An introduction to geology, illustrative of the general structure of the earth

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London, 1813

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Persistent Link: https://doi.org/10.3931/e-rara-9794

Outlines of geology. Introduction.

OUTLINES OF GEOLOGY.

INTRODUCTION.

The objects of the science denominated Geology.—The shape of the earth and the other planets affected by the respective velocities of their rotary motion.—Density of the earth.—Theoretical division of rocks and mountains into primary, intermediate, and secondary.—Arrangement of the mineral districts of England.—The present continents once covered by the ocean: existing proofs of this in England, Spain, South America, and various parts of the world.—Fossil remains of shellfish and zoophytes imbedded in rocks, sometimes intermixed with those of quadrupeds.—Inferences respecting the former condition of the globe.

WHEN we survey the globe we inhabit, where the solid parts of the surface are not covered by soil or loose materials, we observe rude masses of stone or rock lying in confusion upon each other; or should we perceive some regularity in their position extending

over a limited district, we soon lose sight of it again by the intervention of other rocks. In this department of nature, all appears vast, unshapen, and chaotic, and the exquisite skill which is displayed in the organization of the minutest animal or vegetable eludes our observation when we examine the solid pavement of our planet.

In other parts of the universe also, the first view presents us with the same apparent want of order and design. The shepherd who discovered that the planets were not fixed in the heavens, could observe them wandering backwards and forwards amongst the stars; but it was impossible for him to trace any regularity in their courses, much less could he perceive the harmonious simplicity of their movements which subsequent discoveries have demonstrated. Let us not then hastily conclude that the mineral kingdom is composed of a chaotic mass of rocks and stones extending without any order to an indefinite depth, but let us more wisely endeavour to ascertain the means by which we may acquire better information. Were these means bounded by the

the power of man to penetrate the surface of the earth, our knowledge of it must be very limited and imperfect; but natural operations have greatly facilitated our inquiries, and in various situations have raised up or laid bare a considerable depth of the solid covering of the globe.

The knowledge of the structure, composition, and arrangement of the materials which form mountains, rocks, or strata, constitutes the first part of the science called geology. In the second part, we may include the direction, structure, and extent of the mineral dykes and metallic veins by which they are intersected. In the third part, the changes which are taking place on the surface of the globe by the agency of inundations, earthquakes, and volcanoes. There is a fourth part which may be styled speculative geology, or an investigation of the causes that have probably operated in the formation of rocks and mountains, and also those by which the revolutions of the earth's surface have been subsequently effected. Nor is this part, as some assert, entirely useless; the advocates of particular

systems have engaged in an active examination of nature to support their opinions, and have "compassed sea and land to gain proselytes:" thus numerous facts have been discovered, with which we should not have been acquainted had they remained idle in their studies. It may, however, be doubted whether they have not sometimes been insensibly induced to close their eyes on other facts that opposed their favourite theories.

The earth is now well known to be one of those globular bodies called planets, that revolve round the sun in orbits nearly circular, and in stated periods of time which bear a certain ratio to their respective distances from it. They turn round their axes with different degrees of velocity, and this motion appears to have had considerable influence on their external shape by enlarging their equatorial diameters.

In the planet Jupiter, the velocity of the equatorial parts is more than 400 miles per minute, whilst in the same time the equatorial parts of the earth have moved only 17 miles. A difference between the polar and equatorial

rial diameter of Jupiter is perceptible with a telescope that has a distinct magnifying power of 100 times, and it is ascertained to be as 12 to 13. The equatorial diameter of the earth exceeds its polar 37 miles, or is only as 230 to 229.

The relative density of the sun, the earth, and of the other planets, is estimated by the attractive force which they exert on each other as they move round their common centre of gravity. The absolute density or the quantity of matter contained in the earth, compared with an equal bulk of any known substance, may be nearly determined by the attractive force which any given mass of matter exerts upon a plummet (when suspended in its vicinity) to draw it from a vertical line. This will be proportional to the absolute quantity of matter in that mass compared with that of the earth. By this method, it has been found that the mean density of the earth compared with that of an equal bulk of water is as five to one, which is nearly twice the weight of most of the rocks and stones on its surface.

