THE EARTH FORMED—ERA OF THE PRIMARY ROCKS.

Although the earth has not been actually penetrated to a greater depth than three thousand feet, the nature of its substance can, in many instances, be inferred for the depth of many miles by other means of observation. We see a mountain composed of a particular substance, with strata, or beds of other rock, lying against its sloped sides; we, of course, infer that the substance of the mountain dips away under the strata which we see lying against it. Suppose that we walk away from the mountain across the turned up edges of the stratified rocks, and that for many miles we continue to pass over other stratified rocks, all disposed in the same way, till by and bye we come to a place where we begin to cross the opposite edges of the same beds; after which we pass over these rocks all in reverse order till we come to another extensive mountain composed of similar material to the first, and shelving away under the strata in the same way. We should then infer that the stratified rocks occupied a basin formed by the rock of these two mountains, and by calculating the thickness right through these strata, could be able to say to what depth the rock of the mountain extended below. By such means, the kind of rock existing many miles below the surface can often be inferred with considerable confidence.

The interior of the globe has now been inspected in this way in many places, and a tolerably distinct notion of its general arrangements has consequently been arrived at. It appears that the basis rock of the earth, as it may be called, is of hard texture, and crystalline in its constitution. Of this rock, granite may be said to be the type, though it runs into many varieties. Over this, except in the comparatively few places where it projects above the general level in mountains, other rocks are disposed in sheets or strata, with the appearance of having been deposited originally from water; but these last rocks have nowhere been allowed to rest in their original arrangement.

Uneasy movements from below have broken them up in great inclined masses, while in many cases there has been projected through the rents rocky matter more or less resembling the great inferior crystalline mass. This rocky matter must have been in a state of fusion from heat at the time of its projection, for it is often found to have run into and filled up lateral chinks in these rents. There are even instances where it has been rent again, and a newer melted matter of the same character sent through the opening. Finally, in the crust as thus arranged there are, in many places, chinks containing veins of metal. Thus, there is first a great inferior mass, composed of crystalline rock, and probably resting immediately on the fused and expanded matter of the interior: next, layers or strata of aqueous origin; next, irregular masses of melted inferior rock that have been sent up volcanically and confusedly at various times amongst the aqueous rocks, breaking up these into masses, and tossing them out of their original levels. This is an outline of the arrangements of the crust of the earth, as far as we can observe it. It is, at first sight, a most confused scene; but after some careful observation, we readily detect in it a regularity and order from which much instruction in the history of our globe is to be derived.

The deposition of the aqueous rocks, and the projection of the volcanic, have unquestionably taken place since the settlement of the earth in its present form. They are indeed of an order of events which we see going on, under the agency of more or less intelligible causes, even down to the present day. We may therefore consider them generally as comparatively recent transactions. Abstracting them from the investigations before us, we arrive at the idea of the earth in its first condition as a globe of its present size—namely, as a mass, externally at least, consisting of the crystalline kind of rock, with the waters of the present seas and the present atmosphere around it, though these were probably in considerably different conditions, both as to temperature and their constituent materials, from what they now are. We are thus to presume that that crystalline texture of roek which we see exemplified in granite is the condition into which the great bulk of the solids of our earth were agglomerated directly from the nebulous or vaporiform state. It is a condition eminently of combination, for such rock is invariably composed of two or more of four substances—silica, mica, quartz, and hornblende—which associate in it in the form of grains or crystals, and which are themselves each composed of a group of the simple or elementary substances.

Judging from the results and from still remaining conditions, we must suppose that the heat retained in the interior of the globe was more intense, or had greater freedom to act, in some places than in others. These became the scenes of volcanic operations, and in time marked their situations by the extrusion of traps and basalts from below—namely, rocks composed of the crystalline matter fused by intense heat, and developed on the surface in various conditions, according to the particular circumstances under which it was sent up; some, for example, being thrown up under water, and some in the open air, which conditions are found to have made considerable difference in its texture and appearance. The great stores of subterranean heat also served an important purpose in the formation of the aqueous rocks. These rocks might, according to Sir John Herschel, become subject to heat in the following manner:—While the surface of a particular mass of rock forms the bed of the sea, the heat is kept at a certain distance from that surface by the contact of the water; philosophically speaking, it radiates away the heat into the sea, and (to resort to common language) is cooled a good way down. But when new sediment settles at the bottom of that sea, the heat rises up to what was formerly the surface; and when a second quantity of sediment is laid down, it continues to rise through the first of the deposits, which then becomes subjected to those changes which heat is calculated to produce. This process is precisely the same as that of putting additional coats upon our own bodies; when, of course, the internal heat rises through each coat in succession, and the third (supposing there is a fourth above it) becomes as warm as perhaps the first originally was.

