rule of three sum tells us the distance sought, that is, the sun's distance from us. Now the planet which, in its journey round the sun, comes nearest to us is Venus, and she comes, as we now know, near enough to us to allow us to apply the base line method, as in the case of the moon, were it not for the unfortunate circumstance that, as her path lies within ours, when she is nearest to us she is between us and the sun, and, consequently, has her non-illuminated side turned towards us, so that she is generally invisible at such times. But not always, for sometimes she comes exactly between us and the sun, and appears as a black dot on the sun's face; that is, we have a transit of Venus over the sun.

"Now let us regard the sun as a screen on which the planet is visible. In the first place, an observer at the centre of the earth would see the planet travelling in a straight line over some part of the disc. An observer at the North Pole would see the planet's path projected lower down on the sun; similarly an observer at the South Pole would see the path projected higher up. In fact, as seen from the North and South Poles, the paths of the planet over the sun would be separated by a certain interval.

"Now, suppose the sun to be exactly as far from Venus on one side as the earth is on the other, it is evident that the apparent interval between the two paths would represent on the sun a distance exactly equal to that between the two observers; but we know, to start with, that the distances of Venus from the earth and sun are as 28 to 72 nearly, so that the interval between the two paths will always bear this relation to the distance between the two stations on the earth from which they are observed. If it were possible at the same moment of time to photograph the planet on the sun from two distant stations such as we have imagined, the problem would be at once solved, and in this way. We could determine the length of the line, as seen at Venus, which joins the two stations on the earth at which the observations are made; we could then increase this in the ratio of 28 to 72, to find the exact separation of the black dots representing Venus on the photographs. Hence we could determine the size of the sun, and hence its distance. But, in practice, the thing is not so easy: the amount of separation of the apparent paths of the planet over our screen—the sun—can only be laboriously determined from their length, because simultaneous observations are out of the question; and as the difference in the lengths of the paths—that is, the time the planet takes to travel over the sun—is thus the point of inquiry, it is necessary to make this difference as great as possible to give accuracy to the result. From this requirement comes the necessity of choosing the stations at which the transit is to be observed, most carefully bearing in mind at the onset that the earth is a rotating globe—a consideration which greatly complicates the matter."

The principal stations in 1874 will be—Owhyhee, Marquesas Islands, Kerguelen's Island, Mauritius, Rodriquez Island, New Zealand, and Alexandria.

Page 230.—The Tropical Forest.

As an addendum to the text, we offer our readers the following glowing picture of tropical vegetation in the virgin forests:—

"The reader who is familiar with tropical nature only through the medium of books and botanical gardens, will picture to himself in such a spot many other natural beauties. He will think that I have unaccountably forgotten to mention the brilliant flowers which, in gorgeous masses of crimson, gold, or azure, must spangle these verdant precipices, hang over the cascade, and adorn the margin of the mountain stream. But what is the reality? In vain did I gaze over these vast walls of verdure, among the pendent creepers and bushy shrubs, all around the cascade, on the river's bank, or in the deep caverns and gloomy fissures; not one single spot of bright colour could be seen, not one single tree, or bush, or creeper bore a flower sufficiently conspicuous to form an object in the landscape. In every direction the eye rested on green foliage and mottled rock. There was infinite variety in the colour and aspect of the foliage, there was grandeur in the rocky masses and in the exuberant luxuriance of the vegetation, but there was no brilliancy of colour, none of those bright flowers and gorgeous masses of blossom so generally considered to be everywhere present in the tropics. I have here given an accurate sketch of a luxuriant tropical scene, as noted down on the spot; and its general characteristics as regards colour have been so often repeated, both in South America and over many thousand miles in the Eastern tropics, that I am driven to conclude that it represents the general aspect of nature in the equatorial (that is, the most tropical) parts of the tropical regions. How is it, then, that the descriptions of travellers generally give a very different idea? And where, it may be asked, are the glorious flowers that we know do exist in the tropics? These questions can be easily answered. The fine tropical flowering-plants cultivated in our hot-houses have been culled from the most varied regions, and therefore give a most erroneous idea of their abundance in any one region. Many of them are very rare, others extremely local, while a considerable number inhabit the more arid regions of Africa and India, in which tropical vegetation does not exhibit itself in its usual luxuriance. Fine and varied foliage, rather than gay flowers, is more characteristic of those parts where tropical vegetation attains its highest development, and in such districts each kind of flower seldom lasts in perfection more than a few weeks, or sometimes a few days. In every locality a lengthened residence will show an abundance of magnificent and gaily-blossomed plants; but they have to be sought for, and are rarely at any one time or place so abundant as to form a perceptible feature in the landscape. But it has been the custom of travellers to describe and group together all the fine plants they have met with during a long journey, and thus produce the effect of a gay and flower-painted landscape. They have rarely studied and described individual scenes where vegetation was most luxuriant and beautiful, and fairly stated what effect was produced in them by flowers. I have done so frequently, and the result of these examinations has convinced me that the bright colours of flowers have a much greater influence on the general aspect of nature in temperate than in tropical climates. During twelve years spent amid the grandest tropical vegetation, I have seen nothing comparable to the effect produced on our landscapes by gorse, broom, heather, wild hyacinths, hawthorns, purple orchises, and buttercups."—*Wallace*, "*The Malay Archipelago*," i. 371–373.

