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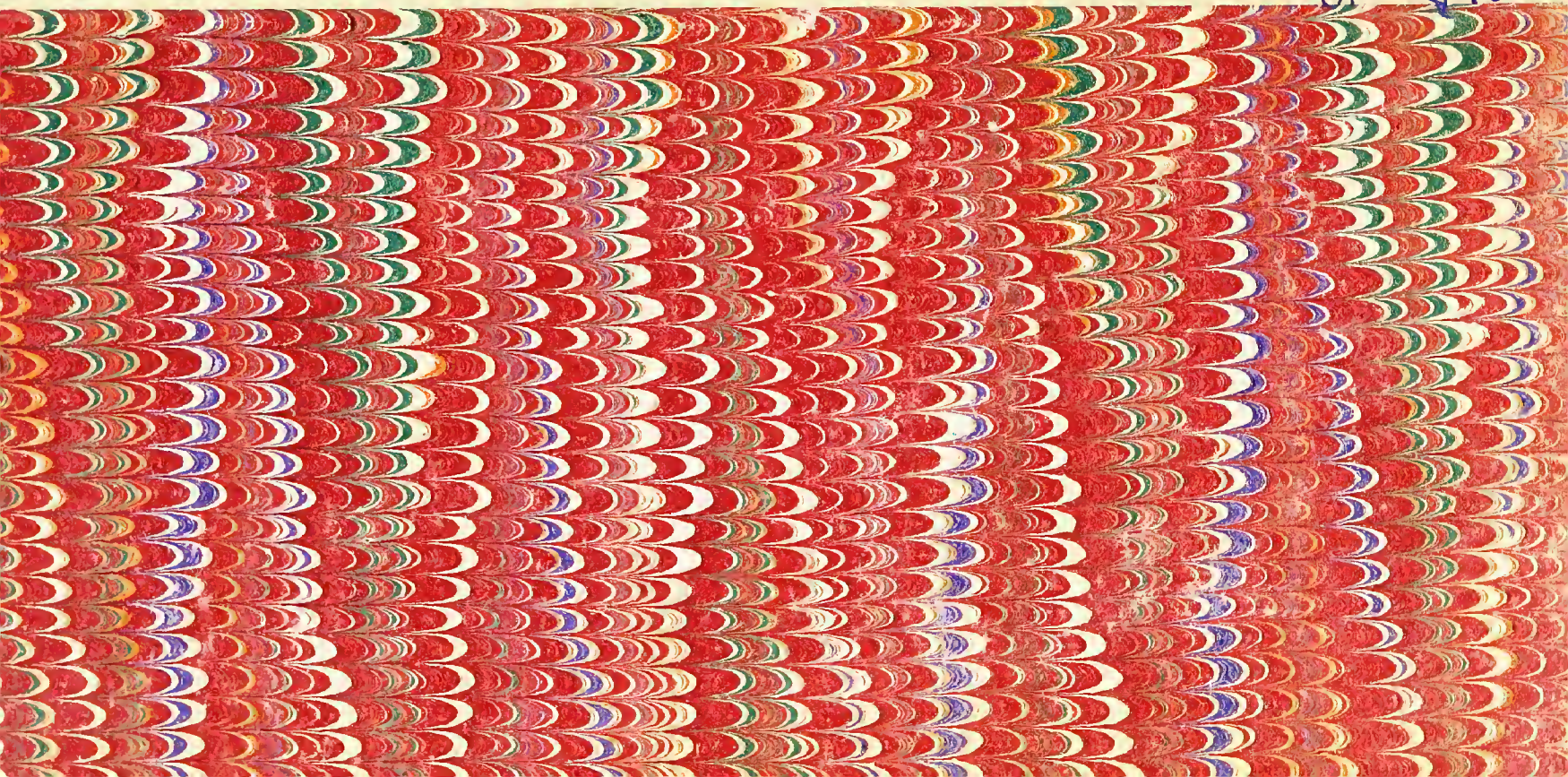

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF THE COUNTRY AROUND NORTHALLERTON AND THIRSK.

(EXPLANATION OF QUARTER-SHEETS 96 N.W. AND 96 S.W.; NEW SERIES, SHEETS 42 AND 52.)

BY

C. FOX-STRANGWAYS, F.G.S., A. G. CAMERON, AND G. BARROW, F.G.S.

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1886.

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NOTICE.

The present Memoir is a further contribution to the detailed description of the Jurassic region of Yorkshire. The maps described in it (Quarter-Sheets 96 N.W. and S.W.) embrace a large part of the Vale of York, and a portion of the low watershed between the basin of the Humber and that of the Tees. The western half of both maps is mainly covered by Permian and Triassic rocks; but on the east side the Jurassic series is admirably displayed, rising steeply into the long escarpments of the Cleveland and Hambleton Hills, and reaching a height of more than 1,400 feet above the sea. This picturesque range of uplands has been deeply trenched by denudation, some portions of them being separated as outliers in front of the main mass, as is well seen along the northern edge of the escarpment at Whorlton, and further east. Many sections are thus laid bare, and nearly the whole Jurassic series can be well studied in this region, from the top of the Rhætic Beds up to the Kimeridge Clay.

A comparison of the two editions of the maps (with and without Drift) will show to what a great extent the lower grounds are covered with superficial formations, while the Jurassic tableland is free from such deposits. The glacial accumulations reach a higher level (600 feet) in the northern than in the southern part of the district (400 to 500 feet), and, as already remarked in the Memoir on the Geology of Eskdale, &c. (Quarter-Sheet 96 N.E.), these Yorkshire high grounds appear to have lain above the limits here reached by the northern ice-sheet. In the Glacial sands and gravels banked up against the escarpment marine shells occur.

The Warp and Lacustrine Clay, which cover so much of the low land to the south of Thirsk, have given rise to considerable doubt regarding their true geological age. In the north they clearly underlie Boulder Clay, and there is no reason to doubt that the Laminated Clay is here the same as that which underlies the Glacial sands and gravels at the mouth of the Tees. To the south, however, the Warp-beds of this region merge into those of southern Yorkshire, which have usually been regarded as Post-Glacial.

ARCH. GEIKIE,
Director General.

28, Jermyn Street,
December 10th, 1885.

NOTICE.

The maps here described were surveyed under the superintendence of Mr. Howell.

The southern part of the Oolites and some of the Lias were mapped by Mr. Fox-Strangways; the greater part of the Lias and the Oolites of Snilesworth Moor, &c. by Mr. Barrow. The Penarth (Rhætic) Beds by Mr. Cameron and Mr. Barrow. The western parts of the maps (Trias and Permian) were surveyed by Messrs. Howell and Cameron.

The drift deposits were mapped over the respective areas by the officers here mentioned.

The maps are illustrated by the following Horizontal Sections (scale 6 inch to one mile):—Sheets 133, 134, 135, and 136.

The 6-inch Geological maps are not published, but MS. Coloured Copies are deposited in the Geological Survey Office for reference.

The surveying officers have contributed to this memoir notes of their respective areas, but the whole has been arranged and edited by Mr. Fox-Strangways. Messrs. G. Sharman and E. T. Newton have revised the lists of fossils.

H. W. BRISTOW,
Senior Director.

Geological Survey Office,
28, Jermyn Street, London, S.W.
December 7th, 1885.

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THE GEOLOGY OF THE COUNTRY AROUND NORTHALLERTON AND THIRSK.

CHAPTER I.

INTRODUCTION.

Area and Physical Features.

The formations described in this Memoir constitute two distinct areas. The Oolites and Lias on the eastern side form the western termination of the Jurassic rocks of the Yorkshire basin in this direction; while the Triassic and Carboniferous rocks are a portion of the extended outcrop of these beds across the county from north to south.

The district included in this description is that contained in the two Quarter-Sheets 96 N.W. and 96 S.W.; it has an area of 432 square miles.

