PHYSICAL GEOGRAPHY.

CHAPTER I.

GEOLOGY.

THE change produced in the civilized world within a few years, by the application of the powers of nature to locomotion, is so astonishing, that it leads to a consideration of the influence of man on the material world, his relation with regard to animate and inanimate beings, and the causes which have had the greatest effect on the physical, moral, and intellectual condition of the human race.

The former state of our terrestrial habitation, the successive convulsions which have ultimately led to its present geographical arrangement, and to the actual distribution of land and water, so powerfully influential on the destinies of mankind, are circumstances of primary importance.

The position of the earth with regard to the sun, its connexion with the bodies of the solar system, together with its size and form, have been noticed by the author elsewhere. It was there shown that our globe forms but an atom in the immensity of space, utterly invisible from the nearest fixed star, and scarcely a telescopic object to the remote planets

of our own system. The increase of temperature with the depth below the surface of the earth, and the tremendous desolation hurled over wide regions by numerous fire-breathing mountains, show that man is removed but a few miles from immense lakes or seas of liquid fire. The very shell on which he stands is unstable under his feet, not only from those temporary convulsions that seem to shake the globe to its centre, but from a slow almost imperceptible elevation in some places, and an equally gentle subsidence in others, as if the internal molten matter were subject to secular tides, now heaving and now ebbing, or that the subjacent rocks were in one place expanded and in another contracted by changes of temperature.

The earthquake and the torrent, the august and terrible ministers of Almighty power, have torn the solid earth and opened the seals of the most ancient records of creation, written in indelible characters on "the perpetual hills, and the everlasting mountains." There we read of the changes that have brought the rude mass to its present fair state, and of the myriads of beings that have appeared on this mortal stage, have fulfilled their destinies, and have been swept from existence to make way for new races which, in their turn, have vanished from the scene till the creation of man completed the glorious work. Who shall define the periods of those mornings and evenings when God saw that his work was good? and who shall declare the time allotted to the human race, when the generations of the most insig-

nificant insect existed for unnumbered ages? Yet man is also to vanish in the ever-changing course of events. The earth is to be burnt up, and the elements are to melt with fervent heat—to be again reduced to chaos—possibly to be renovated and adorned for other races of beings. These stupendous changes may be but cycles in those great laws of the universe, where all is variable but the laws themselves and He who has ordained them.

The earth consists of a great variety of substances, some of which occur in amorphous masses, others are disposed in regular layers or strata, either horizontal or inclined at all angles to the horizon. By mining, man has penetrated only a very little way, but by reasoning from the dip or inclination of the strata at or near the surface, and from other circumstances, he has obtained a pretty accurate idea of the structure of our globe to the depth of about ten miles. All the substances of which we have any information are divided into four classes, distinguished by the manner in which they have been formed, namely—Plutonic and Volcanic rocks, both of igneous origin, though produced under different circumstances; Aqueous or Stratified rocks, entirely due to the action of water, as the name implies; and Metamorphic rocks, deposited also by water, according to the opinion of many eminent geologists, and consequently stratified, but subsequently altered and crystallized by heat. The Aqueous and Volcanic rocks are formed at the surface of the earth, the Plutonic and Metamorphic at great depths, but all

of them have originated simultaneously during every geological period, and are now in a state of slow and constant progress. The antagonist principles of fire and water have ever been and still are the cause of the perpetual vicissitudes to which the crust of the earth is liable.

It has been ascertained by observation that the Plutonic rocks, consisting of the granites and some of the porphyries, were formed in the deep and fiery caverns of the earth, of melted matter, which crystallized as it slowly cooled under enormous pressure, and was then heaved in unstratified masses by the elastic force of the internal heat even to the tops of the highest mountains, or forced in a semifluid state into fissures of the superincumbent strata, sometimes into the cracks of previously formed granite; for that rock, which constitutes the base of so large a portion of the earth's crust, has not been all formed at once; some portions had been solid while others were yet in a liquid state. This class of rocks is completely destitute of fossil remains.

