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Contributions to the Geology of Gloucestershire, intended chiefly for the use of Students. By the Rev. P. B. BRODIE, M.A., F.G.S., Vice-President of the Warwickshire Naturalists' Field Club, and Honorary Secretary and Honorary Geological Curator of the Warwickshire Natural History Society.

WE think it may prove useful and interesting to the geological student if, from time to time, we give a brief sketch of the Geology of some of the more famous localities in England, adding directions where to go, and how to work—which, to say the least, will be a great saving of time and labour, and enable those who are anxious to visit rich and instructive fields of research to make the most of perhaps only a brief holiday—a matter of no little moment in these days of almost unceasing toil.

The lovers of nature who live in the smoky atmosphere of great towns, shut up day after day in a close counting-house, enjoy a ramble amongst new or favourite haunts all the more on this account; and it matters not whether they are naturalists, geologists, artists, or merely admirers of the picturesque—the relish for their particular hobby is more keenly felt because it can be rarely indulged in, even if many difficulties stand in the way.

Few persons who have a scientific turn have unlimited time and means at their disposal; and, therefore, to the majority in such a case it is of some consequence to see as much as they can, and take the shortest route to their destination. The rapid and comparatively cheap means of transit afforded by the railway is equally available both for business and pleasure; but where science is the object, it is not always

easy in a new country to find out the best and most productive places, and a few hints from any one who knows them well are invaluable.

With these introductory remarks, we proceed at once to the more immediate object of this paper. There is no county in the British Isles where the Geology is so varied or interesting as Gloucestershire, associated as it is with diversified and beautiful scenery which would render it attractive to the mere casual observer. When it is recollected that many different Formations, from the Middle Oolite down to the lower Silurian system inclusive, can be studied with comparative ease, and a good suite of fossils collected from each stratum, the geologist will at once perceive the richness and extent of such a series, and the wide field of observation opened out before him. These different geological groups comprise a very extensive mass of rocks of vast bulk and thickness, of great value for economical purposes, and contain a distinct and variable fauna, which gives us an insight into the earth's history in past times, from one of the earliest ages up to a much more recent period.

The neighbourhood of Cirencester is undoubtedly the best for examining the upper portion of the Lower Oolite, the only member of the Middle being the Oxford clay, which has yielded an instructive set of fossils, and includes a band which appears to represent the Kelloways rock. The geological student will do well to devote a few days to the Cornbrash, Forest Marble, and Bradford clay, in connection with the Great Oolite, which may be reached within an easy distance of the town, and form the chief geological features of interest there. Though the Cornbrash is a comparatively thin bed, it makes a valuable soil to the agriculturist, and also yields a rich harvest of organic remains to the palæontologist. These consist chiefly of marine shells, some of which are peculiar to this Formation, while others occur also in the Inferior Oolite, and may be met with in the quarries near Cirencester, and also on the road to Fairford and Cricklade. Among the Brachiopoda there are several species of *Terebratulæ*, and among the Echinodermata several forms of urchins, which are highly characteristic. The most instructive section may be seen at Kemble, on the line of the Great Western railway, where the Cornbrash, Forest Marble, Bradford clay, and Great Oolite are all present *in situ*, and exhibit an instructive fault, the Cornbrash on one side of it being brought down to a level with the Great Oolite on the other.

Next to the Cornbrash the Forest Marble is the most important Formation in this district, which, although occupying hereabouts probably a larger area than the former, and, with its associated clay, thicker than the Cornbrash, is equally rich in fossils, and the thicker calcareous beds are of some value for economical purposes. There are several quarries opened in the neighbourhood of the Agricultural College, where many pretty specimens may be obtained. Of course the student will pay a visit to the excellent museum of the College, for which so much has been done by its present geological professor, Professor Buckman, and if he goes there *first*, he will observe what are the most characteristic fossils found in the Formations under review, and will very likely be able to procure many of them. In places, the Forest Marble contains traces of land plants, besides marine shells and corals, in which respect it resembles the Stonesfield slate, as also in its lithological structure. Many of the slabs quarried are very large, and are strongly ripple-marked, and, like similar strata deposited in shallow water, are frequently covered with worm tracks, and other curious markings not necessarily of organic origin.

Near Fairford, in an argillaceous stratum, probably connected with the Forest Marble,* numerous species of beautiful corals have been discovered, but the locality has been kept secret, and few collectors are acquainted with it. This, we think, is to be regretted; it is a sort of close-borough system, which should never be permitted among men of science, and we are satisfied that a liberal spirit, both in making known interesting localities for rare specimens, and a readiness to lend them when required, is the real mark of the philosopher, and most conducive to the interests of science.

The Bradford clay, which does not always accompany the Great Oolite in its range, is well displayed on the line of the Great Western railway near the Ackman-street station; and, although not exceeding seven feet in thickness, is loaded with fossils, upwards of 200 species having been collected by Professor Buckman from this spot. Most of these are present in the Great Oolite also, but a few, perhaps, may be peculiar to it. One of its most striking organisms—the beautiful Apiocrinite, or pear-shaped Encrinite, does not occur here, though it occurs abundantly in the same stratum at Bradford, in Wiltshire; but there are plenty of pretty shells and corals to repay the collector.