The principal towns are Stokesley, Northallerton, Thirsk, and Ripon; all of which are principally agricultural, there being no manufactures of any importance. There are also a large number of villages or hamlets, most of which are situated on the lower ground, although there are a few among the Oolite hills, where these have been brought into cultivation. The northern part of these hills being almost entirely moorland there are no villages except at the outskirts, but isolated farmhouses are dotted along the dale sides.

With the exception of a small portion in the extreme north through which the Tees flows, the whole of the drainage of this district is to the south by the Ouse and its tributaries.

The line of watershed between these two basins runs along the northern escarpment of the Oolites to Swainby; whence its direction is across the low ground north of the Wiske by Great Smeaton to North Cowton. Its greatest elevation is from 1,000 to a little over 1,400 feet, but near Cowton the ground is not more than 150 feet above sea level. North of the watershed the only streams of any importance are the Tees and its tributary the River Leven. South of this line the drainage is, by the great western escarpment of the Oolites, divided into two areas. In the eastern region are the Rye and its tributaries, which flow west to the Derwent near Malton and thence south to join the Ouse. To the west are the larger streams of the Swale and Ure with their branches the Cod Beck, River Wiske, and several smaller streams, which flow south till they unite to form the Ouse some distance above York.

The most elevated ground is that on the east, comprising part of the three ranges of the Cleveland, Hambleton, and Howardian Hills. The Cleveland Hills rise to a height of 1,427 feet at Drake How, above Kirkby Bank on Cringley Moor; the Hambleton Hills attain a height of 1,309 feet at Black Hambleton, while the Howardian Hills do not rise more than to about the 500 contour line.

The remainder of this district has an average elevation of between 100 and 300 feet, although the ground on its flanks rises above that level, while that to the south of Thirsk is not more than about 50 feet above sea level.

Besides the recent and glacial deposits, the rocks coming to the surface comprise the whole of the Oolites and Lias, the Rhætic Beds and Trias, as well as the upper portion of the Palæozoic rocks, which includes the Magnesian Limestone, and a very small patch of Millstone Grit in the south-west corner.

The following table shows the beds in descending order :—

TABLE OF FORMATIONS.

Post Tertiary	Recent and Post-Glacial	Recent Alluvium.
		River Terraces.
		Peat.
		Warp and Lacustrine Clay with beds of Sand and Gravel.
	Glacial	Boulder Clay, Sand and Gravel.
Secondary	Upper Oolite	Kimeridge Clay.
	Middle Oolite	Upper Calcareous Grit.
		Upper Limestone and Coral Rag.
		Middle Calcareous Grit.
		Lower Limestone.
		Lower Calcareous Grit.
		Oxford Clay.
		Kellaways Rock.
	Lower Oolite	Cornbrash?
		Estuarine Series.
		Scarborough or Grey Limestone Series.
		Estuarine Series, including the Millepore Bed, Eller Beck Bed, and Hydraulic Limestone.
		The Dogger.
	Lias	Upper Lias.
		Middle Lias — Ironstone Series.
		Middle Lias — Sandy Series.
		Lower Lias.
	Rhætic Beds	Penarth Beds.
	Trias	Keuper Marl.
		Keuper Sandstone.
Palæozoic	Permian	Magnesian Limestone.
	Carboniferous	Millstone Grit.

CHAPTER II.

CARBONIFEROUS AND PERMIAN ROCKS.

Carboniferous.

Millstone Grit.—A small patch of Carboniferous rocks just enters this district in the south-west corner to the west of Ripon. These beds, which crop up in the low ground formed by the valleys of the Laver and Kex Beck about Cow Mires, are much obscured by drift deposits, although the grit is seen at the base of the steep bank formed by the Permian beds at Galphay Mill. They constitute the upper part of the Plompton Grit, or are just above that horizon.

At Quarry House, near Tanfield, the rock crops up in the bed of the Ure; but these are the only exposures of Millstone Grit in the country under consideration.

Permian.

Magnesian Limestone.—These beds occupy a narrow strip along the western side of this district. They are throughout the greater part of their outcrop covered by thick deposits of Boulder Clay and Gravel; and, being only seen at a few places, principally in the southern part of the area, it is impossible to say whether the Permian beds are represented by only one bed of limestone, or whether there is a second or Upper Limestone with intermediate bands of Marl, as in the country to the south about Knaresborough and beyond.

The Magnesian Limestone is usually a soft, porous, thick-bedded limestone of a light yellow colour and with a sandy texture; but having occasionally bands of hard blue limestone, which are more compact and crystalline than the general mass of the rock. The base of the formation frequently contains bits of grit and quartz derived from the rocks below and is very coarse and conglomeratic in character, being much harder than the beds above. In Studley Park the limestone is hollowed out by numerous small caves and fissures, which in many cases have been filled with gravel and clay washed in from above. The little River Skell in dry weather runs in one of these caverns for a distance of a mile and a half till it emerges at Hell Wath just above Ripon; it is also probable that a large part of the waters of the Ure between North Stainley and Ripon flow underground for a considerable distance. In the northern part of this area the outcrop of the Magnesian Limestone is not anywhere exposed, and its junction with the Triassic Beds above can only be assumed, although there seems to be some

slight evidence of it from the numerous hollows in the Boulder Clay along this line. These, which mark the site of old tarns, are now filled with alluvium, and appear to be on a line of swallow-holes at the junction of these formations.

At Danby Plantation, south of Pepper Hall, a borehole was put down about 2 miles from this line; the Magnesian Limestone was reached at a depth of 469 feet. The following is the account furnished by the agent:—

Borehole at Danby Plantation.

	Ft.	In.
Silty clay without boulders	69	0
New Red Sandstone	400	0
Magnesian Limestone	291	0
Total	760	0

The Magnesian Limestone towards the bottom was intermixed with black shale, in layers of from half an inch to an inch in thickness, and of a very dark colour, which gave water highly charged with mineral matter. A chalybeate spring with a trace of sulphur now issues from this hole. In the boring at Leeming Lane, the details of which are given below, the limestone was reached at a depth of 195 feet, so that it is evident that the junction cannot be very far to the west of this. There is also evidence for the outcrop of the limestone in the numerous fragments of that rock scattered over the ground about Holtby House and southwards.

Boring at the Vale of Mowbray Brewery, Leeming Lane.

		Ft.	In.
Superficial beds, 34 ft.	Made ground	3	0
	Loose sand	7	0
	Dark clay	19	0
	Gravel and clay	5	0
Keuper Sandstone with marl and gypsum, 161 ft.	Red sandstone rock	64	0
	Red shale	40	0
	Red shaley stone	8	0
	Gypsum	0	6
	Light red hard stone	7	0
	Gypsum	0	3
	Light red hard stone	3	0
	Gypsum and fullers earth	0	9
	Red shaley stone	1	6
	Gypsum and red clay	1	0
	Red shaley stone	1	0
	Conglomerate* and gypsum	9	0
	Conglomerate*	6	0
	Conglomerate* and gypsum	2	0
	Conglomerate*	4	6
	Gypsum	0	6
	Conglomerate*	5	0
	Conglomerate* and gypsum	3	0
	Gypsum, white marl, shaley stone	4	0

* This conglomerate is said to be really gypsum.

		In.	In.
Magnesian Limestone, 132 ft. 6 ins.	Dark flag or limestone	31	10
	Grey limestone	7	8
	Grey shale	9	0
	Gypsum and clay	17	6
	Amber limestone or millstone grit	30	0
	Grey shale, gypsum	5	0
	Grey limestone	31	6
	Total	327	6

To the south of Snape Mires the drift becomes thinner, and the limestone is exposed at several places between Well and Ripon. At the former of these places, where the limestone has been extensively quarried, it is thin-bedded, dark coloured, and very fossiliferous, containing *Productus horridus* in great abundance.