Although granite and the volcanic rocks are both due to the action of fire, their nature and position are very different: granite, fused in the interior of the earth, has been cooled and consolidated before coming to the surface; besides, it generally consists of few ingredients, so that it has nearly the same character in all countries. But as the volcanic fire rises to the very surface of the earth, fusing whatever it meets with, volcanic rocks take various forms, not only from the different kinds of strata which are melted,

but from the different conditions under which the liquid matter has been cooled, though most frequently on the surface—a circumstance that seems to have had the greatest effect on its appearance and structure. Sometimes it approaches so nearly to granite that it is difficult to perceive a distinction; at other times it becomes glass: in short, all those massive, unstratified, and occasionally columnar rocks, as basalt, greenstone, porphyry, and serpentine, are due to volcanic fires, and are devoid of fossil remains.

There seems scarcely to have been any age of the world in which volcanic eruptions have not taken place in some part of the globe. Lava has pierced through every description of rocks, spread over the surface of those existing at the time, filled their crevices, and flowed between their strata. Ever changing its place of action, it has burst out at the bottom of the sea as well as on dry land. Enormous quantities of scoriæ and ashes have been ejected from numberless craters, and have formed extensive deposits in the sea, in lakes, and on the land, in which are imbedded the remains of the animals and vegetables of the epoch. Some of these deposits have become hard rock, others remain in a crumbling state; and as they alternate with the aqueous strata of almost every period, they contain the fossils of all the geological epochs, chiefly fresh and salt water testaceæ.

According to a theory now generally adopted, which originated with Mr. Lyell, whose works

are models of philosophical investigation, the metamorphic rocks, which consist of gneiss, mica-schist, clay-slate, statuary marble, &c., were formed of the sediment of water in regular layers, differing in kind and colour, but, having been deposited near the places where plutonic rocks were generated, they have been changed by the heat transmitted from the fused matter, and in cooling under heavy pressure and at great depths they have become as highly crystallized as the granite itself, without losing their stratified form. An earthy stratum has sometimes been changed into a highly crystallized rock to the distance of a quarter of a mile from the point of contact by transmitted heat, and there are instances of dark-coloured limestone full of fossil shells, that has been changed into statuary marble from that cause. Such alterations may frequently be seen to a small extent in rocks adjacent to a stream of lava. There is not a trace of organic remains in the metamorphic rocks; their strata are sometimes horizontal, but they are usually tilted at all angles to the horizon, and form some of the highest mountains and most extensive table-lands on the face of the globe. Although there is the greatest similarity in the plutonic rocks in all parts of the world, they are by no means identical; they differ in colour, and even in ingredients, though these are few.

Aqueous rocks are all stratified, being the sedimentary deposits of water. They originate in the wear of the land by rain, streams, or the ocean. The débris carried by running water is deposited at the

bottom of the seas and lakes, where it is consolidated, and then raised up by subterraneous forces, again to undergo the same process after a lapse of time. By the washing away of the land the lower rocks are laid bare, and, as the materials are deposited in different places according to their weight, the strata are exceedingly varied, but consist chiefly of arenaceous or sandstone rocks, argillaceous or clayey rocks, and of calcareous rocks composed of sand, clay, and carbonate of lime. They constitute three great classes, which, in an ascending order, are the primary and secondary fossiliferous strata, and the Tertiary formations.

The primary fossiliferous strata, the most ancient of all the sedimentary rocks, consisting of limestone, sandstones, and shales, are entirely of marine origin, having been formed far from land at the bottom of a very deep ocean; consequently they contain the exuviæ of marine animals only, and after the lapse of unnumbered ages the ripple marks of the waves are still distinctly visible on some of their strata. This series of rocks is subdivided into the Cambrian and the upper and lower Silurian systems, on account of differences in their fossil remains.