Page 346.—EARTHQUAKES.

On the vast and important subject of earthquake phenomena, the reader may consult the valuable works of Mallet, Daubeny, and Scrope. The bases on which the former proposes to construct his new science of Seismology require to be carefully examined. In the July number (1869) of *Blackwood's Magazine* a "New Theory of Earthquakes and Volcanoes" is propounded, and supported by some very ingenious reasons. The author denies the existence of the "central sea of fire or molten matter," which most physicists admit, and replaces it by a zone of electric action, close to the surface, and wholly independent of the internal condition of our planet, whatever that may be. The disturbances in this zone he considers to be the immediate causes of earthquakes, which he calls "the thunderstorms of earth;" and he also connects volcanoes with them as "the vents which the subterranean electric action makes for itself, or for its effects, in those regions or localities where it is strongest or most permanent."

He repeats, "the cause of earthquakes and volcanoes is the same; and the subterranean action which produces an earthquake will, if of greater intensity, produce a volcano over the centre of disturbance. The difference in the effects at the surface produced by subterranean convulsions depends upon three things—namely, (1.) the intensity of the convulsion; (2.) its depth or distance from the surface; and (3.) the greater or less resistance which the overlying strata present to the upward explosive movement. The nearer to the surface the focus of convulsion is, the more easily will a convulsion be formed."

Our author concludes:—"Our special object in this paper has been to show that such convulsions—typified by volcanic action and earthquakes—are not attributable to tidal or other commotions in a central molten mass, of which our planet is supposed to consist up to within a few miles of the surface, but to disturbances in the outer rim of earth's solid crust, occasioned by electric action and phenomena analogous to those which have their seat in the atmosphere, in the gaseous zone which surrounds earth's solid surface. But one word in conclusion. Whence come those disturbances? They cannot be produced by the Earth *per se*. Whatever be the condition of our globe, whether slowly cooling in space or not, such *changes* in its condition, frequently sudden and always *local*, must of necessity be ascribed to *extra-terrestrial influences*—to the cosmical action of the surrounding bodies in space. Ordinarily they are produced by the varying action of the sun, moon, and planets; but in their grander forms, as exemplified in the records of geology, these convulsions are doubtless due to the changing position of our whole solar system in space. Who can tell how far the grand geological changes may have been owing to the varying position of the sun and planets in regard to the world of the fixed stars, and the central sun around which our sun with his planets is ceaselessly and swiftly revolving? At present, and ever since the appearance of civilized man on earth, our solar system lies far remote from the thickest clusters of the fixed stars: we are but circling on the rim or edge of the great Plain of the Worlds, indicated by the shining depths of the Milky Way. But it may not, it cannot have been so always in the past; nor is it likely to be so always in the future of our planet. In truth, may we not ascribe to such extra-terrestrial influence one of the most striking features in the present aspect of our globe—namely, the great predominance of land in the northern hemisphere, where the continents appear to have been vastly increasing in extent in the most recent geological periods, while in the southern hemisphere land is not only rare, but over a large area appears to have been gradually sinking? Is it not possible, then, that the superior activity of the upheaving forces in our northern hemisphere, and the comparative absence of land in the southern hemisphere, is due to the greater cosmical influence exerted upon the former, which is turned to immense strata of stars and constellations; whereas in the southern skies there are vast spaces of darkness, where not a single starry world is visible?"