The following fossils were collected by the Rev. J. S. Tute in the quarries at Well, and at Aldfield, a little south of Ripon:—*

Cythere geinitziana, Jones.
Acanthocladia anceps.
Fenestella retiformis, Schloth.
Productus horridus, Sow.
„ *latirostratus*, Howse.
Terebratula elongata, Schloth.
Streptorhynchus pelargonatus, Schloth.
Strophalosia lamellosa, Geinitz.
Spirifera alata, Schloth.
Camarophoria Schlotheimi, V. Buch.
Schizodus truncatus, King.
„ *rotundatus*, Brown.
Bakewellia (*Gervillia*) *antiqua*, Münst.
„ *ceratophaga*, Schloth.
Monotis speluncaria, Schloth.
Solemya.
Pleurophorus costatus, Brown.
Leda speluncaria, Geinitz.
Turbonilla Phillipsii, Howse.
Turbo helicinus, Schloth.
Nautilus Frieslebeni, Geinitz.

Towards Ripon the drift is still thin, and a band of soft unconsolidated or powdery limestone comes in, which is locally called "marl," and is applied to the land without burning. These marl pits have been worked near Lindrick Farm and Double Gates House on either side of the Laver. The best exposures of the Magnesian Limestone are just beyond the limit of the map in Studley Park, where the Skell has cut through this formation, and several good sections are seen. The limestone is here sometimes very concretionary.

* Proc. Geol. Soc. Yorksh., vol. iv., p. 557, 1867. See also Memoirs of the Geol. Survey, Exp. of Quarter-Sheet 93 N.W., p. 10.

CHAPTER III.

TRIAS.

In the map to the south (93 N.W.) the Trias has been divided into the two groups of Bunter and Keuper, but it is rather doubtful whether in the northern part of that map, about Ripon and Boroughbridge, this holds good; probably a greater area should be given to the latter.

In this district, as the result of working from north to south, the whole of these beds seem to belong to the Keuper, and therefore the lower or Bunter division is not carried on. The required corrections will be made in a future edition of the map to the south.

The Keuper itself is, however, easily separable into the two lithological divisions of sandstone and marl, both of which, although nearly everywhere buried by a considerable thickness of Boulder Clay and other superficial deposits, can, by the aid of boreholes and well-sections, be traced across the country in a fairly accurate manner.

Keuper Sandstone.—The Keuper Sandstone through the greater part of this district is buried beneath glacial deposits, so that it is only in comparatively few places that the rock is seen. The best sections are along the banks of the Tees below Preston Junction, at Over Dinsdale, and at Rawcliff near Croft Bridge. From these sections, the two first of which are, however, beyond the limits of the present district, the rock is seen to consist of thin-bedded, flaggy, micaceous sandstone, sometimes thicker and more massive, and usually of a brick red colour, but occasionally having a yellowish tinge. South of the Tees the Keuper Sandstone is exposed in the River Leven about Crathorne, in the Wiske near Yafforth, and in the Swale at Skipton, Catton, and Baldersby; it also comes very near to the surface along the range of low hills from Londonderry to Ripon, and has been quarried in the hill north of Warlaby, near Gatenby, at Theakston Grange, near Sand Hutton, and at several places north-east of Ripon. It has also been met with in the following boreholes and well sections.

Boring at Eryholme, near the Tees, 1809.*

		Ft.	In.
Superficial beds, 34 ft.	Sand	12	0
	Clay and cobble stones	16	0
	Quicksand	2	0
	Cobbles and sand	4	0

* From account given by W. H. Peacock, Trans. Cleveland Lit. and Phil. Soc. vol. ii., 1870.

	Ft.	In.
Red sand post, with water	60	0
Grey soft sand and post	3	0
Ditto rather hard clay following	124	0
Red soft sand post	3	0
Strong red post	300	0
Soft red post	12	0
Hard dark red post	90	0
Clay and post	3	0
Red post	24	0
Flooring	1	0
Hard grey post	12	0
Total	666	0

Boring at Dinsdale, near the Tees, 1789.*

	Ft.	In.
Soil and brown clay	4	0
Darkish stony clay with whin tumblers	20	9
Red metal stone with grey girdles	48	0
Red stone with white girdles	31	3
White and grey stone	4	0
†[Gypsum] with white flinty lumps	7	0
Blue whin with water like the Harrogate Spa	1	6
Strong white post with whin girdles	6	6
Bastard whin	12	0
Strong white post with whin girdles	36	6
Blue grey metal stone with white scars	8	0
†[Gypsum]	2	6
Soft red stone	6	0
Red and white post	19	0
White post with red scars	18	0
Red, white, and grey post, with partings of red metal	27	0
Soft blue-grey metal	4	0
Grey and white post	33	0
Strong blue-grey stone	5	0
Strong white and grey stone	60	0
Whin	3	0
Mixture whin	9	0
Strong white post, supposed to be of a limestone nature, and whin girdles	79	4
Total	445	4

The "New Well" at Croft is 150 feet deep, all in red sandstone. The water in this well can be pumped dry by steam in two days. Ordinary pumping reduces the water 20 feet. Without pumping the water overflows.

* N. J. Winch, Trans. Geol. Soc., vol. iv., p. 98. Wrongly named Woodhead, which is three miles to the south of Dinsdale. This boring is now the site of Middleton Spa. *See* Young and Bird, Geological Survey of the Yorkshire Coast, p. 166.

† "Chalk" in original account.

The following are analyses of the Croft mineral waters by Dr. W. Chisholm:—

The "Canny Well" is a spring, conveyed in pipes to the Pump Room. The "Old Well" is a powerful spring.

	New Well.	Canny Well.	Old Well.	Sweet Well.
	Cubic inches per imp. pint.	Cubic inches per imp. pint.	Cubic inches per imp. pint.	Cubic inches per imp. pint.
Sulphuretted Hydrogen	2·61	·48	·59	—
Carbonic Acid	5·03	5·68	3·98	·535
Oxygen	—	—	—	·173
Nitrogen	—	—	—	·986
Gaseous contents	7·64	6·16	4·57	1·694
	Grains per imp. pint.	Grains per imp. pint.	Grains per imp. pint.	Grains per imp. pint.
Sulphate of Lime	17·960	13·601	19·789	14·70
Carbonate of Lime	3·200	2·292	2·100	·78
Sulphate of Soda	2·356	3·565	·548	—
Sulphate of Magnesia	1·727	2·732	·328	—
Chloride of Sodium	·765	·504	·449	1·75
Carbonate of Magnesia	·630	·412	·164	1·93
Silica	—	—	—	·07
	26·638	23·106	23·378	19·23*

The more massive beds of sandstone are sometimes used as building stone, and, although rather perishable, have been quarried for this purpose near Warlaby and Ripon. Both at the base of the Trias and near its top bands of gypsum occur. Those at the base of the formation were cut through in the boring at Leeming Lane, given above, where they have, including the thin marly bands, a thickness of 49 feet. These gypsum beds are well exposed on the west side of the Ure, between Ripon and North Stainley, where the Trias has been let down between the two large east and west faults, which have crumpled and contorted the beds in a remarkable manner.

In the northern part of the district, on account of the thick covering of Boulder Clay, the base line of the formation is only approximate; and, as we mentioned before, the only evidence is that from the borehole at Danby Plantation and the line of hollows in the Boulder Clay caused by the sinking of the ground along the junction.

Near Leeming Lane the junction is more apparent from the fragments of rock scattered about, and to a certain extent can be fixed by the borehole at that place. From here to Wath the line is not so good, but between the faults on the west side of the Ure it is sharply defined by the outcrop of the gypsum; south of this it follows more or less the line of the river to beyond Ripon.

* With a trace of peroxide of iron.

To the north-east of Ripon the sandstone has numerous swallow holes, which are often of large extent, and sometimes form perpendicular shafts between 60 and 70 feet in depth.*

The Keuper Marl.—These marls are also completely hidden in the northern part of the district by the thick covering of Boulder Clay, except about Rudby, where the superficial beds have been cut through by the Leven, and the marls are exposed in the bottom of that valley.

Further south, about Northallerton, they are better seen, red and green marls being exposed at several places along the slope below the feature formed by the Rhætic Beds from Harlsey southwards to Thornton-le-Street.

