BRIEF NOTES ON THE GEOLOGY OF THE MENDIP HILLS,
WITH REFERENCE TO THE LONG EXCURSION, AUGUST 4TH TO
9TH, 1890.
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The Mendip Hills may be described as for the most part a table-land that stretches from Frome in a north-westerly direction to the Bristol Channel, a distance of about 30 miles. As we proceed towards the coast the ground becomes more diversified, and the hills more and more detached. The elevation varies from about 450 to 1,060 feet, and the breadth of the tract is from three to five miles. Nevertheless, old writers, who united more poetry than we do to their descriptions, speak of these hills as a "chain of mountainous land," or as the "Alps of Somersetshire;" while Crook Peak, near Axbridge, which rises to a height of 640 feet, and is certainly the most prominent of the hills, is spoken of as "a prodigious eminence."

The hills are said to owe their name to their mineral wealth, they were called the "Myne Deeps" (written "Muneduppe" in old records), and have yielded up their lead-ore to the ancient Briton and the Roman. In later times both galena and calamine were worked with considerable energy, but seldom to a depth of more than 30 fathoms. Little has been done of late years, except to work-up the refuse left by the old lead-miners, but this material is found to yield on an average about $12\frac{1}{2}$ per cent. of metal.

The Mendips owe part of their charm to the fine views they afford. To the north lies the vale of Wrington, with Dundry Hill and the Cotteswolds beyond. To the south extends the plain of Sedgemoor, with distant views of the Wiltshire Downs on the south-east, and of the Quantocks on the south-west.

To the traveller in search of the picturesque, the combes and cliffs are the most attractive features in the district. The Cheddar Pass exhibits the grandest inland cliffs we have in this country,

while the Ebbor Rocks, Burrington Combe, Vallis, and other ravines afford much beautiful rocky scenery.

To the geologist, of course, the charms of scenery are enhanced by her or his ability to decipher some of the records of the rocks; and these old rocks, extending it may be said from the Old Red Sandstone to the Forest Marble, are freely exposed to view, without those adjuncts of boulder clay, which in the midland, eastern, and northern counties leave so much for the scientific use of the imagination. But if we miss these relics of the "Great Ice Age," it must be remembered that changes went on despite the absence of the deposits, whether of this or earlier ages, and the missing chapters mean denudation in one form or another.

Yet another source of interest to geologists is the association of the district with the "hammerers" of old days. The results of their labours invest the rocks with a spell they would not otherwise possess; and although papers written fifty and more years ago are sometimes regarded as "ancient history," they are as a rule far more readable than the majority of those produced nowadays, and they are for the most part quite as instructive.

Somersetshire has had a considerable share in the development of geological knowledge. The relations of its Coal-measures to the overlying "Red earth" and "Lias" were shown as early as 1719 by John Strachey, while towards the close of the same century, William Smith was actively engaged in setting out and superintending the works on the Somersetshire Coal-Canal, thereby gaining much of that knowledge which has formed the chief foundation of our science. Smith, however, did not enter much into the geology of the Mendip Hills. The main features in the structure of this range were made out by William Buckland and W. D. Conybeare, whose 'Observations on the South-western Coal District of England' were communicated to the Geological Society in 1822. Three years previously, however, an excellent account of the western portion of the range had been furnished by Thomas Weaver, an old pupil of Werner's at Freiberg, and a man who did much careful geological work. Both these papers were published in 1824.*

Conybeare at this time held a lectureship in the church at Brislington, near Bristol, and was thus intimately associated with the district, and the full account of its geology (accompanied by a

* 'Trans. Geol. Soc.,' Ser. 2, Vol. i, pp. 210 and 317.

map) which he published in conjunction with Buckland, has been the basis of all subsequent work on the Mendips and adjoining areas. On this ground Sedgwick learned some of his earlier geological lessons in 1819, and again in 1820, when he first made acquaintance with Conybeare, whom he came to regard as his master in the subject. Together they examined the country near Bristol and the Mendips, where Sedgwick recognized the same limestone he knew so well about Sedbergh. The two geologists parted on the top of the Mendips in 1820, and Sedgwick then proceeded to Wells.*

Later on we had the Geological Survey Maps, of which the Mendip area was chiefly done by De la Beche, aided by W. T. Aveline. The former added largely to our knowledge of the physical history of the area in his famous essay 'On the formation of the rocks of South Wales and South-western England,' while the denudation of the country was enlarged upon by [Sir] A. C. Ramsay.† De la Beche, indeed, had previously examined much of the ground (as mentioned in the work by Buckland and Conybeare), and he always showed much interest in its geology.

