Geology of the Mendips.

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ONE of the advantages connected with Geological investigation to him who pursues the science arises from the fact that, in whatever part of the world he may be placed, there is certain to be open to him many points of interest, either physical or otherwise, upon which the imagination may be exercised. Whether he be investigating the extended plains of our alluvial or tertiary deposits, or the table lands of the chalk or oolite, or the low levels occupied by the liassic deposits, or his look-out be from one of the glorious peaks of the carboniferous limestone or the old red sandstone of the Mendip Hills, many questions crowd upon him, and he has to endeavour to realise, as far as possible, amongst other points, the physical history of the district at its several epochs; the relative ages of the beds, and their connection with one another; the evidences they may present of unconformability and disturbance; what mineral wealth they contain, and also the palæontological treasures the deposits may severally yield on a patient investigation of their contents.

I believe there is no county in England which is privileged to possess so much Geological variety as the county of Somerset, and resulting chiefly from this, I am certain

there is not one, which presents so great an amount of palæontological interest. On both these points the Axbridge district, in which this year the society assembles, will afford ample illustrations. Before noticing these more in detail, let me mention the different geological formations found within the borders of the county, some of which are in no part of the world to be studied under more favourable conditions—Alluvial deposits, recent marine beds, post glacial drifts and clays, chalk, chalk marl, upper green sand, gault (?), lower green sand, Kimmeridge clay, coral rag, Oxford clay, cornbrash, forest marble, great oolite, fullers' earth, inferior oolite, upper lias, middle lias, lower lias, the Rhætic beds, new red sandstone, dolomitic conglomerate, coal measures, millstone grit, carboniferous limestone, Devonian beds, old red sandstone, eruptive basalts. This lengthened list of geological formations, therefore, shows, what I doubt cannot be said for any other county, that in Somerset, with the exception of the tertiary beds, the Wealden, the Portland oolite, and the Silurian strata, and those following, every Geological horizon is represented in it.

The great geological feature not only of the district in which the society meets, but also of the county of Somerset, centres in the fine range of the Mendip Hills, which are chiefly composed of the old red sandstone, and the carboniferous limestone, whose physical elevation has tended in a very considerable degree to influence and modify many of the younger stratified deposits by which they are seen to be surrounded. The Mendips commence on the east near Frome, where in this direction they pass under and are covered up by secondary rocks, and from thence continue through the centre of the county for a distance of 35 miles, forming the boundary on the south, of the

Somersetshire coal field. They have on their southern escarpments the towns of Shepton-Mallet, Wells, Cheddar, Axbridge, and Weston-super-Mare. From the latter point the beds of which they are composed cross the channel, and are found skirting the South Wales coal field, their western extension being near the town of Bridgend. The old red sandstone is the oldest member of the Mendip range, and makes its appearance near Frome in a narrow belt at Oldford, with an equally narrow strip of carboniferous limestone resting against it, both formations at this place being very much disturbed and contorted. The old red sandstone has then its greatest superficial development to the north of Cranmore and Shepton Mallet, where it is continuous for several miles, it having been brought up through the carboniferous limestone, by which it is bounded both to the north and south, the whole of the rocks forming an anticlinical, the beds of which dip in either direction at a very considerable angle. The old red is then found at Pen Hill, and North Hill, near Priddy, beyond which it is covered up by a large superficial development of carboniferous limestone, which separates the formation from the Black Down Hills above Axbridge, the most westerly point the old red sandstone reaches in this district. The carboniferous limestones are continuous throughout the range, resting sometimes vertically, and always at high inclinations upon the sides of the equally inclined old red beds, having their greatest breadth of six miles north of Wookey, or from Rodney Stoke towards Blagdon, including in their area Stoke Warren, Priddy, Charter House, and Ubley. To the west the limestones continue in two spurs, embracing the old red of the Black Down Hills, the one to the north passing by way of Burrington, Sandford, and Banwell, that to the south including