The reader may also be referred to an interesting article on volcanoes in the *North American Review*, July 1869.

Page 433.—Scenery of Java.

As a pendant to Michelet's brilliant description, the reader will not be displeased with the following:—

"All these features are imposing in their size and loftiness, and yet so delicately executed, so sharply chiselled or modelled, as it were, out of the earth, as at the same time to affect the mind with the solemnity of grandeur and the delight of beauty. But when these mountain steeps are clothed with endless woods of magnificent forest trees, having lofty stems and widely-branching heads, and every glen is crowded with stately palms, drooping and elegant tree-ferns, arching clusters of feathery bamboos, delicately-stemmed acacias, and broad-leaved plantains and bananas, all rising from piles and heaps of plants of lesser growth, ferns and creepers and succulent plants, with huge round-lobed or variously-shaped leaves; and when, among these luxuriant woods, or by the side of these falling waters, wind paths and alleys carpeted with short green turf, twining from dell to dell, as if searching for the loveliest spots, with a fresh cool breeze rustling the leaves above, and a deep blue sky shining over all, against which, here and there, some tall grassy peak starts up above the loftiest heights of wood, I do not believe that more exquisite scenery ever rose before the imagination, even in his youthful dreams. The eye of the gazer becomes satiated with every form of earthly loveliness, and to me, at least, the valleys among these mountains of Java have ever since been the very type of beauty, the remembrance of which will, I hope, dwell with me as long as I exist."—*J. Beete Jukes*, "*Narrative of Surveying Voyage of H. M. S. Fly*," vol. ii., pp. 124, 125.

Page 435.—Volcanoes of Java.

A recent traveller furnishes a graphic description of his exploration of the crater of the Manindyu volcano in Java:—

"Down and down we went, until at last I became quite discouraged, and seriously began to think of explaining to my native guide that the wisest heads which lived in my land believe that the centre of the earth is nothing but a mass of molten rock, and to inquire of him whether he was sure we should stop short of such an uncomfortable place. .... The crater is not circular, but composed of two circles of unequal diameter, which unite on one side. .... The width of the larger crater at the level of the lake, as given on the best maps I have been able to consult, is three geographical miles; that of the smaller crater, at the same level, two and a quarter miles; and the length of the lake, which lies in a northerly and southerly direction, and is approximately parallel to the great Barizan chain in which it is found, is no less than six geographical miles. Even the famous crater of the Yenger Mountains becomes of moderate dimensions when compared with this."—*Bickmore*, "*Travels in East Indian Archipelago*," pp. 399-401.

Page 545.—CATARACTS.

From Captain Burton's recent book of travel we borrow a graphic description of the great falls on the Rio São Francisco (Brazil), appropriately named Paulo Affonso, the King of the Rapids :—

"The walk," says Captain Burton, "leads to a table of jutting rock on the west side, where we cling to a dry tree-trunk, and peer, fascinated, into the 'hell of waters' boiling below.

