The geology of the country around Cheltenham

Edward Hull

MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

GREAT BRITAIN,

AND OF THE

MUSEUM OF PRACTICAL GEOLOGY.

THE

GEOLOGY OF THE COUNTRY AROUND CHELTENHAM.

SHEET 44 OF THE GEOLOGICAL SURVEY.

BY

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The Map (No. 44) referred to in the following Memoir may be had of Messrs. Longman & Co. Price 6s.

NOTICE.

THE following Memoir, the first of a Series which I called for to illustrate the Sheets of the Geological Survey, has, through the great interest attached to the district, naturally led the author, Mr. Hull, so to extend his observations that they really constitute a valuable work. In future it is, however, expected that each Surveyor will, in the first instance, furnish brief references only to those localities, whether natural sections or quarries, the organic remains and mineral contents of which have afforded him the means of completing his labours. Such descriptions to be circulated with the Maps to which they refer.

RODERICK I. MURCHISON,
Director-General.

THE Geological Map (sheet 44) to which the following Memoir refers is the joint production of Mr. Edward Hull and Mr. H. H. Howell, who surveyed the ground under my superintendence, while the late Sir Henry De la Beche was Director-General. The districts adjoining the Severn and Avon, together with Bredon Hill and the northern part of the Cotteswold range as far south as the road between Bourton-on-the-Hill and Snowshill, have been surveyed and described in this Memoir by Mr. Howell. The remainder and larger portion of the country included in the map was surveyed by Mr. Hull, the author of this Memoir.

ANDREW C. RAMSAY,
Local Director of the Geological Survey
of Great Britain.

AUTHOR'S PREFACE.

THE Local Director having stated the part performed by Mr. Howell, it remains for me to acknowledge the assistance received from other sources. Some of the lists of fossils included in this memoir have been kindly furnished by Dr. Wright, of Cheltenham, to whom with several other geologists of the Cotteswolds my thanks are tendered for the readiness with which they have afforded me information and personal assistance during the progress of the survey. Professor Morris has also compiled several of the lists of fossils from collections made by Mr. Gibbs, the fossil collector of the survey. The remainder have been drawn up from the same sources by myself, under the guidance of Mr. Salter, and with the assistance of Mr. Baily, at the Museum of Practical Geology.

I have had recourse frequently to the numerous publications on the geology of Gloucestershire, and amongst these I may especially mention the following :—

Dr. Buckland, Geol. Trans., Old Series, 1818.

Sir R. I. Murchison, Geology of Cheltenham. Silurian System, and Trans. Geol. Soc., Lond., vol. v. p. 331.

Mr. H. G. Strickland, Geol. Trans., vol. v. p. 331.

Mr. I. Lycett, several communications to the Cotteswold Naturalist Club, and Annals of Natural History, &c.

Professor Buckman, Geology of Cheltenham, Ancient Straits of Malvern, &c.

Rev. B. P. Brodie, Basement Beds of the Inferior Oolite, Geol. Trans., and on the Insect Limestone, Geol. Trans.

Dr. Wright, on "the Upper Lias Sands," in Quart. Journ. Geol. Soc., vol. xii. part 4.

Mr. Lonsdale (through Dr. Fitton). Geology of Bath. Geol. Trans.

Professor Phillips, Geology of Yorkshire.

Sir C. Lyell, Elements of Geology.

Professor Morris, Catalogue of British Fossils, &c.

EDWARD HULL.

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CHAPTER I.

Physical Features Dependent upon Geological Structure.

In attempting to describe the geological structure of this district I shall arrange the subject under the following heads:—

1. Physical features in connexion with physical Geology.
2. The secondary Geological Formations.
3. Superficial and Drift deposits.

As portions of the Cotteswold Hills and surrounding districts have already been described in several publications, principally with reference to their palæontology, and as they embrace the region more especially under the observation of the Members of the "Cotteswold Naturalists' Club," which comprehends many able observers, I shall occasionally have recourse to the aid of such publications as have already appeared, the present Memoir being intended as a concise *résumé* of the subject, and more especially to serve as an explanation of the coloured map, Sheet 44, published by the Geological Survey.

Physical Features.

With the exception of a small area formed of Keuper marls and sandstones, extending along the banks of the Severn and Avon, the district consists of two portions, the oolitic and liassic, the table-land and the plain, distinct in geological structure and physical outline.

The former or oolitic district forms a tabulated promontory, terminating in Ebrington Hill towards the north. Gradually expanding towards the south, the western flank forms a continuous portion of the oolitic escarpment of Somersetshire; while the eastern, curving round the southern extremity of the vale of Moreton, commences its northerly course towards Lincolnshire.

The table-land has an average elevation of 750 feet, and presents its most precipitous flank to the westward, in the neighbourhood of Cheltenham, being diversified, however, by numerous curves, which convey to the mind all the impression of bays and headlands. On the opposite side of the promontory, especially towards the southern termination of the valley of the Evenlode, the flank which at Frocester and Leckhampton Hills is nearly 1000 feet in height, crowned by a mural escarpment of Inferior Oolite, has here degenerated into a gentle and almost unbroken slope, generally devoid of any picturesque feature. This contrast is due to the change undergone by the strata in their extension eastward, from a full grown to a comparatively dwarfish development, which has impressed a corresponding change on the outward configuration of each district.

The western escarpment of the table-land forms the watershed of the country, which is continuous across the vale of Moreton, eastward from Ebrington Hill; all the streams on the western and northern side of this line being tributaries of the Avon and Severn, those flowing in opposite directions discharging themselves into the Isis. Notwithstanding, however, the south-eastern slope of the country, the dip of the strata in the same direction is greater, being, according to Mr. Woodward, at the rate of 1 in 130, or nearly half a degree, and sufficient to carry the hill strata beneath those of later date;* so that while we have the Inferior Oolite attaining at Cleeve Cloud an elevation of 1130 feet, we find the Cornbrash, south of Burford, occupying a position not much more than half that height; this, however, being in some degree due to

* Proceedings of the Cotts. Nat. Club for 1847.

the greatly diminished thickness of the underlying strata in the latter locality.

The following are some of the altitudes of the more prominent positions of the district:—*

	Feet.
Tewkesbury Church (ground)	47
Gloucester Cathedral (ditto)	56
Barrow Hill	198
Corse Hill	292
Christ's Church Tower, Cheltenham	343
Robin's Wood Hill	652
Standish Hill	715
Stinchcombe Hill	725
Oxenton Hill	733
Uly Hill	823
Painswick Hill	929
Birdlip Hill	969
Leckhampton Hill	978
Base of Bredon Hill Tower	979
Cleeve Cloud	1,081
Pewsdown Hill (estimated)	1,200 ?

The table-land of the Cotteswold region is intersected by numerous ramifying valleys, generally narrow, their verdant banks sometimes almost precipitous, and extending their arms for miles into the elevated region. The similarity of these valleys and headlands of the Cotteswold to the bays and promontories of a channel or sound, such as that which might have existed between the line of the Cotteswold Hills on the one hand and the Malvern and May Hills on the other, was first pointed out by Sir R. Murchison,† and since then, the "*Ancient Straits of Malvern*" has become a "household word" amongst local geologists. The same idea has been taken up by Professor Ramsay‡ and subsequent writers.

These valleys, which may be traced on a topographical map by the shading, and on a geological map, such as that which illustrates these pages, by means of the boundaries

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* Extracted from the Proceedings of the Cotts. Nat. Club, furnished by Capt. Yolland, R.E., Ordnance Survey.

† Sil. Syst. p. 530.

‡ On the Denudation of South Wales and the adjacent Counties of England. Memoirs of the Geol. Survey, vol. i. p. 334.

of the successive formations as they crop out along their opposite sides, have their finest exemplification in Stroud Valley, now very generally known, since it has become the thoroughfare for the Great Western Railway.

Some of the Cotteswold valleys lie in the directions of faults. Of such we may instance those of Cranham, Steanbridge, Barrington, and Througham; the last being a branch from the Stroud Valley, which it joins opposite the entrance to Sapperton tunnel. There are others which appear to have originated in gentle anticlinals or domes, as those of Northleach and Painswick, but the majority appear to be attributable only to the accidents of marine denudation, aided by the tendency of the surface drainage to run at right angles to the watershed.

Scattered at intervals, though not indiscriminately, over the Gloucester plain are several outliers of the higher formations, rising like islands above the level surface of the Lower Lias. The largest, as well as most northerly of these, is Bredon Hill, the geological structure of which has been surveyed by Mr. Howell. When viewed from the west, it will be observed that this extensive outlier presents its most abrupt flank towards the north, the two most prominent features being the tabulated bluffs of Marlstone, and the escarpment of the Inferior Oolite which forms the crown of the hill. From this position the whole upper surface appears to slope gradually towards the south, till it reaches the level of the plain. This form of outline is a true index to the geological structure of the hill, which is traversed from east to west along its southern termination by a fault, producing a downthrow of the Upper Lias shale and the Inferior Oolite against the Lower Lias of the plain. This fault, by lowering the levels of the strata to the north of its position, and thus rendering them for a time more protected than those of the surrounding area, taken in connexion with the relative position and degrees of hardness of the strata, has been the cause of this hill's stability; and it may seem at first sight a geological paradox that the district which has been subjected to a vertical fall is that which now rises conspicuously above the plain.*

The description above given of the configuration of the north side of Bredon Cloud is a type of that of the whole line of the Cotteswold Hills southward into Somersetshire. Owing to the alternation of two rocky strata with soft sand and clays,—in other words, owing to the Marlstone formation being capped by a bed of calcareous sandstone, and of the Upper Lias Clay and superimposed sand by the still more indestructible beds of the Inferior Oolite,—we find the former series forming a bluff with an upper tabulated surface, and the latter a slope crowned by a mural cliff. These primary features are subject to modifications consequent on local causes, all of which are more or less capable of explanation; and while in some places they assume a more marked and bold scale, in others the platform of the Marlstone is scarcely discernible.

The remaining outliers consist of Toddington, Dixton, Churchdown, Battledown, and Bowden Hills, composed exclusively of Marlstone; Robinswood Hill, which is capped by a narrow ridge of Inferior Oolite, and the two hills of Oxenton and Dumbleton. These, it will be seen by reference to the map, are affected by faults which have contributed to their preservation in a manner similar to Bredon Hill.

From the base of these hills the Lower Lias plain extends westward, being distinguished by no marked feature till we approach the banks of the Severn and the Avon. Here we generally find a rise of the ground parallel to the strike of the beds, and formed by the upper surface of the Lias Limestone series, which generally forms a ridge or escarpment near its junction with the Keuper formation of the Trias.

In conclusion, it may be observed that all the physical features of the district of the Cotteswold Hills are referable to three causes:—

* For a section across this hill, and for fuller explanations of these phenomena see the Author's paper in the Quart. Journ. Geol. Soc. for Nov. 1855, p. 480.

1st. The superposition of the comparatively hard and indestructible limestones of the Oolite upon the softer strata of the Lias.

2d. The subsequent production of slight undulations or rolls of the beds, and faults.

3d. The action of ancient marine denudation acting with greatest energy from the north or north-west.

No one of these causes separately would ever have produced the peculiar physical features and scenery of the Cotteswold Hills.

CHAPTER II.

Geological Formations.

The following is the Tabular List of the formations of the district.

Tabular View of the Strata of Sheet 44, *of the Geological Survey.*

Lower Oolite.	Cornbrash. Forest marble. Great Bath Oolite and Stonesfield slate. Fuller's earth (sometimes absent). Inferior Oolite.	
	Upper Lias Sands (Wright).	"Cephalopoda bed" (Wright). (Dotted sands of Map.)
Lias.	Lias.	Upper lias. } Blue shale. Marlstone or middle lias. Lower lias shale and limestone. " Bone bed."
Keuper, or Upper Part of New Red Sandstone.	Keuper.	Saliferous and gypseous marls. White sandstone.

The description of the Keuper strata and the basement beds of the Lower Lias is by Mr. H. H. Howell, of the Geological Survey, by whom the district occupied by these formations was surveyed.

Keuper, or New Red Sandstone.

"The Upper Member of the Trias is the lowest geological formation which occurs in this sheet. It is represented in its uppermost division only, the New Red Marl, and presents in this district the ordinary appearance which characterizes it throughout the whole of the midland counties of England, being of dark red colour with occasional green bands and veins, which give it a mottled aspect. Traversing the Red Marl is a thin band of white sandstone,* interstratified with green marls. This bed generally occupies the same position wherever it is seen, viz., about 200 feet below the base of the Lower Lias. It is very variable in its thickness, being in some places only a few inches and in others as much as 20 or 30 feet. In the country to which the map, (sheet 44) refers it is extremely thin, and is best seen in the village of Brittle, about three miles north of Tewkesbury. It also runs in a thin band from this northward to Severnstoke. This same bed of Keuper sandstone also appears at Notcliff, three miles south of Tewkesbury."

Lower Lias.

"Immediately above the New Red Marl succeeds the Lower Lias. The following section occurs at Wainlode Cliff, near Norton, about eight miles west of Cheltenham, where the junction between these two formations is most distinctly seen. This section was measured by the late Mr. H. E. Strickland, and published by him in the Proceedings of the Geological Society."

		Ft.	In.
Base of Lower Lias.	1. Black laminated clay, inclosing near the top a band of lias limestone with *Ostreæ* - - -	22	0
	2. Slaty calcareous sandstone, with a peculiar small species of *Pecten* - - -	0	4
	3. Black laminated clay - - - -	9	0
	4. Bone bed, passing into white sandstone - -	0	3
	5. Black laminated clay - - - -	2	0
Top of Keuper Marls.	6. Light green angular marl - - -	23	0
	7. Red marls with zones of a greenish colour - -	42	0

* See Murchison and Strickland, Trans. Geol. Loc., Lond., vol. v., N.S., p. 331

"The junction of Lias and Red Marl is generally marked by a low escarpment, which, however, is remarkably distinct. The boundary, in continuation of the sheet to the north, commences in sheet No. 44, near Defford Common, and runs in a southerly direction through Tewkesbury to the Leigh, about eight miles N.W. of Cheltenham. Here it takes a westerly course, and joins the Severn at Wainlode Cliff, near Norton, where the section above described is to be seen. The whole of this boundary is a natural escarpment, except between Tewkesbury and Brockeridge Common, where a fault throws down the Lias on the east against the Keuper Marls on the west. There are three outliers of the Lower Lias separated from the main body by the Keuper Marls to the west of this escarpment. The first is seen at Ham Court, about two miles south of Upton-on-Severn; it is about a mile in length and half a mile in breadth. The second is much larger, and is bounded on the east by a downcast fault. Its western boundary is a natural escarpment, commencing on the north at Pull Court, two miles N.W. of Tewkesbury, and terminating on the south against the fault two miles south of Tewkesbury. The following section was exposed at Bushley when the Malvern and Tewkesbury Road was lowered; the section is given by Mr. H. E. Strickland, in the Proceedings of the Geological Society, and will be seen to have some of the same beds seen at Wainlode Cliff:—

		ft.	in.
Lias.	1. Black laminated clay - - - -	10	0
	2. Limestone - - - - -	0	4
	3. Black laminated clay - - - -	6	0
	4. Conpact slaty bed, numerous small bivalves, and *Pecten*, the same as that of Wainlode cliff -	0	3
	5. Black laminated clay - - - -	9	0
	6. White micaceous sandstone - - -	1	0
	7. Black laminated clay - - - -	2	6
Keuper.	8. Greenish marl - - - -	20	0
	9. Red marl - - - - -		

The third small outlier occurs at Gray Hill, half a mile south of Apperley Court. One side of this outlier is bounded by a fault. A quarry of limestone formerly existed on the top of the hill where Mr. Brodie found his insect limestone beds."*

The Lower Lias has long been celebrated for the abundance and variety of its fossils. The plain of Gloucester has yielded (especially during the formation of the railroads) rich harvests of organisms,—reptiles, fishes, molluscs, and radiated animals. Reptiles of the saurian tribe were the most remarkable creatures of the liassic period; they were the great tyrants of their day, while the animals which most adorned, by their elegance and variety, the former bed of the seas, and now grace the cabinets of geologists, are the Nautili and Ammonites, the sea-urchins and starfishes.

The beds of the Lower Lias, above the limestone series, consist altogether of blue shale with occasional bands of rubbly limestone, as at Upton St. Leonard's. Under Cheltenham they are supposed to be about 600 feet in thickness, but southward, towards Bristol, the thickness is less,—300 to 400 feet;† and I shall presently have reason to show the probability from analogy of a similar thinning of this formation towards the south-eastern boundary of the district. Upon exposure, the blue colour of the clay gives place to dull brown, and where there is little drift, the junction of this and the Red Marl formation can be readily perceived by the instantaneous change of colour which the soil undergoes.

Lias clay is extensively used in the manufacture of bricks and tiles, and with the exception of railway cuttings, the brickyards offer the only sections of any value in the district. The land is generally laid out in permanent pasture, and is thickly studded with orchards and rows of elms and oaks, which from a distant elevation give the whole plain the appearance of forest.

It is well known that the Lower Lias presents several zones characterized by suites of fossils, which for the most part differ specifically from each other. As representatives of

* Mr. H. H. Howell, MS.
† Horizontal sections of the Geological Survey (Sheets 15 & 17).

these zones the ammonites play an important part; changes in physical geography having affected their range in time, more than ordinary mollusca. We are not yet in a position to trace the range of these zones through the vale of the Severn, though the materials are being collected by Dr. Wright and others. Mr. Strickland was of opinion that there were at least five of these well-marked series of molluscous life. The bone bed, the mollusca of which are all liassic, forms the lowest zone; the Lias Limestone series probably a second; above this there are at least three, as indicated by Mr. Strickland; the suite of fossils at Defford and Eckington differing from those of Bredon, and these again from the series immediately below the Marlstone at Hewlet's Hill, near Cheltenham.

The following lists are extracted from the catalogues in the office of the Geological Survey: the collections have been made by Mr. R. Gibbs, except when stated to be from other sources:—

1. *Fossils from the "Bone Bed" of the Lower Lias, Frethern.*

Ichthyosaurus,—vertebræ.

MOLLUSCA.

Ammonites lævigatus, Sow.
A. laticostatus, Sow.
A. Charmassei D'Orb.?
A. multicostatus, Sow.
A. Turneri, Sow.
Belemnites acutus, Miller.
Pleurotomaria Anglica, Sow.
P. expansa, Sow.
Lima gigantea, Sow.
— antiquata, Sow.
Gryphæa incurva, Sow.
Pecten „
Ostrea „
Modiola Hillana, Sow.
Rhynchonella Moorei, Davidson.
Spine of Cidaris.

2. *Fossils from the "Bone Bed," Aust Cliff, on the Severn.*

Ichthyosaurus and Plesiosaurus.
Hybodus minor, Ag.
Ceratodus altus, Ag.

3. *Fossils from the "Bone Bed," Westbury-on-Severn.*

Ichthyosaurus,—femur of.
Plesiosaurus,—vertebræ.
Saurichthys apicalis, Agass.
Hybodus minor, Agass. (teeth).
Acrodus minimus, Agass.
Ceratodus,—sp.

MOLLUSCA.

Modiola minima, Sow.
Avicula decussata, Goldf.
Pecten.

4. *Fossils from the "Bone Bed," Wainlode Hill.*

(*Bands of argillaceous limestone, with traces of fish.*)

Ichthyosaurus,—vertebræ.
Modiola.
Pecten sublævis, Phil.
Myacites elegans, Phil.

5. *Fossils from the Lower Lias, Denbury Hill, Cheltenham.*

(*From the blue calcareous clay in the railway cutting.*)

Ammonites anguliferus, Phil. abundant.
A. Henleyi, Sow.
A. oxynotus, Quenstedt. Very abundant, chiefly young specimens.
A. Coynarti, D'Orb., and three other species.
Pleurotomaria anglica, Sow.
Trochus imbricatus, Sow.
Hippopodium ponderosum, Sow.
Unicardium cardioides, Phil.
Cardinia Listeri, Sow. var. hybrida.
C. ovalis, Stutchb.
Lima,—sp.
Perna? ventricosa, Sow.
Ostrea læviuscula, Sow.
Gryphæa incurva, Sow.
———small species like G. cymbium.
Terebratula numismalis, Lam.

6. *Fossils from the Lower Lias, Mickleton Tunnel.*

(100 *feet below the Marlstone.*)

CRUSTACEA.

Glyphea liassina, Meyer.

MOLLUSCA.

Ammonites planicostatus, Sow.
Belemnites acutus, Miller.
B. pistilliformis, Sow.
B. elongatus, Mill.
Trochus imbricatus, Sow.
Pleurotomaria expansa, Sow.
Pholadomya ambigua, Sow.
—— very large species.
Hippopodium ponderosum, Sow.
Goniomya literata, Goldf.
Arca truncata, Buckm. (It occurs in masses with Lima pectinoides and Cardium truncatum.)
Arca elongata, Buckm.
Leda,—sp.
Cyprina,—sp.
Cardinia lanceolata, Stutchb.
Cardium truncatum, Sow. Plentiful.
Unicardium cardioides, Phil.
Modiola scalprum, Sow.
Gervillia lævis, Buckm.
Avicula novemcostæ, Brown.
Ostrea læviuscula, Sow.
Lima pectinoides, Sow.
Pecten æquivalvis, Sow.
P. sublævis, Phil.
P. demissus? Phil.

The Lias is chiefly confined to the plains of Gloucester, Moreton, and Bourton, but it occasionally appears in the minor valleys. It may be observed underlying the Marlstone at Paulins Mill, near Painswick, and in the brooks of those canal-like valleys which stretch northward from Tainton, near Burford.

The highest beds are characterized by ferruginous concretionary nodules, which on being broken present a beautiful assemblage of concentric layers, like a Chinese ball:—sometimes Ammonites occur as nuclei. Specimens of these nodules may be seen in brickyards at Hewlets Hill; in the lane leading from Heartly Hill to Charlton Kings; and great numbers, frequently of large size, were brought to light during the excavations for the Railway Tunnel at Mickleton Hill.

The following list of fossils from this zone is given by the late Mr. Strickland:—*

Fossils from the top beds of the Lower Lias, Hewlets Hill.

Ammonites Henleyi, Sow. (A. striatus, Rein; A. heptangularis, Young; A. Cheltiensis, Murchison). Hippopodium ponderosum, Sow. (rugose variety). Modiola scalprum, Sow. Spirifer (granulosus) rostratus, Schl. Rhynchonella (Terebratula) rimosa, Buck. Perna ventricosa, Sow. Cardinia (Pachyodon) attenuata, Stutchb. Littorina imbricata (Trochus, Sow.)

MARLSTONE.

This formation consists of two parts: the lower, a series of yellow, gray, and brown sands, with thin bands of calcareous sandstone, and ferruginous nodules—the upper, a *rock-bed*, being generally an impure limestone weathering brown, but blue in the interior. In the eastern part of the district it is highly ferruginous, and varies from one to ten feet in thickness. The rock-bed forms the surface of the tabulated promontories which produce such picturesque features along the flanks of the Cotteswold Hills and around many of the outliers, while the steep, fertile banks, which descend from the edges of the platforms to the Lower Lias plain, are composed of the underlying beds of sand.

The rock-bed is the principal repository of organic remains, which are very abundant on Churchdown, Oxenton,

* Trans. Geol. Soc., vol. vi. p. 552.

Dumbleton, and Bredon Hills; but along the eastern portion of the district, where the rock becomes highly ferruginous, the fossils are almost confined to a few individuals of Rhynchonella acuta, and Belemnites.

At Leckhampton Hill, the thickness of this formation is 115 feet,* and this is its general thickness around the Cotteswold Hills. "The main body of the marlstone con-" tinues in an almost unbroken escarpment, running in a " north-easterly direction as far as Ebrington Hill, in the " north-east corner of this sheet, round the base of which it " forms an indented circle. It will be seen by referring to " the map that the marlstone round this hill is connected " with the main body by a narrow strip of the same rock " near Chipping Campden, and which was partially cut " through in making the Mickleton tunnel. From Chipping " Campden the marlstone continues in a southerly course as " far as Stow-on-the-Wold, when it turns round the head of " the valley of the Evenlode, and takes a north-easterly " course to Little Compton. The marlstone at Ebrington " Hill and Chipping Campden consists of the usual ferrugi-" nous sands at the base, with a hard calcareous rock forming " nearly the highest bed, and altogether attaining a thickness " of about 150 feet. On the eastern escarpment, however, " between Chipping Campden and Stow-on-the-Wold, it " becomes gradually thinner in a south-easterly direction, " and the bold escarpment which it forms on the north and " north-west side of the promontory gradually disappears. " A small outlier of this rock occurs at Meon Hill, about " a mile north of Ebrington Hill."† At Stow-on-the-Wold we get the following section, in a lane leading from Maugersbury to Oddington; in which a section of the Upper Lias may also be observed, showing a thickness of 25 feet.