These marls contain several bands of gypsum at different horizons, the uppermost one, which is only some few feet below the Rhætic Beds, having been much worked in former times. The little shallow depressions left by these workings, which run just under the brow of the Rhætic escarpment, often give a very clear base-line for the latter formation.

Between Harlsey Castle and Winton the uppermost beds of marl are seen cropping out, while close by Winton the gypsum above referred to has been worked. Further west a broken line of these old workings occurs about Stank Grange and Hallikeld. At the latter place the line suddenly rises to the west, and a fault was proved here in a gallery made by Messrs. Ord and Madeson, of Darlington, to work the gypsum.

At Harrogate farm and by the roadside near Bullamoor red marls are again seen, the fields along the hill face being of a deep red colour for some distance to the south; in fact, the upper boundary of the Keuper Marl is quite clear from Bullamoor till the outcrop turns round abruptly to the east near Thirsk, where it becomes entirely obscured by drift. The upper beds of gypsum with marly partings were met with in wells at Hill Top, Beal House, Viewly Hill, and Wood End, being as much as 40 thick.†

From the neighbourhood of South Kilvington there is no actual outcrop of the Keuper Marls till we reach Sessay, and the information with regard to them is derived from wells and borings. Of these the most important is that at the Thirsk Brewery.

Borehole at Messrs. Marr & Co.'s Brewery, Thirsk.

		Ft.	In.
Superficial Beds, 30 ft. 2 in.	Sand and gravel	6	0
	Soft red clay	4	3
	Rough gravel and water	6	9
	Strong brown stony clay	5	10
	Rough sand and gravel	4	3
	Brown stony clay	3	1

* The Rev. J. S. Tute considers these pits, which are somewhat remarkable, to have been formed by the washing away of the friable marls and gypsum at the base of the formation. (Geol. Mag., vol. v., p. 178, 1868; and Proc. Geol. Soc. Yorkshire, vol. v., p. 2, 1870.) Large swallow-holes are, however, constantly met with in the Permian Limestone like those in the Carboniferous Limestone beds, due to the chemical action of carbonic acid held in solution by water. This may account for the natural pits in the New Red Sandstone near the line of junction.

† *See* Appendix I.

	Ft.	In.
Soft red marl	1	6
Soft grey marl	18	10
Soft red marl	3	0
Soft red and grey marl	5	0
Strong grey shale, hard girdles, with water	5	6
Strong red grey shale with water	6	6
Strong grey shale, with much gypsum	1	6
Strong red shale, with much gypsum	9	0
Strong grey shale, with gypsum	3	6
Red and grey shale, gypsum and water	6	0
Grey shale, post girdles, gypsum, and water	9	0
Red shale and gypsum	52	6
Hard grey shale and gypsum	10	0
Red shale and gypsum	3	0
Strong grey shale, post girdles	3	0
Strong red shale	18	9
Hard grey post	6	0
Strong red metal	29	9
Red shale, hard freestone	13	8
Grey shale with girdles	20	0
Red shale, post girdles, gypsum	3	0
Grey shale and gypsum	15	0
Red shale, with post girdles	8	1
Grey post with water	3	0
Soft red freestone	16	9
Strong red freestone	11	3
Soft red freestone	11	9
Strong red freestone	17	0
Red shale, freestone girdles	9	5
Red freestone	9	6
Total	360	11

To the south of Thirsk and north of the great faults the wells at the farmhouses are often sunk to beds of gypsum, from which a small supply of very hard water is obtained; the district is, however, very poorly supplied with water.

The outcrop of the red marl between the two faults is entirely drift covered, but to the south the highest gypsum bed was proved in the well at Sessay Rectory, and was worked along the bank at Little Sessay. The well at Sessay Park is also sunk through marl into gypsum, while green marl is seen outcropping in the stream at New Mills. At Elmire, again, marl of a greenish colour was sunk into. Near Pilmoor Cottages a boring is said to have been put down some depth into red marl, but the details seem to have been unrecorded.

From the boring at Thirsk the lower part of the red marl is seen to consist of alternations of red and grey marl, with a few thin sandstones, and here and there considerable quantities of gypsum. Above the strata shown in this section are other beds of marl, which in some places, particularly about Hallikeld, Winton, and Little Sessay, also contain, as we have shown above, large deposits of gypsum. These marls in their upper part become greyer, and gradually pass into the tea-green marls at the base of the Rhætic Beds.

The base of the Keuper Marl is everywhere very obscure. In the northern part of the district it is evident that the junction of

these beds with the sandstones below must occur a short distance to the north of Rudby, as the marls are seen at the village, while the sandstone outcrops in the river about Crathorne. Between here and Northallerton there is no evidence, except that marls were met with in a well west of Deighton, proving that the line is west of this place.

Near Northallerton there is more exact data for this boundary, the marls being proved in several of the town wells, while the sandstone, as we mentioned above, is exposed on the west side of the Wiske, near Warlaby.

The most important well at Northallerton is that at the Prison, which, after penetrating the marls, reached the sandstone at 93 feet.

Well at the House of Correction, Northallerton.

	Ft.	In.
Gravel and gravelly clay - - - -	18	0
Red marl - - - - - -	42	0
Gypsum - - - - - -	8	0
Clay with water - - - - -	25	0
Red sandstone.		
Total - -	93	0

Water stands in this well to within 10 feet of the surface. South of Northallerton the junction follows the Wiske for some distance, the marls having been proved at South Otterington Station and Pasture Field House, while the sandstones are said to have been worked at Breckonbrough and Carlton Miniott; beyond which the line is lost in the great sandy plain to the south of Thirsk.

CHAPTER IV.

RHÆTIC BEDS.

The Rhætic (or Penarth) Beds consist chiefly of dark laminated or papery shales with *Avicula contorta* and other fossils resting on the "bone bed," a thin band of hard fine-grained sandstone with casts of *Isodonta Ewaldi* and *Protocardium philippianum* together with the scales and teeth of fish, never more than 1 foot to 18 inches thick and having below a considerable thickness of Tea-Green Marls.* Above the paper shales is a band of grey or brown fine-grained limestone usually about a foot thick with a conchoidal fracture, over which are more shales with thin fossiliferous limestones containing *Pleuromya crowcombeia* in great abundance, which constitute the base of the Lias.

The outcrop of these beds is a continuation of that running from the mouth of the Tees by Eston to Stokesley.

In the northern part of the county they are almost everywhere hidden by Boulder Clay, and it is only from the boring and pit which have been made at Coatham and Eston that we obtain any knowledge of their existence.† In this district no natural section occurs till we reach the neighbourhood of Northallerton where the Rhætic Beds are exposed at several points; and begin to make a small feature, which is very conspicuous to the east of the town. North of East Harlsey the boundaries shown on the map are therefore to a great extent hypothetical, but south of this village the beds begin to appear through the Boulder Clay and form a good feature as far as Winton. At this place they are thrown down by a north and south fault so that they outcrop at a lower level, and thence run in a westerly direction as far as Hallikeld, where they are again faulted.

Turning south once more, the escarpment may be easily followed, though occasionally interrupted by small faults, as far as Wood End near South Kilvington. From this point the outcrop is drift covered for some distance, but reappears at Plump Bank, and continues to form a low bank till it is cut off by the more northerly of the two great faults to be described hereafter.

Though the evidence of the position of the Rhætic Beds is so clear, there is no one complete section showing their exact relation to the Lias above and the New Red Marls below; but by

* In order that the mapping of this area may conform to that of the south-west of England, the Tea-Green Marls have been included in the Rhætic Beds. In lithological character the green marls are the same as the red. They only differ in colour, and no fossils have been found in them in this area.