The Cambrian rocks, sometimes many thousand yards thick, are for the most part destitute of organic remains, but the Silurian rocks abound in them more and more as the strata lie higher in the series. In the lower Silurian group are the remains of shell-fish, almost all of extinct genera, and the few that have any affinity to those alive are of extinct species;

Crinoidea, or stone-lilies, which had been fixed to the rocks like tulips on their stems, are coëval with the earliest inhabitants of the deep; and the trilobite, a jointed creature of the crab kind, with prominent eyes, are almost exclusively confined to the Silurian strata, but the last traces of them are found in the coal-measures above. In the upper Silurian group are abundance of marine shells of almost every order, together with Crinoidea, vast quantities of corals, and some sea-weeds: several fossil sauroid fish, of extinct genera, but high organization, have been found in the highest beds—the only vertebrated animal that has yet been discovered among the countless profusion of the lower orders of creatures that are entombed in the primary fossiliferous strata. The remains of one or more land-plants, in a very imperfect state, have been found in the Silurian rocks of North America, which shows that there had been land with vegetation at that early period. The type of these plants, as well as the size of the shells and the quantity of the coral, indicate that a uniformly warm temperature had then prevailed over the globe. During the Silurian period an ocean covered the northern hemisphere, islands and lands of moderate size had just begun to rise, and earthquakes with volcanic eruptions, from insular and submarine volcanos, were frequent towards its close.

The secondary fossiliferous strata, which comprise a great geological period, and constitute the principal part of the high land in Europe, were deposited at the bottom of an ocean, like the primary, from the

débris of all the others carried down by water, and still bear innumerable tokens of their marine origin, although they have for ages formed part of the dry land. Calcareous rocks are more abundant in these strata than in the crystalline, probably because the carbonic acid was then, as it still is, driven off from the lower strata by the internal heat, and came to the surface as gas or in calcareous springs, which either rose in the sea, and furnished materials for shell-fish and coral insects to build their habitations and form coral reefs, or deposited their calcareous matter on the land in the form of rocks.

The Devonian or old red sandstone group, in many places ten thousand feet thick, consisting of strata of dark red and other sandstones, marls, coral-line limestones, conglomerates, &c., is the lowest of the secondary fossiliferous strata, and forms a link between them and the Silurian rocks by an analogy in their fossil remains. It has fossils peculiarly its own, but it has also some shells and corals common to the strata both above and below it. There are various families of extinct sauroid fish in this group, some of which were gigantic, others had strong bony shields on their heads, and one genus, covered with enamelled scales, had appendages like wings. The shark approaches nearer to some of these ancient fish than any other now living.

During the long period of perfect tranquillity that prevailed after the Devonian group was deposited, a very warm, moist, and extremely equable climate, which extended all over the globe, had clothed the

islands and lands in the ocean then covering the northern hemisphere with exuberant tropical forests and jungles. Subsequent inroads of fresh water or of the sea, or rather partial sinkings of the land, had submerged these forests and jungles, which, being mixed with layers of sand and mud, had in time been consolidated into one mass, and were then either left dry by the retreat of the waters, or gently raised above their surface.

These constitute the remarkable group of the carboniferous strata, which consists of numberless layers of various substances filled with a prodigious quantity of the remains of fossil land-plants, intermixed with beds of coal, which is entirely composed of vegetable matter. In some cases the plants appear to have been carried down by floods and deposited in estuaries, but in most instances the beauty, delicacy, and sharpness of the impressions show that they had grown on the spot where the coal was formed. More than three hundred fossil plants have been collected from the shale where they abound, frequently with their seeds and fruits, so that enough remains to show the peculiar nature of this flora, whose distinguishing feature was the preponderance of ferns: among these there were tree-ferns which must have been forty or fifty feet high. There were also plants resembling the horse-tail tribe, of gigantic size; others like the tropical club mosses: an aquatic plant of an extinct family was very abundant, beside many others to which we have nothing analogous. Forest-trees of great magnitude, of the pine and fir tribes, flourished at