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* The thicknesses of the formations will be seen by referring to the plate at the commencement of this volume, the sections in which are drawn to scale from actual measurement with the theodolite and chain.

† Mr. H. H. Howell, MS.

Section of the Marlstone, Stow-on-the-Wold.

		Ft.	In.
1.	Band of deep reddish purple ironstone - -	0	6
2.	Brown calcareous sandstone - - -	2	0
3.	Band of clay - - - - -	0	6
4.	Brown calcareous sandstone - - -	4	6
5.	Yellow and blue arenaceous shale - - -	3	0
6.	Brown sandstone - - - -	3	6
7.	Blueish clay - - - - -	3	0
8.	Brown sandstone - - - -	1	6
9.	Beds of sand and arenaceous shale - about	25	0
		43	6

No. 1 is filled with good specimens of Ammonites annulatus. It is very constant at the top of the Marlstone all over the neighbourhood, as I have observed this bed and its characteristic Ammonite at Daylesford Quarry, and in the road section south of Little Milton, towards Burford.

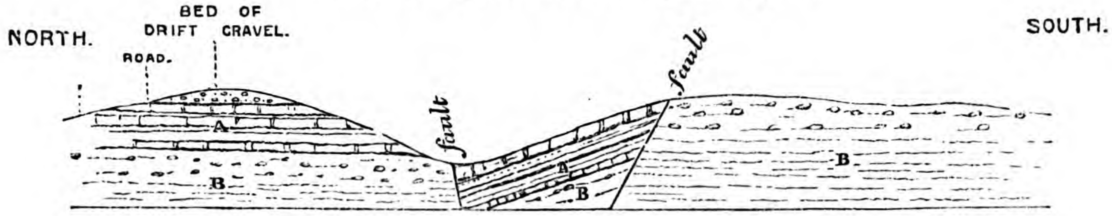
At Chastleton, where the Marlstone produces a bold promontory, the rock-bed has been extensively quarried near the fine old Elizabethan mansion, for which the Marlstone platform forms so suitable a site. The rock is there about 12 feet thick, but contains no fossils except Belemnites and Rhynchonella.

In one locality, and it is the only one with which I am acquainted, the marlstone rock-bed becomes a conglomerate. The bed may be seen in a quarry south of Daylesford. The pebbles which are well rounded, and occasionally 1½ inch in diameter, consist of pieces of slate and sandstone, often of the character of trappean ash, while all the fragments have a silurian aspect. On the top of this occurs the thin band of limestone characterized by Ammonites annulatus.

At Oddington the structure of the Marlstone is complicated by faults, which have the effect of throwing it almost, if not altogether, across the valley of the Evenlode. The following section (No. 1) from north to south will illustrate its position.

Fig. No. 1.

Section through the East Side of Oddington.



A, Marlstone. B, Lower Lias, with nodules of cement-stone and Gryphæa incurva, &c.

In tracing the Marlstone towards the south-east from Stow, we find its thickness becoming gradually less, arising rather from the gradual disappearance of the sandy strata below the rock-bed than from the thinning of the rock-bed itself. In the Tainton valleys, towards Tangley, the Marlstone is frequently composed almost entirely of highly ferruginous sandstone with Belemnites, its thickness varying from 10 to 20 feet. This is proved by the occurrence of blue clay of the Lower Lias in the bed of the brook. In the Stow Road, near the turnpike gate at Burford, the Marlstone is exposed, with blue shales of the Upper Lias resting upon it, and at its base certain bluish sandy shales, which may possibly be those of the Lower Lias, in which case the Marlstone would only be about 6 feet in thickness; but the sections which have placed beyond doubt the remarkable attenuation of the Marlstone towards the south-east of the district were exhibited whilst draining two fields, one near Little Milton, the other east of Shipton. In referring to these sections it will be necessary to anticipate. They show a diminution in thickness, not only of the Marlstone, but also of all the formations to the base of the Great Oolite, so that within the distance of a few yards, and within a thickness vertically of 50 or 60 feet only, we find the representatives of those formations which at Leckhampton Hill compose the flanks of an escarpment rising 600 feet above the plain.*

Instead of presenting a copy of the section obtained from the field trenches, it will be more satisfactory to record a section which every one may observe for himself. It is presented in the lane which leads up the hill from Little Milton to Shipton Downs.

* See Plate at the end of the volume.

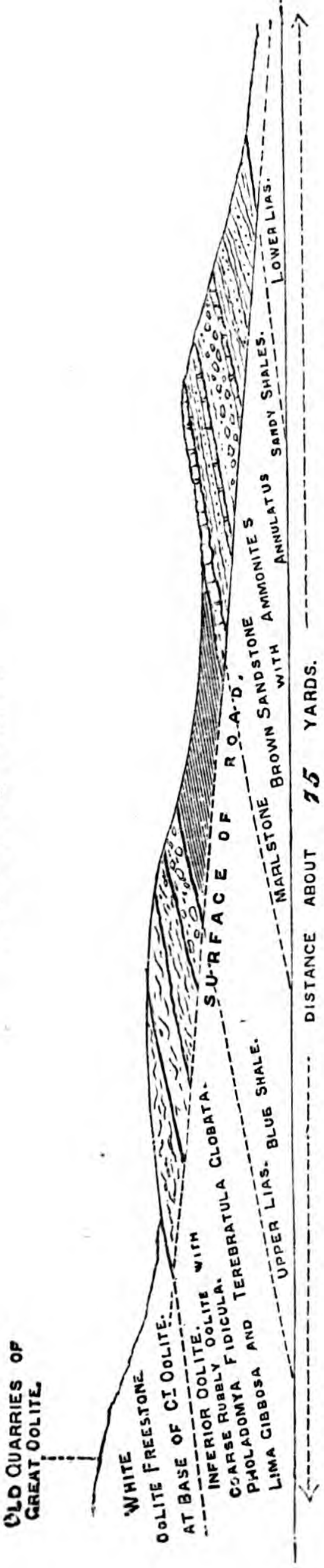


Fig. No. 2.
Section at Shipton Downs.

Fig. No. 2.

Section at Shipton Downs, near Burford.

	Ft.	In.
Inferior Oolite - - - - -	20	0
Upper Lias - - - - - -	20	0
Marlstone - - - - -	24	0
	64	0

The section near Ascott shows a still greater diminution in the thickness of the beds. The field in which it was obtained is situated about a mile east of Shipton, along the south bank of the Evenlode. It may be relied upon, having been verified in several drains some yards from each other; and each formation in this miniature section was thickly charged with its characteristic fossils.

Section near Ascott, Oxfordshire.

	Ft	In.
Inferior Oolite - - -	10	0
Upper Lias - - - - -	6	0
Marlstone - - - - - -	10	0
	26	0

In this section the beds are not one half the thickness of the last, the horizontal interval being 3 miles. Is it not, therefore highly probable that these formations will be found to disappear altogether a few miles further in the same direction?

Fossils of the Marlstone at Gretton Hill, Dumbleton Hill, Stanley Hill, Winchcomb, Mickleton Tunnel, and Leckhampton.

VERTEBRATA.

Ichthyosaurus, vertebræ.

ECHINODERMATA.

Uraster Gaveyi, Forbes.
Tropidaster pectinatus, Forbes.
Ophioderma Gaveyi, Wright.

MOLLUSCA.

Nautilus striatus, Sby.
—— truncatus, Sby.
Ammonites margaritatus, Montf.
—— var., Englehardti, D'Orb.
—— spinatus, Brug.
Belemnites giganteus, Schlot.
—— Bruguierianus, D'Orb.
Pleurotomaria expansa, Sby.
—— anglica, Sby.
Chemnitzia, sp.
Nerinæa, sp.
Myacites donaciforme, Goldf.
—— two other species
—— Vezelayi, D'Arch?
Ceromya, sp.
Arca, large, sp.
Pholadomya Murchisoniæ, Sby.
—— ambigua, Sby.
Unicardium cardioides, Ph.
Cardium truncatum, Sby.
Cardinia crassiuscula, Sby.
Cardinia crassissima, Sby.
Cucullæa, sp.
Modiola scalprum, Sby.
Lima gigantea, Sby.
—— pectinoides, Sby.
—— duplicata, Sby.
Pecten demissus, Ph.
—— cinctus, Sby.
—— æquivalvis, Sby.
Avicula novemcostæ, Brown.
Gryphæa cymbium, Lam.
Ostrea, sp.
Spirifer rostratus, Schl.
Terebratula resupinata, Sby.
—— subpunctata, Dav.
—— punctata, Sby.
—— cornuta, Sby.
—— Edwardsii, Dav.
Rhynchonella tetrahedra, Sow.
—— variabilis, Schloth.
Lingula Beanii, Phill.

The marlstone at Gretton Hill is a hard sandy rock, and at Dumbleton a compact sandy limestone.

UPPER LIAS SHALE.

Of all the formations in the district there is none which affords fewer opportunities for observation than the Upper Lias Shale. Besides the *primâ facie* probability that a stratum of clay, between two rocky and more prominent formations, should seldom appear otherwise than by its surface indications, such as springs and marshes, there is to be added the concealment occasioned by large quantities of tumbled oolitic detritus, to which we have already referred. The consequence is, that there are very few, and these but meagre sections of the Upper Lias Clay in the district. Of the sections referred to there is one at Colesburn, in a brickyard, another in the Oxford Road, near Andoversford, now almost concealed, another in the lowest beds at Dumbleton Hill, and in the same beds at Broadwell, in a brickyard.

The Upper Lias consists essentially of blue clay, with occasional bands of argillaceous lime or cement-stones. These may be noticed in the clay of a brickyard at Rockmill, near Painswick, in a lane at Holcomb on the south side of Painswick Hill, and in profusion in some of the brooks on the sides of the Cotteswold Hills, especially that on the southern base of Crickley Hill, where, if collected, they might prove of value as Roman cement.

Like the Marlstone, the Upper Lias Shale undergoes great changes in its thickness within the confines of the district. The reader will be prepared for this by the sections of the liassic and oolitic strata in the neighbourhood of Burford.* At Leckhampton Hill, according to the measured section, the thickness is 230 feet.† At Cleeve Cloud it must fall little short of 300, judging from the known height of the hill, the thickness of the oolite, and the absence of the so-called Inferior Oolite Sands. "Further North at Chip-" ping Campden, Broadway, and Ebrington Hill, the Upper" Lias Shale is from 80 to 100 feet thick. Like the Marlstone," however, between Chipping Campden and Stow-on-the-" Wold, it becomes gradually thinner towards Stow. At" Bredon Hill the position of the Upper Lias Shale is very" well marked by the wet and marshy ground above the" Marlstone, although sections of it are hardly ever exposed." Its thickness at this hill is probably 100 feet or more." On referring to the map, it will be seen that like the" Marlstone it forms a regular band on the north side of the

* See p. 20, *ante*. † See Plate.

"hill, but on the south side is partially cut out by the east "and west fault before alluded to."* At Stow the average thickness is 40 feet, and at Chastleton 60; at Sherburne, 50; at Tainton, 20; at Burford, 6; and at Knot Nook, on the borders of Wychwood Forest, I found Inferior Oolite lining the sides of the dell, of which Marlstone formed the bottom, with scarce a trace of Upper Lias Shale between. It would appear, therefore, that of the Marlstone and Upper Lias Shale the latter is the less persistent, for while the Marlstone nowhere attains so great a development as does the Upper Lias at Cleeve Cloud, there is no instance of the entire disappearance of the Marlstone within the limits of the district.

The change of thickness which takes place in this formation in its eastern extension it also undergoes towards the south. On reference to the map of the Geological Survey of Great Britain † it will be found that it thins gradually away to Wootton-under-Edge, where it is about 10 feet thick. Beyond this it disappears altogether, and the superior sands rest immediately upon the Marlstone. From this point the Upper Lias Clay gradually increases its thickness towards Cleeve Cloud, reaching at Stroud about 30, and at the northern extremity of Painswick Hill about 80 feet.

AMMONITE SANDS—(UPPER LIAS SANDS. *Wright.*)

The calcareous and ferruginous sands, which are bounded above by the Inferior Oolite and below by the blue shales of the Upper Lias, have hitherto been regarded as connected with the Inferior Oolite, and, in deference to the terminology of Dr. William Smith, have generally been denominated "Sands of the Inferior Oolite."‡

Dr. Wright, of Cheltenham, has recently expressed his conviction,§ that these sands ought to be regarded as essentially connected, by their fossils, not with the Inferior Oolite, but with the Upper Lias Shale upon which they

* Mr. H. H. Howell, MS. † Sheet 35.

‡ See Lyell's "Elements," p. 107.

§ At the Cheltenham meeting of the British Association for the Advancement of Science, 1856.

repose; and the following is a statement of the grounds upon which he founded his proposition:—

At the top of the sands, and immediately underneath the "pea grit" of the Inferior Oolite of Leckhampton and Crickley Hills, near Cheltenham, as also in a similar position on Frocester Hill, towards Wootton-under-Edge, there occurs a thin bed of calcaro-ferruginous sandstone, charged with fossils, especially cephalopoda, most of which were undescribed species. This bed had been long known to geologists as "the ammonite bed;" but the ammonites were supposed characteristic of the Inferior Oolite, and its true importance was overlooked. Dr. Wright, however, found that the species were identical with specimens from the Upper Lias of Whitby, in Yorkshire. About the same time the work of M. D'Orbigny made its appearance,* wherein nearly all the cephalopoda from the ammonite bed are figured and described as "*Toarcien*" or Upper Lias forms, while even in our own district several of the species, as *Ammonites bifrons*, Brug. (*Walcotii* of Sowerby), *Nautilus inornatus*, D'Orb., and *Belemnites abbreviatus*, Mill., from the same stratum at Crickley and Frocester Hill, were known to be characteristic of the Upper Lias Shale.

"The pea grit," says Dr. Wright, "must be a very "distinct formation from the cephalopoda bed on which it "rests, seeing that not one of the twenty species of echi-"noideæ and crinoideæ found in that rock alone have been "discovered in the cephalopoda bed a few feet below it: "nor, on the other hand, has one of the twelve species of "ammonites, nautili, and belemnites found in the cepha-"lopoda bed been discovered in any of the stages of the "Inferior Oolite, so that both positive and negative evidence "bear us to the conclusion that the cephalopoda bed was "the close of the liassic, and not the commencement of "the oolitic formation."†

On these accounts Dr. Wright proposes changing the

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* Prodrome de Paléontologie Stratigraphique, par Alcide D'Orbigny, tom. i., ii., iii.

† See Quart. Journ. Geol. Soc. of London, Nov. 1856, to which the reader is referred for a full and satisfactory statement of the argument.

name of this arenaceous series to "Upper Lias Sands," the top of which is formed of the "cephalopoda bed."†

The following lists have been kindly furnished by him: the fossils are from Frocester Hill (F) and Nailsworth (N):—

Reptilia.

Vertebræ of the Ichthyosaurus. F.

Pisces.

Teeth of *Hybodus*. F.

Cephalopoda.

Ammonites opalimus, *Reinecke* (primordialis, *Schloth.*). F.
—— bifrons, *Brug.* (Walcotii, *Sow.*). F.
—— insignis, *Schübler*. F. and Newmarket, and Ozleworth.
—— hircinus, *Schloth.* F.
—— Jurensis, *Zieten*. F. N.
—— striatulus, *Sow.* (radians, *Schloth.*). F.
—— Thouarsensis, *d'Orb.* F.
—— radians, *d'Orb.* F.
—— Dewalquianus. F.
Ammonites Mooreii, *Lycett*, nov. sp. F.
—— discoides, *Zieten*. F.
—— Raquinianus, *d'Orb.* F. N.
—— Levesquei, *d'Orb.* F.
—— concavus, *Sow.* F.
—— Leckenbyi, *Lycett*, nov. sp. F.
—— variabilis, *d'Orb.* F. N.
Nautilus inornatus, *d'Orb.* F.
Belemnites compressus, *Voltz.* F. N.
—— tripartitus, *Schloth.* F. N.
—— irregularis, *Schloth.* F. N.
—— Nodotianus, *d'Orb.* F.

Gasteropoda.

Pleurotomaria.
Chemnitzia lineata?, *Sow.* N.
*Turbo capitaneus, *Münst.* F. N.
Trochus, near to T. duplicatus, *Sow.* N.

Conchifera.

*Lima bellula, *Lycett.* F. N.
*Pholadomya fidicula, *Sow.* F. N.
*Gervillia Hartmanni, *Münst.* F. N.
*Modiola plicata, *Sow.* F. N.
*Trigonia striata, *Sow.* F. N.
*Perna rugosa, *Goldf.* N.
*Hinnites abjectus, *Phil.* F. N.
*Pecten articulatus, *Goldf.* F.

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† The "cephalopoda bed" has been traced by Dr. Wright from Cheltenham to the Dorsetshire coast, and into France; he considers it the same as the "Grès supraliassique" of M. Terquem, in the department de la Moselle. The Rev. B. P. Brodie, in his valuable paper on the "Basement Beds of the Inferior Oolite" (Journ. Geol. Soc. vol. vii. p. 208), describes the pea grit, and also the "cephalopoda bed" under the name of the Ammonite and Belemnite bed from Cleeve Cloud to Frocester Hill. He states that the latter is characterized not only by cephalopoda but by the remains of fish. At Cleeve Cloud and Crickley Hill he has detected bones, scales, coprolites, and teeth of Hybodus; and while dwelling on these phenomena, he draws attention to the remarkable fact "that in nearly every case the large fragmentary accumulations of the remains of fish or saurians, commonly called 'bone beds,' have "*taken place at the close of one formation and the commencement of another*," as in the case of the base of the Lower Green Sand at its junction with the Wealden, of the *Inferior Oolite at its junction with the Lias*, of the Lias at its junction with the New Red Marl, &c. Now it is evident that Mr. Brodie here implies the liassic age of all the beds below the cephalopoda bed, including the sands. Another step would have anticipated Dr. Wright.

*Gresslya adducta, *Phil.* F. N.
*—— conformis, *Agass.* F. N.
*Myacites tenuistriatus, *Agass.* F. N.
*Goniomya angulifera, *Sow.* F.
*Astarte excavata, *Sow.* F. N.
*Myoconcha crassa, *Sow.* N.
*Astarte modiolaris. N.
*Cypricardia cordiformis, *Desh.* F.
*Pecten comatus, *Goldf.* N.
Opis carinata, *Wright*, nov. sp.† F.
Cypricardia brevis, *Wright*, nov. sp. F. N.
Cardium Hullii, *Wright* (C. Buckmani, *Lycett*). F. N.
Cucullæa, allied to C. inequivalvis, *Goldf.* N.
Lima electra, *d'Orb.* F. N.
Unicardium, nov. sp. N.
Tancredia, nov. sp. N.
Trigonia Ramsayii, *Wright*, nov. sp. F.
Pecten textorius, *Goldf.*? F.
Pholadomya, allied to P. media. F.
——, nov. sp. F. N.
Astarte complanata, *Rœmer.* N.
Lima ornata, *Lyc. MSS.* nov. sp. N.
Astarte lurida, *Sow.* N.
Gervillia fornicata, *Lyc. MSS.*, nov. sp. N.
Astarte rugulosa, *Lyc. MSS.* nov. sp. N.
Arca, allied to A. olivæformis, *Lyc.* N.
Nucula ovalis, *Ziet.* N.
Pholadomya ovulum? *Agass.* N.

Brachiopoda.

Terebratula subpunctata, *David.* F. N.
Rhynchonella cynocephala, *Richard.* F.
——, nov. sp. N.

With regard to the conchifera, it ought to be stated that there are seventeen species common to the sands and Inferior Oolite, marked with an asterisk in the above list.

But Dr. Wright argues that the weight to be attached to this small community of species is by far counterbalanced by the great diversity in those higher forms of animal life whose organization would render them less capable of surviving physical changes, such as those which terminated the liassic and introduced the oolitic period.

The "cephalopoda or ammonite bed" has been accurately described along with its organic contents, by Dr. Wright, at the "Horsepools," Crickley Hill, and Leckhampton Hill, in which localities it is highly fossiliferous.‡

In the last of these localities it contains the following fossils :—

Leckhampton Hill.

Ammonites opalinus Rein. (primordialis, Schlotheim).
Ammonites torulosus, Schübler.
Nautilus inornatus, D'Orbigny.
Belemnites breviformis, Voltz.
Pleurotomaria; Turbo; (Interior moulds only.)
Myacites abductus, Phill.
Pholadomya fidicula, Sby?
Gervillia Hartmanni, Goldf.
Goniomya angulifera, Sby.
Lithodomus,—sp.
Trigonia Ramsayii, Wright.
Trichites, sp. (fragments).
Cucullæa oblonga, Sby.
Rhynchonella subdecorata, Davidson.
„ cynocephala, Richard.
Montlivaltia.

† Quart. Journ. Geol. Soc., vol. xii., part 4, p. 324, &c. ‡ Ib., p. 292, &c.

Lithological Character.—The Ammonite Sands consist essentially of very fine siliceous sediment of various shades of brown, yellow, and gray, becoming clayey towards their base, and calcareous in their upper parts. They frequently contain nodules and lenticular layers of siliceous limestone, as well as balls of ironstone. The highest bed is composed of calcaro-ferruginous sandstone, with occasional oolitic grains of hydrate of iron, and as far north as Cheltenham presents a fine series of Ammonites and allied genera.

Further to the north-east, in the vicinity of Winchcomb, Guiting, and Seizincote, this bed appears to be represented by highly ferruginous and generally calcareous sandstones, sometimes attaining a thickness of 10 feet; but, with the exception of a few belemnites, unfossiliferous.

The following are sections from different parts of the district of the whole series of the sands from the base of the Inferior Oolite:—

Hewlets Hill.

	Ft.	In.
1. Rubbly calcareous sandstone - -	? 3	0
2. Yellow and gray soft sands, with nodules of sandy limestone - - -	25	0
Total -	28	0

Stanley Hill.

		Ft.	In.
Inferior Oolite	1. Oolitic freestone highly false-bedded -	12	0
	2. Yellowish oolite, coarse-grained, full of broken-up shells, corals, plates, and spines of urchins, &c. - - -	2	0
	Total -	14	0
Ammonite sands.	3. Calcareous sandstone bored by lithodomus, with belemnites (ammonite bed ?) - -	0	6
	4. Loose calcareous sandstone - -	1	6
	5. Yellow sand, becoming light blue, and clayey downwards - - - - -	4	0
	Total -	6	0

Farmcott Hill, near Winchcomb.

	Ft.	In.
1. Fine-grained yellow sandstone becoming calcareous upwards - - -	10	0
2. Yellow sands becoming clayey towards their base - - - - -	15	0
Total -	25	0

Sections may be observed at Snows Hill, Dovers Hill, and along the picturesque valleys of the Guitings, especially on the east side at Keynton, where the unfossiliferous yellow sandstone which forms the upper part of the series may be observed in an opening of the bank. In this neighbourhood the whole series is about 30 feet thick.

" North of Snow's Hill the sands continue as far as Chip-" ping Campden, and at Dover's Hill, a mile to the west of " the town, form a prolonged terrace, about a mile in length, " and consist chiefly of soft sand and sandstone. The " Cephalopoda bed of Dr. Wright does not appear to exist " here. From Chipping Campden these sands may be traced " in a south-easterly direction towards Stow-on-the-Wold, " having an average thickness of about 30 feet, but becom-" ing gradually less towards Stow. At Ebrington Hill " these sands are not known for certain to exist, no section " of them being visible, although it is possible that traces of " them may be concealed in the broken ground round the " edge of the tumbled Inferior Oolite that caps the hill."*

At Stow there are from 6 to 10 feet of sand, sections in which may be observed along the Evesham Road and in the lane leading to Broadwell. East of Stow, however, the sands disappear; and we only find them once, namely, at Cornwell, around the Chastleton outlier.