"The Quebrada, or gorge, is here 260 feet deep, and in the narrowest part it is choked to a minimum breadth of fifty-one feet. It is filled with what seems not water, but the froth of milk, a dashing and dazzling, a whirling and churning surfaceless mass, which gives a wondrous study of fluid in motion. And the marvellous disorder is a well-directed anarchy; the course and sway, the wrestling and writhing, all tend to set free the prisoner from the prison walls. Ces eaux! Mais ce sont des âmes; it is the spectacle of a host rushing down in 'liquid vastness' to victory, the triumph of motion, of momentum over the immovable. Here the luminous whiteness of the chaotic foam-crests, hurled in billows and breakers against the blackness of the rock, is burst into flakes and spray, that leap half-way up the immuring trough. There the surface reflections dull the dazzling crystal to a thick opaque yellow, and there the shelter of some spur causes a momentary start and recoil to the column, which, at once gathering strength, bounds and springs onwards with a new crush and another roar. The heaped-up centre shows fugitive ovals and progressive circles of a yet more sparkling, glittering, dazzling light, divided by points of comparative repose, like the nodal lines of waves. They struggle and jostle, start asunder, and interlace as they dash with steadfast purpose adown the inclined plane. Now a fierce blast hunts away the thin spray-drift, and puffs it to leeward in rounded clouds, thus enhancing the brilliancy of the spectacle. Then the steam boils over and canopies the tremendous scene. Then, in the stilly air of dull warm gray, the mists surge up, deepening still more, by their veil of ever-ascending vapour, the dizzy fall that yawns under our feet.

"The general effect of the picture—and the same may be said of all great cataracts—is the 'realized' idea of power, of power tremendous, inexorable, irresistible. The eye is spell-bound by the contrast of this impetuous motion, this wrathful, maddened haste to escape, with the frail steadfastness of the bits of rainbow hovering above; with the 'Table Rock,' so solid to the tread, and with the placid, settled stillness of the plain and the hillocks, whose eternal homes seem to be here. The fancy is electrified by the aspect of this Durga of Nature, this evil working good, this life-in-death, this creation and construction by destruction. Even so the wasting storm and hurricane purify the air for life: thus the earthquake and the volcano, while surrounding themselves with ruins, rear up earth, and make it a habitation for higher beings.

"The narrowness of the chasm is narrowed to the glance by the tall abruptness, yet a well-cast stone goes but a short way across before it is neatly stopped by the wind. The guide declared that no one could throw further than three fathoms, and attributed the fact to enchantment. Magic, I may observe, is in the atmosphere of Paulo Affonso; it is the natural expression of the glory and majesty, the splendour and the glamour of the scene, which Greece would have peopled with shapes of beauty, and which in Germany would be haunted by choirs of flying sylphs and dancing undines. The hollow sound of the weight of whirling water makes it easier to see the lips move than to hear the voice. We looked in vain for the cause: of cataract we saw nothing but a small branch, the Cachoeira do Augiquinho—of the little Augico Acacia—so called from one of the rock islets. It is backed on the right bank by comparatively large trees, and by a patch of vividly green grass and shrubbery, the gift of the spray drifting before the eastern sea-breeze. This pretty gush of water certainly may not account for the muffled thunder which dulls our ears; presently we shall discover whence it comes.

"We will now apply ourselves to the prose of the Great Rapids.

"The name, as mostly happens in these regions, is a disputed point. Some make 'Paulo Affonso' a missionary-shepherd, who was hurled down the abyss by the wolves, his 'Red-skin' sheep. Others tell the story of a friar, who was canoeing along the river, when the Indian paddle-men cried, in terror, that they were being sucked into the jaws of the Catadupa: he bade them be of good cheer, and all descended whole. Similarly in the province of Sao Paulo, the Tiété river has a fierce Rapid, known as 'Araremaudoura'—Cachoeira do Padre, or the Rapid of the Priest. Here, according to Jesuit legend, Padre Michieta, one of the multitudinous thaumaturgi of the Brazil, was recovered from the water 'some hours afterwards, alive, and reading his breviary with a light in his hand.' More sober chronicles declare that the poor man was dragged out half-drowned. Others pretend that Paulo and Affonso were brothers, and the first settlers, who gave their names to the place. I would, however, observe, that on the right bank of the stream, opposite the Illia da Tapéra, one of the many that break the river immediately above the upper break, is a village of fishermen and cultivators, whose name, 'Tapéra de Paulo Affonso,' shows that it has occupied the site of a ruined settlement, probably made by the colonist who left his mark upon the Great Rapids near which he squatted. The 'Tapéristas' are still owners of the right bank; the left belongs to one Nicoláo Cotinguiba, of the Engelio do Pinho, and near 'Carahyba Camp' two properties meet. The Cachoeira is in the Frequezia of the Mata da Agua Brauca.