† These sections will be referred to in the Memoir treating of that country. *See also* Peacock, Trans. Cleveland Lit. and Phil. Soc., vol. ii., 1870, and Tate and Blake, "The Yorkshire Lias," p. 31, 1876.

comparing several sections near Northallerton we get the following summary :—

		Ft.	In.
e.	Brown papery shales with thin wedges of limestone, containing *Ostrea liassica, Pleuromya crowcombeia, Cardium phillipianum* - - - -	25	0
	Thin limestone, full of *Pleuromya crowcombeia* -		
d.	Paper shales, becoming more argillaceous towards the base. Flattened shells or impressions of the same, *Pleuromya* and *Cardium*, apparently rather dwarfed - - - - -	15	0
c.	Small band of whitish argillaceous limestone, about 3 inches thick; no fossils seen - - -	10	0
	White shales; no fossils seen - - -		
b.	Black, crisp, pyritous shales with flattened *Avicula contorta*, about 8 feet - - - -	17	0
	Close-grained, white siliceous bed, *Cardium phillipianum, Isodonta Ewaldi*, fragments of crinoid stems; about 3 inches - - - -		
	Black crisp shales, *Avicula contorta* very abundant; about 7 feet - - - - -		
	Hard, dark, laminated shale, with fish scales and *Avicula contorta* resting on close-grained siliceous bed, very full of *Isodonta Ewaldi*. The whole is about 9 inches thick, and probably represents the "bone bed" - - - - -		
	Dark shales, 1 ft. 6 ins. - - - -		
a.	Tea-green marl, about - - - - -	15	0

Of these beds (*a*) and (*b*) unquestionably belong to the Rhætic Beds and (*c*) to the Lias. From the close resemblance of (*c*) to the "White Lias" it has been included with the Rhætic Beds, but no fossils were found in it. The beds (*d*) are very similar to those above and contain the same fossils though in a dwarfed form, but as they do not include *Avicula contorta* they have been mapped as the basement bed of the Lias.

This section is given first, in order that the bearing of the various small exposures to be described may be better understood.

On the west side of Harlsey Castle the brown paper shale and *Pleuromya* limestone are seen, showing the base of the Lias, while a little further south are old gypsum pits in the highest beds of the New Red Marl.

The Rhætic Beds form a clear low escarpment between Harlsey Castle and Park House, and the brown paper shales are well exposed in the small plantation on the east side of the road a quarter of a mile north of Park House. Gypsum and gypsiferous marls crop out between Park House and Winton; and the paper shales are next found at a much lower level at the foot of the small stream which joins Winton Beck just south of Winton.

To the west of this place the same limestones and the Tea-Green Marls are occasionally ploughed up, but there is no very clear evidence till Hallikeld Farm is reached. In the small stream or ditch running from the Brick Works here, we come upon shales with the *Pleuromya* limestone, and just against the duck pond below the farm more shale is seen belonging to the beds (*d*). Below this the section ceases, but a little to the west, at a some-

what higher level, are a series of drifts made quite recently into the gypsum beds at the top of the New Red Marl, proving a fault here, with an upthrow to the west of some 30 feet or rather more. This gypsum was worked many years ago, and the line of old pits clearly marks the base of the Rhætic Beds for some distance further south.

Proceeding up the south side of the hollow above Harrogate we come first upon a series of old pits with much red marl lying about. Immediately above the highest the Tea-Green Marls are seen, the little hard Bone Bed at their top forming a well-marked terrace, and fragments of the hard siliceous band with *Isodonta Ewaldi* may be picked up along its outcrop. The soft *Avicula contorta* shales are not exposed, but the upper part of the White Lias is seen resting beneath the papery shales of the Lower Lias immediately on entering the small plantation. In both of the roads to the south of this the little hard Bone Bed is seen with red marl at no great distance below.

In Dibdale there is a fairly good exposure of these beds, the little scrub-covered bank on the north side being capped by the lowest band of *Pleuromya* limestone. Exactly below where this is first seen red and green marl outcrops in the stream, and higher up green marl is seen, while some way up the bank fragments of the White Lias Limestone are scatterred about. Still further up the White Lias shale crops out, after which there is a blank for some yards; but the lowest beds of paper shale with the characteristic limestones are turned out in great profusion through the long new plantation to the east. Thus the base and top of the Rhætic Beds are well seen, but the soft *Avicula contorta* shales are, as usual, covered up.

Some 200 yards north-west of Crosby Cote there occurs the best section of the Rhætic Beds to be seen in this district. Commencing where the little stream splits into two, red marl is seen in both branches, and fragments of the Bone Bed may be found along the sharp feature which it makes between the two streams. Passing up the southern branch the following beds may be made out in descending order:—

	Ft.	In.
Paper shales, with *Pleuromya crowcombeia*, *Cardium phillipianum* (?), small and flattened. About 20 feet of these beds are seen altogether, but the section is not continuous A series of pits has been sunk in the upper part of these beds, but they are quite filled up and grown over - -	20	0
Whitish shale (White Lias), about 10 feet; no fossils seen, and the top is obscure - -	10	0
Dark, pyritous, crisp shales, with *Avicula contorta* along certain lines, 8 feet - - -	8	0
Hard, white, siliceous rock, wavy-bedded, about 3 inches thick. Contains *Isodonta Ewaldi* and *Cardium phillipianum* (?), also fragments of encrinite stems - - - - -	0	3
Dark shale, 7 feet, *Avicula contorta* very abundant again along certain definite lines - -	7	0

	Ft.	In.
Hard laminated shale, about 6 inches, *Avicula contorta* abundant. Fish scales and *Isodonta Ewaldi* fairly common	0	6
Close-grained siliceous bed crowded with *Isodonta Ewaldi*. These last two represent the bone bed	0	6
Dark shale, about 1 foot 6 inches	1	6
Tea-Green Marl, about 5 feet seen	5	0

Some 15 or 20 feet below this Red and Green Marls are seen.

On the south side of Crosby Cote just under the overflow sluice of the fish pond is the only clear section of the actual junction of the Lias and Rhætic Beds. Some 7 or 8 feet of shale, platy at first but becoming lighter and more argillaceous, rests upon a small bed of white argillaceous limestone, this again resting on the white shales.

At Crosby Cote there are two wells sunk about 5 feet in blue shale, the water from which is strongly impregnated with sulphuretted hydrogen. The following are the analyses of these waters* :—

	Well in the Courtyard. Grains per Gallon.	*Well in the Park, south of the House.* Grains per Gallon.
Solid matter	66·50	38·15
Chlorine	7·28	2·89
Equal to Chloride of Sodium	12·04	4·06
Nitrogen as Ammonia	·0065	·0014
„ as Albuminoid	·0014	·0196
„ as Nitrates	·0044	·1900
Hardness	31°	22·7
Hardness after boiling	24°	11·1

Solid matter, chiefly carbonate and sulphate of lime.

In a wood about 300 yards north of Thornton-le-Beans is a very clear section of the basement beds of the Lias. The first 25 feet of the section shows paper shales with thin limestones, *Ostrea liassica* being fairly abundant in the uppermost; the lowest bed being the well-known *Pleuromya* limestone, which is almost built up of that shell. Below this come somewhat similar shales with flattened, dwarfed specimens of *Pleuromya* and *Cardium*. There is nearly 15 feet of this shale, and it is so much lighter in colour at the base that it is probably within a foot or two of the "White Limestone."

Again, in the small stream close to Thornton-le-Beans, in the south bank, the lowest limestone is well seen, the shales below being clearly exposed and identical in appearance with those seen in the wood just referred to. A noticeable point here is the occurrence of a hard sandy band just below the limestone, containing casts of an *Ostrea*, probably *Ostrea liassica*, but this is not quite clear. At the foot of the bank, which is some 15 feet high, the beds are very light coloured, and we are again within a foot or so of the White Lias.

On the south side of Thornton-le-Beans the Rhætic Beds are thrown up by a fault, and being covered by Boulder Clay do not

* Supplied by Mr. T. Bell.

make so good a feature; the outcrop is therefore more obscure, but the green marls are seen at several places, and shales above have been proved in the following well-sections, which afford some assistance in tracing the lines near here:—

Saltkiln.—This well is bricked; it is said to be 42 feet deep in blue shale.

