ON THE GEOLOGY OF THE EASTERN PORTION OF THE BANBURY
AND CHELTENHAM DIRECT RAILWAY.*

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Nothing has, of late years, done more for the study of local Geology than the extension of railways. In the course of the great works necessary to the system, sections have been opened that, if not so deep and extensive as those afforded by some of our coasts, are far better adapted for measurement and the collection of their fossils; and the geologist as he passes swiftly by, may, from the windows of a railway carriage, get a knowledge of the more salient characteristics of a formation, often more valuable than the teachings of books. When thus travelling, it has occurred to me that a work might be written upon the geology of our railways, noticing the sections in their order, and taking in the surface indications and physical geography where practicable, which would be interesting and useful to young geologists, and not altogether to be despised by experienced observers. In my own neighbourhood are several such sections worthy of notice; some of them, as the great cutting through the Lower Lias at Harbury, well known. Lately I have described with some particularity a section in the *Jamesoni* zone of the Middle Lias at Fenny Compton,† also on the Great Western, between Banbury and Leamington; and there are good sections of the Great Oolite between these towns and Oxford. The great bones of *Cetiosaurus*, now in the Oxford University Museum, were partly obtained from this formation, close to the Kirtlington Station.

During the last two years a new line, to be called the "Banbury and Cheltenham Direct Railway," has been in course of construction; and the eastern portion of it, starting from King's Sutton, the nearest station on the Great Western Railway, south of Banbury, and passing through or near the villages of Adderbury, Milton, Bloxham, Milcomb, Hooknorton, and Rollright, to the town of Chipping Norton, has afforded such interesting sections, that your esteemed President, Professor Morris, who last summer

* All the localities mentioned in this paper occur in Map No. 45 N.W. of the Ordnance Geological Survey.

† "The Lias of Fenny Compton, Warwickshire," by Thomas Beesley, F.C.S. (Proceedings of Warwickshire Naturalists' and Archæologists' Field Club," 1877.)

did me the honour to visit some of them in my company, has called upon me to briefly describe them for your information.

And here I must ask you to bear in mind that some of the localities most deserving of notice are distant several miles from my place of residence, so that I have been unable to observe their features as fully as I might otherwise have done. This, I trust, will be accepted as some excuse for shortcomings in my account of the imaginary journey which I shall now ask you to make with me.

Some of you may have noticed, when travelling on the Great Western Railway, and nearing Banbury from Oxford, a church with a tower and very elegant spire of the 15th century, the latter richly ornamented with foliated crockets upon its angles, standing upon a gentle eminence above a village station. This is the church of King's Sutton, said by tradition to have been built, at any rate so far as the tower and spire are concerned, by the famous William of Wykham, who held large estates in these parts, and took his name from a village near Banbury. I could tell you many things of archæological interest about King's Sutton, but I refrain, as doubtless you despise matters of so very recent a date. I may, however, just say that in early Saxon times, A.D. 662, a saint was born here, St. Rumbald by name. He lived but three days, but nevertheless found time to *preach* at Brackley, six miles off, whither his body was translated in the following year. He had a chapel here dedicated to him, and also gave his name to a Holy Well, the once somewhat celebrated Astrop Well, at one time much frequented.

The church stands upon the Marlstone or Ironstone, the *Spinatus* zone of the Middle Lias, which about here is richly fossiliferous, and has yielded several new species, as well as some hitherto only known from similar beds in Normandy. Amongst the new species are several corals, lately described at a meeting of the Geological Society, by Mr. R. F. Tomes, and a *Crania* (*C. Griffini*, *Dav.*). The line of railway, which runs along the low ground of the Cherwell valley, is upon the *Margaritatus* zone, a slight section of which is visible near the bridge just south of the station. Here occurs *Cryptænia complanata*, *Desl.*, which in these parts seems to take the place of the common *Cryptænia expansa*, a far less noticeable species.

The new line leaves the Great Western just beyond the bridge, curves westward as it crosses the Cherwell and the Oxford canal;

and, rising gently, passes the extreme east of Adderbury in a cutting of 12 feet deep, where this section is seen:—

						Ft.	In.
Marlstone (<i>Am. spinatus</i>)	...	...	...	...	...	2	0
Sandy Shale	...	...	...	...	...	4	0
Sandy Marlstone (<i>Am. margaritatus</i>)	...	...	...	...	...	2	0
Pale blue sandy Clay	...	...	...	...	...	4	0

The stone is much weathered.

Just above the railway, on the northern side, is a considerable quarry, showing the *Spinatus* beds, capped by 2 or 3 feet of Upper Lias, much broken and disturbed by a succession of little faults into columns of a few feet wide, dipping in all directions; the joints being filled with the grey Upper Lias clay, and fragments of the white marly limestones of the *Serpentinus* zone—the “Upper Cephalopoda beds” of Mr. Charles Moore. A few hundred yards further north is a very extensive ironstone quarry in the same beds; the eastern part similarly capped and faulted. At the top of the marlstone is a transition band of less ferruginous stone, probably the *Annulatus* zone, although the characteristic ammonite has not been found in this part of the country; its place seems to be taken by *A. Holandrei*. This is very rich in fossils, especially gasteropods. I hope at some future time to describe them more fully than was done in my “Sketch of the Geology of Banbury,”* some years ago.