Subsequently William Sanders, of Bristol, personally surveyed the entire area of the Mendip Hills and Bristol Coal-fields on the scale of four inches to one mile, publishing his map in 1862.

While these geologists had interpreted the general structure and physical history of the Mendip Hills, the subject had been by no means exhausted. More detailed observations carried on during a number of years by Charles Moore, of Bath, enriched our knowledge very largely. He discovered a very important exposure of eruptive rocks that had hitherto eluded the notice of previous geologists, and he made many remarkable discoveries of fossil remains in the fissures that traverse the Carboniferous Limestone near Frome. Born on the Lias of Ilminster, he made that formation, together with the Rhætic Beds, the subjects of special study; and it may be said of the Rhætic Beds that they owe their recognition as independent in this country to his enthusiastic researches.‡

* 'Life and Letters of Sedgwick,' by J. W. Clark and T. McK. Hughes, Vol. i, 1890, pp. 217, 218.

† 'Mem. Geol. Surv.,' Vol. i, pp. 1 and 297. The second edition of the Geol. Surv. Map of the district was prepared by H. W. Bristow, H. B. Woodward, W. A. E. Ussher, and J. H. Blake (1867-71).

‡ 'Quart. Journ. Geol. Soc.,' Vol. xvii, p. 483; Vol. xxiii, p. 449.

FIG. 1.—SECTION ACROSS THE MENDIP HILLS. Horizontal Scale an inch to one mile.

[H. B. Woodward, 'Geology of England and Wales.' *Edit. 2.*]

h. Lower Lias.
g. Rhaetic or Penarth Beds.
f. Red Marl and Dolomitic Conglomerate
 (Keuper).

e. Coal-measures.
d. Millstone Grit.
c. Upper Limestone Shale and Carboniferous
 Limestone.

b. Lower Limestone Shale.
a. Upper Old Red Sandstone.

The general structure of the Mendip Hills is usually expressed in the term "Mendip Anticlinal." In reality the table-land is formed of a series of denuded anticlines, which trend in an easterly and westerly direction, and thus do not coincide with the north-westerly and south-easterly direction of the range (Fig. 1).

There is evidence of at least five folds—the summits of which in four instances have been laid bare sufficiently to expose the Old Red Sandstone. As in the case of some of the remarkable folds in the Secondary rocks of the south and south-east of England, the strata on the northern sides of these anticlines usually plunge downwards much more steeply than on the southern side; and there are vertical strata and symptoms of slight overfolding at one or two points on the northern side of the Mendip Hills (at Churchill Batch and near East End, Leigh-upon-Mendip), as well as in the Steep Holmes, an islet in the Bristol Channel.

Connected with the disturbances that produced these anticlines, are the disturbed Coal-measures, on the southern side of the Somersetshire Coal-field, and the small masses of Carboniferous Limestone that appear amidst them, and apparently over them. In one instance, at least, near Upper Vobster, as pointed out by Mr. G. C. Greenwell in 1861,* coal has been worked beneath the older Limestone; and the general evidence is in favour of these isolated masses of Carboniferous Limestone having been brought abruptly over and against the newer Coal-measures. Various theories have been propounded to account for the abnormal positions of these rocks.