* Or, perhaps, the Cornbrash.

We should now recommend him to take the train to the station nearest to Sapperton Tunnel, as this will enable him to examine the Fuller's Earth which was cut through during the excavations for the tunnel, and which may still be seen on the spoil banks adjacent. We have not said much at present about two very important formations which lie between the Bradford clay and the Fuller's Earth, viz., the Great Oolite and Stonesfield slate, because we propose to dwell more in detail upon them when we describe the district in Gloucestershire where they are most largely developed, and can be studied with most advantage. As the Bradford clay is intimately connected with the Great Oolite, so is the Fuller's Earth with the Inferior; the majority of the fossils prevailing in the Oolite below, and a few passing upwards into that above. It is very rarely that the argillaceous band appears *in situ*, its presence being only indicated (like the upper lias), especially on some of the higher escarpments of the Cotswolds, by the soft, wet nature of the ground, and the bursting out of copious springs. A few fossils, chiefly shells, have been obtained at Cubberly, near Cheltenham; but Sapper-ton is the richest locality. Its thickness in this district averages from thirty to seventy feet, and the most abundant fossils are *Modiola*, *Ostrea*, and *Terebratulæ*. From this point the student should make the best of his way to Minchinhampton Common, where the Great Oolite has been long quarried, and from whence some of the finest and most beautiful of its fossils have been obtained. We should advise him by all means to pay a visit to the valuable and instructive collection made by Mr. Lycett at that village, to whom palæontologists are indebted for the discovery and investigation of many new forms of marine animal life (chiefly mollusks) which inhabited the sea during this portion of the Oolitic period.* Abundant and varied as these remains are, it is a remarkable fact that there are no traces of any higher order of animals, either terrestrial, fluviatile, or marine, which would seem to imply that land was far distant, although the sea was probably a shallow one and liable to strong and varying currents. The thickness of the whole of the Great Oolite in the district under review does not exceed 140 feet, the upper portion consisting of several beds of hard limestone and marl, containing the remnants, as it were, of a marine fauna, which abounds

* The majority of these are described and figured by Messrs. Lycett and Morris, in the "Memoirs of the Palæontographical Society," Part III., 1850, and Part IV., 1853.

in genera and species, both univalves and bivalves, in the lower division of this Formation. This latter forms the shelly oolite, locally denominated "planking," and constitutes the upper building stone, which is extremely rich in sea-shells, especially univalves, which here occur in great diversity, size, and abundance. Indeed, there is no other part of England where the Great Oolite is so prolific in fossils of this kind; and though much patience and skill are often required in extracting them, the labour is well repaid, and many a choice specimen added to the cabinet. The Geology of this neighbourhood is extremely interesting in other respects, from the striking physical features which it presents, owing to the numerous breaks which occur in the continuity of the strata, which not only expose many important sections of the strata, but also give rise to the picturesque and beautiful scenery for which this part of Gloucestershire is so justly celebrated. The vales of Brimscomb, Woodchester, Stroud, and Rodborough may be mentioned as among the most striking and attractive. In order to become well acquainted with the geological details of this part of the country, a longer residence would of course be required, and would be always remembered with pleasure; but those whose time is limited must be satisfied with a visit to Minchinhampton Common, and a walk through the valley of Rodborough, all of which may be accomplished in the course of a long summer's day. This is one among the many advantages of Geological pursuits, that it affords healthful exercise for the body as well as food for the mind, so that it has a twofold advantage in this respect. There are probably few geologists who have not a keen appreciation of the beauties of nature, as well as of the wonders of creation. We strongly recommend a walk, hammer in hand, over the breezy Cotswolds; and if perchance, the student should have a day there with the Cotswold Club, he would obtain much assistance from the practical scientific knowledge which its working members possess of the county of which they may be justly proud.

We might have said a great deal more about the Great Oolite and its remarkable fossil contents; but, as our object is to aid the student by as simple an exposition of facts as the nature of the subject will permit, and to point out the most interesting localities over a widely-extended area, we must not dwell too long upon any one of these, but pass on to others equally instructive. The upper division of the Great Oolite may be seen again to the east of Cheltenham,

capping the higher ground, especially near Burford, Northleach, &c. In some respects it differs lithologically from the same Formation on Minchinhampton Common, and it is thicker in its extension eastwards. The top strata usually consist of beds of marl, which are more or less fossiliferous; and the lower of white limestones, which are extensively quarried near Sherborne Park, above Burford: and, according to Mr. Hull, these limestones contain more fossils at a quarry where the Oxford and Shilton roads join, than anywhere else. Near Andoversford, about seven or eight miles east of Cheltenham, many fossils may also be procured in beds of rubbly, white Oolite. The usual fossils are shells and corals, belonging, however, to comparatively few genera, and presenting in this respect a strong contrast to the Great Oolite on the south.