A little beyond the bridge, on the road to Aynho, the cutting ceases, but at the second, or Oxford-road bridge, another and deeper cutting begins; and here the whole depth of the *Margaritatus* zone is seen. At the top is the broken *Spinatus* rubble; then comes the upper *Margaritatus* stone, a rather siliceous Marlstone in concretionary blocks, with much calcite, 2 feet thick—brown where weathered, but blue where preserved from oxidation. Below this we get 9 feet of sandy shale—the upper part light grey, the lower pale blue—resting upon another row of concretionary blocks, rather more argillaceous than the upper ones, and apparently less fossiliferous. Beneath are the dark blue laminated clays of the *Capricornus* zone, of which only a few feet are visible. As the hill sinks down, a fine view is got of the church of Adderbury, with its 13th century tower and spire. Beyond, the line passes through the extreme west of this village, and by the hamlet of Milton, towards Bloxham, marked in the distance by its magnificent

* “A sketch of the Geology of the neighbourhood of Banbury,” by Thomas Beesley, F.C.S., in “Proceedings of the Warwickshire Naturalists’ and Archæologists’ Field Club” for 1872.

tower and spire of early 14th century architecture, having thus brought the traveller within sight of the three finest churches of these parts.

On nearing Bloxham, about 300 yards before reaching the Barford-road bridge, a small fault brings down the Upper Lias about 4 feet against the *Spinatus* beds. For 100 yards further the banks are all Marlstone of this zone; then comes another fault dipping to the east, which throws down the Upper Lias to the base of the section, a depth of 15 feet; the white marly limestone of the *Serpentinus* beds, crowded with *Ammonites bifrons*, *A. communis*, *A. cornucopiae*, *A. heterophyllus*, *A. subcarinatus*, and species of the *Serpentinus* group, with *Belemnites Ilminsterensis*, *B. regularis*,* and *Nautili*, now forming the floor of the line, and over it blue or green shale, 15 feet thick. The faults pass obliquely across the line from N.W. to S.E. The Upper Lias dips slightly to the west, but the line slopes at a higher angle, so that the Marlstone again comes in at the next bridge. Beyond Bloxham the railway runs upon Marlstone, or over the bottom beds of the Upper Lias, past Milcomb, towards Hooknorton. On the north side, the land rises to an elevated tract nearly 700 feet above sea level, and 200 feet above the line of road, occupied by loose sands of the Inferior Oolite of the Northampton type, with some rubbly sandy limestones at the base, containing fossils of the *Murchisonæ* zone. On the northern side of this high ground rises the river Stour, flowing westward to the Warwickshire Avon and the Severn. On the south of the line are the villages of South Newington and Wigginton, situate on the lower beds of the same formation, let down by parallel faults which stretch westward from the Cherwell nearly to Hooknorton, and produce a narrow valley, which carries the river Swere to join the former river. Near Hooknorton the line turns southward, and will have to be cut through a considerable hill of Marlstone, and then carried by a viaduct and embankment over a deep dell and a plateau of Marlstone, to the lofty hill south of the village.† Through this a cutting has been partly made, which, when completed, will be three quarters of a mile long, and for some distance 40 feet deep.

Here let us look back for a moment upon the country over which, for nine miles, we have been travelling. Summing up our

* The fossils of the Bloxham Upper Lias, which have been largely collected by myself and others, will be enumerated elsewhere.

† 700 feet above the sea, and 180 feet above the valley below.

observations, we shall see that our course has been mainly over the Marlstone, here highly ferruginous, the *Spinatus* zone of the Middle Lias, with only occasional excursions upon the Upper Lias. This is of some importance with regard to the future of the railway, as the rock bed of this zone contains from 20 to 30 per cent. of iron, and is from 10 to 12 feet in thickness. At King's Sutton we started at an elevation of 300 feet above the sea. The south hill of Hooknorton is nearly 700 feet; and the line of railway passing through it will be about 650 feet. For the future, until we approach Chipping Norton, our road will run through or over the Lower Oolites.

Over a portion of the Marlstone plateau, and of the slope of the Upper Lias above it, an embankment, 30 feet high, is already made by "tipping" over large oolitic blocks, brought from the cutting to which it forms the approach. Its weight has caused the wet Upper Lias clay to bulge out in great ridges at its base. On the sides of the cutting the strata dip irregularly northwards to the valley. The lower bed is dark blue shale, belonging to the upper part of the Upper Lias. There are a few concretions, but, with the exception of a couple of small ones, 4 or 5 feet from the top, no regular bands of them. The upper part is slightly sandy; but this is evidently caused by the percolating water having removed the line of the limestone above. The thickness cannot be got with accuracy, as there is no complete exposure, and the irregular dip interferes with its calculation. I estimate it at 30 or 40 feet. About Banbury it is 100 feet; at Chipping Norton, 35 feet; at Charlbury, six miles S.E. of the latter place, 10 feet; and at Fawler, a mile further in the same direction, 5 feet. There is no trace of the so-called "Upper Lias Sands," so largely developed in Dorsetshire.

UPPER LIAS FOSSILS—HOOKNORTON.

Ammonites bifrons.	Belemnites subaduncatus.
„ communis.	Cucullæa.
„ fibulatus.	Inoceramus.
„ opalinus.	Modiola.
Belemnites breviformis.	Ostrea Erina, D'Orb.
„ Ilminsterensis.	Leda ovum.
„ inæquistriatus.	Thracia glabra.
„ regularis.	

In some places very fine crystals of selenite occur.