Mr. J. McMurtrie has argued that the Limestones were folded over from the Mendip range on the south;† while I have endeavoured to account for their position by a faulted and inverted anticline, which I should connect with that of Pen Hill on the west, rather than with that of Downhead on the south.‡ The Rev. H. H. Winwood has published some most important facts which have come to light at Upper Vobster since these explanations were attempted. They introduce to our notice on the south side a small tract of Carboniferous Limestone, dipping northward and overlaid by Upper Limestone Shales and Millstone Grit. This mass is

* 'Trans. N. Inst. Mining Eng.,' Vol. x, pp. 110, 115, and 'Trans. Manchester Geol. Soc.,' Vol. v, 1864-65.

† 'Proc. Bath. Nat. Hist. Club,' Vol. iii, p. 287 (and other papers).

‡ 'Geol. Mag.,' 1871, p. 153; 1876, p. 455; and 'Geol. East Somerset,' etc., p. 194.

faulted on the north against an inverted mass of the same series of strata, including also Coal-measures. Still further north the Coal-measures are brought abruptly against another mass of Carboniferous Limestone, "so much disturbed that the dip is difficult to make out," but particular portions dip N., S., N.W., and E. Mr. Winwood has most carefully recorded the facts, but considerably leaves the explanation for others. I saw portions of the section in 1885, but not the inverted strata, which were proved in a tunnel. The facts confirm in a general way that part of my original section of 1871 which represented the Carboniferous Limestone and Millstone Grit to be inverted on the north; but we still have to account for the presence of non-inverted Limestone on the south, and the tumbled and faulted Limestone on the north. So far as I can judge, the minor disturbances attending a great faulted and inverted anticline might account for the phenomena.*

Since "thrust-planes" have come into prominent notice Mr. W. A. E. Ussher has suggested that one of these more or less horizontal displacements affected the Downhead anticline, carrying forward a portion of the saddle of Carboniferous Limestone, etc., over the Coal-measures on the north. In this way, with the help of minor faults and denudation, he would account for the isolated masses of Carboniferous Limestone.† He has, however, not gone so far as to publish any section.

It should be borne in mind that Somersetshire for the past 25 years has been known to possess a "thrust-plane," familiar as the Radstock "slide-fault," or "overlap-fault." By this disturbance, particulars of which have been made known by Mr. McMurtrie, portions of the Coal-measures have been forced over other portions of the same beds from south to north, to a distance of from 120 to 330 yards.‡

Subsequently other striking instances of reversed faulting were discovered nearer Bristol, as pointed out by Handel Cossiam; it is, however, to Mr. McMurtrie that we are most largely indebted for our knowledge of the faults and disturbances in the Somersetshire Coal-field. I have been unable to accept his "overthrow theory" to account for the position of the Vobster Limestone, because I could draw no diagram that would explain the facts by an overfold

* 'Proc. Bath Nat. Hist. Club,' Vol. v, p. 24; and part for 1890.

† 'Rep. Brit. Assoc.' for 1888, p. 659.

‡ 'Proc. Bath. Nat. Hist. Club,' Vol. i, p. 127.

from the Mendips near Downhead; and he himself has not ventured to give an explanatory section, contenting himself with the cautious statement that the beds "must in some way have been folded over from that range, although we may not be able to realize how all this has been brought about."*

The disturbed state of the Coal-measures on the south side of the Coal-basin has been mentioned; there the beds are so broken and contorted that it is said the same coal-seam has been thrice penetrated in one shaft. The general structure of this portion of the Coal-field has been justly compared with that of the Belgian Coal-fields, where similar violent disturbances are met with, and where the qualities of the coals are said to be similar. But it should be borne in mind that while Coal-measures have now been met with at Dover, we have no grounds for assuming that the possible underground tracts of Coal-measures between that locality and the Somersetshire Coal-field, occupy any more regular positions among the folded Palæozoic rocks than do the known Coal-basins in the western and midland areas.

With regard to Prof. Rücker's observations on the particular magnetic attractions met with along certain lines of country,† it may be said that at present they need not seriously disturb our notions on the possibility of underground areas of Coal-measures, even within a short distance of such places as Reading, where the compass-needle was more powerfully affected than in some other tracts. For along the Mendip Hills, in the Old Red Sandstone, near Downhead, there is the dyke discovered by Mr. Moore, an eruptive rock that contains much magnetite;‡ and yet within two miles productive Coal-measures are worked.

