On the Geological Formations in the Neighbourhood of Dunster.

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ALL the lofty hills and high land in this district, including Dunkery Beacon, the north hill at Minehead, Grabhurst Hill, and the Croydon range, with the outlying Quantocks, belong to a geological formation, which for a long time was known as the Grauwacke, but is now more frequently called the Devonian series. On the declivities and near the base of these hills, we find another series of rocks of more recent origin, which, while they skirt the upheaved masses of the older formation, in many places rest upon them in such a manner as clearly to prove that they were deposited after and upon the older sedimentary formations. These rocks are known as the *red-sandstone* series, which, for the most part, compose the lower hills, and supply the characteristic red marls of the lowlands. The red-sandstone, in its turn, is succeeded by later formations. Hence we find the *lias* overlying the red-sandstone along the coast of the Bristol Channel, and

occurring in such circumstances as to leave no doubt of the order in point of time in which they succeeded each other. And in the marsh land, extending from Dunster to Minehead on the one hand, and to Blue Anchor on the other, we have the comparatively very recent *alluvial* deposit, covering over the remains of primæval forests, portions of the foliage and timber of which are exposed to view every day at low water, between Minehead harbour and the Warren point.

These geological formations severally, and as associated together, present features of great interest, and in a striking manner illustrate and confirm the theories of the geologist respecting the physical history of the world. It is not, however, my intention to enter upon the great problems connected with some of the phenomena which this neighbourhood presents; but rather to seize on the more striking features, and to endeavour to present them so associated and connected together that we may be able in some measure to understand the ground over which we travel in our excursions, and with more pleasure to contemplate the physical characteristics of the country, and the vast and mighty agencies by which, through countless ages, these stupendous effects have been produced.

First, then, in point of time, we come to the Grauwacke, or Devonian series, embracing sedimentary rocks differing from each other in some particulars, yet, on the whole, presenting common features which enable the close observer, without hesitation, to refer them to the same great epoch. The term *sedimentary* is applied to this series from the undoubted evidence the rock itself affords of its being the result of the gradual settling of the sandy and mineral matter held in suspension by the troubled waters of that period. When, therefore, we enquire into

the origin of these lofty hills, the revelations of geological science refer us to the time when the now upheaved heights of Dunkery, and Brendon, and Quantock, formed the sea-beds, over which rolled the waves and billows of a boisterous ocean, and into and upon which were precipitated from the vast laboratory which Almighty power alone could form, and Infinite Wisdom alone direct, the metals and minerals which are dispersed among them. The various beds of rock included in this series present varying features, according to the varying circumstances in which the deposits occurred. The direction and force of different currents, together with the varying character of the rocks the detrital matter of which they held in suspension, would necessarily affect the character of the deposit in different localities. Hence we find the rocks of this series more or less calcareous, more or less sandy ; in some places altogether devoid of any traces of organic remains, in others crowded with fragments of corals and of encrinites. The Museum of the Society contains a variety of organic remains found in strata belonging to this series on the Quantock Hills. The honour and merit of the discovery (which is comparatively recent) belong to Mr. Pring, of Taunton, to whom the Society is indebted for many beautiful specimens, and valuable services in the geological department. But while a few beds abound with remains of encrinites and corals, the great mass would seem to be devoid of them. From this we are led to infer that forms of organic life did not abound in the seas of that period ; or if they did, that they were for the most part exposed to such destroying agencies as to prevent their being preserved in the deposits then formed.

It is interesting, however, to observe traces of the analogies which prevail between the seas of that remote

period and those of tropical climes of the present day. The Ordnance Geological Map of this district exhibits streaks or bands of lime-stone interspersed among the rocks of the Devonian series. Thus you have a belt trending from near Withycombe to Treborough, on the Croydon Hills, and patches occur on the Quantocks. Some of these abound to such an extent with calcareous skeletons of corals and madrepores that we cannot fail to regard the bands and streaks of lime-stone which occur among the sedimentary beds as remains of coral reefs, akin to those which, in our own days, are piled up by the wondrous agency of the zoophytic race. So marvellously perfect are the fossil remains when imbedded in the lime-stone rocks, that polished specimens present the minutest features of their organization. During the time we kept living specimens of actiniæ and other zoophytes in our Museum, at Taunton, we had an opportunity of observing this fact. One beautiful actinia had attached its base to the side of a glass vase, and thus exhibited practically a horizontal section of its organism. We placed beside it a polished slab of Over-Stowey limestone, with a corresponding horizontal section of a fossil coral. Neither the naturalist nor the artist could desire a more faithful representation of the base of the living zoophyte than was afforded by the polished section of the fossil coral. But while these coral reefs were being built up, and while these rocks were being deposited in the bed of primæval seas, there were vast and mighty agencies at work, indications of which present themselves in various portions of this formation. Some of these beds were upheaved after they had attained to their present solid form; but others were manifestly disturbed, while as yet they were in a semi-liquid condition. The contortions and curvatures in