Above the Lias comes the Rock-bed of the Inferior Oolite, a sandy limestone, thick-bedded, and with open sandy joints; yellowish brown on the surface; often white and very oolitic within; sometimes blue at heart, and very hard and crystalline. The section is:—

	Ft. In.
1. More or less thick-bedded, rather sandy Oolite, a little disturbed	17 0
2. Compact, concretionary, rather argillaceous, thick-bedded Limestone, blue at heart, joints sandy; surface irregularly undulated, covered with small oysters (sometimes in two beds)	3 0
3. Blue Upper Lias Clay, with concretions; top yellow and slightly uneven	12 0
	<hr/> 32 0

The whole of the Inferior Oolite in this section probably belongs to the zone of *Ammonites Murchisonæ*; not to the type as it occurs near Cheltenham, but to the variety seen at Bredon and Ebrington Hills, at the northern extremity of Gloucestershire. Eastward we should find these beds changing their characters, becoming, between Hooknorton and Banbury, loose sands with unimportant rubbly limestones at the base; but the latter still retaining many of the characteristic fossils. Near Banbury a little ironstone may be seen; and a few miles further, in Northamptonshire, the ferruginous character is strongly marked in ferruginous sandstones and thick deposits of cellular ironstone. The estuarine origin of some at least of the beds may be seen at Hooknorton, in the drift-wood and other vegetable remains abundant in some of the more sandy blocks. For a more complete account of these changes, I must refer you to the admirable "Introductory Essay" to the "Geology of Rutland," by Professor Judd. I should mention that in this cutting we hardly reach the top even of the *Murchisonæ* or lower zone.

FOSSILS FROM THE ZONE OF AMMONITES MURCHISONÆ,
HOOKNORTON.

Cetiosaurus (tooth).	Ostrea Marshii.
Hybodus	„ Sowerbyi.
Pycnodus	Pecten articulatus.
Strophodus	„ demissus.
Ammonites Murchisonæ	„ æquivalvis (?)
var. (?) very	„ lens.
large, 2½ feet.	„ personatus.
Nautilus sp.	„ texturatus (?) (virguli-
Belemnites giganteus.	ferus Ph. ?)

Belemnites gingensis.	Pholadomya fidicula.
„ in sculptus.	Pinna cuneata.
Cerithium limæforme.	Trigonia conjungens, <i>Lyc.</i>
Chemnitzia <i>sp.</i>	„ Phillipsi.
Monodonta lævigata.	„ pullus.
Pleurotomaria ornata.	„ signata.
Turbo capitaneus.	„ V—scripta.
Astarte elegans.	Unicardium depressum.
„ excavata.	Terebratula perovalis.
„ <i>sp.</i>	„ submaxillata.
Avicula inæquivalvis.	Rhynchonella concinna.
Cardium cognatum.	„ quadriplicata.
„ gibberulum.	„ subdecorata.
„ striatum.	Polyzoa.
„ <i>sp.</i>	Serpula deflexa.
Ceromya Bajociana.	„ intestinalis.
Cucullæa cancellata.	„ tetragona.
Gastrochena tortuosa.	Astropecten <i>sp.</i> (<i>Windoes.</i>)
Gervillia acuta. (?)	Extracrinus <i>sp.</i>
Lima cardiiformis.	Pentacrinus Milleri.
„ impressa.	Pygaster semisulcatus.
„ pectiniformis.	Echinoderm (spines).
„ punctata.	Isastræa Conybeari.
„ semicircularis.	„ explanulata.
„ <i>sp.</i> small, tuberculate.	„ Richardsoni.
Modiola cuneata.	„ serialis.
Myacites abductus.	Montlivaltia trochoides.
„ decurtatus.	„ Delabechei.
„ dilatus.	Thamnastræa Defranciana.
„ æquatus.	Coniferous wood.
„ peregrinus	Algæ.
Ostrea calceola (young),	Rain pittings.

The summit of the hill for nearly half a mile is not yet cut through, but considerable work has been done on its southern slope towards "Duckpool Farm." For some distance the beds are horizontal, and this section is exposed :—

	Ft.	In.
1. Soil and Rubble with oysters	2	0
2. Sand	0	3
3. Rubbly Stone	1	6
4. Sandy Limestone with broken shells and <i>Serpula</i> ; large oysters in a band at the top; <i>Trigonia</i> <i>costata</i> , <i>Lima cardiiformis</i> ...	3	6
5. Blue Clay	0	3
6. Grey Sandy Limestone	2	0
7. Sandy Limestone	1	0
8. Upper Lias Clay.		

The beds here are less disturbed and weathered than those on the other side of the hill; and the Inferior Oolite lies at once upon the clay, without any admixture of sand. Its lower surface is often covered with "nagel-kalk." Suddenly, on the east side of the cutting, the beds curve upwards, carrying the Upper Lias to the surface. This continues for a little distance: then comes a fault with an apparent dip to N.E., bringing down the basement beds of the Great Oolite limestone slightly below the top of the Upper Lias, a displacement, probably, of 40 feet. Below the limestone is a series of sandy shales and clays, with one or two bands of indurated sand, reaching to the bottom of the section at this spot. Beyond the fault, the beds curve downwards at an angle of 15° , but gradually approach the horizontal; and 40 yards further on is another parallel fault, with an upthrow of 4 feet; which, with the slope of the surface, soon causes the Great Oolite to run out at the top; whilst another row of limestone blocks makes its appearance for a short space at the bottom of the section, of which Section Fig. 1 is a diagrammatic representation.

The detailed section at the point marked in Section, Fig. 1, is as follows:—

						Ft.	In.
1.	Great Oolite Limestone	...	...	...	...	3	0
2.	Brown sandy Clay	..	...	...	...	1	6
3.	Tough dark olive Clay	...	...	...	...	0	3
4.	Light sandy Clay (with snow-white calcareous concretions)	...	...	...	...	2	6
5.	Greenish-grey Sandstone	...	...	...	...	1	0
6.	Grey Clay	...	...	...	...	2	0
7.	Slaty Sandstone	...	...	...	...	1	0
8.	Brown Clay	...	...	...	...	2	0
9.	Blue Clay	...	...	...	...	2	0
10.	Inferior Oolite Limestone	...	...	...	...	1	0

The appearances on the north-west bank are represented in Section, Fig. 2.