Hence it may be inferred that the interior part of the earth is solid; or, if it be cavernous, the solid matter must possess great density. It is not improbable that iron nearly in a metallic state may be one of the constituent parts of the central mass, and to this it may owe its magnetic polarity.

Dr. Halley has written a very ingenious paper (in the Philosophical Transactions) to prove that the earth is a hollow sphere, in which there is inclosed a central magnetic globe, and by the motions of this globe the variations of the magnetic needle are produced. It is evident that we have no means of verifying or invalidating hypotheses respecting the nature of the central parts of the globe. The matter thrown up from vast and unknown depths by subterranean fires is similar to that of many rocks on the surface; but we know not what changes it has undergone, or what substances were separated from it by fusion.

The rocks and mountains composing the solid parts of the earth's surface have been divided into different classes by geologists; nor

nor are the divisions altogether abitrary. Certain mineral productions, as metallic ores and coal, are confined to certain rocks, in some of which they frequently occur, in others they are never found. There are also distinct characters peculiar to each class.

The names which the classes have received are not free from the objection of being founded on hypothetical principles; but as they have been generally adopted, it may be proper to retain them in a restricted sense, without any reference to theory, particularly as those who are entering on the study of geology will find these names in constant use in every work relating to the science, and in the books of many modern travellers. These divisions include *primary rocks*, *intermediate* or *transition rocks*, *secondary rocks*, *alluvial ground*, and *volcanic products*.

Primary rocks have been so called because no organic remains have been found in them: hence it is supposed they were formed prior to the creation of animals or vegetables. They are extremely hard, and the substances of which they are composed are crystallized.

They form the lowest part of the earth's surface with which we are acquainted; and they not only constitute the foundation on which the other rocks rest, but in many situations they pierce through the incumbent rocks and strata, and form also the highest mountains in alpine districts. We are not to conclude, when we see a mountain or range of mountains bounded by a plain, that they terminate at their apparent bases. On the contrary, they dip under the surface at angles more or less inclined, stretching below the lower grounds and lesser hills, and often rise again in remote districts.

That primary rocks environ the whole globe will not admit of direct proof; but, from their frequent occurrence in mountainous districts in the most distant parts of the world that have been examined, we may infer that some of the rocks of this class constitute the foundation rock of every country. We have no means of ascertaining that the similar rocks of distant districts were formed at the same time, nor can we be certain that the rocks called primary have not once contained

tained organic remains that were destroyed during the process by which they acquired their present crystalline structure. We may, however, with apparent probability, infer that their formation was prior to the existence of animals or vegetables on our planet in its present state, because the intermediate rocks which cover them contain the organic remains of zoophytes, or those animals which are considered as forming the first link in the chain of animated beings.

The intermediate rocks have, on this account, been called by the Germans *transition rocks*, from the supposition that they were formed when the world was passing from a chaotic to a habitable state. These rocks are less perfectly crystallized than the former division, and contain, like the secondary, mechanical depositions. They separate the primary from the secondary rocks, and partake of the nature of both.

The primary and transition rocks contain few saline or inflammable fossils; but they are the repositories of metallic ores, which are not often found in the third division,

or

or what are called the secondary stratified rocks, in many of which numerous remains of vegetables and animals occur. This division contains sand-stone, coal, stratified limestone, chalk, &c. Pebbles and water-worn fragments of rocks belonging to the former divisions are commonly found in many of the secondary rocks: hence it is inferred that they have been formed at a later period, and hence this class receives its name.

Alluvial ground is the land formed from the ruins of other rocks by the agency of water; it consists of gravel, clay, &c.

Volcanic products are the substances ejected from volcanoes, or formed by the agency of subterranean fires. They constitute no inconsiderable portion of the earth's surface, though they are scarcely noticed by some geologists.

Each of these classes has its appropriate mineral productions; and it would be as vain to seek for common coal in the primary and transition rocks, as to expect statuary marble or metallic veins in the upper secondary strata or in alluvial ground.