At Sherborne we arrive at the south-eastern limit of these beds, but they form the banks, fifteen feet high, of a valley leading northward towards Clapton, in which I found a large ammonite (A. heterophyllus? Sow.), 1 foot 8 inches in diameter.†

On referring to the map (Sheet 44.) it will be oberved that the district contains the western, northern, and eastern limits of the sands, Oxenton Hill, Ebrington Hill, and the elevated land between the vales of Bourton and the Even-

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* Mr. H. H. Howell, MS.

† This ammonite is now in the Museum of Practical Geology. Unfortunately the internal mould is alone preserved; and the specimen strongly resembles *A. heterophyllus*, but is considerably larger than any specimen of that ammonite with which I am acquainted. It may possibly be a new species.

lode, forming respectively the limits of this series of arenaceous deposits in these directions; while, on the other hand, these strata increase in thickness towards the south east, attaining their greatest development around Stroud, at the southern extremity of Painswick Valley. It is well known that this increase of thickness is generally continuous along the line of the oolitic escarpment into Dorsetshire, where there is an apparent compensation in the increased depth of the lower or argillaceous portion of the series to the northward.*

INFERIOR OOLITE.

The Inferior Oolite forms by much the most conspicuous formation of the district, and one which has generally received from geologists the greatest share of attention. The typical section is that which is presented at Leckhampton Hill, laid bare principally by the opening of quarries, some of the beds forming an admirable building stone, almost rivalling the "Caen stone" in purity of colour, capability of being moulded, and durability. When first taken from its bed the block may be cut with a saw, but soon hardens on exposure.†

Two sections of the Inferior Oolite at Leckhampton Hill have been published; one by Messrs. Buckman and Strickland in "*Murchison's Geology of Cheltenham;*" another by Dr. Wright in his memoir on the so-called "*Sands of the Inferior Oolite.*" The section which accompanies the present Memoir has been measured with the theodolite and chain, and may, on that account, claim a close approximation to accuracy.

From this section it will be seen that the total thickness of the formation from the top of "the cephalopoda bed" is

* Mr. J. Lycett, in his memoir on the "Fossil Shells from the Inferior Oolite of Gloucestershire," read before the Cotteswold Naturalists' Club, July 1850, gives the thickness of the "inferior oolite" sands at Stroud at only 40 feet; but I think this much too low an estimate.

† The freestone beds have furnished the material for the internal decoration of Magdalen College Chapel, Oxford, one of the most elaborate specimens of the "florid" style in that city.

no less than 236 feet, a thickness at which the Oolite arrives in no other place in England.

We find in this section one very remarkable stratum—the Pea-grit, which dwindles away in every direction till it finally disappears within six miles; and as it will afterwards be shown, the same remarkable process of attenuation which affects the upper portion of the liassic series towards the east is also true with regard to this formation.

The Leckhampton Hill section has been divided into several very well marked zones, which are characterized both by certain fossils peculiar to each, and also by difference of mineral character. In the accompanying section these zones are marked,* and it will facilitate description to trace each of them separately over their respective areas, from which it will be seen that while the highest—that of the "rag-stones,"—is remarkably persistent, the inferior beds disappear within a distance of less than 20 miles eastward.

Pea Grit.†—This unique stratum forms, according to Dr. Wright, the true base of the Inferior Oolite, and it is a worthy introduction to an *oolitic* series of deposits, presenting, as it does, the oolitic structure on an unusual scale. It is composed of multitudes of flattened spheroidal masses about the size of a pea, one fourth or one fifth of an inch in diameter. Most of the ovules consist of layers of carbonate of lime, aggregated around some organic or inorganic fragment, and the concentric structure is frequently apparent. In many of the spherules, however, no concentric structure is discernible even with the aid of the magnifying glass; on the contrary, they appear to be fragments of limestone transported and worn into their present form.

At Leckhampton Hill the Pea-grit is about 38 feet in thickness, according to Mr. Brodie; and while the upper portion is but loosely connected by a ferruginous sandy paste, the lower 10 feet is cemented into a solid mass by carbonate of lime.

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* Plate 1.

† This name as used by the country people was first introduced as a geological term in Murchison's Cheltenham, 1838.

The base of the Pea-grit rests on the calcaro-ferruginous sandstone of the cephalopoda bed, while its upper boundary is very clearly defined along the face of the cliffs.

At Crickley Hill this zone is nearly 40 feet thick, according to Dr. Wright, who has measured it. He says, "The higher beds of the Pea-grit of this hill contain many "fossils which in general are not well preserved. The "echinodermata are sometimes found with the test in "a good state of preservation. The mollusca are most "frequently denuded of their shell; but when they "happen to have been preserved in the clayey or sandy "seams of the Pea-grit, the sculpture of the shell is sharp "and perfect."*

The horizontal range of the Pea-grit is very limited. Towards the south it does not extend further than Painswick Hill, though we find traces of it in Cranham Valley, but seldom or never *in situ;* nor does it occur in Robin's Wood Hill. Eastward we find Roe-stone in a pit by the Cirencester Road, near Lothbury Lodge, Colesburn, but not far beyond this; and Notting Hill, where there is but an occasional trace of the bed, forms its northern limit.

This zone is charged with a splendid assemblage of organic remains, especially echini, some of which, as *Pygaster semisulcatus* (Phill.) and *P. Conoideus* (Wright) are found in no other beds. It is also remarkable for the variety as well as abundance of its corals, serpulæ, and crinoids, which are here found in greater profusion than in any other part of the Inferior Oolite. In fact, there can be no greater contrast than that between the organic contents of the Cephalopoda bed and Pea-grit. In one we find evidence of a sea abounding in the highest class of mollusca to the exclusion of radiate forms; in the other, it appears to be the case of a sea teeming with radiate animals to the exclusion of nearly all classes of mollusca, with the exception of the brachiopoda. Some of the corals are figured and described by Milne Edwards and Haime, but there are many species in the collection of the Geological Survey hitherto unnamed.

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* Ibid., p. 298.

The following list, furnished by Dr. Wright, if compared with that from the cephalopoda bed and its underlying sands, will show what a large assemblage of new forms have been introduced contemporaneously with the Pea-grit. In this list are also included specimens collected by the Geological Survey from the same beds at Cleeve Cloud, and one or two from Winlay Hill.

*List of Fossils from the Pea Grit of Crickley Hill and Cleeve Cloud.**

MOLLUSCA.

Ammonites Murchisoniæ, Sow. Cl.
Nautilus truncatus, Sow.
Belemnites giganteus, Schlotheim.
—— two doubtful species. Cl.
Littorina ornata, Sow.
Pleurotomaria ornata, Defrance.
—— Aglaia, D'Orb, Pl. 1, f. 7.
Patella rugosa, Sow.
—— inornata, Lycett
Nerita costata, Sby.
Natica adducta, Phil.
Cirrus nodosus, Sow.
Trochotoma carinata, Morr. and Lyc.
Rimula tricarinata, Sow.
Chemnitzia, sp.
Lima punctata, Sow. - - Cl. & Cr.
—— duplicata, Sow.
*——potata, Goldf.
—— lunularis, Desh.
—— læviuscula, Sow.
*——sulcata, Münst.
—— ovalis, Sow.
—— impressa, Morr. and Lyc.? Cl.
Pecten articulatus, Schloth.
—— lens, Sow.
—— clathratus, Roëmer.
Plicatula tuberculosa, Morr. and Lyc. Cl.
—— elongata, Lycett.
—— complicata, Lycett, Pl. 1. f. 2. Cl.
Avicula inæquivalvis, Sow. Cl.
—— sp. Cl.
—— complicata, Buckm.
Hinnites velatus, Goldf.
—— tuberculosus, Goldf.
Placuna jurensis, Roëm.
Ostrea costata, Sow.
Gervillia Hartmanni, Goldf. Cl.
Mytilus bipartitus, Sow.
—— pectinatus, Sow.
—— pulcher, Goldf.
—— striatulus, Goldf.
—— cuneatus, Sow.
Modiola plicata, Sow.
—— furcata, Goldf. Cl.
Pinna cuneata, Bean.
Psammobia lævigata, Phil.
Myoconcha crassa, Sow.
Gresslya peregrina, Phil. Cl.
Myacites decurtatus, Goldf. Cl.
—— punctatus, Buckm.
—— securiformis, Phil. Cl.
Ceromya concentrica, Sow. Cl.
Unicardium parvulum, Morr. and Lyc. Cl.
Pholadomya fidicula, Sow. Cl.
Trigonia (internal mould) Cl.
Trichites (sp. undeterminable)
Terebratula simplex, Buckm.
—— plicata, Buckm.
—— submaxillata, Dav.
—— perovalis, Sow. Cl.
—— carinata, Lam. Cl.
—— Etheridgii, Davids. Winlay Hill.
Rhynchonella Forbesii, Dav. Cl.
—— oolitica, Dav. Cl. & Cr.
—— concinna, Sow. Cl. & Cr.
—— subdecorata, Davidson.
—— tetrahedra, Sow.
—— angulata? Sow.

* *Note.*—Those marked Cl. are only found at Cleeve Cloud, the rest are Crickley Hill. All the species marked with asterisks, are new to British lists.

ZOOPHYTA.

Montlivaltia de la Bechii, Edw. and H. Cl. & Cr.
—— trochoides, id. Winlay Hill.
Latomeandra Waterhousii, Edw. and H. Cl. & Cr.
—— cupuliformis, Edw. and H.
—— Wrightii, Edw. and H.
—— Flemingii, Edw. and H.
—— Davidsoni, Edw. and H.
Axosmilia Wrightii, Edw. and H.
Thecosmilia gregaria, M'Coy.
Thamnastræa Dessancrana, Edw. and H.
—— Mettensis. Edw. and H.
—— unguiformis, Edw. and H.
—— Terquemi, Edw. and H. Cl. and Cr.
Isastræa tenuistriata, M'Coy.

ECHINODERMATA.

Cidaris Fowleri, Wright.
* —— Bouchardii, Wright.
* —— Wrightii, Desor.
* Rhabdocidaris Wrightii, Desor.
Acrosalenia Lycettii, Wright.
—— spinosa, Agassiz.
Diadema depressam, Ag.
Echinus perlatus, Desm.
Echinus germinans, Phill.
Hyboclypus agariciformis, Cl. and Cr.
* Polycyphus Deslongchampsii, Wright.
Hemipedina Bakeri, Wright.
—— tetragramma, Wright.
—— perforata, Wright.
—— Waterhousii, Wright.
—— Bonei, Wright.
Pygaster semisulcatus, Phill., Cl. and Cr.
—— conoideus, Wright.
Hyboclypus caudatus, Wright.
Extracrinus, n. sp.

OOLITIC FREESTONE.

This constitutes the middle division of the Inferior Oolite of Murchison and Lycett, except that this term as used by them includes the Pea-grit, which has already been described, and which contains a large number of fossils peculiar to itself. In the present description the Freestone subdivision is to be considered as only that portion of the section of Leckhampton Hill included between the Pea-grit and the Ragstones.

In the sections it will be found to include the minor divisions, viz., the Upper Freestone, Oolite Marl, and Lower Freestone.

THE LOWER FREESTONE.—This subdivision constitutes the greater portion of the Inferior Oolite at the typical section, being 127 feet according to measurement. From it is de-

Note.—The coralline character of the early sea-bed of the Inferior Oolite was probably co-extensive with the formation in England. Such is the case in the neighbourhood of Bath, as mentioned by Mr. Lonsdale (Trans. Geol. Soc., vol. iii. p. 248) though the Pea-grit is not present there.

rived all the building stone of the Inferior Oolite, of which the principal quarries are at Bourton, Broadway, Guiting, Stanway Hill, Cleeve Cloud, Leckhampton Hill, Painswick Hill, Sheepscomb Mill, Hellcomb, Lyreford, Brockhampton, and Longborough. The block when taken from its bed is generally so soft as to be squared by the saw, but hardens upon exposure, and retains its sharpness for centuries, as is illustrated in the case of Sudeley Castle, and is capable of being delicately moulded. Unless frequently scraped, it soon becomes covered with lichens, which give it a venerable grayish tint. The presence of this oolite has imparted a peculiar character to the social architecture of the hilly districts as contrasted with that of the plains. Some of the farmsteads, as old as Henry VIII. or Elizabeth, are good specimens of the style of the period, and are built exclusively of stone; while on the other hand, in the liassic plain, where wood was abundant and stone scarce, we find the same style of architecture modified by the introduction of bricks and wooden framework.

Upon close inspection it will be found that this freestone is to a large extent composed of shells, chiefly in a fragmentary state, cemented by oolitic carbonate of lime.

Although the presence of Foraminifera in the ovules of this formation might be inferred from their occurrence in the oolitic beds of the Carboniferous limestone, and from the fact of the Chalk being to a large extent composed of their shells, as has been shown by Mr. Lonsdale, yet Mr. Etheridge, of Bristol, who has examined numerous specimens, has never yet been able to detect their presence. He says,* "I have made sections of the oolitic beds of the " Great and Inferior Oolite, and find the spherules of which " the rock is composed made up entirely of concentric layers " of carbonate of lime, having from eight to fifteen distinct " layers, but in no instance have I detected any organism " within the spherule. In the *calcaro-siliceous* beds I have " found siliceous centres round which the lime has formed,

* In a communication to the Author.

" but generally the immediate centre is of the same chemical " constitution as the envelope."

The beds which rest immediately on the Pea-grit are generally sandy and ferruginous. They are frequently pierced by *Lithodomus attenuatus*, Lycett, and are filled with spines and plates of echini, corals, and pentacrinite stems. The beds above these and below the Oolite Marl are considered most valuable as furnishing building material. They present the obliquely laminated structure very frequently, remarkable examples of which are exhibited in one of the quarries at the north side of Cleeve Cloud, and at Frocester Hill.

Oolite Marl.—This subdivision is 7 feet thick at Leck hampton Hill, and forms a very well defined zone extending over almost the whole promontory of the Cotteswold, from the vales of Moreton and Bourton on the east to the plain of Gloucester on the west. It consists of layers of white or yellowish marl, and marly stone, though sometimes it is almost entirely in a consolidated state, as at the Leckhampton quarries. In the cliff above Southfield Farm, Heartly Hill, we get the following section:—

Oolite Marl, Cheltenham.

	Ft.	In.
1. White compact marl stone - - -	1	0
2. Yellowish laminated marl - - - -	0	6
3. White soft marl (fossiliferous) - - -	3	6
4. White and yellowish compact marlstone - -	1	8
	6	8

The Oolite Marl is generally non-oolitic, and in the face of a cliff may easily be distinguished by its chalky aspect. At the quarries in Cleeve Cloud, and on the hills east of Winchcomb, it is rather thicker than in our typical section and is crammed with its peculiar fossils, especially *Terebratula fimbria*, Sow. It may also be observed at Condicote, and near Miserden, where it has yielded a large number of beautiful specimens to the fossil collector of the Survey, preserved in a yellow and white marl. The shells may often be detached in good preservation, and present a white silvery aspect: Bryozoa, Serpulæ, and Thecidia are frequently attached to the surface.

At Turk Dean we get the following section, in a quarry near a barn east of the Roman fossway.

Section of the Inferior Oolite near Turkdean.

		Ft.	In.
Ragstone*	Beds of hard sandy limestone interstratified with softer beds of sandy oolite, with Terebratula globata, and Trigonia costata - - - - -	4	6
Oolite Marl.	White argillaceous oolite and marlstone interstratified with cream-coloured marls and shales, with Terebratula fimbria, and Natica Leckhamptonensis? (very large) -	4	0

Fossils of the Oolitic Marl from Miserden, Sudeley Hill, and Cleeve Cloud.

Pleurotomaria, sp.
Natica, sp.
Astarte, sp.
Lucina lirata, Ph.
Modiola gibbosa, Sow.
Perna, sp.
Lima cardiiformis, Morr. and Lyc.
Terebratula fimbria, Sow.
—— maxillata, Sow.
—— — var. submaxillata, Morris
—— Waltonii, Dav.
Terebratula carinata, Lam., exhibiting the wavy lines of punctuation.
—— plicata, Buckm.
—— perovalis, Sow.
—— globata, Sow.
—— emarginata, Sow.?
Rhynchonella concinna, Sow.
—— Lycettii, Dav.
—— angulata, Sow.
—— tetrahedra, Sow.
—— subtetrahedra, Dav.

Towards the south of the district sections may occasionally be found along Painswick Valley; but the finest with which I am acquainted is exhibited in a large quarry on White Hill, south-west of Pitchcomb, where the Oolite Marl shows a section of about 8 feet, and contains several of the characteristic fossils.

It is not improbable that this marl, so similar to some beds of the Chalk, is of animal origin, and by examination would amply reward the microscopist.†

* The above is not the total thickness of the ragstone here.

† According to the Rev. B. P. Brodie the oolite marl extends into Lincolnshire, and occurs in the neighbourhood of Grantham, where it preserves its marly character, and is characterized by Natica adducta, Nerinæa, &c. besides many corals.—Cottesw. Nat. Club, 1850.

The following are the most characteristic fossils of this zone from the neighbourhood of Cheltenham:—

Fossils of the Oolite Marl.

Natica adducta, Phil.
„ Leckhamptonensis, Morr. and Lyc.
Nerinæa, sp.
Lucina lirata, Phil.
Lima læviuscula, Sby.
Mytilus sublævis, Sby.
Astarte elegans, Sby.
Terebratula fimbria, Sby.
„ plicata, Buckman.
„ maxillata, Sby., var. submaxillata, Morris.

THE UPPER FREESTONE is 28 feet thick at Leckhampton Hill, and consists of regularly stratified oolite, compact, and not so highly fossiliferous as the remaining beds of the series. Eastward this bed disappears sooner than the Oolite Marl, as at Turk Dean. Near North Leach we find the Ragstone resting directly on the latter subdivision.

Towards the northern part of our district most of the freestones assume a yellowish tinge, which increases in intensity towards the base. Thus at Stanway Hill there is a very large quarry showing a vertical section of 35 feet, and capable of yielding blocks of any required size, the whole of which is tinged yellowish brown. There are also fine quarries with a similar description of stone at Broadway Hill, Temple Guiting, Seizincote, and Bourton-on-the-Hill. Around Snowshill, Condicote, and Lower Swell, the beds become very fissile on exposure to the air, and appear to have been made use of as rough slates. "About five "miles to the north-east of Broadway there are two small "outliers of the same stone, which form the summit of "Ebrington Hill. The stone is very similar to that quarried "at Broadway Hill, and probably represents the very same "beds."* Above Bourton-on-the-Hill there are several quarries. Some of the beds are traversed by bands of pure hæmatite, in which the fibrous structure is apparent. There is also a band of what might be called a "terebratula conglomerate," 4 inches thick, made up entirely of these and a few other shells cemented together. The shells are frequently hollow, and encrusted with calcareous spar.

* Mr. H. H. Howell, MS.

At Turkdean, near North Leach, all the subdivisions which are present may be seen in their order of succession along the lane leading from the south side of the village down to the brook. The total thickness to the base of the Oolite appears to be only 70 feet (see vertical section), of which 24 feet are composed of the Oolite Marl and Ragstone, leaving but 46 feet for the thickness of the Freestone, which rests on about 14 feet of yellow sandstone belonging to the Upper Liassic Sands. Further east, on the north side of the valley opposite Sherborne, we find a still greater diminution in the thickness. The following section along the lane may be made out, showing that we are here approaching the limits of this subdivision:—

Section at Sherborne.

Ragstone	Rubbly oolite, with impressions of Trigonia costata, Clypeus sinuatus, Terebratula globata, with Gresslya, Lima gibbosa, &c.	
Oolitic Freestone.	Yellow oolitic freestone becoming sandy towards the base. - - - - - - about	5 ft.
Upper Lias	Yellow sandstone and sands - - - - - Blue clay with Ammonites Walcottii.	8 ft.

Within a mile or so east of Sherborne this zone entirely disappears, and at Stow, Rissington, and Burford, we find the Ragstone resting directly on the Upper Lias Shale.

BREDON HILL.

Inferior Oolite.

Whenever the Inferior Oolite occurs in detached masses, or occupies small areas, it is usually found in a broken and disturbed state. This is true in the case of the ridge west of Painswick Valley, and of the hills around Stow, east of Adlestrop, and at Bredon Hill. This is no doubt a consequence of the infirm foundation on which the oolite rests; and some of these fractures, though not partaking the character of *faults*, may date as far back as the original disturbances of the country. Everywhere on the Bredon outlier the oolite is in a most disjointed state, showing apparent dips in all directions, and this not only along the skirts but in the very centre of the area.

The basement beds are similar to those east of the Vale of Winchcomb, consisting of thick-bedded calcareous sandstone, highly ferruginous, and containing bands of brown hæmatite. From the absence of fossils in these beds it is impossible to say whether or not they may occupy the horizon of the Cephalopoda beds at the base of the Pea-grit. The only organic remains I could find were small fragments of *Pentacrinus*. These beds are more than ten feet thick, and are well shown in a quarry above Hemerton.

The Pea-grit being absent, these beds are succeeded, or pass into, those of the Freestone series, which are well exposed in a quarry on the west side of Overbury Park, near Kemerton Hill Farm. Here there is a section of thirty-five feet of oolite, precisely similar to the beds above the Pea-grit at Leckhampton Hill.

The strata have an apparent but false dip to the northward from the cause already stated, and consist of fine-grained oolite of a yellowish-brown colour, which increases in intensity downward. They are more or less composed of broken shells of mollusca and radiata, but there are occasional vesicular bands in which the fossils are less fragmentary, though it is difficult to find an entire specimen.

This quarry probably contains the highest beds of Bredon Hill, and yet these are below the *Oolite Marl.* From the thickness of this subdivision on Winchcomb Hill we may infer its former existence on the Bredon outlier, more especially when we recollect that there is a tendency in the Inferior Oolite to increase in thickness westward. Hence we have a clue to the cause of the denudation of the oolite marl, and its superincumbent beds. Being of a soft friable nature it would offer but slight resistance to marine agency, and in this sense would act the part towards the superior beds of the Upper Lias to the Inferior Oolite, or of the Fullers Earth to the Great Oolite.

In conclusion it may be stated, that, notwithstanding the numerous pseudo-dips and dislocations, there is probably no fault of any consequence affecting the Inferior Oolite with the exception of that which traverses the south side of the hill, and which is proved, *inter alia*, by a comparison of the levels of the formation along the north and south boundaries.

Southward from Leckhampton towards Stroud, there is a similar thinning away of these beds. According to a section which I made at Rodborough Common, the thickness of the beds below the Oolite Marl are only from 30 to 35 feet. However this may be, the fact of this southern attenuation is acknowledged by all local geologists.

With regard to the fossils of this subdivision, Mr. Lycett states, that "they are generally small, even minute, and are "disengaged from the investing stone with great labour and "perseverance;" that they present a remarkable similarity of aspect, and frequent specific identity with those of the Great Oolite of Minchinhampton, a similarity first pointed out by Professor Buckman; and that out of 181 species from Leckhampton Hill, 59, or 33 per cent., pass upwards.* At the same time there is a remarkable dissimilarity between the fossils of the Freestone and those of the Pea-grit, and greater still between them and the fossils of the Ragstone, arising principally from the abundance of echini, mya-like shells and Cephalopoda in the latter, and their entire absence in the Freestone series. The following list is arranged on the basis of Mr. Lycett's "Tabular View," those from the Pea-grit being omitted, of which, however, there are very few common to the two subdivisions.

List of Fossils from the Freestone† *subdivision of the Inferior Oolite* (*b*, *c*, *d*, *of the section*), *Leckhampton Hill.*

MOLLUSCA.

Nautilus lineatus, Sow.
Cirrus nodosus, Sow.
Cylindrites attenuatus, Morr. and Lycett.
,, mamillaris, id.
Delphinula funata, Goldf.
Emarginula scalaris, Sow.
,, Leckhamptonensis, Morr. and Lyc.

* Mr. J. Lycett on "Fossils from the Inferior Oolite of Gloucestershire," read before the Cottes. Nat. Club, 1850.

† This list includes the Upper Freestone and Oolite Marl as well as the lower Freestone.