The Inferior Oolite at the base is evidently a higher bed than any met with in the previous sections, and no fossils have as yet been found in it; but the limestone at the top, which I have attributed to the Great Oolite, has yielded me

Nerinea punctata,	Trigonia costata,
„ Eudesii (?)	Rhynchonella concinna,
Cypricardia Bathonica,	Clypeus Plottii,
Cyprina Loweana,	Cidaris spines,
Pecten annulatus,	

FIG. 1.—SECTION SOUTH-EAST SIDE OF CUTTING.

FIG. 2.—SECTION NORTH-WEST SIDE OF CUTTING.

1. Great Oolite,
2. Upper Estuarine.

3. Inferior Oolite.
4. Upper Lias.

which can leave no doubt about its geological position. The series of sandy clays must then be classed with the "Upper Estuarine beds" of Professor Judd. No fossils have been found in the upper part of them, but one or two imperfect ones in the sandstones, one a *Trigonia*, resembling *T. Moretoni*. In the bottom clay fossils are abundant, particularly *Ostrea Sowerbyi*, and *Rhynchonella concinna*.

LIST OF FOSSILS FROM THE UPPER ESTUARINE, HOOKNORTON.

<i>Cypricardia Bathonica</i> .	<i>Pecten vagans</i> .
<i>Cyprina Loweana</i> .	<i>Placunopsis socialis</i> .
<i>Ostrea Sowerbyi</i> .	<i>Trigonia Moretoni</i> (?)
„ <i>acuminata</i> (?)	<i>Rhynchonella concinna</i> ,
„ <i>subrugulosa</i> .	<i>Clypeus clunicularis</i> .

Hitherto, these beds, except in a very reduced condition, and not clearly separable from the Lower Estuarines immediately below them, have been unnoticed in Oxfordshire. Two or three years ago, from an examination of some small openings for sand on Constitution Hill, a mile west of Banbury, I was able to prepare the following section :—

	Ft.	In.
1. Grey slaty Limestone	3	0
2. Brown Clay with decayed shells	0	4
3. Coarse brown Sand	1	6
4. Brown sandy Clay, with many decayed shells, and with vegetable stains below	0	4
5. Rather compact black Sand, with carbonaceous fragments	2	0
6. Brown Sand, white at top	6	0
7. Rubbly Oolite, with Inferior Oolite fossils...	not known	

No. 1 seems to be a transition bed. Many years ago I recollect to have seen a fine impression of a large fern upon one of its slabs. 2, 3 and 4 are Upper Estuarine; 5 and 6 Lower Estuarine.

The fault, which lets down the beds just described, is marked on the map of the Geological Survey (No. 45, N.W.), as branching from another and longer one, a little north-east of Swerford. These run parallel for about four miles, in a W.S.W. direction, and three quarters of a mile apart, letting down the Great Oolite in a trough which forms the valley of the river Swere. Between these faults, on the northern slope, the line now runs; the undisturbed Inferior Oolite rising above it to table land, on the right, 700 feet above the sea; with a corresponding range, a mile distant, on the other side of the valley. We first pass over a short embankment,

which leads to a shallow cutting in the lower rocks of the Great Oolite. These dip a little to the west, and probably also more considerably to the south, but the trench is at present too narrow to observe this; and their original continuity with the beds at the top of the Estuarines which we have just left is clearly distinguishable. The stone is white, compact and marly, as is usual in Oxfordshire; and is very fossiliferous.

SECTION.

									Ft.	In.
1.	Marl	...	...	...	...	...	...	...	0	9
2.	Limestone	...	...	...	...	...	...	...	2	6
3.	Rubbly Limestone	...	...	...	...	...	...	...	4	0
4.	Limestone	...	...	...	...	...	...	...	2	6
5.	Sand	...	...	...	...	...	...	...	1	0
6.	Rubbly Stone	...	...	...	...	...	...	...	1	0
7.	Limestone, with corals	...	...	...	...	...	...	...	1	0
8.	Limestone	...	...	...	...	...	...	...	3	0
9.	Marl	...	...	...	...	...	...	...	Not known.	

No. 7 has a continuous band of corals in its upper half, the most abundant species being the branching *Thamnastræa Lyellii*. *Nerinea* is abundant, and of several species. *Cypricardia Bathonica*, *Cyprina Loweana*, *Homomya Vezelayi*, *Myacites calceiformis*, *Mytilus imbricatus* and *M. Sowerbyanus*, *Ostræa Sowerbyi*, *Pholadomya Heraulti*, *Pecten annulatus*, and *Trigonia costata* are common. The section strongly reminds one of the same beds exposed in the lower part of the cuttings on the West Midland Railway, at Stonesfield and North Leigh, which the Association visited under the guidance of the late lamented Professor Phillips, three years ago.

After this comes a long embankment, and opposite Rollright Heath, another unimportant cutting in the Great Oolite, showing higher beds, with abundant *Cypricardias*. Through the greater portion of the next Oolitic hill, no work is done,* but as we get within a quarter of a mile of a bridge leading to Great Rollright, very near the spot where "Pest House" is marked on the map, we come suddenly upon a very interesting section. At the top is a bed or two of Oolite limestone, the upper full of *Terebratulæ*; and below a mass of grey or blue calcareous shales, with many thin and irregular blue calcareous bands, which at the bottom become thicker, and sometimes very hard, dark, and crystalline.

* A small and shallow excavation shows marly beds full of oysters, differing from *O. Sowerbyi*, and resembling those common in the Forest Marble.