the Cheddar Cliffs, Shutshelve Hill above Axbridge, and Wavering Down above Compton, Crook's Peak at this point yielding one of the most interesting panoramic views that can be imagined, and from which the greater part of the physical geology of the county may be gathered. Beyond this may be seen the isolated outcrops of the carboniferous limestones of the Bleadon and Worle Hills, with Brean Down and the Steep, and Flat Holmes in mid-channel. The older rocks of which I have been speaking form the boundary within the borders of which, so far as we at present know, the coal measures are confined. The outlines of the Somersetshire and Gloucestershire carboniferous series by the outcrops of the carboniferous limestone are on the whole very well defined. Even on its eastern border, where only any doubt can exist, and where the carboniferous limestones are generally covered up by later deposits, its area may still be traced, as it is known that the carboniferous limestone occurs under the secondary beds at Batheaston, and at the surface over very small areas at Grammar rocks near Bath, and at Wick and Codrington in Gloucestershire, Cromhall being their northern extremity, whilst the grand escarpments of the Mendips form their southern boundary. It is true that whilst we have the carboniferous limestones of this range dipping rapidly to the south, on its eastern side passing under the oolite and lias, in the Axbridge and Cheddar districts they apparently pass under the moor lands towards Bridgwater and Cannington, near that town, where there is a small outcrop of limestone, which until lately was supposed to belong to the carboniferous series, in which case it would indicate the continuation of these beds in that direction; but it has lately been suggested by Mr. Etheridge, though with some doubt, that the Cannington limestone is of Devonian age.

The question of the continuance of the coal measures south of the Mendips is one surrounded by very considerable difficulty. Under any circumstances, though I should not be sanguine of success and should rather incline to the opinion that workable coal would not be found in that direction, I think the time has come when the Somersetshire landed proprietors should combine and provide a fund, which with the improved means now attained for boring operations need not be a very large one, in order to settle a point which, if successful, would not only be of great importance to themselves but to the country generally. I shall presently point out some of the difficulties they would have to meet, but they chiefly resolve themselves into a question of cost, and nothing would give me greater pleasure, as soon as they are ready, than to offer them any assistance I can render as hon. consulting engineer, keeping them informed of their prospects as their mining operations proceed. The coal measures which overlie the carboniferous limestone are in the Somersetshire basin calculated at the enormous thickness of 12,000 feet. In a paper I have lately published on "the Abnormal Conditions of the secondary deposits when connected with the Somersetshire and South Wales Coal Basins," I have suggested that it was probable the carboniferous limestone, which is now seen to surround our coal fields, formed the edges of an attol-like basin, within which the vegetation flourished from which the coal has been derived. It is certain that with our carboniferous deposits there have been many mixed, or rather alternating physical conditions of the area within which they are found, which have not yet been satisfactorily worked out. Take for example one of the coal beds on the north of the Mendips. There are there found on a single horizon of only a few feet or inches in

thickness, indications of a land area, from the vegetation of which it has been probably formed; this may be succeeded by shales or other deposits of greater or less thickness, in which there may be traces of either marine or brackish water organic remains. The land again emerges from the water and is once more clothed with vegetation, and, with the same physical conditions repeated from time to time, still higher coal beds are deposited, each in its turn being covered up by interposed shales or other deposits which have been brought into the area by the continued depression of the district in which they have been accumulated. No doubt some of the beds were deposited more or less rapidly, though this could not be the case with the coal itself. It has been calculated that the vegetation necessary to the formation of one yard of coal would, even in the tropics, take a thousand years in its growth. If this calculation be anything like correct, we shall require thousands of years for the formation of the true coal beds alone, which in the Somersetshire coal field are about twenty-four feet in thickness, and if so, what date are we to assign to the intercalated shales and rocks of which the carboniferous series a few miles on the north side of the Mendips is in great part composed? In illustration of the period that might be occupied in the formation of some of the coal series, I may mention an incident which has just occurred to myself. Lately I found several minute seeds of a coniferous plant named *Flemingites gracilis*, in a lead mine in Yorkshire, next I found it in the carboniferous series in Staffordshire, and lately, when visiting the Radstock coal works, I discovered a bed of shale almost entirely composed of this little seed alone. Although as I have above indicated there must have been a continued depression of the area within which the coal measures

were being deposited, the fact that the same thin veins of coal are generally to be traced over the whole coal field is sufficient to show that there were uniform periods of rest within which the same conditions everywhere prevailed; what those several physical conditions were, will still afford ample scope for the imagination of geologists.