The country to the south of the Mendip Hills, and more especially perhaps that near Evercreech and Glastonbury, offers a favourable tract for speculative boring, for at present no one has ventured deep enough on this side of Mendip to prove the nature of the Palæozoic floor. There are, I believe, traces of Millstone Grit at one point, south of Dinder, and again to the west of the Ebbor Rocks; both localities being on the southern side of the range. (See Fig. 7, p. cxiii, *supra*).

* *Ibid.*, Vol. iii, p. 299.

† A. W. Rücker, "On Underground Mountains," 'Good Words,' Jan. to Mar., 1890. See also paper by W. Whitaker, and discussion, 'Journ. Soc. Arts,' Vol. xxxviii, April, 1890, pp. 543, etc.

‡ See F. Rutley, in 'Geology of East Somerset,' etc., by H. B. W., p. 208.

The oldest rocks of Mendip, the Old Red Sandstone, consist for the most part of red and brown micaceous sandstone, with quartzose conglomerate; the latter disintegrated in places into a kind of gravel. No fossils, beyond obscure plant-like markings, have been recorded from the Old Red Sandstone of Mendip, but some fish-remains have been found at Portishead, near Bristol. There is a gradual passage upwards from these rocks into the Lower Limestone Shales—well shown north of Black Down, in a gully that leads towards Burrington Combe, and here the passage-beds yield Trilobites, of the genus *Phillipsia*. These beds comprise alternations of sandstone and shale, merging upwards into the main mass of shales, and these, higher up, contain bands of limestone, and pass thus gradually into the Carboniferous Limestone. Both Lower Limestone Shales and Carboniferous Limestone yield many fossils, but at present the beds on Mendip have not been very carefully searched. Thin Upper Limestone Shales occur above, and these are succeeded conformably by Millstone Grit and Coal-measures. The disturbances that produced the Mendip folds took place in the interval between the period of the Coal-measures and that of the Trias. The eruptive rock of Downhead may then have been intruded. Sir A. C. Ramsay, who drew sections to show the amount of material removed from the hills, calculated the loss as amounting in places to 6,000 feet. Be this as it may, the entire tract bears evidence of great denudation, and in many cases we have actual evidence of very even plains or terraces of denudation. This is conspicuous in the vales near Frome, and may be observed near Wells.

Of succeeding strata, the oldest comprise the beds of Dolomitic Conglomerate, that were marginal accumulations of the Keuper Marls. These beds consist of breccia and conglomerate formed mainly of angular and rounded fragments of Carboniferous Limestone, cemented sometimes by a dolomitic matrix, but often by ferruginous matter and carbonate of lime. Much of the material is evidently due to sub-aerial waste of the land, being the angular detritus cemented at or near the spots where it accumulated; other portions have been more or less rolled.* Remnants of this Dolomitic Conglomerate occur along the higher grounds of Mendip, as well as along the borders of the range.

* De la Beche, 'Mem. Geol. Surv.,' Vol. i, pp. 243, etc.; and C. Lloyd Morgan, 'The Mendips: A Geological Reverie,' p. 19.

Of the succeeding Rhætic Beds we have had good exposures along the Great Western Railway west of Shepton Mallet, described by Charles Moore; at Milton Lane, near Wells, described by the Rev. P. B. Brodie; and along the Great Western Railway at Uphill, described by Sanders, Bristow, Etheridge, and others. Where we find these beds on the Keuper Marls, we have a gradual passage upwards of Grey Marls, Black Shales (with *Avicula contorta*, etc.), and White Lias. The Lower Lias comes on in entire conformity. Traces of Cotham Marble, which occurs at the base of the White Lias, are to be seen here and there, as at Stone Easton on the north, and East Horrington on the south of the Mendips. Rhætic sandy beds, with *Pullastra arenicola* and *Avicula contorta*, occur on top of the Mendips, at Harptree Hill, while remarkable infillings of Rhætic material have been found in the fissures of the Carboniferous Limestone by Moore. Attention will be called to some of these fissures near Frome, where there have been obtained, teeth of the Mammal, *Microlestes Moorei*, and of the Fishes *Acrodus minimus*, *Gyrolepis Alberti*, *Hybodus reticulatus*, *Saurichthys acuminatus*, etc.