MOLLUSCA—*continued.*

Fissurella acuta, Deslongch.
„ Brodieii, Morr. and Lyc.
Patella nitida, Deslongch.
„ retifera, Morr. and Lyc.
Monodonta sulcosa (Nerita), D'Archiac.
„ Lyellii, D'Arch.
Natica Leckhamptonensis, Morr. and Lyc.
Naticella decussata (Natica), Goldf.
Nerita cassidiformis, Morr. and Lyc.
„ lineata, id. Lyc.
Phasianella turbiniformis, id. Lyc.
Pileolus lævis, Sow.
„ plicatus, Sow.
Rimula minutissima, Morr. and Lyc.
Trochus monilitectus, Phil.
Turbo Gomondei, Morr. and Lyc.
Arca pulchra, Sow.
„ lata, Dunker.
„ trisulcata, Gold.
Astarte excavata, Sow.
Cardium cordiforme, Morr. and Lyc.
„ lævigatum, id. Lyc.
„ cognatum, Phil.
„ punctato-striatum, Morr. and Lyc.
„ granulatum, id. Lyc.
„ Buckmanni.
Corbis lævigatus, Morr. and Lyc.
Cucullæa elongata, Sow.
„ dense-granulata, Morr. and Lyc.
„ amœna, id. Lyc.
„ cucullata, Goldf.
„ nana, Morr. and Lyc.
„ bipartita, id. Lyc.
„ cancellata, Phill.
Corbula involuta, Goldf.
„ imbricata, Morr. and Lyc.
Corbula depressa, Phil.
Sphæra Madridi (Cardium), D'Arch.
Dreissena lunularis, Morr. and Lyc.
Gervillia tortuosa (Gastrochæna), Phil.
„ costatula, Desl.
„ lævigata, Morr. and Lyc.
Hinnites sepultus, id. Lyc.
Lima squamicostata, Buvignier.
„ punctatilla, Morr. and Lyc.
„ minutissima, id. Lyc.
Lithodomus attenuatus, id. Lyc.
Lucina lyrata, Phil.
„ despecta, Phil.
Myacites oblongus (Sanguinolaria), Buckman.
„ punctatus (Sanguinol.), Buck.
Nucula variabilis, Sow.
Mytilus subrectus, Morr. and Lyc.
„ crenatus, id. Lyc.
Pecten vimineus, Sow.?
„ lineolatus, Morr. and Lyc.
Perna mytiloides, Lam.
Ptychomya Agassizii, Morr. and Lyc.
„ debrita, Goldf.
Trigonia clavo-costata, Morr. and Lyc.
„ lineolata, Agass.
„ angulata, Sow.
„ striata, Sow.
„ costatula, Morr. and Lyc.
„ V— costata, id. Lyc.
„ tuberculosa, id. Lyc.
Tancredia donaciformis, Lyc.
Tancredia curtansata, Phil.
Trichites nodosus, Morr. and Lyc.
Venus trapeziformis, Roëmer.
„ curvirostris, Morr. and Lyc.
Terebratula fimbria, Sow.
„ carinata, Lamarck.
„ Buckmani, Davidson.

ECHINODERMATA.

Pygaster semisulcatus, Phil.
Diadema depressum, Agass.
Acrosalenia Lycettii, Wright.
„ spinosa, Agass.

ANNELIDA.

Serpula lævigata, Morr. and Lyc.
Serpula socialis, Goldf.

Fossils from the Inferior Oolite, near Stroud.

(*Probably including several sub-divisions.*)

Palatal teeth of Fishes—*Acrodus.*

MOLLUSCA.

Ammonites Martinsii, D'Orb.
A. Parkinsoni, Sow.
A. subradiatus, Sow.
Natica Leckhamptonensis, Morr. and Lyc.
* N. Pictaviensis, D'Orb.
Pleurotomaria carinata. ?
Pholadomya fidicula, Sow.
Trigonia costata, Park.
Cypricardia cordiformis, Desh.
Ceromya concentrica, Sow.
* —— Sarthensis, D'Orb.
Gresslya peregrina, Phil.
Myacites dilatus, Phil.
Modiola furcata, Goldf.
—— cuneata, Sow.
Mytilus.
Avicula digitata, Desl.
Lima gibbosa, Sow.
*—— sulcata, Desl.
Gryphæa Buckmani, Lyc.
Ostrea Marshii, Sow.
O. acuminata, Sow.
Pecten vagans, Sow.
P. lens, Sow.
P. demissus, Phil.
Terebratula fimbria, Sow.
T. globata, Sow.
T. carinata, Lam.
T. plicata, Buck.
T. intermedia, Sow. var.
Rhynchonella spinosa, Schloth.

RAGSTONE.

This is the highest member of the Inferior Oolite, and presents a remarkable contrast to the beds already described, for although only 38 feet thick at Leckhampton Hill, or one sixth of the whole formation, yet it preserves a very uniform thickness over nearly the whole district, and at its south-east extremity is the sole representative of the Inferior Oolite. The Ragstone affords evidence of deposition in a sea of a tranquil character, and of greater depth than that which deposited the Freestones; and this is borne out by the vast number of sea-urchins, especially *Nucleolites* (*Clypeus*) *Plotii* * and *N. clunicularis* with which it is stored, and which, in the neighbourhood of Stow and Naunton, are ploughed up, and collected into heaps in the fields.

* *N. sinuatus.* Forbes in Morris Catal. 2d. ed., and of most writers. See Mem. Geol. Surv. Decade, 5. pl. 7. p. 5. (note). Dr. Wright agrees in this.—J. W. S.

The following is a section at Leckhampton Hill:—

	Ft.	In.
1. Ragged, incoherent sandy limestone, filled with *Trigonia costatula*, *T. clavellata* (casts only), *Trichites undatus*, *Terebratula globata*, *Serpula plexus*, *&c.*	5	6
2. Compact thin-bedded oolitic limestone, upper surface pierced by *Lithodomus*	4	6
3. Yellow marl	1	3
4. Brown calcareous sandstone	1	4
5. Yellow marl	0	6
6. Brown calcareous sandstone	0	5
7. Yellow calcareous marl	1	4
8. Unseen	2	0
9. Hard sandy limestone with *Gryphæa* and *Ostrea Marshii*	2	0
10. Loose irregularly bedded brown sandy beds with *Gryphæa* and *Trichites*	5	6
11. Regularly bedded limestones interstratified with sandy marls and shales (not clearly exposed to view)	14	0?
	38	0

At Cleeve Cloud, the Ragstone contains a bed of yellow siliceous sand at or near the base, which may also be observed on Broadway Hill near the tower, in a quarry. The upper bed is also bored by *Lithodomi.* This bed of sand appears in some localities to give place to clay or shale, as may be seen by the following section east of Stanway Hill Barn, intermediate between the localities above alluded to.

Ragstone.—Stanway Hill.

	Ft.	In.
1. Thin-bedded, brown calcareous sandstone alternating with marly beds, with Modiola plicata, Ostrea Marshii, and Trigonia (casts)	7	6
2. Yellow calcareous sandstone	2	0
3. Variegated sandy shales	4	6
4. Light brown sandstone	1	0
5. Variegated sandy shales and clay	8	0
6. Yellow, brown, and black shale, with a bed of small oysters	2	0
7. Hard limestone with blue centre	3	0

In this quarry, the beds have a dip to the westward of 10 degrees, occasioned by a fault which traverses them some distance west of this spot.

A bed of very hard intractable limestone occurs near the base of the Ragstone, and extends over the greater portion of the area included between the valleys of Winchcomb and Bourton, and north and south from Broadway Hill to North Leach. This bed has been perforated by a large species of *Lithodomus*, the shell of which is always absent, leaving large circular cavities penetrating 3 or 4 inches into the stone. Blocks from this bed may frequently be found built into walls along the fields and lanes of which the Ragstone forms the substratum; but the bed may be seen in situ on the Stowe Road, within half a mile of Naunton Inn, on Cutsdean Hill, on the top of the hill above Aylworth, as also in the road near Forster's Ash, south of Birdlip, and at Scolchanar Hill.

At the fine old encampment on Painswick Hill, the Ragstone, as is the case with all the remaining beds of the Oolite, is clearly developed. Towards the base it becomes very sandy, and contains a bed of silicious sand of considerable thickness. The rock is very fossiliferous, being charged with Gryphæa, Trigonia, Modiola, and Lima. The whole thickness of the zone cannot be less than 45 feet.

Towards the south-eastern part of the district, the Ragstone gives place to a coarse, rubbly white oolite, which always occurs at the top of the formation immediately below the Fuller's Earth. This bed, which may be called the *Clypeus grit*, is characterized by many of the fossils of the Ragstone. It makes its appearance within two or three miles east and south of Leckhampton Hill, and may be seen in the cuttings of the lanes and quarries immediately below the Fuller's Earth, north of Colesburn, and around Brimpsfield.

At Stow, there is an excellent section in these beds, a little way north of the town on the Moreton Road, where they are quarried for road material. It is there a very coarse-grained oolite, containing large numbers of the *Clypeus* and other fossils; and in this locality rests directly on the sands of the Upper Lias, being, in fact, the only remaining member of the Inferior Oolite.

At Rissington, where the sands are absent, we find springs bursting forth at the junction of this grit and the Upper Lias Clay, and in a quarry above the village we find the following section:—

Section of the "Clypeus Grit," Little Rissington.

	Ft.	In.
1. Coarse white rubbly oolite with Nucleolites (Clypeus) Plotii, Terebratula globata, Pholadomya, &c.	4	0
2. Coarse soft marl	0	8
3. Compact white oolite	4	0
4. Soft marly oolite with Nucl. Plotii and N. clunicularis, with N. orbicularis	4	0
5. Unseen, about 4 feet.		
6. Upper Lias clay.		

Such is the general character of this subdivision over the high land extending from Icomb Camp to Burford; the thickness in the former locality being from 30 to 40 feet, and diminishing to more than one half at the latter. At Swinbrook, there is a very good section just at the confines of the district near the banks of the Windrush. About 15 feet of rock is exhibited, of an exceedingly coarse-grained oolite, in which were noticed *Clypeus Plotii*, *Terebratula globata*, and *Lima gibbosa*. It is capped by shelly freestone of the Great Oolite, without the intervention of the Fuller's Earth, which has altogether disappeared.

On the north side of the valley of the Evenlode, at Church Hill and Chastleton, the only beds of the Inferior Oolite are those of the Clypeus grit, in which there are some old quarries along the Norton Road at Adlestrop Park, and along the northern flank of the ridge; but the best section is exhibited along the lane leading from Cross Hands Inn to Mill Hill Bridge near Cornwell. The bed is about 10 feet thick, of the usual coarse oolite, and plentifully stored with the characteristic fossils already named.

On the south side of the Evenlode, sections of these beds have already been presented (p. 20), at Little Milton and Ascott, all confirmatory of the easterly attenuation of the Inferior Oolite, a formation which, in the typical section attains a thickness of 230 feet.

Fossils from the " Ragstone" or Highest Zone of the Inferior Oolite.

Name.	Localities.
Cephalopoda.	
Ammonites Parkinsoni, Sow. - -	Barrow Hill, Leckhampton Hill, Cleeve Cloud, Andoversford, Colesburn, Turkdean.
—— Murchisonæ, Sow. - -	Leckhampton Hill, Stanley Hill.
—— Sowerbyi, Miller - -	Leckhampton Hill, Sudeley Hill.
—— Brodiæi, Sow. - -	Leckhampton Hill.
—— Martinsii, d'Orb. - -	Leckhampton Hill.
—— concavus, Sow. - -	Sudeley Hill.
—— Dorsetensis, Wright. -	Clapton, near North Leach.
Nautilus obesus, Sow. - - -	Leckhampton Hill, Andoversford.
—— truncatus, Sow. - -	Leckhampton Hill.
—— lineatus, Sow., young and imperfect specimen -	Stanley Hill.
Belemnites abbreviatus, Miller - -	Leckhampton Hill, Winchcomb? Cleeve Cloud.
—— elongatus, Miller - -	Leckhampton Hill.
—— acutus, Miller? - -	Stanley Hill.
Gasteropoda.	
Cirrus carinatus, Sow. - - -	Leckhampton Hill.
Pleurotomaria fasciata, Sow. - -	Leckhampton Hill, Sudely Hill.
Phasianella striata, Sow. - - -	Leckhampton Hill, Cleeve Cloud.
*Bulla subquadrata, Roëm. - -	Stoney Cockbury.
Natica, Nerinæa, Trochus } as casts or moulds only -	Andoversford, Stoney Cockbury.
Cylindrites, sp.—casts only - -	Andoversford.
Conchifera.	
Myacites securiformis, Phil. sp. - -	Leckhampton Hill, Cleeve Cloud, Andoversford, Sudeley Hill, Upper Swell, Fulbrook.
—— decurtatus, Phil. - -	Leckhampton Hill, Stanley Hill, Stoney Cockbury, Cleeve Cloud, Andoversford.
—— calceiformis, Phil. - -	Sudeley Hill, Colesburn.
—— rotundatus, Sow. - -	Quarry, east of Andoversford.
—— Jurassi, Brong. - - -	Andoversford.
—— crassiusculus, Morr. and Lyc.	Stoney Cockbury.

Name.	Locality.
Gresslya peregrina, Phil. - -	Stoney Cockbury, Colesburn, Cleeve Cloud, Andoversford, Sherborne, Fulbrook, Stow? Clapton near North Leach.
Pholadomya fidicula, Sow. - -	Leckhampton Hill, Sudeley Hill, Stoney Cockbury, Stanley Hill, Cleeve Cloud.
—— ambigua, Sow. - -	Sudeley Hill, Colesburn, Cleeve Cloud, Stanley Hill? Andoversford.
—— Murchisonæ, Sow. - -	Leckhampton Hill, Stoney Cockbury, Andoversford, Pen Hill, Upper Swell?
—— lyrata, Sow. - -	Leckhampton Hill, Barrow Hill.
—— gibbosa, Sow. - -	Leckhampton Hill.
—— ovalis, Sow. - -	Leckhampton Hill.
Modiola bi-partita, Goldf. - -	Leckhampton Hill.
—— plicata, Sow. - - -	Leckhampton Hill, Stanley Hill, Stoney Cockbury, Sudeley Hill, Cleeve Cloud.
—— explanata, Morris, Pl. 1, f. 1 -	Stoney Cockbury.
* —— jurensis, Bronn. - -	Leckhampton Hill.
—— gibbosa, Sow. - - -	Leckhampton Hill, Stoney Cockbury.
—— imbricata, Sow. - -	Burford, Andoversford?
—— furcata, Goldf. - - -	Stoney Cockbury.
—— tumida, Morr. and Lyc. -	Cleeve Cloud.
Isocardia rhomboidalis, Phil. - -	Leckhampton Hill.
—— cordata, Buck. - -	Leckhampton Hill.
Ceromya concentrica, Sow. - -	Leckhampton Hill.
* —— plicata, Agass. - -	Stoney Cockbury.
Pinna lanceolata, Sow. - -	Leckhampton Hill.
—— mitis, Phil. - - -	Leckhampton Hill.
Trigonia costata, Park. (a very abundant and characteristic shell)	Leckhampton, Stanley Hill, Cockbury, Andoversford, Burford, Stowell, Sudeley Hill, &c.
—— V - costata, Morr. and Lyc. -	Leckhampton Hill.
—— striata, Sow. - - -	Leckhampton Hill, Cleeve Cloud?
Cardium striatulum, Sow. (cast) -	Stoney Cockbury, Andoversford.
—— cognatum, Phil. - -	Andoversford.
Astarte excavata? Sow. - -	Cockbury, Sudeley Hill.
Lucina lirata, Phil. - - -	Andoversford, Stow Road, Stowell.
—— Bellona d'Orb.? - -	Cockbury, Andoversford, Stanley Hill, Cleeve Cloud.
—— rotundata, Roëm. - -	Stanley Hill.
Cyprina? sp. Pl. 1, f. 5 - -	Stoney Cockbury.
Unicardium parvulum, Morr. and Lyc.	Cockbury.
Goniomya V-scripta, Sow. - -	Andoversford.
Avicula inæquivalvis, Sow. - -	Colesburn.
Gervillia acuta? Sow. - - -	Stanley Hill.
—— Hartmanni, Goldf. - -	Cleeve Cloud, Sudeley Hill.
Lima gibbosa, Sow. - - -	Leckhampton Hill, Andoversford, Sherborne, Clapton, Stow, Burford.

Name.	Locality.
Lima proboscidea, Sow. -	Leckhampton, Cleeve Cloud, Andoversford, Stoney Cockbury, Stowell, Turkdean.
—— ovalis, Sow. - - -	Leckhampton Hill.
—— duplicata, Sow. - - -	Sudeley Hill, Andoversford.
—— punctata, Sow. - - -	Sudeley Hill, Cleeve Cloud.
Pecten annulatus, Sow. - -	Leckhampton Hill.
—— demissus, Phil. - - -	Andoversford.
—— ambiguus, Munst. - - -	Leckhampton Hill.
—— arcuatus, Sow.? - - -	Andoversford.
—— vimineus, Sow. - -	Leckhampton Hill.
—— grandævus, Goldf. - -	Leckhampton Hill.
—— lens, Sow. - - -	Sudeley Hill, Andoversford, Turkdean.
—— vagans, Sow. - - -	Andoversford.
—— symmetricus, Morris, Pl. 1, f. 3	Andoversford.
Gryphæa Buckmani, Morr. and Lyc. (very abundant over the western part of the hills) - -	Leckhampton Hill, Cleeve Cloud, Andoversford, North Leach, Colesburn.
Ostrea Marshii, Sow. - - -	Leckhampton Hill, Stanley Hill, Cleeve Cloud.
—— gregaria, Sow. - - -	Leckhampton.
—— acuminata, Sow. (and one or two undescribed species) -	Stowell, Naunton, Andoversford.
Brachiopoda.	
Terebratula globata, Sow. - -	Passim, a most abundant species.
—— maxillata, Sow. - -	Leckhampton Hill, Colesburn, Pen Hill.
—— Buckmani, Dav. -	Andoversford.
—— ornithocephala, Sow. -	Leckhampton Hill, Cleeve Cloud.
—— perovalis, Sow. - -	Leckhampton Hill, Cleeve Cloud, Cockbury, Sudeley Hill, Stanley Hill.
—— impressa, Von Buch. -	Leckhampton Hill.
—— carinata, Lam. - -	Stanley Hill, Stowell.
—— Wrightii, Dav. - -	Leckhampton Hill.
Rhynchonella concinna, Sow. - -	Leckhampton Hill, Andoversford, Clapton, Sherborne, Stow.
—— angulata, Sow. - -	Stanley Hill, Cockbury, Andoversford, Turkdean.
—— spinosa, Schloth. - -	Andoversford, Burford, Fulbrook.
—— sub-tetrahedra, Dav. -	Cockbury, very rare.
—— quadriplicata, Zeiten -	Cockbury, very rare.
—— inconstans, Sow. -	Andoversford, very rare.
Echinodermata.	
Nucleolites (Clypeus) Plotii, Leske (very abundant over the central parts of the hills (*C. sinuatus*, Auct). -	Cleeve Cloud, Cubberley, Pen Hill, Stow, Adlestrop, North Leach, Naunton, Burford.
—— clunicularis, Llhwyd. -	Leckhampton Hill, Andoversford, Swell, North Leach, &c.

NAME.	LOCALITY.
Diadema depressum, Agass. - -	Colesburn.
Echinopsis (Pedina) rotata, Agass. -	Leckhampton Hill.
—sp. - - - - - -	Stow Road, east of Andoversford.
Holectypus depressus, Lam. - -	Leckhampton Hill, Stow Road, near Andoversford.
Hyboclypus caudatus, Wright - -	Leckhampton Hill.
—— gibberulus, Agas. - -	Leckhampton Hill.
ANNELIDA.	
Serpula socialis, Goldf. - - -	Fulbrook.
CORALS.	
Anabacia orbulites, Lamx. - -	Common about North Leach, with another (oval) species.

FULLER'S EARTH.

This argillaceous deposit forms the zone separating the Great from the Inferior Oolite, and contains a general assemblage of forms common to both.

The upper beds are frequently interstratified with sandy slates and limestones, similar to those of the Great Oolite.

But few sections of this formation are exhibited in the district, and its presence is to be detected by the outburst of springs at the base of the Great Oolite, by marshes and marsh plants, by dark-coloured mould, and, lastly, by the rich green of the grass or meadow land. Indeed, the Fuller's Earth, with its surrounding formations, illustrates the connection between agriculture and geology. Throughout the Cotteswold Hills, it will generally be found that the "brash lands," of which the substratum is rocky, are turned up by the plough for cereals, when cultivated at all, while the ground of which the various clayey deposits form the under-surface is thrown into meadows or permanent pastures; nor can farming be undertaken successfully if these natural changes of subsoil be overlooked.

This deposit consists of regularly bedded blue and yellow shales, clays, and marls, with occasional layers of limestone, rubble, or calcareous sandstone. There are but few fossils, except oysters and terebratulæ, which often occur in great profusion; some of the stoney bands being composed entirely of *Ostrea acuminata* cemented together.

The fossils, as Professor Buckman remarks,* are not distinctive, being found either in the Great or Inferior Oolite. In the following list those species to which an asterisk is affixed are inserted on his authority; the others have been collected by the Geological Survey at Cubberly.

Fossils from the Fuller's Earth near Cubberly, &c.

MOLLUSCA.

Nerinæa, two or three species only occurring as casts.
Goniomya angulifera, Sow. (abundant.)*
Modiola Hillana, Sow.*
—— plicata, Sow.*
Cucullæa cucullata, Goldf.? imperfect.
Myacites terquemeus, Buv.
Pecten hemicostatus, Morr. and Lyc.
—— vagans, Sow.
Pholadomya Murchisonæ, Sow.
P. lyrata, Sow.*
Ostrea gregaria, Sow.
O. acuminata, Sow., abundant.
Avicula echinata, Sow.*
—— inæquivalvis, Sow.*
Terebratula globata, Sow.
T. perovalis, Sow.
T. maxillata, Sow.
Rhynchonella concinna, Sow., abundant.
—— media, Sow.*

ZOOPHYTA.

Anabacia, an oval species, abundant.

ANNELIDA.

Serpula,—sp.

ECHINODERMATA.

Acrosalenia spinosa, Agass.

The horizontal extension of this formation is very much the same as that of the Upper Lias sands. Northward of Sevenhampton and Eyreford districts, it appears on the point of dying out. This is certainly the case at the south-east part of the sheet, towards Burford, where, as shall presently be shown, the Great Oolite rests directly on the Inferior. It is also shown by the section of the Geological Survey (Sheet, No. 14) that southward, towards Bath, the thickness increases to 150 feet; and at Stroud Valley, it is 70 feet, as given by Mr. Lycett. At the south-western portion of the Cheltenham Sheet, in the valleys of Rendcomb, Bagendon, Miserden, and Througham, the general thickness is between 30 and 40 feet, while, as a maximum, the depth at Aston Blank, Pen

* Stone Steps, 2 edit. p. 20.

Hill, and west of Througham, is probably not less than 60 feet.*

It is needless to dwell longer on this band, as the geologist will be able, by inspecting the map, to calculate its thickness in the various localities where it occurs, as well as observe its superficial limits.

Great Oolite.

It has been shown that the Inferior Oolite is capable of subdivision into several members, which are continuous and distinguishable over considerable areas both by mineral character and their inclosed organisms. The case is similar with the Great Oolite, which may be separated into upper and lower zones over the entire district, each of which may be advantageously described separately. These two zones might be termed "Stonesfield Slate," and "Great Oolite;" but the former is objectionable, as it would be a misnomer if applied to the whole district; and the latter is inconvenient, as it applies to a part a name which properly belongs to the whole. I therefore propose upper and lower zones as simple terms by which to designate these subdivisions.

Lower Zone of the Great Oolite.—Stonesfield Slate.

This is an exceedingly variable series of beds, being composed in some places of sandy flags, slates, and blue limestones, and in others, of white oolitic freestone, with much false bedding, and not unlike the freestones of the Inferior Oolite. Where these beds become sandy and fissile, as at Sevenhampton Common, Througham, Eyeford, and Naunton, they are capable of being split into slates, which form a very suitable roofing material, especially for buildings built in the Tudor or other styles of Gothic architecture; on the other hand, where they assume a highly oolitic type, as at Farnington, Windrush, and Tainton Downs, an observer would scarcely imagine them to be on the same geological horizon with the beds in the former localities.

* M. Lycett states the thickness at Througham to be only 9 or 10 feet; this is a mistake into which he was probably led by the existence of a fault terminating the east side of the slate district.