"The locale of the Paulo Affonso has been very exactly misrepresented by geographers who write geography for the people. This sudden break in the level of the bed, this division between the upper and lower São Francisco, is not formed by a prolongation of the Serra da Borborema, nor by the Chapada das Mangabeiras, nor by Thyapaba 'fim da terra,' nor by the Cairirys old or new, nor by the Terra da Borracha, alias Moribéca, so imminent in our maps. The humbler setting of the gem is a rolling plain brown with stone, scrub, and thicket, out of which rise detached blocks, as the Serra do Retiro, about three leagues to the north-west; and to the west the lumpy Serra do Padre. On the south-western horizon springs, sudden from the flat, a nameless but exceedingly picturesque rangelet of pyramidal hills and peaks, here and there bristling in bare rock, and connected by long blue lines of curtain.

"Though our prospect lacks the sublime and glorious natural beauty of Niagara, tempered by the hand of man, and though we find in Paulo Affonso none of the sapphire and emerald tints that charm the glance in the Horseshoe Falls, still it is original and peculiar. In 'geological' times the stream must have spread over the valley; even now, extraordinary floods cover a great portion of it. Presently the waters, finding a rock of softer texture and more liable to decay, hollowed out the actual 'Talhadão,' or great fissure, and deepened the glen in the course of ages. We have also here the greatest possible diversity of falling water; it consists, in fact, of a succession of rapids and caldrons, and a mighty Fall ending in the Mãi da Cachoeira; upon whose terrible tangle of foam we have just looked down. If Niagara be the monarch of cataracts, Paulo Affonso is assuredly a king of rapids; an English traveller who had seen the twain, agreed with me in giving the palm to the latter, as being the more singular and picturesque of the two, which are both so wondrous and so awful."—*Captain R. F. Burton*, "*The Highlands of the Brazil*," vol. ii., pp. 444–448.

Page 621.—A Coral Reef.

In further illustration of the text, we quote Mr. Jukes' vivid description of a coral reef:—

"In a small bight of the inner edge of this reef was a sheltered nook, where the extreme slope was well exposed, and where every coral was in full life and luxuriance. Smooth round masses of mæandrina and astræa were contrasted with the delicate leaf-like and cup-shaped expansions of explanaria, and with an infinite variety of branching madreporæ and seriatoporæ, some with mere finger-shaped projections, others with large branching stems, and others again exhibiting an elegant assemblage of interlacing twigs, of the most delicate and exquisite workmanship. Their colours were unrivalled—vivid greens, contrasting with more sober browns and yellows, mingled with rich shades of purple, from pale pink to deep blue. Bright red, yellow, and peach-coloured pulliporæ clothed those masses that were dead, mingled with beautiful pearly flakes of escharæ and retepora—the latter looking like lace-work in ivory. In among the branches of the corals, like birds among trees, floated many beautiful fish, radiant with metallic greens, or crimsons, or fantastically banded with black and yellow stripes. Patches of clear white sand were seen here and there for the floor, with dark hollows and recesses beneath overhanging masses and ledges. All these, seen through the clear crystal water, the ripple of which gave motion and quick play of light and shadow to the whole, formed a scene of the rarest beauty, and left nothing to be desired by the eye, either in elegance of form or brilliancy and harmony of colouring."—*J. Beete Jukes*, "*Narrative of the Surveying Voyage of H. M. S. Fly*," vol. i., pp. 117, 118.

Page 623.—Formation of Coral Islands.

Mrs. Somerville's account of the development of coral-building in the ocean is as follows:—

"Four distinctly different formations are due to the coral-building polypes in the

Pacific and Indian Oceans—namely, lagoon-islands or atolls, encircling reefs, barrier reefs, and coral fringes, all nearly confined to the torrid zone.