FIG. 2.—SECTION IN VALLIS—Showing Inferior Oolite resting on Carboniferous Limestone.

(After DE LA BECHE.)

It is noticeable that where the Triassic and Lower Jurassic Beds abut against the Mendips, we find evidences not only of conglomeratic conditions, but of attenuation and overlap, so that some-

times Dolomitic Conglomerate, sometimes Rhætic Beds, Lower or Middle Lias, or Inferior Oolite will be found directly on the older rocks. The plain or terrace of denudation on which, in some cases, the strata rest, may have been formed at an earlier stage than that of the particular deposit now resting on it, previous accumulations having been swept away (Fig. 2).

The varying positions occupied by these Secondary strata on the flanks and higher grounds of the Mendips are likewise in part due to marginal deposits being laid down at different relative levels, and in part to subsequent faulting or irregular elevation.

The Rhætic Beds, Lower Lias, and Inferior Oolite exhibit conglomerate conditions, and the Lower Lias also exhibits considerable modifications, as will be seen at Shepton Mallet. There we have a rock like the Sutton Stone of Glamorganshire, a pale and more or less granular and tufaceous kind of limestone, containing occasional fragments of chert derived from the Carboniferous Limestone. The proximity of the Lias to this Limestone appears to have had something to do with the lithological characters of the rock. We find very similar beds of Lias on Broadfield Down, north of the Mendips.

On Harptree Hill we find a very distinct and still more remarkable form of Lower Lias. There it appears in layers of a hard pale-buff cherty rock. Fortunately these beds have yielded fossils such as *Ammonites planorbis* and *Ostrea liassica* that prove their age. How the rock came to present these characters may still be considered a puzzle. It is true that I offered an explanation in the days of my youth.* I compared this cherty Lias with that at Portrush in the N.E. of Ireland, where the beds have been metamorphosed into a dark cherty rock by contact with eruptive rock. On the Mendips we have no evidence of eruptive rocks nearer than Downhead. It is, however, possible there may have been some intrusive rock which did not find its way to the surface, but made its influence felt by the agency of heated water. This, in short, is the hypothesis I ventured to advocate; and the fact that the Triassic Beds in the neighbourhood are also of a peculiar cherty nature lent some support to the notion. I may add that near Frome the Inferior Oolite, in places, exhibits a very cherty character. Mr. McMurtrie has called attention to this.

The Members will have the opportunity of seeing the ordinary

* 'Geol. Mag.,' 1871, p. 400.

beds of the Lower Lias at Street, near Glastonbury, and also at Shepton Mallet, while the Middle and Upper Lias are to be seen at Glastonbury Tor. This remarkable conical hill, a monument, as it were, of the denudation of surrounding areas, is capped by the Midford Sands. These beds form a passage between the Upper Lias clays and the Inferior Oolite. No fossils have been obtained in them at Glastonbury, but one species of Ammonite, to which the name *Grammoceras fallaciosum* has been affixed, has been obtained by Mr. Hudleston from these beds near Cranmore.* The Sands do not, as a rule, occur near the Mendip Hills, being overlapped by the higher beds of the Inferior Oolite (Fig. 3).

The Inferior Oolite will be seen at Doultling, but the quarries do not offer many temptations to the collector. The beds belong to the zone of *Ammonites parkinsoni*, that species being obtained by Moore, and Mr. John Phillis, of Shepton Mallet, has lately discovered *Terebratulina morieri*, a species hitherto only found in this country at Bradford Abbas.† Passing upwards in the geological scale, something may be seen of the Fuller's Earth near Frome. As a rule it is very fossiliferous, especially when we get an exposure of the Fuller's Earth Rock. No traces of the Bradford Clay have been exposed, though it should be present at the base of the Forest Marble. The shelly and oolitic limestones of this group have been quarried in many places near Frome, and indeed the rock is locally known as "Frome stone."