The Forest Marble appears at Coln Rogers and near Aldsworth, about six miles south-east of Northleach, as well as near Burford, and the Cornbrash also near Shilton. We merely, however, mention this in case the student should like to compare them with their equivalents near Cirencester; for it often happens that even within a very few miles the divisions and sub-divisions of any given Formation present striking lithological differences—certain beds coming in, and others thinning out, which it is always necessary to note carefully, and which can only be done by a minute and accurate examination of every available section, and a close comparison of the zoological contents of each stratum.*

There is another and very important member of the Great Oolite with which it is intimately connected, and of which it forms an integral part, viz., the Stonesfield slate, to which we must now turn our attention. It forms the lower division of this Formation, and consists of a coarse, brown, fissile, ragstone, sometimes sandy and slaty, or passing into a shelly, oolitic freestone; and these characters are very variable over a considerable area in the Cotswolds. Formerly, there were several quarries worked at Sevenhampton Common, five miles east of Cheltenham, and are even now well worth a visit. The ragstone, which is a more compact slaty stone, often blue in the centre, is there

* We advise the student to get Mr. Hull's valuable and interesting memoir on "The Geology of the Country round Cheltenham," published by the Geological Survey, price 2s. 6d., where detailed sections are given, with copious lists of fossils, and ample details of every spot worth visiting.

overlaid by a few inches of clay, which contains many small shells, among which a small species of oyster (*O. accuminata*) is particularly prevalent. The ragstone is thirteen feet, and the very fissile slate, about five feet thick, immediately underlies it. The neighbourhood, however, of Naunton, Eyeford, and Temple Guiting affords the best sections, and numerous quarries are in constant work—as many as 120,000 slates being obtained during the season. At Northleach the slate becomes an oolitic freestone, mainly composed of small shells, more or less comminuted. This portion of the Great Oolite occupies a considerable extent in the eastern district of the Cotswolds, and may also be noticed at Notgrove, Miserden, and on the descent from Minchinhampton to Brimscomb. Lithologically and zoologically it is identical with the slate at Stonesfield, in Oxfordshire, which has long been famous for its organic remains; indeed, it may be distinctly traced, with few interruptions, from Sevenhampton to Stonesfield. The slate itself, like the Minchinhampton Oolite, is extremely valuable for architectural purposes, and forms a good and useful building stone. The young geologist, however, can see far more of it in Gloucestershire, where many sections are exposed at the surface; while in Oxfordshire, it is worked underground, and the workings are reached by means of a shaft.

To the palæontologist the Stonesfield slate is particularly interesting, from the abundance and variety of its fossil contents; for here we have, for the first time in the oolitic group, the relics of Mammalia and land saurians, though occurring again at a much later interval, higher up, in the Purbeck and Wealden at the close of the system. The Lower Oolite group in the Cotswold Hills contains, as we have seen, little else but an assemblage of marine shells, which attest the condition of the ocean at that epoch. The Stonesfield slate, on the other hand, affords a remarkable exception—for shells are not very numerous, the characteristic fossils being land plants, and relics of fish and saurians, terrestrial and marine, chiefly bones, teeth, and jaws. Parts of Insects, wing covers, and bodies of beetles, and wings of dragon-flies, which doubtless formed the prey of the insectivorous Mammals of the period, are not unfrequently associated with the above. Hitherto, no traces of Mammalia have been met with in Gloucestershire, but it is by no means improbable that they will be hereafter detected. A few jaws only of small opossum-like animals of this class have been discovered in Oxford-

shire, but it is quite possible that other and larger genera flourished in that part of the country which formed the then existing land. These were accompanied by a gigantic carnivorous reptile, the *Megalosaurus*, which roamed at large amongst the tropical Palms, *Zamia* and *Cycas*, which constituted a portion of the oolitic flora.

Another singular flying lizard, called the *Pterodactyl*, uniting in itself the characters of several distinct groups, appears to have abounded at the same time.

The common fossils are the remains of land plants, which occur more or less throughout the slate, fronds of ferns and small fruits being the most prevalent. The shells associated with the above are entirely marine, and usually exist only in the form of casts. Two new beautiful species of Star-fish have been met with, the largest belonging to the recent genus *Solaster*. The latter is a single specimen, and was obtained by Lord Ducie from the quarries at Windrush, in whose collection it now is. He also possesses an entire fossil fish from the same place, the first one, in a perfect state, ever found in the Gloucestershire oolites.

We have dwelt longer upon the fossil contents of the Stonesfield slate, because it affords a clearer insight into the geological history of its Formation, and the terrestrial conditions which prevailed. They were clearly very different to those of the higher zone which succeeded it, and yet, throughout the whole, the changes were often marked and variable—indicated not only by the lithological structure of the stone, but also by the character of the fossils.

We think the student must be interested in the details given above, and we are sure that a careful examination of the whole of the district, the geological features of which have been thus imperfectly described, will amply repay any time or labour spent upon it.

We hope, in our next article, to resume the subject, and to give a brief account of the Inferior Oolite and Lias in their turn.

[Since writing the above, Mr. Lycett's monograph on "The Cotteswold Hills"* has appeared, and the student would do well to obtain a copy, as it gives him a most complete and admirable account of the country referred to in this paper, especially the southern part of it, with which Mr. Lycett is well acquainted.]

* Piper and Stephenson, price 5s.