The

The situation of the various mineral productions of England offers a proof of this. From the western side of the county of Dorset a waving line may be traced in a north-east direction to near Scarborough in Yorkshire: see the map A. A. The whole of the country between this line and the German ocean is composed of chalk, calcareous sandstone, and other secondary strata, or alluvial ground, in which no beds of workable coal or metallic veins occur: it is coloured yellow in the map. This part of England I denominate the low district. On the coast of Lincolnshire and part of Yorkshire there is a subterranean forest about seventeen feet under the present high-water mark. This forest appears to have extended eastward, as stumps and roots of trees may be seen at low water at a considerable distance from the coast: it is coloured green. West of the line A. A. the country is composed of secondary strata of a different kind, in many parts of which are beds of iron-stone and coal: it is coloured blue. This I denominate the middle district. It is bounded

bounded on the north by mountains of metalliferous lime-stone, which range along the line C. C. and terminate in Derbyshire. In the west this district extends to the mountains of Wales and Devonshire. See the map. The line C. C. is continued from Derbyshire through the southern counties, to denote that no metallic veins are found east of it in any part of England*.——Along the western side of the island the primary and transition mountains are situated, in which metallic ores occur. They constitute the alpine parts of England, extending from Cornwall and

* The calcareous strata of the low district appear again on some parts of the eastern side of Durham and Northumberland, beyond the alum rock near Whitby marked B in the map. The principal coal-fields are situated in that part of the middle district which extends from Derbyshire to Northumberland, and in that part of Wales bordering on the Bristol channel (see chap. VI and XI of the present volume.) On the western side of Cumberland, the coal strata border a small part of the alpine district, and dip under the sea. The strata on the eastern side of the line C. C. generally dip or decline to the south-east. West of this line they are more broken and irregular.

Devonshire,

Devonshire, through Wales, into the north-west parts of Yorkshire and Lancashire, and through Westmoreland and Cumberland, and from thence to the northern part of Scotland: they are coloured red. In the direction E. E. all the rock salt and brine springs are situated: other particulars in the geology of England will be subsequently adverted to. The writer is not aware that this arrangement has been before noticed;—it is introduced here to excite the attention of persons entering on the study of geology, who may be more impressed by local illustrations than by general descriptions.

Three fifths of the surface of the globe are covered by the sea, the average depth of which has been estimated at from five to ten miles: but great changes have taken place in the relative position of the present continents with the ocean, which, in former ages, rolled its waves over the summits of our highest mountains. Of this, demonstrative proofs exist in our own island and in various parts of the world.

The calcareous or lime-stone mountains in Derbyshire, and Craven in Yorkshire, rise up

to

to the height of about 2000 feet above the present level of the sea. They contain through their whole extent fossil remains of zoophytes, shellfish, and marine animals, but more abundantly in some parts than in others. Particular species occupy almost exclusively distinct beds, and in some situations the whole mass appears a compact congeries of these marine organic remains. In Derbyshire the beds of lime-stone are separated by different beds of a stone called toad-stone, varying in thickness from 50 to 150 feet, in which are no organic remains; but we meet with them again whenever we come to the lime-stone either above or below the toad-stone.

The distinct characters which the separate beds in these mountains present, prove that they have not been brought there by any sudden inundation. They must have remained for ages under the ocean prior to their elevation above its surface.

The mountains of the Pyrennees are covered in the highest part at Mont Perdu with calcareous rocks, containing impressions of marine

rine animals; and even where the impressions are not visible in the lime-stone it yields a fetid cadaverous odour when dissolved in acids, owing, in all probability, to the animal matter it contains. Mont Perdu rises 10,500 feet above the level of the sea; it is the highest situation in which any marine remains have been found in Europe*. In the Andes they have been observed by Humboldt at the height of 14,000 feet.

