

eruption. The hot waters are in constant ebullition and have their intermittent jets. Besides escaping steam, there is some carbonic acid given out, and siliceous deposits are made from the hot waters. Geysers occur also on the island of Celebes, in the volcanic region on its northeastern extremity in the district of Manado.

IV. METAMORPHISM.

Metamorphism signifies change: not merely change in form, as might be inferred from the composition of the word, but also, like the corresponding word metamorphosis, change in nature or constitution. In geology, it is change in texture, crystalline structure, or mineral constitution; as when a common limestone becomes crystallized, and thereby converted into statuary marble, or a sandstone into gneiss or granite, or an augitic rock into a hornblende rock, or a massive rock into a laminated or foliated kind.

The terms *metamorphic* and *metamorphism* were proposed by Lyell in the first edition of his *Principles of Geology* (1831-1833) with reference to altered rocks of both local and regional extent.

In Vol. III. he says, on page 372: "It appears from sections described by Hugi, that some of the secondary beds of limestone and slate, which are overlaid by granite, have been altered into gneiss and mica schist. These altered sedimentary formations are supposed by M. Élie de Beaumont to be of the age of the Lias of England, and others to be even as modern as the Jurassic or Oölytic formations." On page 373 he says: "According to these views, gneiss and mica schist may be nothing more than micaceous and argillaceous sandstones altered by heat, and certainly in their mode of stratification and lamination, they correspond most exactly."

"Granular quartz may have been derived from siliceous sandstone; clay slate may be altered shale, and shale appears to be clay which has been subjected to great pressure." "Granular marble has originated in the form of ordinary marble, having in many instances been replete with shells and corals now obliterated." In the edition of 1842, he speaks of fossiliferous formations, some of them of the age of the Silurian strata, as near Christiania in Norway, others belonging to the Oölytic period, as around Carrara in Italy, which had been converted partially into gneiss and mica schist and statuary marble. Among *local* changes he mentions the case of the basalt dike in Anglesea, 134 feet wide, cutting through strata of shale and limestone which were altered for 30 feet from the dike, "having the shale in several places converted into hard porcelaneous jasper, in the hardest parts of which the fossil shells, principally *Productæ*, were nearly obliterated"; "and the argillaceous limestone had lost its earthy texture and become granular and crystalline." Through investigation since, such facts, both of *regional* and *local* origin, have been greatly multiplied.

The Taconic region, on the borders of New York and New England, affords a good illustration. The rocks are least crystalline in the northern and the western parts of the region, and consequently *fossils* were to be looked for in those parts. They have been found in Vermont down to