In speaking of sedimentary rocks, we may be said to be anticipating. It is necessary, first, to shew how such rocks were formed, or how stratification commenced.

Geology tells us as plainly as possible, that the original crystalline mass was not a perfectly smooth ball, with air and water playing round it. There were vast irregularities in the surface,—irregularities trifling, perhaps, compared with the whole bulk of the globe, but assuredly vast in comparison with any which now exist upon it.

These irregularities might be occasioned by inequalities in the cooling of the substance, or by accidental and local sluggishness of the materials, or by local effects of the concentrated internal heat. From whatever cause they arose, there they were—enormous granitic mountains, interspersed with seas which sunk to a depth equally profound, and by which, perhaps, the mountains were wholly or partially covered. Now, it is a fact of which the very first principles of geology assure us, that the solids of the globe cannot for a moment be exposed to water, or to the atmosphere, without becoming liable to change. They instantly begin to wear down. This operation, we may be assured, proceeded with as much certainty in the earliest ages of our earth's history, as it does now, but upon a much more magnificent scale. There is the clearest evidence that the seas of those days were not in some instances less than a hundred miles in depth, however much more. The subaqueous mountains must necessarily have been of at least equal magnitude. The system of disintegration consequent upon such conditions would be enormous. The matters worn off, being carried into the neighbouring depths, and there deposited, became the components of the earliest stratified rocks, the first series of which is the *Gneiss and Mica Slate System*, or series, examples of which are exposed to view in the Highlands of Scotland and in the West of England. The vast thickness of these beds, in some instances, is what attests the profoundness of the primeval oceans in which they were formed; the Pensylvanian grawacke, a member of the next highest series, is not less than a hundred miles in direct thickness. We have also evidence that the earliest strata were formed in the presence of a stronger degree of heat than what operated in subsequent stages of the world, for the laminæ of the gneiss and of the mica and chlorite schists are contorted in a way which could only be the result of a very high temperature. It appears as if the seas in which these deposits were formed, had been in the troubled state of a caldron of water nearly at boiling heat. Such a condition would probably add not a little to the disintegrating power of the ocean.

The earliest stratified rocks contain no matters which are not to be found in the primitive granite. They are the same in material, but only changed into new forms and combinations; hence they have been called by Mr. Lyell, metamorphic rocks. But how comes it that some of them are composed almost exclusively of one of the materials ot granite; the mica schists, for example, of mica—the quartz rocks, of quartz, &c.? For this there are both chemical and mechanical causes. Suppose that a river has a certain quantity of material to carry down, it is evident that it will soonest drop the larger particles, and carry the lightest farthest on. To such a cause is it owing that some of the materials of the worn-down granite have settled in one place and some in another.* Again, some of these materials must be presumed to have been in a state of chemical solution in the primeval seas. It would be, of course, in conformity with chemical laws, that certain of these materials would be precipitated singly, or in modified combinations, to the bottom, so as to form rocks by themselves.

The rocks hitherto spoken of contain none of those petrified remains of vegetables and animals which abound so much in subsequently formed rocks, and tell so wondrous a tale of the past history of our globe. They simply contain, as has been said, mineral materials derived from the primitive mass, and which appear to have been formed into strata in seas of vast depth. The

* Delabeche's Geological Researches.

absence from these rocks of all traces of vegetable and animal life, joined to a consideration of the excessive temperature which seems to have prevailed in their epoch, has led to the inference that no plants or animals of any kind then existed. A few geologists have indeed endeavoured to shew that the absence of organic remains is no proof of the globe having been then unfruitful or uninhabited, as the heat to which these rocks have been subjected at the time of their solidification, might have obliterated any remains of either plants or animals which were included in them. But this is only an hypothesis of negation; and it certainly seems very unlikely that a degree of heat sufficient to obliterate the remains of plants or animals when dead, would ever allow of their coming into or continuing in existence.