Some of these calcareous bands, the upper surfaces of which are very undulating, are covered with curious impressions of the tracks of marine (?) animals; and amongst them are beautiful specimens of the "Zopfpfatten," figured in Quenstedt's "Jura" (Tab. 46, fig. 1, p. 334), so called from the resemblance of the tracks to plaits of hair. Inclosed in one at least of the lower and thicker bands of indurated calcareous mud, is a layer of lignite, in large pieces, mostly coniferous wood in a fine state of preservation; and showing, when thin sections are examined under the microscope, most beautifully the "glandular" tissue. Some of this drift-wood is bored by mollusks, or covered with oysters and other shells. The beds are rather undulating in the section, rising in a gentle curve to the east, and have a general dip of 10° to S.S.W. The following is the section at the eastern end of the cutting:—

	Ft.	In.
1. Soil and Oolitic subsoil	2	0
2. Great Oolite Limestone	2	0
3. Grey Shale, with thin stony bands	2	6
4. Stone band	0	2
5. Grey Shale	4	0
6. Stone band	0	2
7. Bluish grey Clay, with occasional stony bands	4	0
8. Slaty Stone, in variable layers	2	0
9. Clay, with much lignite	1	6
10. Stone band inclosing much lignite, slaty and irregular at top, with many "tracks"	1	0

The stone bands are very variable, both in thickness and extent. In the grey beds, fossils, in a recognisable state, are not common, and mostly occur on the surfaces of the thicker and harder limestones. The most abundant seem to be *Ostrea Sowerbyi*, *Pecten vagans*, and *Placunopsis socialis*. The following species have been noticed:—

Tooth of Saurian.	<i>Ostrea subrugulosa</i> .
<i>Pycnodus</i> .	" <i>acuminata</i> (?)
<i>Hybodus</i> .	<i>Harpax</i> (?)
Teeth and scales of fish.	<i>Pinna cuneata</i> .
<i>Cerithium Roissii</i> (?)	<i>Pecten annulatus</i> .
<i>Astarte sp.</i>	" <i>personatus</i> .
<i>Cypricardia Bathonica</i>	" <i>vagans</i> .
<i>Cyprina Loweana</i> .	<i>Placunopsis Jurensis</i> .
<i>Lima duplicata</i> .	" <i>socialis</i> .
" <i>sp.</i> small, with very finestræ.	<i>Trigonia costata</i> .
<i>Mytilus furcatus</i> .	" <i>formosa</i> (?)
<i>Ostrea Sowerbyi</i> .	<i>Tancredia truncata</i> .

<i>Terebratula maxillata.</i>	<i>Serpula</i> (3 <i>species</i>).
<i>Rhynchonella concinna.</i>	<i>Cidaris Wrightii</i> (?) (spines abundant).
Tracks of crustaceans (?)	
<i>Terebellaria ramosissima.</i>	Coniferous wood (bored).
<i>Stomatopora.</i>	<i>Zopfpplatten.</i>

West of this section, as far as the Rollright Bridge, the banks are sloped and smoothed, so that only a mass of shale, with occasional thin platy bands, is visible; but just beyond the bridge the Great Oolite again comes in.

The appearance of the beds just described is so unusual in this part of the country, that I was at first, after a very cursory examination, inclined to attribute them to the "Upper Estuarines" of Professor Judd; and in this I seemed to be confirmed by the few fossils then found in the overlying white limestones, as well as by the petrological character of the latter, which seemed to point to the Great Oolite. However, three days before the reading of the present paper, I had the privilege of visiting the spot with Professor Morris and Mr. W. H. Hudlestone, F.G.S., who were of opinion that the grey beds represented a condition of the Forest Marble, not unusual in the South of England; and their view was fully confirmed by the discovery of Cornbrash fossils in the overlying white limestones, such as *Avicula echinata*, *Terebratula intermedia* and *T. obovata*.

The Great Oolite beyond shows the following section:—

							Ft. In.
1.	Limestone	...	...	...	...	...	0 6
2.	Limestone, marly at top	...	...	...	...	...	1 6
3.	Blackish Clay	...	...	...	...	...	4 6
4.	Limestone	...	...	...	...	...	3 0

The dip is 5° south. No. 2 is exceedingly rich in fossils, especially gasteropods and small bivalves, as *Astarte*, in fine condition. The large *Chemnitzia Roissii* (?) is abundant. Some are, I think, undescribed. Splendid collections might be made here. The resemblance to the fauna of the Stonesfield and Northleigh beds is again apparent, but in this case it is to the higher beds of these places.

The following species have been found here:—

Fish teeth.	<i>Chemnitzia variabilis.</i>
<i>Actæonina parvula.</i>	<i>Monodonta, sp.</i>
<i>Cerithium quadricinctum.</i>	<i>Natica canaliculata.</i>
" <i>Roissii.</i>	" <i>pyramidata.</i>
" <i>n.s. (?)</i>	" <i>Stricklandi.</i>

Nerinea Dufrenoyi.	Limopsis ooliticus.
„ Eudesii.	Macrodon Hirsonensis.
„ punctata.	Myacites abductus.
„ „ var.	„ calceiformis.
„ Voltzii.	„ securiformis.
Nerita minuta.	Mytilus furcatus.
Phasianella acutiuscula.	„ imbricatus,
Stomatia Buvignieri.	„ Lonsdalei.
Trochotoma discoidea.	„ Sowerbyanus.
Trochus sp.	Ostrea costata.
Anatina sp.	„ Sowerbyi.
Avicula echinata.	Pecten annulatus.
Astarte angulata.	„ arcuatus.
„ sp.	„ vagans.
Cardium Stricklandi.	Pholadomya Heraulti.
Ceromya Bajociana.	„ socialis.
Ceromya Symondsii.	Pholas costellata.
Corbis Lajoyei.	Pteroperna costatula.
Corbula Hulliana.	Quenstedtia oblita.
Cypriocardia Bathonica.	Trigonia Moretoni.
„ nuculiformis.	„ V—costata (?)
Cyprina Loweana.	Unicardium impressum.
Gresslya peregrina.	Terebratula globata.
Isocardia sp.	„ maxillata.
Leda lachryma.	„ perovalis.
Lima duplicata.	Rhynchonella concinna.
	Acrosalenia.