Summer Carr.—Blue shale on red marl with much gypsum, 72 feet to bottom of well.

Hill Top.—Three wells, all in blue shale, 51, 21, 20 feet deep respectively; the last changes to a rough sand at the bottom.

*Purgatory**.—Fifteen feet of dark shale.

Near Thornton-le-Moor the paper shales are seen at a few places, and fragments of the Bone Bed are occasionally met with.

West of Thornton-le-Street the outcrop is hidden by Boulder Clay, but the Tea-Green Marl and black shales above are seen in Big Wood near Wood End.

On the outlier to the west of this at Abel Grange the well went into shales belonging to the Lower Lias, while on the west face of the little hill is an opening in the Tea-Green Marl.

South of Wood End the beds curve round to the east, and are not again seen till a very small outcrop is reached near South Kilvington. This occurs in a field at the north side of the first bend in the road leading to Kilvington Hall; where, by removing the surface soil to make a small pond, the black shales with *Avicula contorta* have been exposed. At Plump Bank, about a mile east of Thirsk, black shales with thin limestones were turned up in laying the water pipes for the town supply. The highest of these contained *Ostrea liassica* and were clearly of Lias age, but the lowest shales exposed probably form part of the Rhætic Beds, though they were too decomposed to be sure of their age. This little feature at Plump Bank, though covered further south by thin drift, is clearly visible as far as Bagby, where the lowest beds of the Lias are dug out of the wells close to the surface; but beyond this, the outcrop of paper shale above the Rhætic Beds in Thirkleby Park is the only clue to their position.

The two great east and west faults shift the Rhætic outcrop some miles westward and its position between them is purely hypothetical. To the south of these faults its position is at first fairly clear, being proved by the upper limit of the New Red Marl about Sessay, and by the gypsum workings at Little Sessay. A little to the east of the latter village there is a farm house, the well of which is sunk through the Tea-Green Marl of the Rhætic Beds.

In the new junction railway at the south end of Sessay Wood a great quantity of paper shale was exposed, which although not quite in place could not be far removed; while a boring at Pilmoor Cottages and the wells in the neighbourhood help to give an approximate outcrop near Pilmoor Junction, but further south the country is so completely covered by the great sheet of Warp that no attempt is made to carry on the lines.

* T. P. on one inch map.

CHAPTER V.

THE LIAS.

Lower Lias.

In the district here described the Lower Lias consists of a mass of dark slightly sandy shales, with hard marly bands in the lower part. Owing to the covering of drift in the great plain in which these beds outcrop, the type of country that they form is only seen in two districts; the first between Thirsk and Northallerton on their east side; the second, which is not so well marked, to the south-east of Thirsk, about Bagby. It may be noted that at the foot of the main escarpment the steep lower part consists of the shales without marly bands; and these same shales extend in a broad, more or less drift-filled hollow, for some distance to the west. The rise of the beds in this direction brings up the marly bands, which form a low table-land, having at its base the escarpment of the Rhætic Beds overlooking the Vale of Mowbray.

At the foot of the great northern escarpment, near Cold Moor and Cringley Moor, the upper beds of the Lower Lias are well seen in landslips or scars that occur at intervals; two of these show as much as 150 feet of shale with rows of ironstone nodules containing *Ammonites capricornus*. To the west of this the drift creeps up the hill, only one small section being seen in the stream just below the entrance to Scugdale; from this Messrs. Tate and Blake* record *Myoconcha decorata* and *Modiola scalprum*. The bottom of Scugdale itself is entirely filled with superficial deposits, but passing over the watershed into Raisdale a small section of Lower Lias is seen just south of the fault. A considerable exposure occurs in the bottom of the eastern branch of the dale north of this forming a small inlier; while some distance to the east, just above the junction with Bilsdale, shales of this horizon are seen in the high bank on the south side of the stream.

Returning to the area about the main escarpment, the uppermost beds of the Lower Lias are seen close against the fault in the north-east face of Whorl Hill.

In the railway cutting just west of Whorl Castle soft shales with *A. armatus* are seen, and a few yards north of this the first of the marly bands appears. This forms the top of the zone of *A. oxynotus* of Tate and Blake; while the marly beds with *Gryphœa incurva*, seen in the roadside by Potto Hill Farm, belong to their zone of *A. Bucklandi*.

Along Limekiln Bank and further west no outcrops are seen at the foot of the hill owing to a thick covering of detritus and

* *See* Tate and Blake, Yorkshire Lias, p. 99.

drift, and in Mount Grace Wood only little patches are exposed in the footpaths washed bare by the rain. The junction of the Middle and Lower Lias is very clear under Thimbleby Lodge and in the Cod Beck, and exposures of shale occur for some distance below. Passing down the stream, just at the ford below Ellerbeck Mill, shales with calcareous bands are seen with a considerable number of fossils, the following being recorded by Messrs. Tate and Blake:—*

Ammonites semicostatus.
„ *bisulcatus.*
Nautilus striatus.
Belemnites acutus.
Gryphœa incurva.
Cardinia crassiuscula.
„ *Listeri.*
Lima succinta.
Lima gigantea.
„ *pectinoides.*
Pecten Thiollieri.
Pinna Hartmanni.
Unicardium cardioides.
Lucina limbata.
Cidaris Edwardsi.

Further down the stream, in the neighbourhood of Foxton, there are several exposures in the Lower Lias, the best of which are in Foxton Wood. A few obscure exposures are seen in the moat at Sigston Castle, in the road at the Manor House, and further north in the little stream at Willowtree House, the latter being in rather higher beds than the other sections.

Between the main escarpment and the faulted outlier on which the village of Borrowby stands there are no exposures of Lower Lias, but to the west of the latter hill they are fairly numerous. In the woods under Landmoth the calcareous bands with *Gryphœa incurva* are frequently seen, resting in one place against the Jet-rock of the Upper Lias.

To the west of Cod Beck is a low flattish plateau formed of these harder bands of the Lower Lias. The beds beneath form the upper part of the low hill facing Northallerton and Thirsk, and these beds are seen at intervals along the hill. Commencing at Hallikeld Farm, platy shales with fragments of calcareous bands containing *Ostrea liassica* crop out just south of the house; and the lowest beds of Lias are exposed at Harrogate, Dibdale, Crosby Cote, and Thornton-le-Beans.

At North Kilvington, just to the east of Spittle Bridge, a thin band of hard limestone is seen dipping north; and further up this stream, near Crake Bank, is a small outcrop of soft shale containing small specimens of *Ammonites armatus*. Further south another siliceous limestone, similar to the above, is seen in Whitelas Beck near Grizzle Field House, north of Feliskirk Lane.

Some distance north of Thirsk the outcrop of the lowest beds of the Lias turns eastwards but is obscured by drift as far as Plump Bank; where, in laying the pipes for the water supply of Thirsk, shales with the thin *Ostrea liassica* limestones were turned up on the summit of the hill; while fragments of the

* *See* Tate and Blake, Yorkshire Lias, p. 67.

Pleuromya limestone which are scattered about, would seem to mark the top of the Rhætic Beds.

The paper shales with *Ostrea liassica* were proved in the wells at Bagby, the small hill immediately to the west being the escarpment of the Rhætic Beds veiled by drift. The same shales may be seen in a ditch in Thirkleby Park, close to the road opposite Stockhill Green.

The lower shale beds are also met with in the cellars at the Hall, and in the beck at Great Thirkleby.

A little further south a great fault, having a throw of over 700 feet, shifts the outcrop of these beds some miles to the west. Barf Hill being composed of Middle Lias, the upper limit of the Lower Lias is evidently at the western foot of it. The only other evidence of these beds between the faults is seen in the Swale below Topcliffe, where shale with hard calcareous bands, outcrop on the edge of the river, and the chief fossils are *Lima gigantea* and *Gryphœa incurva*; so that we are still some distance above the base.

