

frozen into it. In order to understand in what manner long and straight grooves may be cut by such agency, we must remember that these floating islands of ice have a singular steadiness of motion, in consequence of the larger portion of their bulk being sunk deep under water, so that they are not perceptibly moved by the winds and waves even in the strongest gales. Many had supposed that the magnitude commonly attributed to icebergs by unscientific navigators was exaggerated, but now it appears that the popular estimate of their dimensions has rather fallen within than beyond the truth. Many of them, carefully measured by the officers of the French exploring expedition of the *Astrolabe*, were between 100 and 225 feet high above water, and from 2 to 5 miles in length. Captain d'Urville ascertained one of them which he saw floating in the Southern Ocean to be 13 miles long and 100 feet high, with walls perfectly vertical. The submerged portions of such islands must, according to the weight of ice relatively to sea-water, be from six to eight times more considerable than the part which is visible, so that the mechanical power they might exert when fairly set in motion must be prodigious.* A large proportion of these floating masses of ice is supposed not to be derived from terrestrial glaciers,† but to be formed at the foot of cliffs by the drifting of snow from the land over the frozen surface of the sea.

We know that in Switzerland, when glaciers laden with mud and stones melt away at their lower extremity before reaching the sea, they leave wherever they terminate a confused heap of unstratified rubbish, called "a moraine," composed of mud, sand, and pieces of all the rocks with which they were loaded. We may expect, therefore, to find a formation of the same kind, resulting from the liquefaction of icebergs, in tranquil water. But, should the action of a current intervene at certain points or at certain seasons, then the materials will be sorted as they fall, and arranged in layers according to their relative weight and size. Hence there will be passages from *till*, as it is called in Scotland, to stratified clay, gravel, and sand, and intercalations of one in the other.

I have yet to mention another appearance connected with the boulder formation, which has justly attracted much attention in Norway and other parts of Europe. Abrupt pinnacles and outstanding ridges of rock are often observed to be polished and furrowed on the north side, or on the side facing the region from which the erratics have come; while, on the other, which is usually steeper and often perpendicular, called the "lee-side," such superficial markings are wanting. There is usually a collection on this lee-side of boulders and gravel, or of large angular fragments. In explanation we may suppose that the north side was exposed, when still submerged, to the action of icebergs, and afterwards, when the land was upheaved, of coast-ice which ran aground upon shoals, or was *packed* on the beach; so that there would be great wear and tear on the seaward slope, while, on the other, gravel and boulders might be heaped up in a sheltered position.

Northern origin of erratics.—That the erratics of northern Europe

* T. L. Hayes, Boston Journ. Nat. Hist. 1844.

† Principles, ch. xv.