We now pass, on an embankment, the road leading from Roll-right to Over Norton. A little further on, the line is cut through the northern slope of a hill. Great Oolite is here seen dipping strongly to N. by E., and rising on the banks at an angle of 5° to W. ; the far greater part of it running out before reaching the next, or “Langton,” bridge, on the Long Compton road, distant 330 yards from the commencement of the cutting; whilst the Inferior Oolite comes in at the bottom, below a black clay with oysters and *Pecten vagans*, apparently the “Upper Estuarine.” The Great Oolite limestones are separated by clayey oyster-bands of variable thickness. Beyond the bridge, thick-bedded limestones of the Inferior Oolite rise successively above the surface, dipping 14° to N.W., and curving downwards upon the banks. Beneath the black estuarine clay appears a layer of reddish-brown sand, which, on careful examination, is seen to be continuous with a bed of soft, travertine-like sandy limestone, with casts of gasteropods, many of them having the look of *Paludina*, and vegetable remains. This limestone, which under the microscope has exactly the aspect of

The upper part of the section (1, 2, 3, 4) is too much obscured by *débris* for the separate measurement of the beds. Beds (1-12) belong to the Great Oolite; (13) presumably to the Upper Estuarine; the remainder to the Inferior Oolite. Possibly, the "Paludina" bed may represent the Lincolnshire Limestone, or the Stonesfield Slate. I have found no distinct evidence of the occurrence of the "Clypeus Grit," of which we get some traces at Chipping Norton. The thickness of the Great Oolite in this fine section exceeds 70 feet; and to this is to be added at least the two upper beds of the Rollright Bridge section, given before. The late Professor Phillips estimated it at 60 feet for Oxfordshire; for the neighbourhood of Banbury I have taken it, but on very uncertain data, at 50 feet. From this spot the line runs in a considerable curve along lower ground mostly occupied by the *Capricornus* clays, skirting the outcrops of the *Margaritatus* and *Spinatus* zones, as far as Salford Hill, north of Chipping Norton. This hill, according to the Ordnance Survey, is 728 feet above sea level; and its summit is more than 150 feet above the low ground at its base. *Capricornus* beds are at bottom, surmounted in order by the *Margaritatus* and *Spinatus* zones of the Middle Lias, the Upper Lias, and the Inferior Oolite; the "Clypeus Grit" of the *Parkinsoni* or upper zone of the latter occupying the summit, and its "wash" extending to a considerable distance over the flanks, hiding a good deal of the outcrop of the Upper Lias. This "wash" also covers the outcrop of the *Murchisonæ* zone, if it is present, as it ought to be, for it is well developed in the hill above the town of Chipping Norton, although at Charlbury, six miles S.E., it is no longer found, "Clypeus Grit," with *Ammonites Parkinsoni* being only present.

An embankment of no considerable height, leads to a cutting in the hill that forms the approach to the tunnel. Here we at once notice the large blocks of bluish nodular marlstone, characteristic of the *Margaritatus* zone; and above them reddish-brown lumps and rubble belonging to the *Spinatus* zone, to which the term "Marlstone" is now ordinarily restricted. Unfortunately, for the sake of keeping up the banks, which are unusually steep, and often very wet, grasses have been sown upon them, so that they cannot now be observed so readily as a year ago. Above the mouth of the tunnel a few feet of black Upper Lias clay is seen, but without any of the bands of concretionary argillaceous limestone usually met with at the base, as at Bloxham. From a plan of the tunnel,

for which I am much indebted to the courtesy of J. A. Moseley, Esq., the resident engineer, I gather the thickness of this formation to be from 30 to 36 feet.

The rows of blocks of the Middle Lias, though somewhat irregular from minor displacements, are upon the whole nearly horizontal; but near the mouth of the tunnel they dip perceptibly. Observations in the tunnel itself, for which I am also indebted to Mr. Moseley, show that the beds roll over within the hill, so that in the middle the lower row of stones is above the roof, and the roadway is excavated in the *Capricornus* clays below. From these were brought up the fine specimens of *Ammonites Capricornus*, *A. Davoei*, *A. Henleyi* and *A. fimbriatus*, and other species.

The base of the tunnel is 108 feet below the summit; the shafts by which it is worked are 70 feet deep. It is about three-quarters of a mile in length.

SECTION AT ENTRANCE OF TUNNEL.

						Ft.	In.
	1.	Upper Lias Clay	...	...	...	10	0
	2.	Brown sandy Marlstone (<i>Spinatus</i>)	...	...	...	11	0
	3.	Shale	...	...	...	5	6
Margaritatus Zone.	4.	Bluish-grey siliceous Marlstone (with a band of <i>Serpulæ</i> in middle)				2	0
	5.	Shale	...	...	...	4	0
	6.	Blue siliceous Marlstone	...	...	...	2	6
	7.	Blue <i>Capricornus</i> Shales.					

In the cutting, the marlstones of the *Spinatus* zone are much corroded and decayed from the great quantity of water draining through them from the gathering ground above. Some of the harder parts stand out from the face like concretionary blocks; but even these have lost a portion of their lime, and are more or less soft and sandy. Little has been done with them, and it is hardly worth while to give a list of the few common fossils noticed. The harder stones of the underlying zone have been much better preserved, and their unusually abundant and interesting fossils are in wonderfully fine condition—their tests, even in the case of delicate shells, and their external ligaments, being generally perfect. *Cardium truncatum* and *Cypricardia intermedia*, Moore (the typical *C. cucullata*, is very rare), of large size, occur in masses, and in a condition rarely seen. *Macrodon liassinus* is plentiful, and equally fine. The abundance of *Anatinidæ* is worthy of notice, and with the drift wood and leaves of *Zamites*, points to the vicinity of land.