South of the long strip of higher beds let down between the two great Coxwold faults, the outcrop of the several divisions of the Lias is in many places hidden by the thick covering of drift and alluvium; several small faults which have broken up the beds have rendered the stratigraphy here somewhat intricate.

From the position of the Keuper Marl and Rhætic Beds at Sessay, and the Middle Lias at Hutton Sessay and Thormanby, it is evident that the Lower Lias must come on between these places, although it has not been met with to our knowledge anywhere in this area.

At Carlton Husthwaite "grey shales" are said to be met with at a depth of 12 yards, but there is not much evidence as to what the shales are. The first place that the Lower Lias is really exposed is in the railway cutting near Husthwaite Station. There is not much of the bed seen here, but the outcrop along the valley towards Coxwold may be easily made out by the position of the Middle Lias in the bank above.

In the country to the south towards Easingwold the position of the Lower Lias is even more obscure, and its outcrop can only be inferred by tracing the beds above.

Middle Lias.

In the northern half of the area here described the Middle Lias is divisible into two parts. The upper or Ironstone Series consists of rather soft shales with ironstone bands of varying thickness; the lower or Sandy Series is composed of thin flaggy sandstones and sandy shales, with beds of *Gryphœa*, *Cardium*, &c., constituting a sandy marl. As we follow these beds southwards, the upper part becomes so sandy in nature that the distinction gradually ceases to hold good; the outcrop is also often very

obscure, and the beds being much diminished in thickness it has been found advisable to map the Middle Lias as one division.

Sandy Series.—These beds first enter the area under consideration at Broughton Plantation. Here, and throughout almost the entire length of their outcrop in the escarpment, they form a finely marked step-like feature in the face of the hill, by which they may be easily traced.

The Sandy Series is well exposed in Tom Gill Scar in Carlton Bank, and consists of sandstones and thin shales with shelly bands for the first 35 feet; below which is about 40 feet of sandy shale, still rather hard, with the usual characteristic bands of *Gryphœa cymbium* at the base. As a rule, the great scars of Lower Lias are capped by these basement beds of the Middle Lias, so that along the face of Dromonby Bank sections are fairly numerous and clear.

In the eastern of the two upper branches of Raisdale these beds form two flat topped terraces, the little stream cutting a narrow gorge between and exposing a small part of the Lower Lias. The junction of the latter with the Sandy Series is well marked in the stream at the low end of the dale, the *Gryphœa* bands being strongly developed.

Only the upper beds crop out in the western dale, forming as usual a flattish area round the stream in which the calcareous flags are seen at intervals, especially about Broomflat.

In the main valley of Raisdale the Sandy Series is suddenly faulted up near High Crosslets, from which place these beds trend south-east and east, the whole of them being shown in Hartman Gill. On the north side of the dale a considerable part of the series is faulted out, but small outcrops are visible about West Cote and Cock Flat.

Returning northwards the flaggy beds are well seen at the north end of Whorl Hill, and on the east side of the great fault the *Cardium truncatum* sandstones lie right against the Upper Lias. Nearer Swainby Mines the ground is entirely drift covered, and for some distance along the north side of Scugdale the Sandy Series is faulted out; the first exposure being in a small stream below Scugdale Hall. In the main stream there is only one section of thin sandstone, the superficial deposits completely covering the bottom of this dale throughout its entire length; but to the south the beds are at a somewhat higher level and rise clear of the drift. The position of the series is in consequence marked by the well-known terrace, and good sections are seen about Holiday House. To the west of Harfa Bank the outcrop is thrown up by a considerable fault, and beyond this is clear of drift for a great distance. Still, in passing through Limekiln Bank Woods, the downwash is sufficiently thick to obscure the rocks till the road up to Scarth Nick is reached, where there is a clear section of the whole series.

The large fault at Scarth Nick throws these beds down below the level of the drift, and they are completely obscured till the

outcrop is thrown up again by another fault round the north-west corner of the escarpment. Throughout the Arncliffe Woods small fragments of the characteristic sandstones may be picked up, and the actual junction of the Middle and Lower Lias is well seen below Lady's Chapel. There are several exposures in Far Clack Wood, Clack Wood, and the road between them, after which the drift again creeps up the hill side and obscures the strata. In Oak Dale the little stream cuts right through the sandy series, the following being a brief summary of the section. At the top comes the usual alternation of thin sandstones and sandy shales, below which is the typical sandstone, some 12 feet thick, crowded with fossils. The chief of these are *Cardium truncatum*, *Gryphœa cymbium*, *Dentalium giganteum*, and *Pecten æquivalvis*. Some 15 feet of sandy shale separate the last bed from a shaly sandstone, 10 feet thick, containing the usual *Gryphœa* beds near its base.

At the weir above Osmotherley Corn Mill thin lenticular sandstones, with alternating bands of sandy shale pass completely up into the Ironstone Series, so that the lithological boundary betweeen the two divisions is ceasing to exist, the whole Middle Lias becoming more arenaceous.

About Thimbleby there are only a few small exposures; but south of Nun House, at a small hollow in the hillside, the following section is seen.

Section at Nun House, near Over Silton.

		Ft.	In.
Ironstone Series.	Soft grey shale	5	0
	Ironstone, shelly, oolitic, **Avicula Seam**	1	1
	Ferruginous shale with nodules	6	0
Sandy Series, 36 ft. 0 in.	Lenticular sandstone "dogger," resting on sandstone with thin shale partings	18	0
	Shaly sandstone	5	0
	Hard flaggy sandstone, with *Cardium truncatum*	1	0
	Soft rubbly sandstone, with *Gryphœa* bands at base	12	0

This is probably an under estimate, and 40 feet would be more exact; but, considering that on the coast the beds in one place attain a thickness of nearly 100 feet, it is evident that they are slowly dying away in a south-westerly direction.

There is, moreover, only six feet of shales below the Avicula Seam in this section, whereas further N.E. there is as much as 25 feet.

For some little distance to the south the outcrop of the Sandy Series is clear, and exposures numerous; but after rounding the corner of the escarpment at Over Silton the drift creeps up the hill and hides these beds for several miles. In the outlying hill of Upsall the *Cardium truncatum* sandstones may be seen in the road below Upsall Castle, after which no exposures occur till Hole Wood south of Feliskirk Village is reached, where fragments

of sandstone and sandy shale are seen, the beds making a well-marked feature in the hill face.

To the south and east of this no rock is visible *in situ* for a considerable distance, and the outcrop has to be inferred from the relative position of the Upper and Lower Lias, the whole Middle Lias being mapped as one division. We will therefore take the outcrop of the Ironstone Series before we return to the country south of the great faults.

Ironstone Series.—The outcrop of these beds in the escarpment may be easily followed by the feature they make jutting out below the soft Grey Shale. To the north-east of the area described the Main Seam of Ironstone is so thin as to be at present valueless, but following its course westward it thickens slowly, and forms a well marked low terrace at the scar above the head of Trow Beck.

At the north-west point of Dromonby Hill the seam forms a considerable spread, the ground being covered with fragments of Ironstone. A trial drift was made here, but has fallen in. The base of the seam, which is a marly ironstone, caps the scar at the head of Tom Gill and the following section is seen :—

Section at Tom Gill, Busby Moor.

	Ft.	In.
Base of Main Seam of Ironstone.		
Dark ferruginous shale - - -	6	0
Flaggy ferruginous siliceous nodules -	0	4
Ferruginous shale - - - - -	12	0
Hard, oolitic Ironstone (**Avicula Seam**) -	1	3
Ferruginous shale, harder at base -	31	0

Passing down the valleys at the head of Raisdale, the Ironstone Series has a well defined outcrop; but rock exposures are rare, owing to the thick covering of downwash, and no trial-holes have been made till the two streams unite. Just at this junction is a drift which has now fallen in, but from which Messrs. Tate and Blake give the following section of the Main Seam :—*

		Ft.	In.
Main Seam	Ironstone with dogger band at top and base -	2	8
	Shale - - - - -	1	5
	Ironstone with dogger band at top -	1	9

Just south of this there is a fault which throws up the Ironstone some distance to the south side, so that the Main Seam outcrops in the road close by High Crosslets, and the beds below have been exposed by the denudation. The outcrop on the south

* *See* Tate and Blake, The Yorkshire Lias, p. 140.

side of Raisdale is quite clear, and in Harton Gill the following section may be seen:—

Section of the Ironstone Series in Harton Gill, Raisdale.