But I want once more to return to the Mendip Hills, and to refer to some most interesting phenomena, which appear to have occurred after the close of the coal period. It must not be forgotten that the old red sandstone, the carboniferous limestone, and the coal beds within the basin were laid down horizontally, and that their present physical elevation has been due to subsequent uplifting by volcanic agency. Whatever doubt there might be of former changes there can be none regarding the cause of their elevation, the time it was effected, and the modifications that have been caused thereby, especially to Somersetshire geology. The rocks which form the Mendip Hills, and including the coal measures also which have been brought up by the same movement, cannot be estimated at less than 30,000 feet in thickness. Their length, from near Frome to Weston, where they cross the channel, to beyond Bridgend in South Wales, where the carboniferous limestone terminates, is about 72 miles. Meeting as we do at the foot of this mountain chain, and seeing, as we shall in our excursion, the magnificent Cheddar gorge, the Burrington Coombe, and the other ravines that have been caused by the elevation of this chain of hills, you may the more readily imagine the enormous forces exerted in early geological periods by such convulsions. Grand, indeed, as compared with their present appearance, must have been the ragged peaks of the rocks as they were first brought up from the ocean's depth, since which time through long

geological ages they have been modified by denudation and other causes. So great has been the power of denuding forces, especially to the east, that the dense limestone of the range, which must have gone up into peaks of considerable elevation, have been worn down quite horizontal, much of the material thus removed forming the conglomerates along the Mendip range and covering up the coal within the basin. The presence of the agent, by whose power this has been effected, is to be found in a basaltic dyke near Stoke Lane, under the Ridgeway and one of the most elevated portions of the Mendips. A north and south section there shews the protrusions of the volcanic matter, and that the old red sandstone and the carboniferous limestone have been brought up vertically by it, and as the convulsion was subsequent to the coal period those beds have been equally affected thereby. Nothing in geological history can be clearer than the time when the Mendip hills were up-lifted. The fact that no beds subsequent to the coal measures have been disturbed, and that all the secondary formations which repose on them on either side of the Mendips are horizontal, shew that the date of the volcanic movement is to be fixed at about the middle or latter part of the triassic era.

The uplifting of the Mendips, I have before remarked, has tended very much to modify the general geology of the district, and I know of no part of the world in which there are so many interesting physical phenomena to be studied. In my paper before referred to, and from which I am compelled to quote, I have suggested that, through the greater part of geological time since the coal measures the Mendips have presented an island barrier, which to a great extent has prevented the irruption of the secondary seas within the coal basin to the north, and I have given

comparative sections which I think clearly establish this fact. I have shown that whilst on the south of the Mendips there have been deep sea deposits, in which the secondary beds attain very considerable thickness, on the north they are often entirely wanting or have a very insignificant development which the following table will show :—

	Without coal basin	Within coal basin
Triassic beds ..	2,000 ..	50
Rhætic beds ..	50 ..	50
Lower lias ..	700 ..	2
Middle and upper lias	500 ..	42
Inferior oolite ..	170 ..	25
	3,420	169

This comparison, as showing the different physical conditions under which the beds on either side of the Mendips were deposited, is most instructive. The new red sandstone in a coal boring at Compton Dundon, was sunk into for 600 feet, whilst within the coal basin the dolomitic conglomerates and the "red ground" are often under 50 feet, and in a very curious section of the lower lias at Munger less than two feet represents this important formation, which sometimes numbers to the south many hundred separate beds. These facts will serve to show that in any attempts made to discover coal in the latter direction great care must be exercised in the selection of suitable spots for experiment. Another point of interest which I have only recognised along the flanks of the Mendips, and their continuation through South Wales, is that when the secondary rocks come in contact with those of earlier ages or lie in any small basins on their surface

they present all the conditions of an ancient coast line, and are so changed in their general character, that it would be difficult to recognize them as the equivalent of liassic or other beds, that were deposited under ordinary or more tranquil circumstances, in the deeper seas beyond. Thus towards Frome, and at Shepton Mallet, the Rhætic beds are composed of a dense conglomerate analogous to the pebbly coast line of our present shores, and occasionally contain an association of remains of several geological periods. Thus in one block I have a vertebra of *Plesiosaurus*, *Acrodus* teeth, *Avicula contorta*, of Rhætic age, and *Encrinites* of the age of the carboniferous limestone. The liassic beds also, where their edges meet the carboniferous limestone, are likewise conglomeratic, and the beds are lithologically different, presenting a white or crystalline aspect instead of the usually dense gray or blue appearance under which they are otherwise found. At Harptree these beds are very siliceous, and, but for their fossils, would be difficult to recognise as belonging to the liassic series. These facts I think assist in the conclusion that the Mendip range was at the time of the deposition of the secondary beds an island barrier, producing abnormal conditions of deposition when the latter beds came within its influence. Before I leave this part of the subject I must refer to another most interesting point, which is not only intimately connected with the Mendips but is also a new feature in Geological phenomena. I allude to the age and mode of the mineral deposits in its area. There can be no doubt that the carboniferous limestones which form an anticlinical from their original line of elevation, dip more or less rapidly to the south under the secondary rocks. Over a large surface of the sea bottom they formed the floor of the ancient ocean to the south when the Rhætic and liassic