In England, the calcareous mountains I have described contain no remains of vegetables; but, in the thick beds of shale and grit-stone lying upon them, are found various vegetable impressions, and above these regular beds of coal, with strata containing shells of fresh-water muscles. In the earthy lime-stone of the upper strata are sometimes found fossil

* Cette montagne est non seulement la plus haute des Pyrennées, elle est encore la plus élevée de nôtre hémisphère, où l'on trouve des débris organiziques: elle est de tous les monumens connus des derniers travaux de la mer la plus considérable par son volume, et la plus remarquable par sa structure; un pareil terrein est classique pour l'étude des montagnes secondaires, et pour l'histoire des dernières révolutions du globe.—*M. Raymond.*

flat

flat fish, with impressions of the scales and bones quite distinct; and lastly, in and under the thick beds of clay covering chalk, in the southern counties, the bones of the rhinoceros, the elephant, and the mammoth, are not uncommonly discovered. The sagacious naturalist Cuvier has examined these bones from different parts of the world with much attention, and has observed characteristic variations of structure, which prove that they belong to animals not now existing on our globe: nor have many of the various zoophytes and shellfish, found in calcareous rocks, been discovered in our present seas.

The fossil remains of animals not now in existence, entombed and preserved in solid rocks, present us with durable monuments of the great changes which our planet has undergone in former ages. We are led to a period when the waters of the ocean have covered the summits of our highest mountains, and are irresistibly compelled to admit one of two conclusions, either that the sea has retired and sunk down below its former level, or some power operating from beneath has lifted

lifted up the islands and continents, with all their hills and mountains, from the watery abyss to their present elevation above its surface. We are also led to infer that great revolutions have taken place at distant periods of time. The inundations which buried vegetables and quadrupeds in distinct separate strata, were subsequent to each other, and were both posterior to the formation of the lime-stone resting upon primary rocks; for different organic remains are not found existing together, except in those stony masses which are formed from the *debris* or fragments of rocks and strata broken down and again consolidated*. If apparent instances to the contrary sometimes occur, I believe it will be found, on a careful examination of all the circumstances, that they do not form exceptions to this position. I shall state two remarkable facts of this kind.

In sinking for lead in a mountain near Wirksworth, in Derbyshire, in 1663, a cavern was unexpectedly discovered, in which

* As in the calcareous rock of Gibraltar.

was found the entire skeleton of an elephant; its skull was so large, that it is stated to have held four bushels of corn. One of the teeth I have seen in the possession of Mr. Watson, of Bakewell. There can be little doubt that this cavern had once been open, and was afterwards closed by the deposition of calcareous earth forming stalactites, instances of which are common in Derbyshire. Into this cave I conceive the animal had retired to die, at a period long after the existence of the marine animals which are imbedded in the surrounding rock.

The other instance, apparently more surprising, lately came to my knowledge when engaged in a mineralogical examination for the Earl of Moira, in the vicinity of Ashby de la Zouch, in Leicestershire: it will evince how cautious we ought to be in drawing general conclusions in geology from single facts. A thick bed of coal belonging to his lordship, at a place called Ashby Wolds, is worked at the depth of 225 yards; it is covered with various strata of iron-stone, coal, and solid rock. On an estate adjoining to his lordship's manor,

nor, in the same bed of coal, (which is ninety-seven yards below the surface,) the entire skeleton of a man was found imbedded. No appearance existed of any former sinking for coal; but the proprietor ordered passages to be cut in different directions, until the indication of a former pit was discovered, though the coal had not been worked. Into this pit the body must have fallen, and been pressed and consolidated in the loose coal by an incumbent column of water, previously to the falling in of the sides of the pit.

Facts of this kind deserve particular attention, as no instances have yet been known to occur of human bones being found in regular stratified rocks, except where mines have been worked; nor have they been discovered in undisturbed alluvial ground, where the remains of quadrupeds are not uncommonly met with. This would appear to indicate that man is the most recent tenant of the globe, and is coincident with the oldest records or traditions of the human race. Those who are desirous of pursuing such inquiries may consult Parkinson's Or-

ganic Remains, and the elaborate researches of Cuvier. Sufficient has been advanced to prove that great revolutions have changed the antient condition of the globe; and the changes now taking place in distant parts of the world, by the agency of subterranean fires, are too important and extensive to admit us to believe that our planet is an inert mass. The same wisdom which regulates the external universe has "laid the foundations of the innermost parts of the earth," and appointed certain laws by which its surface is renovated, and adapted to the support of vegetable and animal life.

CHAP-