The Stonesfield slate has been shown by Mr. Lonsdale to lie at the base of the Great Oolite,* and is chiefly remarkable for the varied character of its organic remains. In this deposit are contributions from air, land, and sea. As representatives of the first, we find remains of Pterodactyles, and elytra of beetles; of the second, fruits, leaves, and stems of plants; and rarest and most valuable of all, seven lower jaw bones of mammiferous quadrupeds,† which have been discovered in the typical district of this formation at Stonesfield, near Oxford; and lastly, Fishes, radiated and molluscous animals, the denizens of the sea.

The slate districts of Sevenhampton Common and Eyeford have been minutely investigated by local geologists, and are described, with their organic remains, in Murchison's "Geology of Cheltenham." The former is bounded on the north and south by faults which have depressed it to a lower level than the Ragstone of the Inferior Oolite on the opposite sides; while along the east and west, the Fuller's Earth, marked by springs and a swamp, may be traced along the base of the slate round the flanks of the hills. These faults are correctly indicated in that work.‡ The following section § accurately describes the series in this district.

Section of the Stonesfield Slate, Sevenhampton Common.

	Ft.	In.
1. Soil - - - - - - -	2	0
2. A thin seam of stone, almost entirely composed of Ostrea acuminata, cemented together by calcareous matter -	0	3
3. A thin seam of indurated whitish clay, composed of the smaller arms of *Apiocrinites*, cemented as above -	0	1
4. Blue sandy marl, fossils scarce - - - -	8	0
5. *Ragstone*, occasionally intermixed with slabs having blue centres (obliquely laminated) - - - -	14	0
6. *Stonesfield Slate.*—Flat slabs of stone, splitting up into thin layers, the best of which are used for tiling, but becoming soft and sandy towards the bottom -	4	0
Bottom of quarry, yellow clay (Fuller's earth.)		

* Proceedings of the Geological Society, vol. i. p. 414.

† Amphitherium and Phascolotherium.—Owen.

‡ Murchison's Geology of Cheltenham, edited by Messrs. Buckman and Strickland. 2d Edit. p. 21.

§ Ibid., p. 18.

The slates* in this locality are nearly exhausted; but slate splitting is in active operation in the district north of Naunton. This latter is bounded on the north and south by faults, and is remarkable for the flatness of its surface, which, in fact, corresponds to the upper surface of this lower subdivision of the Great Oolite.

Section of the Stonesfield Slate, Summer Hill, Eyeford.

	Ft.	In.
1. Brown sandy slate - - - - - -	0	6
2. Thin-bedded light blue limestone - - -	1	4
3. Brown fissile sandstone - - - -	1	0
4. Blue thin-bedded limestone - - -	1	4
5. Brown fine-grained sandstone, splitting into flags and slates - - - - -	2	0
6. Thin irregular-bedded limestone - - - -	0	6
7. Brown finely-grained sandstone, splitting into slates -	1	0
Clay, probably Fuller's Earth.		

Such is the general character of these beds in this isolated district. They are on the whole regular, and free from the obliquely laminated structure which elsewhere characterizes their contemporaries.†

In the neighbourhood of Aston Blank the lower beds yield good slates and flagstones, but the higher beds become oolitic. Such is also the case at Salperton and Hawling. In the neighbourhood of North Leach, the greater portion of the Stonesfield slate, or lower zone passes into an oolitic freestone, often quarried for building, and made up principally of fragments of shells. False bedding is very prevalent, and the formation is remarkable for the minute character of its fossils.

The following section from a quarry near Burford exhibits the junction of the two zones, and affords an illustration

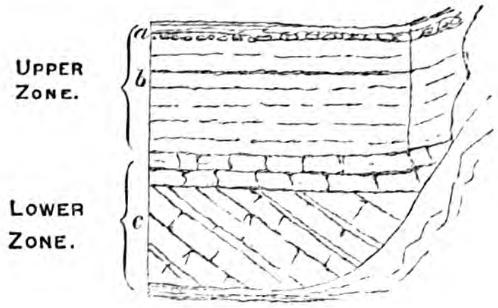
* Though called slates, they are thin flagstones or tilestones only, slaty clavage being entirely unknown in the oolite series.

† A beautiful collection of fossils from the Stonesfield slates of the above localities has been made by the Rev. E. Witts, Rector of Slaughter.

of the phenomena of an oblique lamination, to which I have referred.

Fig. No. 3.

Section in the Great Oolite, Swinbrook, Burford.



	Ft.	In.
Soil - - - - -	0	4
a. White rubbly limestone - - - -	0	3
b. Soft yellow and white marl and shale, with thin partings of stone - - - -	8	0
c. White shelly oolitic freestone - - -	9	0

On referring to my note book, I find the following section of a quarry east of Leygore Farm, on the east side of the Roman foss-way near North Leach.

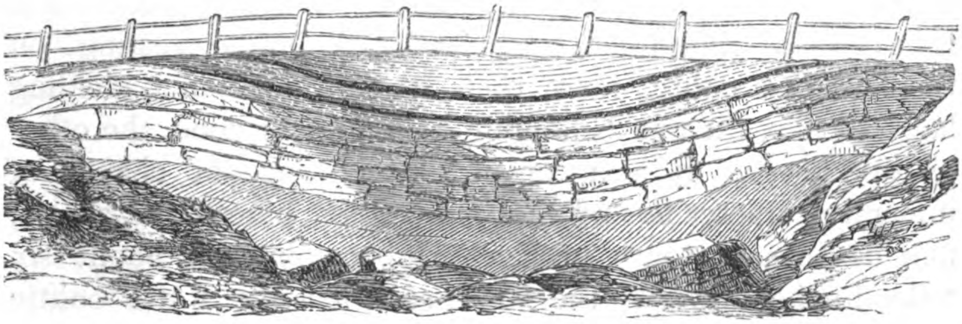
Great Oolite, (Lower Zone), North Leach.

	Ft.	In.
1. Coarse shelly oolite, obliquely laminated - -	2	2
2. White calcareous oolitic marl - - - -	0	4
3. White argillaceous oolite - - - -	0	6
4. Grey calcareous slaty sandstone - - -	1	0
5. Brown and white sandy marl - - -	0	5
6. Grey sandy limestone - - - -	2	0

At Sherborne Park there is a fine quarry in these beds, the stone having been used in building Sherborne Hall. The quarry shows a gentle synclinal, which has the effect of bringing in the marly beds, which invariably form the base of the upper zone of the Great Oolite in this district.

Fig. No. 4.

Section in Sherborne Park.

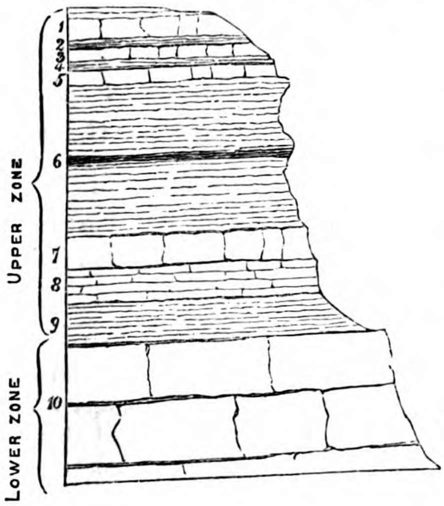


This section towards its base presents a very good example of oblique lamination.

The lower oolite is extensively quarried at Windrush, and is followed under the hill by tunnelling. In many places the superposition of the upper and lower zones may there be observed, of which the following section will give a general idea:—

Fig. No. 5.

Section at Windrush Quarries.



	Ft.	In.
Upper Zone:—		
1. Loose white argillaceous limestone - - -	1	6
2. Parting of marly shale - -	0	6
3. Thin-bedded brown calcareous sandstone - -	0	8
4. Yellow slaty marl - -	0	8
5. Brown calcareous sandstone, very fossiliferous - -	1	0
6. Yellow, brown, and white sandy marl, with a parting of stone - - -	10	0
7. Hard sandy limestone, slightly oolitic - - -	2	6
8. Sandy oolite (soft) - -	2	6
9. Marls and shales - -	2	6
Lower Zone:—		
10. Fine white oolite coming out in large blocks; the only bed fit for quarrying more than	7	0

There are large heaps of rubbish, the débris of ancient quarries, on Tainton Downs, from these same beds, which are said to have furnished the material for the beautiful

Church of Burford, the stone of which has well stood the test of time.* On Milton Field, in a large quarry, a section similar to that at Windrush is exhibited. There we find about 17 feet of interstratified marls, shales, and thin-bedded limestones, highly fossiliferous, resting on thick-bedded oolite, more than 12 feet thick, and yielding large blocks, the one belonging to the upper zone, the other to the lower. It is a remarkable instance of change of mineral character to find the thin-bedded limestones, shales, and fissile sandstones of Eyeford becoming, at about six miles further towards the south-east, massive white oolitic freestones, in one case yielding slates for the roofs, in the other blocks for the walls of edifices!

On the north side of Shipton Downs the lower zone of the Great Oolite becomes of a more flaggy character, is excessively false-bedded, greatly broken, and full of slips towards its margin, so as to conceal the inferior strata. At Swinbrook, however, we find a section similar to that at Windrush, in a quarry north of the church, showing the marly beds of the upper zone resting upon oolitic freestone of the lower.

It has already been remarked, that east of Barrington we lose all trace of the Fuller's Earth, so that the basement beds of the Great Oolite rest upon the Ragstones of the Inferior Oolite. That this is the case, is proved by the section of the south bank of the Windrush River opposite Swinbrook, where, by means of a quarry close by the side of the lane which leads to the Oxford Road, and the cutting

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* The freestone at Tainton quarries has furnished the stone for some of the oldest buildings in Oxford, viz., those of the 12th, 13th, and 14th centuries, and is still in good preservation; the mouldings being sharper and less weathered than of some buildings of the 17th and 18th centuries, which are cut out of blocks from Heddington Hill quarries. near Oxford.

In one of these quarries the Earl of Ducie discovered an unique specimen of a fossil starfish, which is figured and described under the name of *Solaster Moretonis*, in the Memoirs of the Geol. Survey, Decade V. As some doubt existed respecting the formation to which the specimen belonged, it may now be proper to state, that it was derived from a zone contemporary with the Stonesfield slate, near the base of the Great Oolite.

in the lane itself, immediately underneath the quarry, we obtain a section in both formations.

Section near Swinbrook, showing the Junction of the Great and Inferior Oolite.

Fig. No. 6.

Great Oolite.

a. Clay or marl, with oysters, being the base of the upper zone of the Great Oolite.

b. Yellow sandy oolite, full of oblique lamination, and splitting into slabs; few or no fossils. Lower zone of Great Oolite.

Inferior Oolite.

c. Coarse-grained white oolite, rather rubbly with *Clypeus Plotii*, and *Terebratula globata.*

The beds of this formation, which cap the higher portions of the ridge extending from Adlestrop eastward, belong almost entirely to the lower zone. They are composed of yellowish fine-grained oolite, with few fossils, often obliquely laminated, and containing one or two beds of variegated clay or marl. The following is a section taken from a quarry near Oakham.

Section of Great Oolite, near Oakham.

	Ft.	In.
1. Soil, brown loam - - - - - -	0	8
2. Brown fissile limestone slightly oolitic - -	0	2
3. Brown marl, full of small oysters - - -	1	2
4. Thin-bedded ragstone, with oysters - - -	0	6
5. Blue, yellow, and brown clay or marl, with Terebratulæ, oysters, &c. - - - - - -	4	0
6. Light brown oolitic freestone, quarried for building stone	7	0

The thick bed of marl (No. 5) is very constant over the district, and may again be observed in the quarries in the Moreton Road, as also in a quarry near the gate of Daylesford Park, which opens into the Cornwell Road, where it is associated with thin bands of sand and gravel. It may possibly represent the basement beds of the upper zone which we find at Milton Field, Swinbrook, and Windrush.

At Oddington, Icombe, and Stow, the Great Oolite consists of the same yellowish compact oolite, full of false bedding, and splitting up into coarse slates and flags. On the east side of Stow a bed of conglomerate may be observed in a quarry. The pebbles, which are well rounded, and not larger than a pigeon's egg, consist of white limestone, unfossiliferous and slightly oolitic. It is therefore uncertain whether they are to be regarded as drifted pebbles, or merely fragments of the the rock itself broken up by waves, and subsequently re-imbedded.

About a mile from Stow on the Evesham Road we find an excellent section, not in the lower but in the upper zone of the great oolite. These beds are let in by faults, and the structure of the district is rather complicated.*

Towards the south-west part of the hilly district we find the beds of the lower zone undergoing similar variations in lithological character, which only permit of their being occasionally employed as slates. With this intent, they are or have been quarried north of Chedworth, Pewsdown near Nutgrove, Nettlecombe near Birdlip, Misenden, Rendcomb, and Througham; in all these cases the beds become locally sandy, and are generally characterized by numbers of small shells, amongst which *Trigonia impressa*, *Ostrea acuminata*, and *Avicula ovata* predominate.

On the whole, this lower zone presents evidences of having been deposited in a shallow sea, the sediment of which was frequently changing its nature, and of having been subjected to the influence of ever-varying currents. But though this is the case, the thickness of the subdivision is very uniform over the whole district, varying from 12 to 20 feet, and generally forming a slight mural escarpment at the top of the Fuller's Earth. The conditions under which it was deposited must have changed considerably upon the introduction of the higher zone, in which there is much

* See section Fig. 16.

greater uniformity of mineral character and stratigraphical arrangement; and which, from the greater abundance of the brachiopoda and echini, was evidently deposited in a deeper and more tranquil sea.

Upper Zone.

There is nothing more remarkable in the physical geology of the lower oolitic group than the evidence it affords of alternations of tranquil and irregular deposition; or rather of periods during which the British oolitic seas were swept by contrary currents originating the various phenomena of oblique lamination, at length giving place to periods of prolonged tranquillity. Thus we find the Freestones of the Inferior Oolite composed of vast heaps of broken-up shells and skeletons of radiated animals, and everywhere exhibiting the obliquely laminated structure, succeeded by the Ragstone in which the majority of the fossils, such as the echini and trigoniæ, being of the most delicate framework, are well preserved, while the strata nowhere present the appearance of oblique lamination. The phenomena presented by the lower and upper zones of the Great Oolite are of a similar character.

The upper zone of the Great Oolite is so well marked throughout the whole of the district, that there is no difficulty in drawing a boundary line at its base. It is generally introduced by beds of marl, and is terminated by one or more strata of limestone, usually devoid of the oolitic structure, and weathering to a degree of whiteness scarcely surpassed by the chalk. This limestone is generally very hard, and along the Cheltenham and Oxford road produces the best available road material.

These upper beds have been swept off almost the whole of the Eyeford and Sevenhampton districts, but it is not improbable the bed of marl, 8 feet thick, at Sevenhampton Common, is the basement bed of the series. I also found a small portion of a field near the south-east extremity of the area strewn over with fragments of white limestone, but no section of it occurs. A band of the white limestone, with *Clypeus solodurinus*, Ag. extends from near Summer Hill to Hill Barn, across the Stonesfield slate ground, north of Naunton.

These beds are open to view in two quarries not far from Andoversford, one being by the side of the Stow road, near Hampen Farm, the other near the milestone 5 miles from North Leach. In these quarries the beds are similar, and very full of fossils. They consist of rubbly cream-coloured oolite, alternating with beds of marl and shale. At the Hampen quarry the beds dip northward at about 6°, being in close proximity to a fault which cuts them off against beds of the lower zone. These latter may be viewed, by way of contrast, in a quarry about a quarter of a mile west of this place, where they consist of blueish-grey compact limestone, interstratified with brown fissile sandstone, the whole being highly false-bedded, and containing but few fossils.

The marly beds near the base of the upper zone may be seen in a small quarry near the " Seven Springs," North Leach. Here they yield, besides two or three species of echini, some beautiful specimens of *Terebratula digona*, Sow. in translucent calcareous spar, and with these a coral, *Anabacia orbulites*, and another oval species not unfrequent in this neighbourhood.

On attaining the summit of the ridge which extends in an unbroken line along the southern bank of the Windrush river, by the Oxford Road, we reach the top beds of the Great Oolite, composed of hard white limestone; and along this line of road, to the extremity of the district, there are numerous quarries, as this limestone affords the best road metal in the country. The largest quarries are opposite New Barn Inn, Sherborne Park gate, above Burford, and further on near the junction of the road which leads down to Burford. This last quarry offers the following section:—

Section of Great Oolite. Burford.

(*Upper Zone.*)

	Ft.	In.
1. White and yellowish slaty oolite, with fragments of oysters, being the base of the Forest Marble - -	0	3
2. Yellow and white oolitic sand, mixed with fragments of the underlying bed apparently tossed about, the fossils being waterworn - - - -	1	2
3. White compact limestone, with *Nerinæa?* - -	2	0
4. Hard white sandy limestone, in one bed - -	2	0

The quarry at the meeting of the Oxford and Shilton Roads above Burford is, however, the most important in the neighbourhood. These beds of the upper zone are in general by no means highly fossiliferous; indeed, with the exception of an occasional Echinus or Terebratula, they are remarkably barren. In this quarry, however, so abundant and varied are the fossils, that in half an hour a collection, which would probably contain the great majority of species of this highest zone, might be made. They are preserved in a soft marly matrix, from which they may be detached with ease.

A list of the species collected will be found further on (page 67).

The beds below the limestones may be seen in the Burford Road which leads down the hill from the Oxford Road, and are similar to those which rest on the freestones at Windrush quarries, consisting of marls and calcareo-arenaceous shales, with thin beds of limestone. The unbroken ridge on the south side of the Windrush is formed by this hard limestone, and has a slight slope to the south. This slope is not so great as the dip of the strata, as it allows of the superposition of Forest Marble and Cornbrash.

I have already alluded to the quarry on Milton Field as offering to view the *basement* beds of this upper zone, consisting principally of marls and thin-bedded stony bands. The following section in the same neighbourhood, from a quarry by the Burford Road, east of Shipton Barrow, will illustrate the *uppermost* beds, as we find quarries in Forest Marble at a short distance both east and west of this position.

Section of Great Oolite. Shipton Downs.

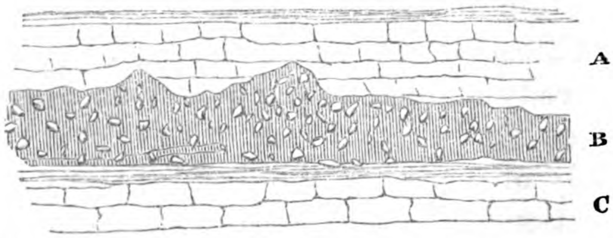
	Ft.	In.
1. Brown loam, with drift pebbles of quartz - -	0	6
2. Rubbly white oolite - - - -	0	6
3. Light bluish green marl, becoming dark green at top -	2	7
4. White indurated marl - - - - -	0	6
5. Hard thick-bedded white limestone - -	3	6
6. Bed of white oolite - - - -	2	0
	9	7

The total thickness of this upper zone in the neighbourhood of Burford is probably little short of 100 feet.

The upper rock bed is frequently pierced by *Lithodomi*, and also affords interesting evidence of having been consolidated contemporaneously with its deposition. Occasionally we find beds of conglomerate formed by waterworn fragments of the underlying limestone. The fragments may be seen standing on end, or loosely heaped together, as if they had been broken up by a storm, dashed about, and then retained in their places by the rapid formation of new calcareous matter. The quarry above Burford presents us with an example of the phenomena referred to; but another and better illustration was observed in a quarry by the Burford road, near Westwell, of which the annexed sketch will afford some idea. A similar case was observed in the quarry of which the section is given above, and it is probable all these cases have been occasioned by one and the same cause.

Fig. No. 7.

Section near Westwell.



A, White limestone with a very irregular base.
B, Bed made up of broken fragments, waterworn, and passing into sand or gravel at base.
C, Bed of white limestone.

The high table-land above Chedworth Woods is composed of the same white limestone, only occasionally oolitic, and rarely containing organic remains. The marly beds sometimes give origin to springs as at Calmsden; and in the direction of Bibury the beds become more oolitic. Good sections are exposed to view on the Cirencester Road south of Foss Bridge, and in the Burford Road above Bibury. The general thickness of the formation from the Fuller's Earth to the Forest Marble is from 60 to 70 feet.

On the west side of the valley of the Churn we again meet with these beds, as also along the Ermine Street, from Beech Pike southwards; also near Duntshorn, Sulgrove, and forming a narrow band close to the north and south fault from Wisharmar to Druffham Slade, overlying the Stonesfield slates of Througham.

This limestone is frequently pierced by *Lithodomi*, and contains sandy druses, in which urchins and other fossils frequently lie concealed. I have been particular in describing it, because it forms a very marked geological horizon, in fact, the only one which offers a line of demarcation between the Great Oolite and Forest Marble. It is succeeded by a series of very variable strata, which afford evidence of a change of physical conditions, and which must all be included in the Forest Marble.*

Verifying Mr. Lycett's observation, that on Minchinhampton Common the upper zone of the great oolite, or the white limestone, disappears, or is on the point of doing so, I agree with him when he says, that *there* at least

* Mr. Lycett evidently refers to this bed when he says:—" At the upper part " of the series, or about 90 feet above the Fuller's Earth, is a bed of from one and " a half to two feet in thickness, emphatically termed the '*limestone bed*,' which is " distinguished from all the associated strata by a remarkable uniformity of thick- " ness (?) and mineral character over a large area. It may be described as a very " hard, homogeneous, cream-coloured rock, occasionally containing shells, which " agree specifically with those of the beds of the building or planking. It has " been traced from the town of Minchinhampton, on the west, to a deep section " made by the Swindon and Gloucester Railway, close to the east entrance of the " smaller of the two Sapperton tunnels, where it appears near the middle of the " section."—Lycett on the Oolite of Minchinhampton. Proceedings of the Geological Society of London, December, 1847, p. 185.

"no positive line of separation can be drawn between the "Forest Marble and the Great Oolite." But in localities such as Sapperton Tunnel, and the district described in this Memoir, where these limestones are present, a line of demarcation can always be traced.

At Sapperton Tunnel these limestones are at least 20 feet thick, and at Burford the upper zone (the limestones and underlying marly series) is at least 80 feet, so that the section of the Great Oolite at Minchinhampton, which has yielded so rich a collection of organisms to the hammer of Mr. Lycett, is not so complete as in other localities. The Great Oolite, therefore, is an exception to the general law of attenuation eastward which, as we have seen, characterizes all the subordinate strata as low down at least as the Marlstone.

Fossils from the Lower Zone of the Great Oolite, North Leach.

(*Coarse shelly white Oolite.*)

PISCES.

Pycnodus. } teeth.
Acrodus. }

MOLLUSCA.

Cerithium muricatum, Sow.
Sp. of Nerinæa, Trochus, Phasianella, Patella, and Cylindrites.
Placunopsis? Astarte, Tancredia, Arca.
Trigonia costata, Park.
Trigonia Moretonis, Morr. and Lyc.
Cypricardia Bathonica, D'Orb.
Astarte elegans, Sow.
Quenstedtia oblita, Phil. sp.
Corbula striata, Buckm.
Ostrea acuminata, Sow.
Avicula echinata, Sow.?
Pecten vagans, Sow.
Lima cardiiformis, Sow.
,, punctata? Sow.
,, duplicata, Sow.
Anomia, 2 species.
Terebratula maxillata, Sow.
Rhynchonella concinna, Sow.

ECHINODERMATA.

Nucleolites clunicularis, Llhwyd.
Diadema, and Acrosalenia, sp.

ZOOPHYTA.

Anabacia, small species.

Fossils from the Great Oolite, Foss Bridge.

Trochotoma obtusa, Morr. and Lyc.
Ceromya concentrica, Sow.
Pecten lens, Sow.
Terebratula digona, Sow.
,, maxillata, Sow.
,, perovalis, Sow.

Nature of Rock, marly oolitic limestone.

Fossils from the Lower Beds of the Upper Zone, Great Oolite, Windrush Quarries.

(*Sandy Marl.*)

Unicardium gibbosum, Morr. and Lyc.
Anatina, Pinna—sp.
Myacites calceiformis, Phil.
Trigonia Moretonis, Morr. and Lyc.
„ costata, Park.
Modiola imbricata, Sow.
Venus nuculiformis, Rœmer.
Cypricardia rostrata, Sow., var. truncata, Pl. 1., f. 8.
Ceromya, Thracia—sp.
Pholadomya Heraulti, Ag.
„ socialis, Morr. and Lyc.
Pecten annulatus, Sow.
„ lens, Sow.
Ostrea Sowerbyi, Morr. and Lyc.
Gervillia socialis, id.—a costated species.
Terebratula maxillata, Sow.
Solaster Moretonis, Forbes.