beds were being deposited, and we have the curious fact that in consequence of some physical disturbance they then became fissured and received within their walls not only the organic remains that were then living, but also various minerals of the same period, with which in the veins they are now to be found associated. In consequence of this, whenever a vein of whatever breadth is met with in the carboniferous limestone of the Mendips, it may fairly be inferred that the vein is either of Rhætic or liassic age, which is often to be clearly established by the presence of remains of those periods. A complete network of veins and fissures in this way occupies the whole line of the Mendip Hills, some of which, of considerable breadth, are to be traced for some distance. In one open section at Holwell fifteen of these are present, nearly one-third of what was supposed to be carboniferous limestone belonging to the younger age. A good example again occurs in a wide vein at Gurney Slade, where in a quarry of carboniferous limestone the vein infilling has been left standing up like a wall with liassic shells in its matrix, shewing the hematite iron ore there seen to be also contemporaneous. Other examples might be mentioned, but I shall only refer to the one of greatest interest which happens to be at Charter House, within a few miles of where we are assembled, and which will be visited in one of the excursions.

On the carboniferous limestone table land at this place a shaft has been sunk for the discovery of lead ore, and I was surprised to find at its mouth blue clay and conglomerates containing organic remains of the age of the lower lias, a formation not to be found within some miles of the spot. This came from the bottom of the mine at a depth of 270 feet. It affords another remarkable illustration of the liassic seas having occupied the fissures of

older formations, and from the fact that this liassic infilling is found either below or associated with the minerals in the vein, it proves conclusively that the latter are of liassic age. Mixed with a few species of organic remains from the carboniferous limestone, not less than eighty five species of the age of the lias were obtained, some of these being of the highest palæontological interest. The genera *Helix*, *Proserpina* and *Vertigo* thus found are with one exception the oldest land shells, and *Valvata*, *Hydrobia* and *Planorbis* the oldest freshwater genera ever discovered.

Before leaving the subject of minerals I should remark that in what are mapped as dolomitic conglomerates to the north of Axbridge, at Rowberrow, and Shipham, large quantities of calamine were formerly extracted, and hematite iron ores occur at Wrington and other localities. These conglomerates usually fill up basins in the limestone or rest against their sides, but owing to their not yielding any organic remains it is difficult to determine their exact age. It is not improbable they are younger than has been supposed, especially as it is seen that the other minerals of the district are of a later date.

Whilst within the coal basin to the north of the Mendips, as I have before intimated, there is an extraordinary thinning out of all the secondary deposits, on the south and south-west the beds above the coal, where they have been clearly deposited in deeper seas and beyond the modifying influences exercised by the Mendip range, assume their normal conditions and attain great thickness.

The triassic beds have not a large superficial development, from the fact that they are to a great extent covered by the lias or by the moorlands of the district. The upper beds of the new red sandstone can be best studied along the lines of the numerous escarpments by which the

moorlands are generally surrounded, especially to the north of Wedmore, on the south flanks of the Polden Hills, and around Somerton. In ascending from the upper beds of the new red sandstone, usually seen at the base of these escarpments, the Rhætic beds may generally be detected, their upper horizon being bounded by the cream-coloured beds of what have been termed the "white lias," but which are now included in the Rhætic series. These beds in the south-west of England, as I have shown in my paper on the "Avicula contorta and Rhætic series," forming a most marked and persistent horizon between the lower lias and the new red sandstone. Probably in no part of the world are the beds of the lower lias more finely developed than in this direction. Instead of the altered conditions they present when they meet the outcrop of the older Mendip rocks against which they rest as they pass into the deeper ocean, the uniformity of their depositions is most remarkable. If a good typical section of lias be carefully studied it may be seen not only that the beds present certain lithological distinctions, and are of varying thickness, but that almost every bed has its peculiar assemblage of organic remains, and these conditions throughout the south-west of England are so persistent they are to be recognised in every liassic quarry over an area of hundreds of square miles. The horizons of the middle and upper lias are in this district but feebly developed in the solitary island in the moor towards Bridgwater of Brent Knoll, in the Tor Hill at Glastonbury, and in its continuation in the Pennard Hills, whilst the inferior oolite, but for a thin capping on the Tor Hill, would be scarcely represented. From this date, as we have none of the secondary or higher tertiary deposits, the revolutions recorded on the leaves of the great stone