the slates and rocks, as exhibited in the cliffs between Minehead and Hurlstone Point, as well as elsewhere, clearly prove that the volcanic or other agency to which they are to be referred acted upon the deposit while it was yet in a plastic state, for the curve line is unbroken, and the strata present no such fractures, as would necessarily result from similar action on rocks which had already become hardened. That the period during which the deposit took place was one of great volcanic disturbance is evident from the general character of the stratification; and the elevated position and irregular outline of the district equally prove that by some great convulsion of nature the sea-beds became changed into mountain heights, and the waters of the ocean were thrown into new channels.

Then began, in the bottom of this new sea, a new geological formation. From the manner in which the new red sand-stone series rests upon the Devonian rocks in various parts of conjunction both on the Quantocks and the Brendon Hills,* it is clear that they are the deposit of an ocean whose margin, in this neighbourhood at least, was the uplifted district of the Devonian series. At that time —(and I would observe in passing that when the geologist speaks of time, he does not count by years, but by ages and cycles of ages, far exceeding the power of human computation)—at that time, it is evident that what are now the Quantock Hills was an island lying off shore, separated from the main land by the trough or channel, now indicated by the red sand-stone rocks and marls of the valley running from Williton into Taunton Deane. The hill on which Cunnegar Tower stands was likewise

* A beautiful instance of conjunction occurs in the lane leading from Withycombe to the Fire-beacon.

isolated ; for while the hill itself belongs to the Devonian series, its base is surrounded by the red sand-stone deposit.

The special object of this paper will not admit of our entering on the probable extent of surface over which the seas of the *New red sand-stone* extended. We must, therefore, confine our observations to that portion which belongs to this immediate neighbourhood. Most of the characteristic features which distinguish the series present themselves in this locality. We have the conglomerate, into the composition of which fragments of the rocks composing the neighbouring hills enter largely. We have the finer detrital matter, in the form of sand, held together by a natural red ferruginous cement, and the various grades and shades between these two. We have the red marl, which forms so striking a feature in the agricultural aspect of our large valleys. And as in the Devonian, so likewise in the red sand-stone, we have streaks or bands of lime-stone. The cementing matter of the conglomerate lime-stone contains so large a proportion of magnesia as to obtain the name of magnesian lime-stone. In some places it contains rounded fragments of the Devonian rocks, united in one solid mass by a magnesio-calcareous cement, thus clearly indicating its origin and the circumstances under which it was formed.

The lower beds of the red sand-stone series are peculiarly interesting in this neighbourhood, from their affording in great purity the only truly precious metal of our country—I mean *iron*. If you refer to the Geological Map you will observe that during the time the red sand-stone was deposited, a gulf of the sea must have occupied the opening at Porlock, skirting Luccombe, and flowing up as high as Timberscombe. At the

head of that gulf, in the beds of red sandstone, at Luccombe and Brockwell, as many of you are aware, is found the red *hæmatite* iron. It occurs in large patches, mixed up with the sandstone and conglomerates peculiar to the series, and is worked in the open quarry ; and it seems that near Porlock the rock upon which the new red sandstone rests contains veins of brown hæmatite. This, very probably, is the source from whence was derived the red hæmatite of the succeeding formation. Copper has likewise been found in the same formation. At Treborough and Luxborough, in the rocks of the Devonian series, a peculiarly rich iron-ore has recently been found, the discovery of which is of national importance. In quality this metal is said to be equal to the best Silesian iron, and in quantity more abundant.

The value of these mineral treasures has long been known by the successive generations and races of men that have occupied this district. That the Romans worked these mines is most clearly proved by the coins, and mining implements, which have been discovered in the refuse matter in this neighbourhood. How they worked, and to what extent they brought their characteristic energy to bear upon these sources of wealth, would be an interesting subject for investigation, and one peculiarly within the province of this our Archæological Society. On this subject, however, I must not enter, as I desire to confine myself to the physical aspects of the district.

While, then, we have *iron* in the lower beds of this series, we have *gypsum* in the higher beds. This mineral, which may be described as the *crystals of native sulphate of lime*, occurs in the red-marl, on the coast near Blue Anchor, sometimes in isolated masses ; at other times in veins lying parallel to, and between layers of, the marl ; and occasion-

ally passing in thin laminæ through the intermediate layers, and thus connecting the successive strata together. While valuable as an article of commerce, it also adds considerably to the striking appearance of the rocks on the sea-coast in which it abounds.