Fossils from the Great Oolite, near Seven Springs, North Leach.

(*Marl and marly Oolite at base of Upper Zone.*)

MOLLUSCA.

Trigonia costata, Park.
Myacites—sp.
Lima cardiiformis, Sow.
Ostrea gregaria, Sow., covered with Diastopora.
Terebratula maxillata, Sow.
„ digona, Sow.
„ intermedia, Sow.?

BRYOZOA.

Alecto gracilis, M. Edw.
Diastopora diluviana, M. Edw.

ECHINODERMATA.

Nucleolites clunicularis, Llhwyd.

ZOOPHYTA.

Anabacia orbulites, Lamx.
Astræa.

Fossils from the Upper Zone of the Great Oolite, Burford.

(*This quarry is by the side of the Oxford Road.*)

MOLLUSCA.

Natica, 3 species, casts.
Nerinæa and—Alaria sp., casts.
Ceromya similis, Morr. and Lyc.?
„ concentrica, Sow.
Thracia incerta, Thurmann.
Lucina lirata, Phil.
Pholadomya Heraulti, Ag.
Trigonia costata, Park., *var.*
Corbis Lajoyei, D'Arch.
* Venus nuculiformis, Rœmer.
Myacites dilatus, Phil.
Isocardia angulata, Phil.
Pecten annulatus, Sow.
Terebratula maxillata, Sow., abundant.

ECHINODERMATA.

Hemicidaris intermedia, Flem.?
Nucleolites orbicularis, Phil.

Fossils from the Great Oolite, Upper Zone, Sherborne Park.

Natica, Neritopsis, Phasianella.
Lucina, Ceromya, Cyprina, Unicardium.
Lima cardiiformis, Sow.
Corbis Lajoyei, D'Archiac.
Terebratula maxillata, Sow.
Nucleolites clunicularis, Llhwyd.

(* Fossils generally in casts.)

Fossils from the Great Oolite, Upper Zone, North Leach.

(*Quarry, one mile east of the Town by the Oxford Road. White Oolitic Limestone. Fossils generally in casts.*)

MOLLUSCA.

Chemnitzia, Natica, Nerinæa, Trochus.
Lucina lirata, Phil.
Corbis Lajoyei, D'Arch.
Arca Hirsonensis, D'Arch.
Pholadomya lyrata, Sow.
Avicula echinata, Sow.
Cyprina, Pecten, Ostrea.
Lima cardiiformis, Sow.
Cardium pes-bovis, D'Arch.
Ceromya, undulata, Morr. and Lyc.?
Trigonia costata, Park. *var.*
Rhynchonella concinna, Sow.
Terebratula maxillata, Sow.

ECHINODERMATA.

Nucleolites clunicularis, Llhwyd.
„ solodurinus, Ag.?
Hemicidaris.
Acrosalenia hemicidaroides, Wright?

BRYOZOA.

Heteropora, sp.

ZOOPHYTA.

Anabacia orbulites, Lamx.?

FOREST MARBLE.

Under this head are included all the beds, of whatever description, between the Cornbrash and the white limestone of the Great Oolite.

From a zone presenting great uniformity in lithological character, we pass at once to a geological horizon extremely variable in composition and irregular in its stratification. We find coarse fissile oolite full of false bedding, giving place to blueish marls and shales; in other places, as in the vicinity of Cirencester and Malmesbury, we meet with beds of yellow siliceous sands with large spherical blocks of sandy limestone; and lastly, oolitic freestone, yielding blocks for building, and not unlike the beds of the lower zone of the Great Oolite at Windrush. Taken as a whole, the conditions under which the Stonesfield slate was deposited appear to have been repeated in the Forest Marble, and have produced a similar variety of strata.

This formation takes its name from Wychwood Forest the western border of which extends into the south-eastern portion of our district. It is confined exclusively to the south-east part of the map, and in that direction first makes its appearance in occasional detached outliers, capping the higher parts of the general plain, like islands which are first seen on nearing a continent.

The so-called "Bradford clay," is not in my opinion entitled to be considered a separate sub-formation. In the neighbourhood of Cirencester there are it is true beds of marl which have been referred to a supposititious formation of that name. But the fossil evidence upon which the assumption of a "Bradford clay formation" was founded, has failed; since the two fossils *Apiocrinus rotundus* and *Terebratula digona* have been also found in beds of the Forest Marble and Great Oolite. The Bradford clay is probably a local thickening only of a Forest Marble clay, and this opinion is confirmed by the authority of Mr. Lonsdale, who has described the Forest Marble in the neighbourhood of Bath. I may also add, that the supposed Bradford clay cannot be taken as a true zone of separation between the Great Oolite and Forest Marble, though in some instances a bed of clay or marl does actually form the base of the latter formation.*

At Coln Rogers the Forest Marble attains a thickness of 40 feet. In some places we find the lowest beds composed of false-bedded, shelly oolite, splitting into rough slates upon exposure. In others, as at Fox's Cross, the beds which rest immediately on the white limestone of the Great Oolite, and are therefore in the same horizon as the above, are formed of blue and grey flags and slates with thick beds of clay; one of these beds of clay extends continuously from Hedgeley to Barnsley Wold, and is overlaid by a second series of slaty oolite, generally filled with fragmentary oyster shells. These clays, however, are very variable, appearing and vanishing most capriciously, occurring sometimes near the top of the formation, sometimes in the middle, and sometimes at the base.

NOTE.—The fact of Apiocrinus rotundus having been found in other beds of the Forest Marble besides the "Bradford Clay," is asserted by Mr. Lonsdale in his valuable Memoir on the Geology of the Bath Oolites (Trans. Geol. Soc., vol. iii. p. 255), and by Dr. Wright in a communication to myself on the subject. With regard to Terebratula digona, I have myself found it in considerable quantities, at the base of the Great Oolite at North Leach.

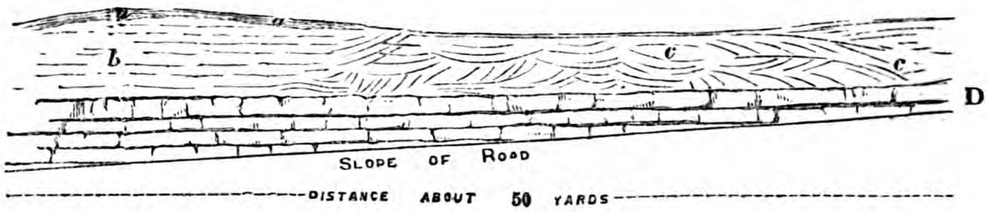
* I am also informed by Professor Ramsay, that at Bradford itself the Bradford clay is but a very thin stratum.

The following section will illustrate these remarks. It is afforded by the cutting in the Oxford Road, near Aldsworth.

The flags which are quarried for roofing and other purposes, are usually associated with the clays. When first

Fig. No. 8.

Section in the Forest Marble and Great Oolite near Aldsworth.

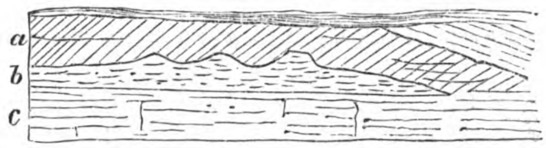


a. Dark brown loam.
b. Light brown clay, about 5 feet.
c. Hard, flaggy calcareous sandstone, with beds of shelly oolite, the whole highly false-bedded, 4 to 5 feet.
D. Great oolite, hard grey, and white sandy limestone, regularly stratified.

taken from the quarry, they are generally of a deep blue colour, and bespangled with oyster shells, stems of pentachemites, ossicula of ophiura, spines and plates of echini, as well as small shells such as *Pecten varians*, *Avicula*, *Astarte*. They are frequently rippled and marked by the tracks of annelides, and, according to Prof. Buckman, of gasteropoda. Fish teeth are frequent, and were found in great abundance in a quarry near a farmhouse at the southern side of Bibury Racecourse. Carbonized stems of plants are not uncommon, but there is nothing so remarkable as the immense heaps of oyster shells, which not only compose a large proportion of the more oolitic beds, but even form lenticular layers, in one instance, two feet in thickness, and extending several yards. The locality to which I refer is situated by the Burford Road, at a quarter of a mile south of Aldsworth, where some of the beds are quarried for flagstones and slates. Indeed, oysters must have been abundant in the period, for many of the shelly beds are composed almost entirely of thin fragments.

Fig. No. 9.

Forest Marble, Aldsworth.

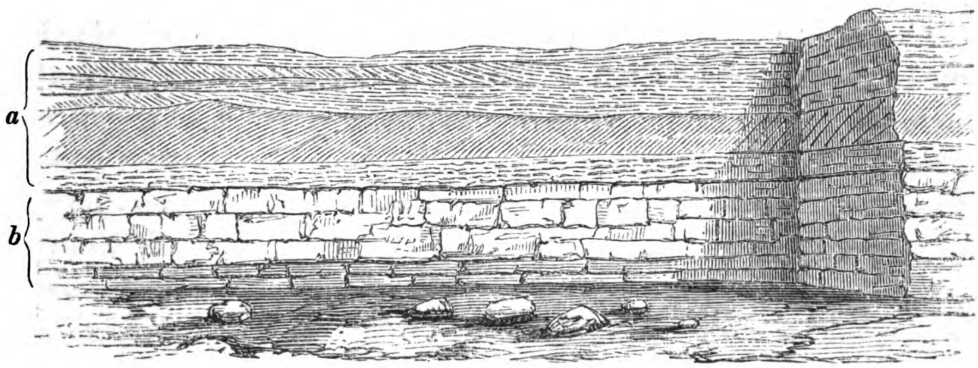


a. Brown irregular flaggy oolite.
b. Loose oyster bed.
c. Grey oolite flags, full of oysters, pieces of carbonized wood, &c.

False-bedding is one of the most characteristic features of this formation, and one by which it may be contrasted with the beds of the upper zone of the Great Oolite, showing a marked change in the nature of marine conditions, coincident with the introduction of this formation. The section given above, near Aldsworth, exhibits this contrast, but another illustration at a distance of 5 miles from the former may be added.

Fig. No. 10.

Section through the Forest Marble and Great Oolite, Crickley Barrow.

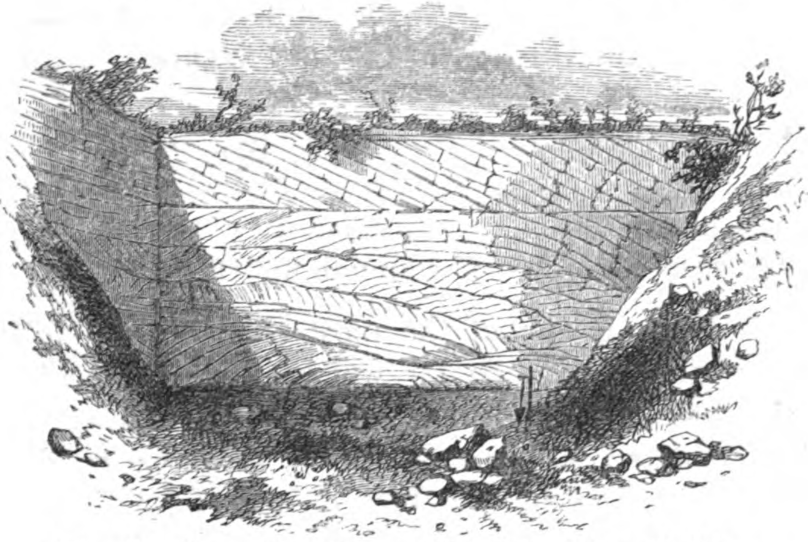


a. Shelly oolite with oyster beds (Forest Marble).
b. Hard, grey, and white sandy limestone, regularly bedded (Great Oolite .

The following sketch, copied faithfully from nature, shows oblique lamination of a very marked kind. If such features were observed in drift sand, or in any pure sand-rock, it would excite no surprise; but in this case, the beds are formed of the débris of shells and other fragments of organic origin cemented together by a calcareo-oolitic paste.

Fig. No. 11.

Section in Forest Marble, Warren Farm, near Burford.



Fossils from the Forest Marble, Foss Bridge.

Nerinæa, as casts only.
Lima cardiiformis, Lyc. and Mor.
Nucula lachryma, Sow.?
Cardium semicostatum, Lyc. and Mor.
Astarte, Ostrea, Lucina,—sp. of.
Acrosalenia radiata, Forbes.? with plates and spines of Cidaris.

The figured species of Corbula, *C. Hulliana*, Morris, Pl. 1. f. 6. is from fields at Northleach.

The strata from which these specimens were obtained consist of mottled flags and slates, partially oolitic, and made up in a great measure of fragmentary shells.

Cornbrash.

This is the most recent rock which it comes within my province to describe; and it will be observed, that it forms but a very small portion, scarcely one square mile, of the district.

Glancing at the N.W. part of the map we perceive that it is formed of the oldest formation in the district, viz., that of the Keuper, or highest division of the New Red Sandstone. Hence we at once obtain an index to the general direction of the dip, E. 35° S., which must be along the line intersecting the areas occupied by these two formations. This general dip is of course greatly modified by faults, and rolls of the strata; but on the whole, by crossing the district along this line, we would arrive continually at higher or lower beds, according as our direction lay towards the south-east or north-west. It is almost unnecessary to state, that the line at right angles to the dip is parallel to the axis of elevation for this district, and nearly coincides with that of central England generally.

The origin of the term "cornbrash," like that of the "red marl," "lias," and some other formations, is agricultural. Breaking into "brash," or fragmentary rubble where it forms the subsoil, it is well adapted for the growth of corn, of which it produces luxuriant crops; while the clayey formations both above and below are generally appropriated to meadow or pasture lands.

Professor Buckman* has shown that, as compared with the subordinate oolitic formations, the Cornbrash contains the largest percentage of phosphate of lime, a circumstance doubtless attributable to the great abundance of its organic remains. This fact explains the adaptation of this formation to the growth of cereals, but the exact proportion must vary in different localities; and as a point of comparison, the Inferior Oolite as a whole would be inaccurate, as there is doubtless a greater quantity of phosphate of lime in the *ragstone*, than in the *freestone* of that formation.

The Cornbrash, as it occurs in the district, may be described as a rubbly, cream-coloured limestone, breaking up into thin beds with very uneven surfaces. Each fragment has a coating of a deep red colour, which it imparts to the soil, and there are occasionally thin partings of sandy marl, from which the fossils may be dislodged in a perfect state.

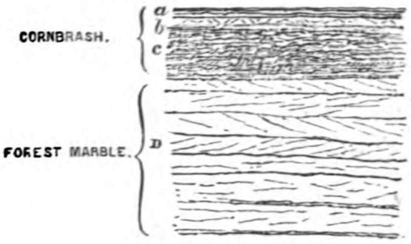
The Cornbrash is quarried for road-metal along the Burford Road, near Shilton. At its northern termination it rests upon a bed of blue clay, belonging to the Forest Marble; but not far from this, in some quarries opposite Alvescott Down Farm, we find it resting on oolitic limestone of the same formation, as the annexed section will show; while in the lane south of Rock Farm we again find it overlying alternating beds of blue clay and flagstones. This

* From analysis made by Professor Voelcker, and published in Mr. Buckman's paper on the Cornbrash of the neighbourhood of Cirencester.—Proc. Cot. Nat. Club, vol. 1, p. 263.

change within so small an area is by no means an uncommon occurrence, and arises from the variable nature of the Forest Marble strata.

Fig. No. 12.

Section through Cornbrash and Forest Marble, Alvescott Downs.



Cornbrash.

	Ft.	In.
a. Reddish brown soil - - - -	0	6
b. Hard thin-bedded ragged limestone - -	0	6
c. Loose rubbley limestone, very fossiliferous - -	3	0
Forest Marble.		
D. White fine-grained oolitic freestone, obliquely laminated -	10	0

The beds south of Shilton are very fossiliferous, and are perforated by some species of Lithodomus. The following fossils were found:—*Pholadomya fidicula? P. ambigua? Myacites securiformis, Lima gibbosa, Avicula echinata, Terebratula obovata, T. maxillata, Nucleolites clunicularis.*

CHAPTER III.

Faults.

At first sight it might have been supposed that in a region such as that of the Cotteswold Hills, composed of secondary strata, and resting in positions slightly removed only from the horizontal, faults, or lines of dislocation, would be rare. Such a supposition would, however, be altogether erroneous. Though we do not find the oolites thrown into those highly inclined positions assumed by their Jurassic contemporaries, or dislocated on so grand a scale, yet faults are exceedingly plentiful over the Cotteswold Hills and adjoining districts.

The existence of some of these lines of dislocation had already been known to our local geologists,* and two of them will be found mentioned, and illustrated by a diagram, in Sir R. Murchison's "Geology of Cheltenham." The late Mr. Strickland† had also marked out with great precision some of the faults affecting the Red Marls and Lias in the neighbourhood of Tewkesbury; but without a detailed survey it would not have been suspected that they are so numerous as is actually the case. It is also to be recollected that over the Lias plain there is in all probability a considerable number of faults, which, for want of evidence, it is impossible to trace. It will be seen, upon inspection of the map, that several of the outliers are connected with these lines of dislocation; but, had the outliers been removed by denudation, the evidence of the existence of the faults would have been removed with them; and we may reasonably conclude that there are as many faults traversing the Lias of the plain of Gloucester, as are to be found amongst the neighbouring hills in proportion to their respective areas.

It will be observed that there are two systems to which almost all the faults of the district may be referred. They are probably contemporaneous, for the production of a series of faults in one direction necessarily involves the formation of cross fractures of a compensating character. One of these systems has a general direction about ten degrees north of west, and comprehends the great majority of these faults. The direction of the other series is north and south.

It being very unusual to find any of the faults exposed to view, the evidence for their existence rests, in almost all cases, upon the juxta-position of strata of different ages. In cases of valleys along the lines of dislocation, each side will generally present different aspects. This is especially striking when the Fuller's Earth forms one side and the Inferior Oolite the other; in such case the broken slope,

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* Trans. Geol. Soc. 2d Series, vol. v. p. 260.

† See Messrs. Brodie and Buckman, on the Cotteswold Hills. Proceedings of the Geol. Soc. 1845, pp. 223–4.

covered with grass, and capped by a ridge of Great Oolite, contrasts with the more abrupt smooth bank of the subordinate formation. Instances of this kind occur along the valleys east of Elkeston and north of Hawling.

Faults of the New Red Marl.—The north fault which passes through Ripple depends on several points for the evidence of its existence. South of Tewkesbury it throws in a large tract of the Lias, at a distance of about 400 yards beyond the natural outcrop of the formation; and though lost sight of under the alluvium of the Severn for a distance of about three miles, it again shows its presence by throwing in the Keuper sandstone of Ripple.

A parallel fault, about half a mile to the east, produces a down-throw of the Lias against the Red Marl on the east. As the hades or slopes of these faults diverge as they recede from the surface they have probably once intersected. The existence of this fault is proved by the absence of the ridge of the limestone series, together with the fact of the Keuper sandstone striking against the Lias at Brockridge Common.

Crossthorp Farm Fault.—This line of dislocation is mentioned by Mr. Strickland. It is evident that the fact of the Red Marls making their appearance apparently in the very heart of, and high up in the Lias, can only be the result of elevation along a line of fracture.

*Bredon Hill Fault.**—If a person takes up a position at some distance either to the east or west of this outlier, he will obtain at a glance the evidence upon which the existence of a fault traversing the southern side of the hill has been determined. He will observe, that upon the north side the Marlstone rises from the plain in bluffs, which are succeeded by the more gentle slope of the Upper Lias, and finally by the Inferior Oolite, which attains its greatest elevation of 979 feet at Bredon Tower. From this point the surface

* Determined and mapped by Mr. Howell.

of the hill, which corresponds to the dip of the Inferior Oolite, has a gentle inclination southwards till it reaches the plain at the village of Overbury at a level nearly the same as that of the base of the Marlstone on the north side of the outlier. This of itself would be sufficient to establish a fault; but the evidence is strengthened by the entire absence of the Marlstone at Westmancot and east of Overbury.—The influence of this fault in the preservation of this outlier has already been alluded to; and in my paper on "The Physical Geography of the Cotteswold Hills,"* a section through the hill is drawn along a meridional line passing through Bredon Tower, which renders a second in this place unnecessary. The maximum *throw* is at least 500 feet.

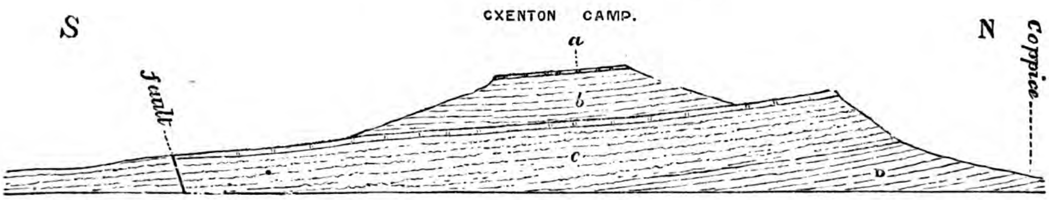
Dumbleton Hill Fault.—This dislocation produces the contact of the Upper and Lower Lias, the boundaries of which are capable of being very accurately traced, at the north side of Dumbleton Wood. The throw at this point is therefore equal to the thickness of the Marlstone or about 100 feet.

Oxentan Hill Fault.—In viewing this outlier from Stanley Hill, it will be perceived that the Marlstone platforms have a decided dip toward the south, that is *against* the Lower Lias, as the adjoining section is designed to illustrate.

At Wolston, also, the Upper Lias, capped by Inferior Oolite, is brought down against the Lower Lias by means of the fault already referred to, and a second perpendicular to it.

Fig. No. 13.

Section across Oxenton Camp.



a Inferior Oolite. *b* Upper Lias. *c* Marlstone. D Lower Lias.

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* Quart. Journ. Geol. Soc., 1855, p. 480.

Brockhampton Common Faults.

These have already been alluded to, and are illustrated by a diagram in Murchison's Geology of Cheltenham. By their means the Stonesfield slate and Fuller's Earth is dropt into a depression bounded on both sides by the Ragstone of the Inferior Oolite.

Cooper's Hill Fault.—The evidence of this fault is best exhibited at a quarry above the wood, from which some coarse Stonesfield slates have been obtained. Close to this spot the Inferior Oolite will be found at a considerably higher level on the opposite side of the dislocation. The amount of throw is therefore somewhat more than the thickness of the Fuller's Earth, or about 40 feet.

Painswick Hill Faults. -This locality seems to have undergone an unusual amount of disturbance. Above Sponebed Farm the Inferior Oolite pitches toward the south at high angles, and might have been taken for an undercliff were it not that there is no cliff from which it could have fallen. The beds must be broken off by a fault, which is probably the same as that exhibited in a quarry on the west side of Kingsbury Camp. The fault referred to is almost an unique example, as there is scarcely another exposed to view in the whole range of the Cotteswold Hills. There are several other fractures in this neighbourhood, the details of which it will be unnecessary to enter upon, as they are better explained by reference to the map.

Cranham Valley Fault.—The first evidence we obtain of this fault in proceeding up the valley is at Cox Mill, when, in the lane on the east bank of the brook, the Marlstone will be found dipping at 45° east. Further up, at Sutton Mill, the Upper Lias is exposed to view on the left bank down to the brook, while on the opposite side the Marlstone forms a bank from 30 to 40 feet in height. The Cranham fault is probably terminated by another, which crosses the ridge east of Prinknash, which brings the Ragstone of the Inferior Oolite, shown in the road, against lower beds of the opposite bank.

Crickly Hill Fault.—This fault traverses the southern base of Crickly Hill, having probably been the primary cause of its preservation in the form of a headland. It is scarcely visible along the cliff, though we may stand with a foot on each side. On ascending the hill by the Birdlip road, we find a section in the upper Ragstone, immediately above which, to the left of the road, the Fuller's Earth appears, giving rise to a small stream which trickles down the cliff. Close to this brook is the fault; for, upon ascending further up the hill, we find the Freestone at a higher level.