The upper band of this stone is greyish-blue, hard and somewhat

crystalline. In the middle is a seam with abundance of *Ditrypa circinata*. The fossils noticed *in situ* upon one occasion were—

Ammonites Algovianus,	Avicula papyria,
„ margaritatus.	Cypricardia intermedia.
Belemnites elongatus.	Gryphæa gigantea.
Chemnitzia cithara.	Macrodon liassinus.
„ foveolata.	Modiola scalprum.
Dentalium <i>sp.</i>	Pecten æquivalvis.
Astarte, small, 2 or 3 species.	Pleuromya ovata.
Avicula cygnipes.	Hemipedinæ (spines).
„ inæquivalvis.	Pentacrinus <i>sp.</i>
„ Münsteri.	

The lower stone, at the northern cutting, $2\frac{1}{2}$ feet, but at the southern, said to be $4\frac{1}{2}$ feet thick, is of a darker blue, and more sandy and marly. Fossils observed *in situ* were—

Belemnites elongatus.	Ostrea.
Chemnitzia Blainvillii.	Pecten liassinus.
Cypricardia intermedia.	„ strionatis.
Gryphæa gigantea.	Pleuromya rostrata.
Leda Zieteni.	Rhynchonella lineata.
Limea acuticosta.	Crustacean.
Macrodon liassinus.	Zamites.
Modiola scalprum.	Drift wood.

In sandy nests, in a few of the quarried blocks, but of which bed is not clear, many beautiful little gasteropods and bivalves have been found; some of them not yet identified with described species.

The abundance and fine condition of the fossils of these beds have drawn the attention of collectors to the spot, and several good collections have been made, amongst which I may especially mention those of Mr. T. J. Slatter, of Redditch, and of Mr. James Windoes of Chipping Norton. I mention these gentlemen, not only on account of the surpassing excellence of their collections from this spot, but also for their extreme liberality and kindness in allowing me to make use of them in the preparation of the accompanying list. Mr. Slatter's extensive and accurate knowledge of Lias fossils is well known, and the names to which [S] is attached, are, I am satisfied, deserving of all confidence. Of the latter gentleman I shall have occasion to speak hereafter.

FOSSILS FROM THE CAPRICORNUS AND MARGARITATUS ZONES,
CHIPPING NORTON TUNNEL.

[C.] *Capricornus* zone. [S.] names of species contributed
by Mr. Slatter alone.

Fish teeth (*Pachycormus*?) and Ammonites Algovianus, Oppel.
vertebræ. „ capricornus, Schlot (C.)

- Ammonites Davoei*, Sow. (C.)
 „ *fimbriatus*, Sow. (C.)
 „ *Henleyi*, Sow.*
 „ *margaritatus*, Mont.
 „ *nudus*.
Belemnites apicicurvatus Blainv. (C.)
 „ *breviformis*, Voltz.
 „ *brevis*, Dum. (S.)
 „ *clavatus*, Blainv. (C.)
 „ *elongatus*, Sow.
Nautilus, sp.
Actæonina Ilminsterensis, Moore.
 „ *marginata*, Simp.
Cerithium, cf. *acicula* (S.)
 „ sp. (S.)
Chemnitzia Blainvillii. Münst.
 „ *cithara*.
 „ *citharella* (?) Tate.
 „ *crassicosta* (S.)
 „ *foveolata*, Tate.
 „ *nuda* (?) Münst.
Cryptænia complanata, Desl.
 „ *expansa*, Sow.
Dentalium elongatum, Münst.
 „ *giganteum*, Phill.
 „ *gracile*, Moore (S.)
 „ *minimum*, Str.
Discohelix aratus, Tate.
 „ *Wrightii*, Tate.
Eucyclus imbricatus, Sow.
 „ *Julia*, D'Orb. (S.)
 „ *undulatus*, Ph.
Littorina biornata, Tate.
 „ *Clevelandica* (?) Tate.
Orthostoma fontis, Dum. (S.)
Pleurotomaria similis, Sow.
Rostellaria, sp. (S.)
Trochus mammillaris, Moore (S.)
Turbo cyclostoma, Münst.
 „ *Dunkeri* (?)
Anatina myacina, Tate. (S.)
Anomia numismalis, Q. & sp. (S.)
Arcomya concinna (?) Tate.
 „ *elongata*, Röm.
 „ *hispida* (?) Simps.
 „ *longa*, Buw.
Astarte consobrina. C. & D. (C.)
 „ *Lugdunensis*.
 „ 4 or 5 minute species.
Avicula calva, Schlot.
 „ *cygnipes*, Y. & B.
 „ *inaequivalvis*, Sow.
 „ „ v. *interlævigata*
 „ „ v. *acuticosta*.
 „ *Fortunata*, Dum. (S.)
 „ *Münsteri*, Goldf.
 „ *papyria*, Q.
Cardinia antiqua, Phill.
 „ *hybrida*, Stuch.
 „ *crassissima*, Sow. (S.)
 „ *lævis*, Y. & B. (S.)
Cardita liassina, Ph.
 „ *multicosta*, Moore.
Cardium truncatum, Sow,
 „ sp.
Cypriocardia cucullata, Münst.
 „ *intermedia*, Moore.
 „ *pellucida*, Moore. (S.)
Ceromya petricosa, Simp.
Cucullæa Münsteri, Ziet.
 „ *ovum*, Q. (?) (S.)
 „ *nitidissima*, Tate (S.)
Gervillia erosa, Simps.
 „ *lævis*, Buck. (S.)
Goniomya hybrida, Münst.
Gresslya intermedia, Simp.
 „ *punctata*, Simp.
 „ *lunuluta*, Tate.
 „ *Seebachii*, Brauns (S.)
Gryphæa gigantea, Sow.
Hippopodium ponderosum, Sow.
Harpax lævigatus, Dum. (S.)
Inoceramus ventricosus, Sow. (C.)
Leda Zieteni, Brauns.
 „ *graphica*, Tate.
 „ *Galatea*, D'Orb.
 „ *minor*, Simp.
Limea acuticosta, Goldf.
Lima Hermannii, Voltz.
Lucina pumila, Münst. (S.)
Macrodon Buckmani, Rich.
 „ *liassinus*.
 „ *intermedius* (?) Simp.