book have been entirely obliterated in this district, and we come to the later pages of the world's most wonderful history. On it are recorded changes, which in the Mendip district, and for our own county have their special interest. I allude to the period of the post pliocene deposits, within which are included most of our superficial gravels, and the infillings of our limestone caverns, with the abundant remains of extinct mammalia they contain.

These bring us forward from the time when shoals of *Ichthyosauri* and *Plesiosauri* swarmed in the seas which washed the base of the Mendip Hills, to the remote but still more recent one when the liassic sea bottom had become dry land, and the cave lion, the rhinoceros, the hyæna, the elephant, the wolf, the musk sheep, and other extinct animals swarmed in the district, roaming through its tangled forests, and retreating to the caves of Banwell, Hutton, Loxton, and Wookey, and others not yet discovered, where their remains are now so abundantly found. There is little doubt that at this time the general physical contour of the country was very similar to the present. The Mendip range stood out as boldly as at this day, and the various islands of new red sandstone and lias in the low ground occupied the positions in which they are now found. So recently in geological time was this great change effected, it must have been within the period when the human race existed, for there can now be no doubt that man was contemporaneous with these extinct mammalia. It is also certain that many of the shells which are found associated with their remains have lived on to the present time ; and yet within this comparatively short Geological period what revolutions must have occurred in this immediate district. Its climate has changed from a temperate to that of an arctic one, and has again returned to its

former condition, and within this yesterday of geological time an arctic fauna existed and has passed away. An attempt has been made by an eminent mathematician to fix the date of the last great change, who has calculated two periods of great cold, in which we had arctic climates in this latitude, one of which he shews extended from 980,000 to 720,000 years ago, the other from about 240,000 to 80,000 years ago, and should his calculation be correct, we must carry back man's advent and that of the extinct mammalia, since which no great physical change has occurred in the Mendip district, to at least the lesser of the above periods. When I remark that the great physical outlines of the Mendips and the country beyond were in glacial and post-glacial times much what they are at present, it does not follow that there have not been since those periods influences at work which have to some extent been modifying and altering the condition of the district. It is impossible for instance to say how far the waters which now occupy the Bristol channel have encroached over the low levels ; possibly they reached nearly to the foot of the Mendips on the south-west, still more probable is it that they were not far removed from Glastonbury and the numerous escarpments of the new red sandstone and the lias in that direction. Certain is it that the waters of the ocean overspread the moors so far up as Burtle, Sutton, and Middlezoy, for at these places are to be found recent marine deposits containing organic remains still living in the channel, and but for the alluvial covering they have since received there is little doubt they might be recognized in many other localities. The last and most recent change in the district to be noticed is the great extent of the turf moors and rich alluvial lands to the south of the Mendips, and also on the west in the direction of Bridgwater and

Burnham. Since the recession of the ocean these low levels appear to have been receiving their accumulations of alluvial deposits by the drainage into them of materials brought down into the basin they occupy by the rivers Axe, Brue, and Parrett, the overflow of whose waters in early times, as occasionally at the present, probably converted a great part of the country into an inland lake. During this time the rhinoceros, the bos longifrons, the reindeer, and a few of the post-pliocene mammals still lingered. In the same deposits we find traces of the ancient Briton and of Roman occupation, and thus we insensibly graduate from the pre-historic into historic times—from the dim eras of the past into the present. My object has been rather to treat of the physical revolutions that have been in progress in the area in which we are assembled than to refer at any length to the still more interesting palæontological facts they have involved. The laws by which these changes have been effected in the past are as surely in operation at the present, and who can say in what bold relief, as compared with the past, the footprints we are now leaving in the sands of time may stand out to record our world's history in the future.