But we must leave the sandstone, and pass on to the LIAS. And, in order fully to comprehend the transition, we must imagine the bed of the sea to be again changed, its waters to be drained off, the red sandstone deposits become dry land. In fact in this neighbourhood the red sand-stone series with its marls constituted the lowland shore of the *Lias* sea. In this new sea a new deposit takes place, and a record of each change is faithfully preserved in the imperishable archives of creation. Yea, a record, not only of each change, but of the varying forms of organic life peculiar to each period, and, not unfrequently, of the agencies, chemical and dynamical, by which the changes were produced. The sea-cliffs between Watchet and Sherton Bars afford most interesting and instructive sections of this portion of the earth's crust, and show, with great accuracy and minuteness, how the strata succeeded each other, and point most unmistakeably to many of the disturbing influences to which this series of rocks has been subjected.

The natural sections presented in the cliffs on the coast clearly show that the *lias* was deposited upon the red-sandstone. In very many places the strata lie conformably, one above the other; in other places they seem to abut against each other, yet always in circumstances which clearly indicate the action of great disturbing forces. The disturbance in the stratification of the rocks, technically termed a *fault*, as presented in the section of the cliff near Lilstoke, is only one of a great many, the traces of which are left in the change

of dip in the strata, which is very considerable; and in the few points of difficulty which occur at Blue Anchor, as to the relative position of the lias and red marl, there can be no doubt the obscurity is to be referred to these disturbing causes. During which particular geological period the disturbing cause was in operation, it is impossible to determine. The probability is there was a succession of convulsions. Some evidently occurred while the lias beds were plastic, for they are curved so regularly, and with so unbroken a line, as would be impossible if the rock had become indurated. Others have taken place long after, as the great disturbance in the stratification clearly indicates.

While these changes were going on, and the lias was being deposited, the sea-shores of that period were crowded with living creatures, differing most widely from those of the present time, yet presenting analogies which help the comparative anatomist to determine the simple types according to which animated being appears to have been arranged by the great Creator. To reproduce the living forms of that period—to re-people the shores of that ancient sea—to look into the deep pools swarming with strange and beautiful forms of life—would seem almost to require a spirit's vision and a super-human power. But it is not so in reality. The record of that time, as writ by the finger of God upon the very rocks themselves, supplies the knowledge we need, and almost all the information we require. The fossil remains are so abundant, and in general so well preserved, that we have little difficulty as to the main features of the Fauna of that period. The animals themselves stand before us. Shoals of *Ammonites* and *Nautili* crowd near the shore, now floating on the surface in their chambered shells, with their formidable arms stretched out in search of prey, and in an instant disappearing, on the

approach of danger, and sinking into the sea-depths by the aid of their syphon. With rapid backward motion, their kindred, the *Sepiæ* and *Loligenes*, the cuttle-fish of that period, dart after their prey, and then, as now, when attacked in its turn, envelope themselves in a cloud of black ink, and so make their escape. Close by, in deep pools and on rocky ledges, the marvellous encrinite lifts its tall stem, spreads out its thousand arms, opens its flower-like petals—every stem, every arm, every petal, built up of thousands and tens of thousands of separate joints, and each joint moveable and supplied with the requisite muscular apparatus. While we gaze on the marvellous beauty of this plant-like star-fish, near the shore, the huge *Ichthyosaurus* plunges into the deep waters after its prey, devouring everything within reach, not sparing even the young of its own species. Leaving these Saurian monsters of the deep—part lizard and part fish—which for the most part frequent the deep waters, we look with wonder on the *Plesiosaurus*—a creature with the body of a fish, the tail of a crocodile, the head of a lizard, and a long neck like a huge snake, now swan-like swimming on the sea, and anon clambering along the shore—not improbably on this very spot of earth where we are now met to talk of them and their times. Then, more curious than all, we behold flitting around us that most extraordinary compound of bird and bat and lizard, the *Pterodactyl*—a creature which the renowned Cuvier pronounced the furthest removed of any from the types of living beings with which we are acquainted. That these forms of life existed here we know, for the rocks in this neighbourhood contain their skeletons, and their remains most clearly explain the habits of their life.

Such are a few among the leading facts in the history

of the earth's crust, which the rocks in this district afford. I have not attempted to do more than state them in their simplest form. This will suffice for those who have already paid attention to the subject, and, I trust, serve to induce others to study this most delightful and interesting department of physical science, and thus, likewise, to promote one of the objects of our Society—the cultivation and advancement of the Natural History of the county of Somerset.

This paper was very fully illustrated with enlarged copies of drawings and sections of the coast made by the late Mr. W. Baker, of Bridgwater. For some of these, as well as for large maps of the district geologically coloured, the Society is indebted to Mr. J. D. Pring, of Taunton.