"An *atoll* is a ring or chaplet of coral, enclosing a lagoon, or portion of the ocean, in its centre. The average breadth of that part of the ring which rises above the surface of the sea is about a quarter of a mile, often less, and it is seldom more than from six to ten or twelve feet above the waves; hence the lagoon-islands are not visible even at a very small distance, unless when they are covered by the cocoa-nut palm, or the pandanus, which is frequently the case. On the outside, the ring or circlet shelves down for a distance of one or two hundred yards from its edge, so that the sea gradually deepens to about twenty-five fathoms, beyond which the sides of the ring plunge at once into the unfathomable depths of the ocean, with a more rapid descent than the cone of any volcano. Even at the small distance of some hundred yards, no bottom has been reached with a sounding-line a mile and a half long. All the coral in the exterior of the ring, to a moderate depth below the surface of the water, is alive; all above it is dead, being the detritus of the living part washed up by the surf, which is so heavy on the windward side of the tropical islands of the Pacific and Indian Oceans, that it is often heard miles off, and is frequently the first warning to seamen of their approach to an atoll.

"The outer margins of the Maldive atolls, consisting chiefly of nullipores and porites, are beat by a surf so tremendous, that even ships have been thrown by a single heave of the sea high and dry on the reef. The waves give innate vigour to the polypes by bringing an ever-renewed supply of food to nourish them, and oxygen to aërate their juices; besides, uncommon energy is given and maintained by the heat of a tropical sun, which gives them power to abstract enormous quantities of solid matter from the water to build their stony homes—a power that is efficient in proportion to the energy of the breakers which furnish the supply.

"On the margin of the atolls, close within the line where the coral is washed by the tide, three species of nullipores flourish; they are beautiful little plants, very common in the coral islands. One species grows in thin spreading sheets, like a lichen; the second in strong knobs as thick as a man's finger, radiating from a common centre; and the third species, which has the colour of peach blossom, is a reticulated mass of stiff branches about the thickness of a crow's quill. The three species either grow mixed or separately, and, although they can exist above the line of the corals, they require to be bathed the greater part of each tide; hence a layer two or three feet thick, and about twenty yards broad, formed by the growth of the nullipores, fringes the circlet of the atolls and protects the coral below.

"The lagoon in the centre of these islands is supplied with water from the exterior by openings in the lee-side of the ring, but as the water has been deprived of the greater part of its nutritious particles and inorganic matter by the corals on the outside, the hardier kinds are no longer produced, and species of more delicate forms take their place. The depth of the lagoon varies from fifty to twenty fathoms, or less, the bottom being partly detritus, partly live coral. In these calm limpid waters the corals are of the most varied and delicate structures, of the most charming and dazzling hues. When the shades of evening come on, the lagoon shines like the Milky Way with myriads of brilliant sparks. The microscopic medusæ and crustaceans, invisible by day, form the beauty of the night; and the sea-feather, vermilion by daylight, now waves with green phosphorescent light. This gorgeous character of the sea-bed is not peculiar to the lagoons of the atolls; it prevails in shallow water throughout the whole coral-bearing regions of the Pacific and Indian Oceans.

"Encircling reefs differ in no respect from the atoll ring, except in having islands in their lagoons, surrounded also by coral reefs. Barrier reefs are of the same structure as the atoll rings, from which they only differ in their position with regard to land. They form extensive lines along the coast, from which they are separated by a channel of the sea of variable depth and breadth, sometimes large enough for ships to pass. A very long one runs parallel to the west coast of New Caledonia, and stretches for 120 miles beyond the extremity of the island. But a barrier reef off the north-eastern coast of the Australian continent is the grandest coral formation existing. Rising at once from an unfathomable depth of ocean, it extends for 1000 miles along the coast, with a breadth varying from 200 yards to a mile, and at an average distance of from 20 to 60 or 70 miles from the coast, the depth of the channel being from 10 to 60 fathoms. The pulse of the ocean, transcendently sublime, beats perpetually in peals of thunder along that stupendous reef, the fabric of almost microscopic beings."—*Mrs. Somerville*, "*Molecular and Microscopic Science*" (London, 1869), ii. 143, *et seq.*

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