These and other Jurassic rocks must at one time have buried up the Mendip Hills, and, after a certain amount of uptilting, they all suffered considerable denudation during the great Cretaceous overstep. Both Upper Greensand and Chalk must have spread over the Mendip Hills and far away. Their present outcrops are within easy reach of Frome, the neighbourhood of Warminster being one of the most famous localities for Upper Greensand fossils.

Thus the Mendip area has seen great changes since its old rocks were plicated. It has suffered denudation again and again, and when laid bare in Post-Cretaceous times it has been more or less continuously weather-beaten.

Many of the fissures and fractures are of old date, containing

* S. S. Buckman, "Inferior Oolite Ammonites," 'Pal. Soc.,' p. 168.

† The specimen was presented to the Museum at Jermyn Street by Mr. S. G. Perceval.

FIG. 3.—SECTION THROUGH GLASTONBURY TOR.

[H. B. Woodward, 'Geology of England and Wales.' *Edit. 2.*]

4. Clays	} Lower Lias.
3. Limestones	
2. Rhaetic Beds.	
1. Keuper Marls.	

F. Fau't.
8. Alluvium.
7. Midford Sands.
6. Upper Lias.
5. Middle Lias.

metalliferous deposits, of which detrital portions have been found in the Secondary strata. Infillings of Rhætic and Liassic material doubtless took place at different periods, and a commingling of material is seen in some cases to have resulted. It may be, as Moore suggested, that certain open fissures received material during Rhætic and Liassic times, for along modern cliffs of Carboniferous Limestone, as in Glamorganshire, great chinks occur here and there into which the breakers cast much detrital material.

Many of the great fissures on Mendip, originating along joint-planes or lines of fracture, have been so enlarged as to form caverns and ravines; the latter in some cases (as suggested by John Phillips) having resulted from the former. The solvent action of carbonated water, aided by frost and streams, mainly contributed to the result. In the case of Cheddar it will be seen that the dip of the strata has exercised much influence on the shape of the cliffs—what may be called the conservative side standing up boldly and precipitously and exhibiting but little change in the course of years—while the other side, the dip-slope, may be said to be exceedingly liberal. It affords abundant evidence of the disintegration of the land, sending showers of detritus now and again on to the roadway beneath. To such radical changes we owe nearly all that is beautiful in our scenery. The base of the Cheddar Pass is now a well-paved road; hence the stream, which lies buried underground, can exert no influence on the fallen blocks, and it is needful for man to remove the spoils of denudation (Fig. 4).

FIG. 4.—DIAGRAM SECTION OF THE CHEDDAR CLIFFS. H. B. Woodward.
(Reduced from *Geological Survey Memoir*.)

To reply to the query, when were the Cheddar Cliffs and other ravines formed? it may be answered that all are, to some extent, in

process of formation. The underground streams still carry away much carbonate of lime in solution, and they must abrade the fragments that strew their courses. Thus the *débris* that annually falls, sinks down (where it can) to be in turn acted upon. It is difficult to form any notion about the period when these chasms may have been commenced. Joints, no doubt, originated from the original consolidation of the strata. Fractures attended their earliest upheaval and folding. Rains, perhaps, beat down on portions of the elevated ridges in Triassic times and widened the cracks ; but in course of time they were, in a measure, sealed up by Jurassic and Cretaceous sediments, and we know that materials of Jurassic age filled some of the old fissures. No doubt the main features, as we now see them, were marked out long after this great covering was removed, and from the later Tertiary period to the present day would give ample time for the work. It must be remembered too that the drainage-areas would have been vastly different before the vales on either side of the Mendip were excavated ; and for long periods subterranean waters may have exerted their solvent powers.

Excepting the fissures containing Jurassic material, we have no evidence of caverns or crevices with fossil remains of earlier date than the later part of the Pleistocene period, and there is reason to believe that all the main features we see had then been outlined by rain, rivers, and estuarine action, agents which may have exerted a more potent influence during some of the vicissitudes of Glacial times.