Along a line extending from Heartley Hill to Miserden, a distance of less than six miles, we cross as many faults, ranging nearly east and west. The down-throw of them all is on the same or north side; and had it not been for their influence, it is very doubtful if we should have had Leckhampton Hill so far north as it is. Instead of attempting the description of each separately, it will probably be as satisfactory to present a section along the line indicated.*

Wishhanger Fault.—The hamlet of Wishhanger is traversed by two faults at right angles to each other. That which ranges east and west is the less important, and terminates against the greater. The other follows the line of the valley, or rather the line of the valley coincides with it, for a distance of a mile and a half from north to south. At the hamlet the throw of the fault is greatest, for the highest or white limestone beds of the Great Oolite are brought down on the west side against the base of the Inferior Oolite on the east. There is a general dip of the beds on the *downcast* side towards the fault, as may be seen by observing the ridge of the Great Oolite at Hazle House from the south side of the valley, and we arrive at the same conclusion from the fact, that the Fuller's Earth along its outcrop occupies a more elevated position than the Great Oolite in proximity to the fault.

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* See horizontal section, Fig. 17.

The amount of throw at the fault may be thus calculated:—

Great oolite and Stonesfield slate - - -	40 Ft. nearly.
Fuller's earth - - - -	50 „ „
Inferior oolite - - - - -	150 „ „
Sands - - - - -	10 „ „
	250

Cubberley Fault.—This line has a range of at least six miles, and is terminated at the east by a transverse fault near Postcombe, while, at the other extremity, it gradually disappears along the valley west of Cubberley, which it has originated. Along its course it throws in three detached outliers of the Fuller's Earth and Stonesfield slate, sections in which are laid open at Upper Cubberley, where the evidence of the fault may be most advantageously studied.

Colesburn Fault.—This is but a slight dislocation, not reaching more than 30 feet vertically. The position of the fault may be satisfactorily ascertained at the top of the hill above Monkscombe Wood, where, in a quarry, the Stonesfield slate will be found in juxta-position to the Inferior Oolite.

Elkston Fault.—It will be sufficient to state, that where this fault crosses the valley near Combend, the Stonesfield slate is on a level with the top of the Inferior Oolite, the amount of throw being therefore about 60 or 70 feet.

Shewell Wood Fault.—This line is parallel to the last, equal to it in amount, and presents similar features when traversing the valley at Westcombe Barn.

Hawling Lodge Fault.—This is one of the most persistent faults of the district, traversing the country for a distance of at least 7 miles from the Lower Lias in the Vale of Winchcomb to within a short distance of Bourton-on-the-Water. It has given rise to a valley along the greater portion of its length. The evidence of this fault may be well studied at Fox Hill, where the oolitic freestone of the Inferior Oolite will be found coming against the Fuller's Earth.

Benborough Fault.—The existence of this N. and S. line is proved by the entire absence of the Fuller's Earth in certain localities along the western edge of the slate district.

Eyeford Fault.—The evidence of this fault may be observed most advantageously towards the upper end of Eyeford, where the sands of the Upper Lias will be found exposed to view in a pit, and almost in contact with the Stonesfield slate. There are several branches of this meridional line, one passing by Harford Hill Barn, where the Ragstone is brought against the Stonesfield slate; the second is in the line of the picturesque valley which turns westward from Eyeford, at a short distance from which the sands of the Upper Lias at the base of the bank on the north side will be found on a level with the Fuller's Earth on the opposite. These sands are terminated by a cross fault, which strikes right across the hill in a north-east direction.

Hawling Faults.—In this neighbourhood there is a series of small east and west faults, which, however, are not strictly parallel to the general direction of the system. They all produce slight depressions in the ground, and are accompanied by the outburst of springs.

Salperton District.—Between Hawling and the River Coln, the strata are traversed by seven faults of considerable magnitude, both vertically and horizontally. Three of these cross the valley between Salperton and Notgrove, and can be readily traced by the eye by means of the bands of Fuller's Earth, which are terminated in succession against them. The section Fig. 18 will illustrate these faults.

Stow District.—The faults around Stow are illustrated by a section (Fig. 16) referred to in a former page.* These are at least five in number, and they belong to the East and West system. The disturbed and fractured character of the Marlstone further to the east at Oddington has also been dwelt upon.† The remaining faults are those in the neighbourhood of Cornwell, where it will be observed the Upper Lias and Inferior Oolite are let down against the Lower Lias east of Mill Bridge. That Kingham Furze is

* Page 60. † Page 21.

occupied by the Lower Lias, is evident from its position with reference to the Marlstone, while on the north side of the fault, the Great and Inferior Oolite (the latter being here very thin) may be observed in a quarry near Mill Bridge. The amount of throw is, therefore, about 60 feet in this position.

Burford Fault.—It has already been stated as not improbable that the Lower Lias occupies the bed of the brook at Burford, for on descending the hill from Tainton Downs we pass successively from the Great Oolite to the Marlstone. On the south side of the brook at Upton it will be found that the Great Oolite, and at Upton the Inferior Oolite, descends to the water's edge; consequently there must be a fault along that valley, throwing down the Oolites against the Marlstone or Lower Lias. This fault is terminated eastward, by another ranging north and south, and bringing up the Marlstone against the Great Oolite, which may be clearly ascertained by observation along the lane leading from Weston to Fulbrook, the Marlstone being there exposed to view.

Waterloo Farm Fault.—This line, which ranges east and west, may be best evinced at Fox Grove, where a line of Forest Marble quarries have been opened in the downcast side, north of which, accompanied by a rise in the ground, we find the white limestone of the Great Oolite reaching the surface, the higher formation being thus thrown into a less elevated position, while the stratification is either horizontal or inclines gently *towards* the fault.

Forest Marble Faults.—A series of these traverse the district from east to west in the neighbourhood of Aldsworth, and as they are of slight amount, are only to be ascertained by very carefully tracing in the bands of clay, and observing the relative levels of the white limestone and the varied Forest Marble beds. Such being the case, it is almost impossible to mention any precise points where their evidence is especially apparent.

Springs.—The Cotteswold Hills may be called emphatically " the land of rivers and fountains of waters." From the bases of their mural cliffs—from the sides and heads of their dells and valleys copious springs gush forth—of the clearest water, supplied by the natural underground reservoirs which remain unexhausted long after the surface of the ground is parched.

The springs are too intimately connected with the geological structure of the district to be left altogether unnoticed; for while they are interesting as producing tributaries to the two most important rivers in England, they are important to the geologist in assisting him to trace those lines of boundary between the formations of which they are the frequent and unerring indicators.

There are two chief sources of springs amongst the Cotteswold hills; one at the base of the Great Oolite or Stonesfield slate, at its junction with the Fuller's Earth, and the other at the base of the Upper Liassic sands, or, in case of their absence, at the base of the Inferior Oolite. It is from this last position that the Thames rises at the "seven springs" near Cheltenham. As minor sources, the base of the Marlstone, the upper surfaces of Forest Marble clays, and the termination of masses of shingle along the flanks of the hills, may be mentioned. In all these cases it will be observed that the necessary conditions are the superposition of porous on impermeable strata, the sources of supply being the rains and snow.

There are other cases, though few in number, where springs burst forth at the base of the Inferior Oolite when it rests upon the Upper Liassic sands. Such cases, however, are not difficult of explanation. They occur when the quantity of water in the subterranean reservoir is so great that it finds a more ready exit at this point than by percolating, many feet lower, through beds which, though porous to a considerable extent, are much *less so* than the incoherent beds of the Inferior Oolite. An instance of this kind occurs on the south side of the Stroud valley, opposite Chalford, at the base of the cliffs which line the railroad.

From these perennial fountains the towns of Gloucester and Cheltenham are partially supplied; the former, by collecting the rills which trickle down the flanks of Robin's Wood Hill, and guiding them into reservoirs situated on the north side, near its base; the latter, by adopting a similar plan with the waters which reach the surface at the base of the oolite and underlying sands along the flanks of Hewlett's Hill, and collecting them into a reservoir on Battledown Hill, about 150 feet above the town.

Saline Springs.—The saline springs of Cheltenham differ from those we have been considering in several respects. They rise to the surface on the principle of artesian wells, and find their way through fissures of the Lower Lias, except in the cases where borings have been made, as at Pitville and some of the other spas.

The depository from which the salt with which these waters are impregnated is derived is no doubt the Keuper, the same formation which at Droitwich and in Cheshire yields such vast supplies of this mineral. These beds dip nearly conformably with the Lower Lias towards the east, and at their outcrop, beyond the boundary of the Lias, they reach a greater elevation than Cheltenham. Hence the rain water which falls upon the Red Marl percolates along the strata, (being probably assisted by the beds of Keuper sandstone, which are much more porous than the shales,) to continually increasing depths towards the eastward, and will endeavour to rise upwards through the superincumbent strata, whenever it can find a fissure. The rise of the saline waters of the Red Marl through the Lower Lias, and the consequent change in their medicinal contents, was first explained by Murchison, "Geology of Cheltenham," p. 63.

CHAPTER IV.

Superficial Accumulations and Pleistocene Deposits.

The quantity of superficial or oolitic débris, from the size of gravel to masses of rock large enough to be quarried, which is scattered over the flanks of the Cotteswold Hills, cannot fail to have struck the most casual observer. So great are these surface coverings of oolite, that frequently the whole series of formations, from the Lower Lias to the base of the Oolite inclusive, are entirely hidden from view to a depth which is sometimes 30 or 40 feet. Such obscurations of the strata will be observed upon ascending the hills by the lanes leading from Prestbury to Cleeve Cloud, along the Leckhampton road near Cheltenham, in the lanes east of Stanway, and in many places in Painswick valley. At Stanway these slipped masses of oolite are particularly remarkable from the regularity wherewith several beds are found to preserve their relative position, and the distance they have slid from their original sites, due in all probability to the slippery nature of the Upper Lias clay.

The superficial detritus *on the flanks* of the Cotteswold escarpment may be arranged under four heads:—

1. Recent atmospherical débris and Landslips.
2. Marine Undercliffs.
3. Ancient sea beach.
4. Glacial débris?

On the first of these it is not necessary to dwell, so insignificant are the effects of the atmosphere in comparison to those which have been produced by marine agency. The most authentic case of a landslip occurred at Hewlet's Hill near Cheltenham, where "a large knoll of Upper Lias "slipped from its place down an inclination of several "hundred yards, taking trees and hedges along with it, and "causing great derangement of the soil."*

* Murchison's Geology of Cheltenham, edited by Messrs. Buckman and Strickland, p. 59.

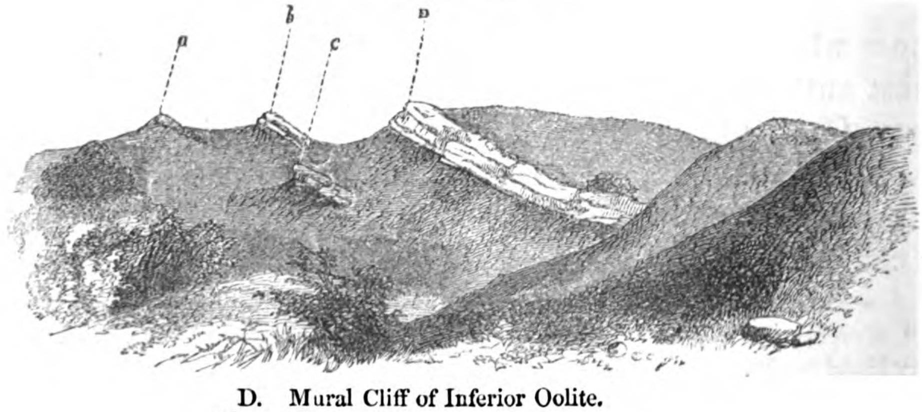
Similar instances are no doubt of occasional occurrence, and every year's frost dislodges a certain quantity of rock from the oolitic cliffs; but the mass thus dislodged forms but a small proportion of the tumbled detritus, the greater part being due to the agency of the sea.

2. *Marine Undercliffs.*

Those slips which present the aspect of marine undercliffs are of frequent occurrence along the Cotteswold escarpment, and, as was remarked by Professor Ramsay, they increase in number along that portion of the district from Crickly Hill northward where the Oolite reposes directly, or nearly so, upon the Upper Lias clay. Further south, where the sands at the base of the Oolite are so largely developed, these undercliffs are of less frequent occurrence.

One of the finest examples occurs at the foot of the oolitic cliff on Lineover Hill. In this instance at least 60 feet of the lower beds have slid for about 80 yards, and, preserving their original order of succession, dip apparently into the hill at an angle of 75 degrees. In other instances we find not only one, but several undercliffs forming a succession of pseudo-escarpments, resembling repetitions occasioned by parallel faults. These repetitions are exemplified in a marked manner along the western escarpment of Cleeve Cloud, and are noticed in the "Geology of Cheltenham." An endeavour is made below (Fig. 2.) to represent them as they are seen from a position about a quarter of a mile to the southward.

Fig. No. 14.
Cleeve Cloud.



D. Mural Cliff of Inferior Oolite.
a b c. Undercliffs.

Besides undercliffs proper to the Inferior Oolite, there is another series, though not on so grand a scale, belonging to the escarpment of the Great Oolite. In one case we have Inferior Oolite resting on Upper Lias, in the other, Great Oolite superimposed on Fuller's Earth, and from similar physical conditions similar results have arisen.

As might be expected, the undercliffs of this horizon are most numerous where the Fuller's Earth is thickest, and consequently they are very common along Stroud valley and its branches. In Sapperton, or the "golden valley," two or more terraces are of frequent occurrence underneath the true base of the formation; to which might be added half-formed undercliffs, where a portion of the rock bed has slipped from its original site, but remains attached by its other extremity.

3. *Ancient Sea Beach.**

If any proof were necessary that the mural cliffs of the Inferior Oolite once formed a bold line of sea-coast, it would be found in the fact of the occurrence, at intervals along the whole line of the Cotteswold Hills, of vestiges of a true sea-shore beach, formed of oolitic gravel, waterworn and stratified.

This gravel-bed may be distinguished from the accumulations already referred to, first, by its position, which is always at or near the base of the oolitic cliff; secondly, by the waterworn appearance and general smallness of the pebbles; and, thirdly, by the evident stratification of the whole.

Upon my first noticing this beach, I stated that one of the localities where it might be most satisfactorily observed was at the base of the cliffs on Leckhampton Hill, near Cheltenham. I may now, however, state that this is not the most favourable place, better examples being available in

* For the first notice of this beach, see Paper by the Author, in Quart. Journ. Geol. Soc. for Nov. 1855, p. 848. Mr. Jones, of Gloucester, has since informed me that he had frequently noticed its existence.

the following positions:—At the Cleeve Cloud quarries, especially those on the N.W. side; above Corndean; in a pit at the southern extremity of the Sevenhampton valley, by the side of the Whittington road; in an opening on the N. side of Crickly Hill; in Witcombe Wood; at Cooper's Hill, in a pit by the side of Cheltenham road, near its junction with the road to Upton St. Leonards; on the east side of Painswick Hill; in Stroud Valley, especially in the railway cutting south of Chelford; and above Hill House, near Brimscomb.

False bedding, or oblique lamination, is of frequent occurrence; and that it may not be supposed to be due to the overfall of loose gravel from atmospheric waste, the lamination is sometimes *towards* the hill side, and is quite independent of the form of the ground. As an example, I may mention the section referred to at Cooper's Hill.

The elevation of this beach is usually about 700 feet above the sea. At Cleeve Cloud, on the west side, where it rests on the Oolite, its position must be at least 900 feet. The difference of level of this gravel, which is generally of a character so marked that when once observed will always be easily recognized, may perhaps be due not alone to a difference in vertical thickness, but may also indicate an irregularity in the elevation of the sea-coast, as is remarkably illustrated in the case of the raised beaches on the Norwegian coast mentioned by Professor James Forbes.*

In conclusion, I may mention that I have not been able to detect traces of marine shells. If they ever existed there, the nature of the deposit would seem to be unfavourable to their preservation.

4. *Supposed Glacial Débris.*

We occasionally find masses of angular fragments of oolitic and local rocks heaped together without the least appearance of stratification, and situated at different elevations along the escarpment, but sometimes as far down

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* Norway and its Glaciers.

as the base of the Marlstone. Together with the pieces of rock, which are of all shapes and sizes, but very little if at all waterworn, there are irregular and lenticular layers of clay and sand, presenting a rudely stratified aspect. As a whole, the masses to which I refer present the appearance of a mixture of stratified and unstratified fragments; and while their position often forbids the supposition that they might be the immediate result of the waste of the oolitic cliffs by atmospheric agency, their disordered and angular appearance renders it improbable that they were deposited in the ordinary manner of stratified deposits, to which they present a striking contrast.

One of the best examples of the accumulations referred to, occurs along the Leckhampton road, in a quarry or pit near the foot of the lowest tramway-incline.

The manner of the formation of this débris had long been a point of uncertainty with me, until Professor Ramsay, upon his tour of inspection, suggested that they might be referable to the agency of coast-ice of the glacial epoch; and it would be unaccountable indeed if the Cotteswold Hills did not present any traces of the action of an agent now generally admitted to have acted so prominent a part in modifying the configuration of the surface, and adding to the superficial accumulations of our country. I therefore look upon the hypothesis of Professor Ramsay as the most satisfactory explanation that has been offered for the productions of these irregular masses of shingle.

To one engaged in tracing geological boundaries the overspread of these various kinds of detritus occasions much uncertainty, by either falsifying or concealing the points of evidence upon which he usually depends. For example, on the north side of Cleeve Cloud, and in Painswick Valley, the oolitic débris extends in one unbroken and regular slope to positions greatly below the true base of the Oolite.

In Painswick Valley the detritus or slipped masses of shingle are frequently terminated by a cliff, the base of which may happen to rest either on the Upper Lias Clay or Sands indiscriminately. In either case they give origin to copious springs, as the sands, especially near their base, are sufficiently impervious to allow of a copious discharge at the base of the much more permeable mass of shingle. To one unacquainted with these circumstances, this pseudo-cliff might readily appear to form the true base of the oolitic formation, and hence he might draw very false conclusions as to the thickness and position of all the strata, or infer the presence of faults which had no actual existence.

On these accounts it has been found necessary, in some places, to trace the boundaries hypothetically, in which cases they will generally be found drawn on the geological map in the form of dotted lines.

Fluviatile Gravel and Drift, or Pleistocene Deposits.

The accumulations we have hitherto been considering are confined to the flanks of the hills; those about to be described have a much wider range, and have, for the most part, been transported over considerable areas.

They may be considered under three varieties, which are generally sufficiently distinctive, and are as follows :—

1. Fluviatile—of the recent period.
2. Estuarine, or Mammaliferous—of "the second stationary period."
3. Marine, or Northern Drift—of the glacial period.

1. The fluviatile deposits comprehend not only those which occupy the broad plains of alluvium or silt which line either side of the Severn and Avon, and which are subject to their overflow, but also, according to the authors of the "Geology of Cheltenham," certain beds of sand and gravel at heights of from 10 to 45 feet above the present surfaces of these rivers.* Of such a character are the gravels opened up by the railway on either bank of the Avon, between the villages of Defford and Bredon Norton, at which places, upon a still greater elevation of the ground,

* The rise and fall of the Severn below Gloucester is very great, reaching about 20 feet during full tide when accompanied by floods, and the waters cover a tract from two to three miles in breadth.

they are succeeded by gravels abounding in chalk flints, which are doubtless referable to the more ancient period of the northern drift. The freshwater gravel is minutely described by Sir R. Murchison* and the late Mr. Strickland,† and contain freshwater mollusca, agreeing closely with the list published in the "Silurian System," as coming from similar deposits at Cropthorn, the most abundant forms being *Cyclas amnica* and *C. cornea*, associated with which bones of the following mammalia have been discovered:—*Elephas primigenius*, *Hippopotamus major*, *Bos urus*, and *Megaceros hibernicus?*

To account for the formation of these deposits, the above-mentioned authors consider that before the last elevation of the vale of Worcester the sea overspread a considerable portion of the area as far as Tewkesbury. The vale was then from 60 to 80 feet below its present level, and the ancient Avon overspread considerable areas on either side, forming a chain of lakes, and being dammed up by the influx of the estuarine waters. Through its agency the gravels of the more ancient drift were re-stratified, and became charged with the remains of extinct mammalia and of freshwater mollusca, all of which, with the doubtful exception of three species, at present survive. These deposits, therefore, which I feel confident are nearly contemporaneous with the gravels of Stroud valley, more properly belong to the next period, that of the *estuarine* gravels about to be described.

I must not neglect to mention a fact of much interest, for which I am indebted to Dr. Wright, of Cheltenham, that "in "cutting the Cheltenham sewer bones and horns of the fossil "ox (*Bos primigenius*) and a large human lower jaw were "found in alluvial gravel beneath 12½ feet of undisturbed "clay." It is also well known that in the silt of some of the Cotteswold streams bones and antlers of red deer have been found. Thus it would appear that, from the evidence in our own district, at least one species of ox had become extinct, and that other animals, such as the red deer, which are now

* Sil. Sys., p. 554, *et seq.* † Trans. Geol. Soc., vol. vi. pp. 554-5.

cooped up amongst the Highlands of Scotland, have all disappeared within the period of the occupation of Britain by the human race. I am aware, however, that this fact has been long established upon other than geological evidence.

2. *Estuarine, or Mammaliferous.*

These deposits occupy the valleys and plains, seldom occurring at a greater elevation than 250 feet above the sea level. They may be distinguished from northern drift by the predominance of detritus derived from the waste of local rocks, either broken up and stratified by the action of the estuarine sea itself, or carried down the slopes from the hilly districts by brooks.

Occasional pebbles of more distant origin occur in these gravels, which have been derived from the northern drift, a more ancient deposit, much of which must have been re-stratified during this second elephantine period.

The principal localities for this gravel are the following:—Stroud Valley, celebrated for the abundance of the remains of mammalia, principally the tusks of extinct elephants;* at Gloucester, east of the railway station; along the valley of the Chelt; at Charlton Kings, where the gravels, which, as they approach the hills, are almost exclusively composed of liassic and oolitic fragments, in the opposite direction, towards Cheltenham, give place to fine silicious sand containing fragments of marine shells. Similar gravels are found in the vale of Bourton, and along the valley of the Evenlode, particularly near Ascott, where they have been found to contain elephant remains; on the banks of the Avon, as already mentioned; and, finally, in the low districts of the Oxford clay between Cricklade and Cirencester; which localities, however, are not properly within the district. In all these places the gravel consists principally of fragments of oolite, well waterworn and regularly stratified,

* Some of these are in the possession of Mr. Carpenter, of Caincross: and a tusk of *E. primigenius*, in the Museum of the Royal Agricultural College, Cirencester, must originally have measured 14 feet in length.

though with the occasional admixture of pebbles of quartz or grit derived from the previously formed northern drift.

3. *Northern Drift.*

This is the most ancient pleistocene formation of the district, and is always to be distinguished by being composed of the débris of rocks and ice-transported boulders, of which the known positions are north or north-east of the Cotteswold country.

Northern drift is scattered but very sparingly over the southern portion of the Gloucestershire plain; still, quartzose gravel extends as far south as Cleeve, near Cheltenham, and increases in frequency and thickness in proportion as we proceed northward. Around the flanks of Bredon Clouds drift of northern, and (as proved by the presence of chalk flints) of eastern detritus, is plentifully distributed, but principally, as Professor Ramsay informs me, on the northern side. At Bredon village this gravel is from 10 to 15 feet in thickness according to Mr. Strickland, and at an elevation of about 70 feet above the Avon, or 35 feet above the freshwater gravel already described. This deposit is strictly marine, and indicates the limits of the ancient freshwater basin or lake, as it has apparently been beyond the influence of its waters.

The drift of the vale of Moreton is distinctly a combination of eastern and northern detritus, as stated by Dr. Buckland as far back as 1818;* for while on the one hand fragments of chalk and chalk flints are plentiful, on the other, rounded pebbles of quartz, semi-angular grits, and pieces of slate form the great majority of the mass. Thus, at Adlestrop in a section 12 feet deep, consisting of gravel and coarse

* I regret that when drawing up my Paper on the Drift of the Cotteswold Hills I was ignorant of the lucid description of this deposit from the pen of the learned Dr. Buckland, being then unable to refer to the earlier volumes of the Geological Transactions. In that description (Trans. Geol. Soc., vol. v. Old Series), Dr. Buckland traces the origin of the erratics of the vale of the Evenlode to their sources, one of which is the New Red Sandstone and Carboniferous rocks of the midland districts, and the other to the Chalk of Lincolnshire, which at Spilsby contains the hard red kind of chalk which is to be met with in the drift of the vale of Moreton. Geologists will see that my views with regard to the combined northern and north-eastern origin of this drift are in unison with those of that eminent man.