* Mr. Windoes has a portion belonging to one 18 in. diameter.

Macrodon pulchellus, Slatter (S.)	Ditrypa circinata, Tate.
Modiola numismalis, Oppel. (C.)	„ etalensis, Dum.
„ scalprum, Sow.	„ quinquedulcata, Müntst. (S.)
Nucula cordata, Goldf.	Serpula pentagonalis, on Pentacrinites.
„ navis, Piette. (S.)	„ plicatilis, Goldf.
Opis Ferryi, Dum. (S.)	Cidaris Edwardsii, Wright.
Ostrea irregularis, Goldf. (S.)	Hemipedina spines
„ sportella (?) Dum. (S.)	Pentacrinus scalaris.
Pholadomya ambigua, Sow.	„ sp.
„ „ v. recurva. (S.)	Cristellaria crepidula, F. & M. (S.)
„ „ v. Voltzii. (S.)	„ Bronnii. Röm. (S.)
„ Simpsoni, Y. & B. (S.)	„ pauperata T. P. (S.)
Pinna folium, Y. & B. (very large)	„ recta, D'Orb. (S.)
Pecten acuticostatus, Lam. (S.)	„ rotulata, Lam. (S.)
„ æquivalvis. Sow.	„ rustica, Terq.
„ calvus (?) Goldf.	„ varians, Röm. (S.)
„ liassinus, Röm.	Dentalina funiculosa, Terq. (S.)
„ frontalis, Dum. (S.)	„ matutina, Terq.
„ priscus, Schl.	Flabellina radiata. (S.)
„ strionatis, Q.	„ rugosa, D'Orb. (S.)
„ textorius, Schl.	Fronicularia Terquemi, D'Orb. (S.)
„ Rollei, Dum. (S.)	„ sulcata, Röm. (S.)
Pleuromya costata, Y. & B.	Glandulina humilis, Röm. (S.)
„ granata, Simp.	Lagena elongata (?) Ehr. (S.)
„ Jauberti, Dum. (?)	Lingulina tenera, Röm. (S.)
„ mundula (?) Tate.	Marginulina dichotoma.
„ ovata, Röm (?)	„ v. Burgundiæ. (S.)
Plicatula spinosa, Sow.	„ inæquistriata. (S.)
Tellina fabalis, Tate.	„ picta, Terq. (S.)
„ gracilis, Dum.	„ prima.
Unicardium cardioides, Ph. (C.)	„ raphanus. L. (S.)
„ globosum Moore (?)	Nodosaria humilis, Terq.
„ (S.)	„ prima, Terq.
„ varicosum. (S.)	„ raphanistrum, L.
Lingula sacculus, Ch. and D.	„ raphanus, L.
Rhynchonella lineata. Y. & B.	Oolina pentagona (?) (S.)
„ rimosa, Y. & B.	Polymorphina simplex Terq. (?)
Spiriferina oxygona, Desl.	(S.)
Pseudoglyphæa Etalloni (?) Oppel	Planularia.
Crustacean, sp.	Trochammina gordialis.
Bairdea dispersa, Blake (S.)	Zamites. (leaf).
„ liassica, Brodie.	Drift wood.
Cytherella crepidula, Blake. (S.)	
Polyclope, sp. (Mr. E. Walford.)	
Ditrypa capitata, Ph.	

About Chipping Norton a great quantity of Dinosaurian re-

mains have been found in the Inferior Oolite, many of them belonging to *Cetiosaurus*. I have seen by the road-side a heap of stones largely composed of these bones.

Looking back from the lofty hill which has been the western limit of our excursion, upon the Oolitic tract over which we have lately travelled, I may remind you that we have had the opportunity of studying, more or less completely, all the formations from the *Capricornus* zone of the Middle Lias to the Cornbrash of the Lower Oolites; and most of them have presented interesting, and in some cases, unexpected features. We have examined them very hastily, and have left very much for future observers and collectors to complete. The Inferior Oolite, in particular, is deserving of the most careful study. Its thickness, although far below that in Gloucestershire and elsewhere, is considerably greater than was thought probable; and it is not unlikely that a critical examination may prove that other zones may be present than those previously noticed in these parts.

Having now brought my very imperfect description to a conclusion, I have only again to express my obligations to those gentlemen whom I have already named, as well as others, without whose assistance this paper would have been still more unworthy of your attention. To Mr. Windoes, of Chipping Norton, I am especially indebted. Distance from the field, and other occupations, have prevented me from paying that attention to the actual sections which is so necessary for a trustworthy account of them. Mr. Windoes has always been ready and zealous in assisting me. Not only has he at once communicated to me the very numerous and rare fossils which he has extracted from every bed, and without which my lists would often have been meagre; but he has always been ready, in the little leisure he could snatch from his daily avocations, to visit any spot about which I might need information, and most intelligently explore and observe it. Should the Association be disposed to visit the sections which I have endeavoured to describe, I know that he would gladly give them all the help in his power.