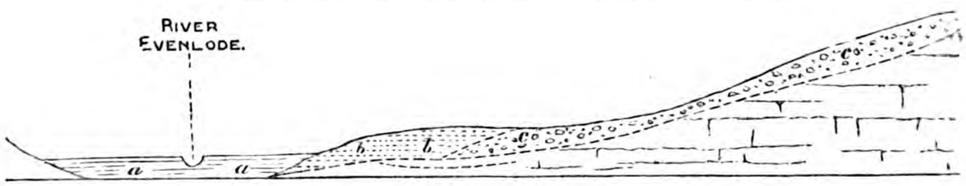
red silicious sand, we find the following pebbles: Yellow chalk flints (abundant), white and coloured quartz (abundant), subangular fragments of gritty sandstone, like millstone grit, pieces of hardened slate (few), coarse ribbon jasper (one fragment), chert (one fragment).

Of a similar character are the pebbles mentioned by Mr. G. E. Gavey in the drift of Mickleton Hill, at a height of 490 feet; but of the fragments and boulders of granite, syenite and igneous rocks, so abundant in the contemporaneous drift of the midland and northern counties, I have been unable to find an example. The quartzose pebbles are distinctly the broken-up and restratified pebbles of the New Red Sandstone. The grits strongly resemble those of the Carboniferous series, their connexion with which is established by the occasional presence of coalsmut and fragments of chert of the Carboniferous Limestone. The red sands and clays are such as would be produced by the destruction of several members of the Trias; and with regard to the origin of the flint gravel there can be no second opinion.*

The relative position of the Northern and Estuarine Drifts may be advantageously observed along the valley of the Evenlode, near Ascott. For while we find the former occurring at a height of 150 feet above the river, the latter lies at a much lower level, or not more than 20 feet above the same point. Taking the flint and quartzose gravel in the pit above Langley Mill and the oolitic gravel in the railway cutting near Ascott as points of comparison, the relative position and composition of the two deposits will be represented by the following section:—

Fig. No. 14.

Section across the Valley of the Evenlode, near Ascott.



a. Silt or alluvium.

b. Estuarine beds, composed of fine yellow and brown sand, and fine gravel, composed principally of local oolitic detritus, with elephant remains.

c. Coarse red silicious sand mixed with gravel, composed of rounded quartz, chert, flints generally angular, and grits.

Distribution of the Northern Drift.

While the vales of Gloucester and Moreton are overspread at intervals to a greater or less degree with patches of northern and eastern drifts, and while the presence of these drifts in the form of scattered pebbles may be recognized on the high lands of the Great Oolite, which extend southwards from the valley of Morton, the greater portion of the Cotteswold Hills is altogether free from drift. From whatever cause, whether from the impassable barrier which the outliers and cliffs of Inferior Oolite afforded to their transportation, or from the possibility of these hills having been above the level of the drift sea, or from some other cause at present indeterminable, the fact remains that the whole table-land of the Cotteswolds, from its western escarpment eastward to the neighbourhood of Stow-on-the-Wold, is entirely free from the presence of erratic pebbles. Over the hills and valleys composing the south-eastern portion of our district pebbles of quartz and carboniferous grits are sprinkled, independently of the form of the ground; and on approaching their western limit, which may be roughly represented by a line drawn from the southern end of the vale of Bourton to Cirencester, they become so sparingly scattered that their presence is only to be ascertained by carefully searching the ploughed fields. Drift pebbles are also to be met with on the ridge of the Great Oolite, extending from Adlestrop eastward towards Chipping Norton, and the height which they attain on this and the ridge on the south side of the Evenlode is about 600 feet. The higher portions of Bredon Hill and Ebrington hills are stated by Mr. Howell to be free from erratic pebbles; and, from my own observations, the same is true with regard to the remaining outliers of the vale of the Severn.*

Boulders.

I am not aware of the existence of genuine ice-drifted

* These quartz ore gravel may be traced into the Thames Valley, passing by Oxford and Abingdon. See Professor Phillips in the Oxford Essays, 1855.

boulders south of Bredon Hill, on the vale of the Severn. This great outlier, stretching right across the head of the vale, must, to a great extent, have acted as a barrier to rafts or bergs of ice on their voyage southwards; but blocks of sandstone, resembling Millstone Grit, generally sub-angular, and varying in size up to 3 feet in diameter, are by no means rarely scattered over the vale of Moreton, and increase numerically towards the north. I have observed them as far south as the village of Bowl, but am not aware of any instances over the hilly district of the Great Oolite.

From the foregoing details it will be observed that there is a marked connexion between the extent of surface covered by erratics in the hill country and the form of the flank along which the table-land is elevated above the surrounding plains. Over the tabulated promontory between the vales of the Severn and Evenlode, as also on the upper surface of Bredon, Stanley, and Dumbleton Hills, we find no evidence of erratic pebbles; and it will be observed that all these elevated districts possess precipitous flanks, generally crowned by mural cliffs facing the north. On the other hand we find pebbles of northern drift, not only to the southern termination of the Evenlode Valley, but also swept for many miles further south over the high grounds of the Great Oolite, in which locality the precipitous escarpment, which we find elsewhere, has degenerated into a mere slope or swell of the ground. I have always regarded these two facts in the light of cause and effect, considering that the elevated barrier was a sufficient explanation of the absence of erratic pebbles on the one hand, and that the more gradual elevation of the ground allowed of their transportation on the other.*

Origin of the Physical Features described.

In a memoir published by the Geological Society of London, I endeavoured to show that the main features of the district, that is to say, the Cotteswold promontory

* For a map of the various drifts of these regions, see Quart. Journ. Geol. Soc. for Nov. 1855. By the Author.

and the vales of Moreton and Bourton, are the natural result of marine agency acting from the north, in the first case, on a synclinal, and in the two latter on anticlinals, the axes of which have north and south directions. As the instructions of the Director General are that the memoirs illustrative of the maps are to be essentially descriptive of the physical and geological phenomena of each district, theoretical views being avoided, I have simply to refer the reader to a previous publication of my own.* I may venture, however, to offer one illustration.

The town of Winchcomb stands in a valley of Lower Lias, which opens northward into the Gloucester plain, and extending southward, becomes narrower in this direction till it finally enters the valley of the Coln, near Andoversford. Now, it is evident, that if it can be proved that there exists a N. and S. synclinal line in the hills which bound the valley on the west, and that there is an easterly dip on the opposite side of the valley, there will be a resulting anticlinal running along the vale of Winchcomb, which, according to the principles which I have endeavoured to establish, I maintain to have been the inducing cause of its formation.

The easterly dip on the east side of the valley will be evident to any one who crosses the escarpment towards Guiting. Upon reaching the summit of the Oolite, he will find the same stratum gradually sloping for at least a mile in that direction. With regard to the existence of an opposite dip on the west side of the valley, to be convinced, it is only necessary to take up a position which commands a view of Stanley and Notting hills from the south. From the north side of Cleeve Cloud the upper surfaces of these hills may be observed to slope towards each other in a very decided manner, and this slope of the surface of the oolite is coincident with its dip. The existence of this undulation of the strata being thus established, there can be no doubt but that it is intimately connected with the scooping out of

* See Quart. Journ. Geol. Soc. of London, on the "Physical Geography and Pleistocene Phœnomena of the Cotteswold Hills;" in which the origin of all the principal features of the district is discussed.

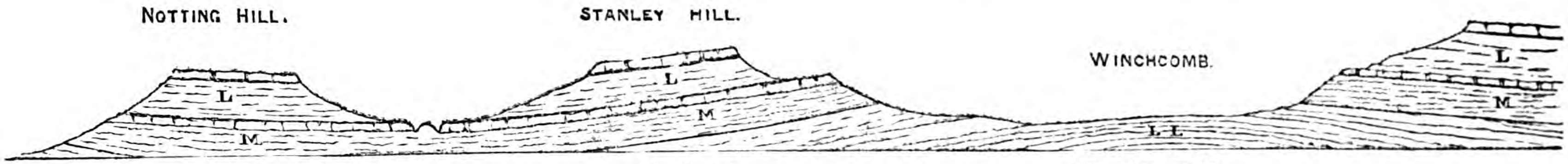
the valley of Winchcomb, on the one hand, and of the preservation of the hills, by which it is bounded on the west, by the other.

The annexed section (Fig. 15) across the vale of Winchcomb is intended to illustrate this hypothesis.

Fig. No. 15.

Section across the Vale of Winchcomb, showing the position of the Synclinal and Anticlinal Axes.

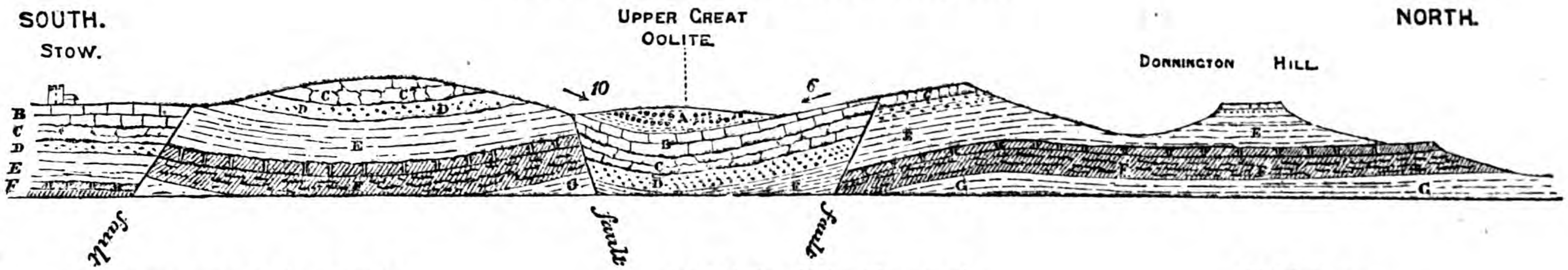
W.S.W. ⟷ E.S.E.



L Upper Lias. M Marlstone. LL Lower Lias.

Fig. No. 16.

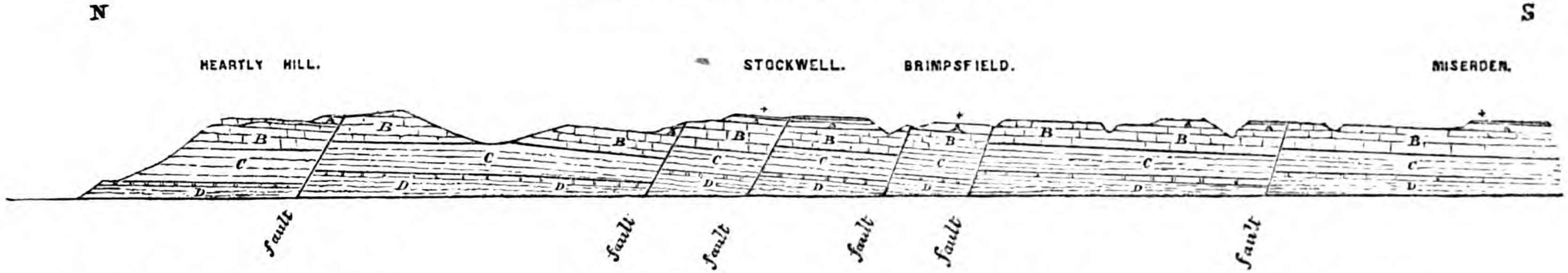
Section nearly along the Evesham Road, Stow.



A Upper zone of Great Oolite.
B Lower do. do.
(Representing the Stonesfield Slate.)
C Inferior Oolite (Ragstone).
D Upper Lias sand.
E Upper Lias clay.
F Marlstone.
G Lower Lias shale.

Fig. No. 17.

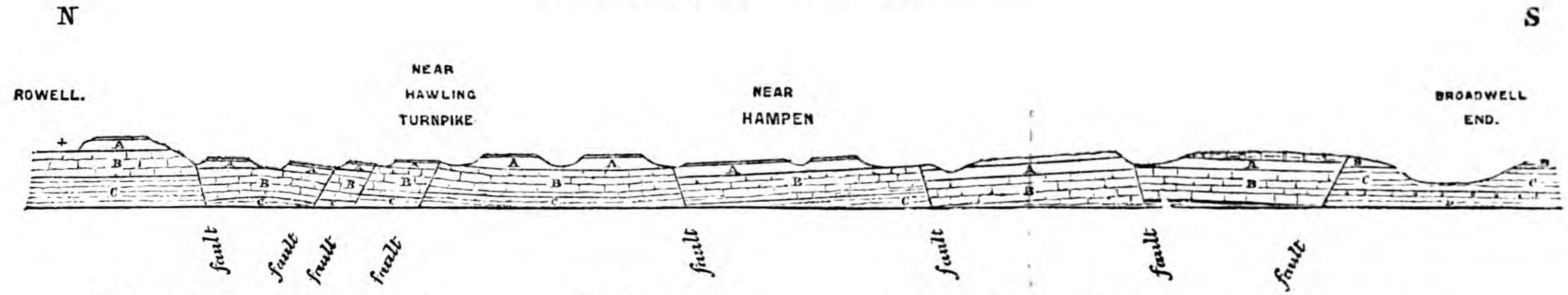
Section north and south through Brimpsfield.



A Great Oolite and Fuller's Earth. B Inferior Oolite. C Upper Lias. D Marlstone.

Fig. No. 18.

Section north and south near Salperton.



A Great Oolite and Fuller's Earth. B Inferior Oolite. C Upper Lias, and Sands. D Marlstone.

Descriptions of the Figured Species of Fossils,

by John Morris, Esq., F.G.S., &c.

Terebratula Etheridgii. Davidson.—Plate 1, fig. 4, 4 *a*, *b*.

Ter. Etheridgii. Dav. Mon. Brit. Foss. Brach. Appendix, p. 20, pl. A., f. 7, 8.

This seems a rare shell. Our specimens are somewhat intermediate in character between those of Davidson's plate, having the ventral sinus flat and well defined, and much narrower than in his fig. 7. It is scarcely represented deep enough in our figure.

Davidson's specimens were somewhat doubtfully referred to the Inferior Oolite.

Locality.—Inferior Oolite; Winlay Hill, in pea-grit.

Plicatula complicata. Lycett, sp.—Plate 1, fig. 2.

Placuna? complicata. Lycett, An. Nat. Hist., 1850, vol. 6, p. 420.
(*Placunopsis.* Morris, Catal. 2d edit. 179.)

Shell irregularly ovate-trigonal; upper valve convex, and ornamented with numerous tubular conical spines, disposed in an irregular radiating imbricated manner; the spines near the umbo adpressed, those towards the ventral margin elevated and attenuated.

The under valve cannot be described, as it is imbedded in a mass of shelly oolite, containing fragments of Echini, Pentacrinus, Bryozoa, &c.

Locality.—Inferior Oolite, Cleeve Cloud, Cheltenham, in pea-grit.

Pecten symmetricus. Morris.—Plate 1, fig. 3, 3 *a—c*.

Shell small, equivalve, nearly circular, convex, ornamented with about twenty-two somewhat obtuse costæ, with slightly prominent spines at irregular distances, which become more numerous towards the anterior margin, forming imbricated lamellæ. The insterstitial furrows are not so wide as the ribs. Umbones prominent and incurved; auricles nearly equal, the right one (fig. 3 *c*) marked by a prominent imbricated ridge, which corresponds to a furrow on the opposite valve, left or posterior auricle with three slightly raised ridges, and the area of the lunule with granulated striæ.

This is a distinctly marked species, and the symmetry of the valves renders it an interesting form among the oolitic species of the genus, as in this character it somewhat approaches *Lima.*

Locality.—Inferior Oolite. Andoversford, in the ragstone.

Modiola explanata. Morris.—Plate 1, fig. 1.

Shell elongated, ovately reniform or somewhat trigonal, convex, thin, imbricated or marked by the concentric lines of growth, which are more prominent on the dorsal margin; umbones subterminal, obtuse; hinge line straight, and about half the length of the shell; ventral margin slightly concave. Anterior side obtuse, posterior compressed, curved, and dilated. A broad obtuse ridge proceeds from the umbones to the posterior ventral margin. The length of the shell is about twice the height. Length 4 inches; height 2¼ inches; depth of valves united 1⅝ inch.

The size of the shell and the compressed and expanded posterior margin appear to separate this shell as a distinct form, although in the young state it presents some resemblance to *M. imbricata*, Sow.

The shell of some of the specimens has been perforated by parasitic animals, the casts of the irregular tubular cavities only remaining.

Locality.—Inferior Oolite of Stoney Cockbury, (in the ragstone).

Cyprina? sp.—Plate 1, fig. 5.

Cast ovately elliptical, inequilateral, ventricose, anterior margin rounded, posterior rather truncate. Umbones prominent, muscular impressions indistinct; posterior hinge-line oblique.

This cast in shelly oolite is doubtfully referred to *Cyprina*, as it presents some resemblance to the gibbose varieties of *Lucina*. No muscular impressions can be traced. It may however serve to call attention to a fine species.

Locality.—Inferior Oolite. Stoney Cockbury (in the ragstone).

Cypricardia rostrata. Sow. sp., *var.* truncata.—Plate 1, fig. 8.

Isocardia rostrata. Sow. Min. Con. Tab. 295, fig. 3.

Cypricardia rostrata. Morris, Catal. Brit. Foss., 2d edit. p. 199.

? Cardium Beaumontii. Archiac. Mém. Geol. Soc. France, vol. 5, t. 26, f. 4.

The casts figured are considered to be merely varieties of the *C. rostrata*, a species which is somewhat widely distributed in the lower oolites.

Locality.—Great Oolite. Windrush Quarry?

Corbula Hulliana. Morris.—Plate 1, fig. 6.

Shell thick, gibbose, subequivalved, ovately trigonal, inequilateral; anterior side longest, and rounded; posterior short and angulated, with a fold on the cardinal slope — that of the right valve sharply inflexed; ventral margin irregularly curved. Surface of both valves with numerous concentric prominent ridges, the half of the smaller valve only, towards the produced side marked with radiating striæ, which give to that portion of the valve an imbricated appearance, and a somewhat notched margin (fig. 6 *c*).

This species, with which I have associated the name of its discoverer, who has worked out in detail the oolitic rocks of Gloucestershire, is an interesting form, as the genus is not common in the oolites. It also presents a resemblance to some tertiary species, especially from the nummulitic group.

Locality.—Forest Marble. Fields at Northleach.

Pleurotomaria Aglaia, D'Orb., *var.*—Plate 1, fig. 7, 7 *a—c*.

Pleurotomaria Aglaia, d'Orb. Prod. 1, p. 268. Terr. Jur. pl. 381, f. 1—5.

Shell depressed umbilicate; volutions five, somewhat quadrate, concentrically and longitudinally ribbed, producing a decussated appearance; upper part of each whorl tabulate, the outer margin tuberculated (fig. 7), the band placed below the upper row of tubercles (fig. 7 *d*), the umbilical surface marked by prominent concentric and sometimes tubercular ridges, crossed by the numerous finer transverse lines (fig. 7 *c*).

Locality.—Inferior Oolite. In the pea-grit, Crickley Hill, Cheltenham.

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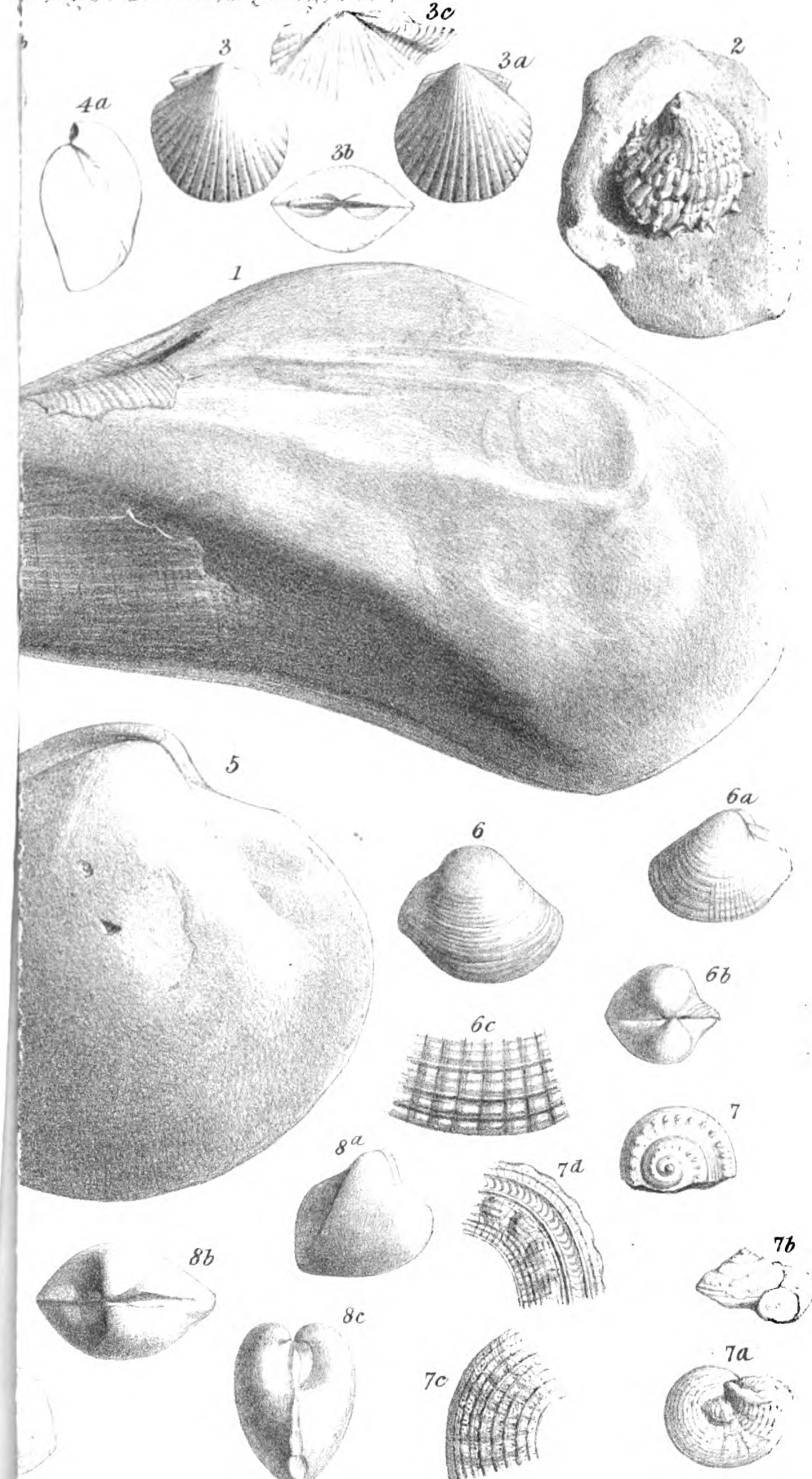

Day & Son, Lith^rs to The Queen

...diola explanata, Morr. _ 2 *Plicatula complicata* Lycett _ 3 *Pecten symmetricus* Morris.
...at. Etheridgii, Davids. _ 5. *Cyprina ? sp.* _ 6 *Corbula Hulliana* Morris. _
...tomaria Aglaia, D'Orb. _ 8 *Cypricardia rostrata*, Sow. var. *truncata*.

Plate 2.

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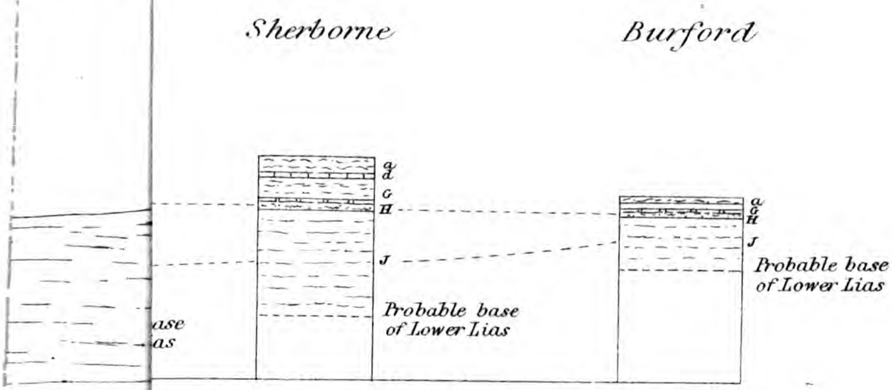
Comparative Sections.



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