	Ft.	In.
Thin indurated sandy band.		
Shale	4	0
Indurated band	0	6
Shale	1	0
Sulphur band	0	1
Ironstone dogger	0	4
Shale	1	0
Ironstone*		
Shale*		
Ironstone, 2 feet	**Main Seam**	4 0
Shale	6	0
Ironstone, **2-Foot Seam**	0	9
Shale	6	0
Laminated sandy Ironstone (*Cardium truncatum*)	0	3
Shale, well-bedded	10	0
Ironstone, **Avicula Seam**	0	9
Shale with few doggers	25	0
Total	60	8

The hard, laminated, sandy, ironstone band, crowded with *Cardium truncatum*, is very characteristic in this area. Its hardness often causes it to have a bare outcrop, and from it the position of the Main Seam can be fixed, even when the latter, as is often the case, is quite obscured by downwash.

At the head of the small beck south of Breck House a trial-hole was made, which has since fallen in. Here the bottom band of ironstone is 2 feet thick, of an oolitic and shelly character, while above are two other bands of ironstone, harder and more siliceous. The thickness of the whole with shale partings is about 6 feet.

Returning once more to the main escarpment the feature alone marks the position of the Ironstone Series along the west face of Carlton Bank, and no trial holes occur till Swainby Mines, where the following section was proved:—

Section at Ironstone Mines, Swainby.

	Ft.	In.
Hard sandy ferruginous bed	3	6
Sulphur band (iron pyrites)	0	1
Flaggy sandy bed	0	10
Sulphur band (iron pyrites)	0	1
Ironstone — 3 ft. 4 in.		
Shale — 0 „ 10 „		
Ironstone dogger — 0 „ 4 „	**Main Seam** 6	0
Ironstone — 1 „ 6 „		
Hard black shale	2	3
Dogger band	0	4
Softer dark shale	3	0
Sandy hard shale	7	0
Softer shale	4	0
Hard white ironstone	1	10

* Obscured by rubbish.

Passing up Scugdale the outcrop of the Ironstone Series is faulted out for some little distance, but the ironstone was proved by two drifts further east, both of which showed the Main Seam to deteriorate in this direction. This is well shown by the section at the head of the dale, which is as follows:—

Section of Ironstone Series at Head of Scugdale.

	Ft.	In.
Indurated shale band.		
Shale, soft and ferruginous	7	0
Ironstone	0	9
Shale	2	6
Ironstone - 1 ft. 8 in. Shale - 0 „ 9 „ **Main Seam** Ironstone 2 „ 0 „	4	5
Shale, soft and ferruginous	3	0
Small dogger band	0	3
Shale, ferruginous	3	6
Ironstone, blue oolitic, and very fossiliferous, **2-foot Seam**	1	2
Soft shale	4	4
Laminated sandy ironstone	0	6
Soft ferruginous shale	4	6
Small dogger band	0	3
Shale	3	0
Oolitic white Ironstone, *Avicula*, *Pecten*, *&c.*, **Avicula Seam**	0	9
Shale, rather sandy	2	0
Ironstone, with erect *Myacites*	0	9
Shale	0	6
Doggers	0	3
Hard sandy shale	2	0
Ferruginous shale	15	0
	56	5

Though the position of these beds may be easily followed on the south side of Scugdale there are no clear outcrops nor trial holes, and it is not till Limekiln Bank is reached that the beds are again seen *in situ*. The Main Seam has been worked by drifts in different parts of this wood, but the ironstone is considerably thinner than in the present Swainby mines and was consequently abandoned. Below one of the drifts part of the beds beneath the seam are exposed, but not sufficiently clearly to be measured.

Close by Scarth Nick the Ironstone Series are thrown down between two north and south faults, the eastern of which has a throw of more than 100 feet; between these two faults the position of all the Lias beds is very difficult to fix. Just to the west of the second fault a small ditch shows—

	Ft.	In.
Shales.		
Ironstone, **2-Foot Seam**	1	0
Shales (about)	20	0
Ironstone, **Avicula Seam**	1	4

This is the last clear evidence of these seams about the Arncliffe Woods. In the little outlier of Whorl Hill the jet pits show sufficiently clearly the position of the Ironstone Series, but there are no good exposures.

In Cod Beck near Thimbleby Lodge the following section is seen :—

	Ft.	In.
Hard shale band	0	6
Shale with small doggers	4	0
Ironstone - 2 ft. 0 in. / Ferruginous shale - 1 „ 4 „ / Ironstone - 1 „ 0 „ — **Main Seam**	4	4
Shale	10	0
Ironstone, full of small fossils, **2-foot Seam**	1	6
Shale	20	0
White Ironstone, **Avicula Seam**	0	6
Shale	10	0
Thin, lenticular, ferruginous sandstone	1	0
Sandy shale	2	0
Thin sandstone	2	0
Shale	1	0
Thin sandstone	2	0
Shale	6	0
Main bed of sandstone (Sandy Series).		

The occurrence of alternating flaggy sandstones and sandy shales in the lower part of the Ironstone Series is well seen here. As we proceed south the whole series becomes so arenaceous that it was found impracticable to separate these beds from the Sandy Series below. Along Thimbleby Bank all the upper beds of the Middle Lias are obscured by drift, the only section being in a small hollow to the S.E. of Nun House, where a thin seam of Ironstone is seen, probably the Avicula or lowest, about one foot in thickness. From this point the outcrop of the Middle Lias gradually sinks below the drift, except a doubtful exposure near Upsall Castle which must be about the junction with the Sandy Series. It is not till Feliskirk is reached that the Ironstone Series is seen again.

In the sharp bend of the road above the Church ironstone, which is evidently part of the Main Seam, is exposed, and the Grey Shales come on immediately above.

A boring was put down on the top of the hill to prove the ironstone in this district and gave the following section* :—

		Ft.	In.
	Oolitic iron-rock	7	0
	Upper Lias shale	116	0
Middle Lias.	Nodular ironstone	0	7
	Soft shale	3	0
	Nodular ironstone	0	6
	Shale	7	6
	Marlstone	1	9
	Sandy shale	20	9

* Prof. J. Phillips, Quart. Journ. Geol. Soc., vol. xiv., p. 96, 1858.

The whole of the beds below the Ironstone nodular bands given here belong to the Ironstone Series not to the Sandy Series; the gradual change of the former to an arenaceous deposit being referred to in describing the Thimbleby section.

There are only two isolated exposures of the Ironstone Series near Sessay, where the Middle Lias is let down by two faults between New Red Marls. The first of these is close to Sessay Station, in the railway cutting at the "Darlington 27" mile-post, where gravelly ironstone has been dug out recently, while a few yards to the south the platy Jet Rock is seen. The other onterop is at Barf Hill, the summit of which is covered by a similar gravelly ironstone. There must evidently be some thickness of the bed, but how much is not clear.

South of Coxwold the Middle Lias forms a feature which may be followed along the hill side to Husthwaite, where the sandstone is exposed in the village and makes a well-marked terrace.

Beyond this the beds are depressed by a fault so that the next exposure is at the village of Thormanby, where there is a good section of the sandstone and limestone with bands of fossils, principally *Cardium truncatum*, *Avicula cygnipes*, and *Pecten æquivalvis*, seen in the road dipping at an angle of 4 degrees to the south-east.

West of Thormanby the Middle Lias passes beneath the sands and alluvium of the flat, and from the general strike of the other beds probably curves round by Boscar Grange and Peep-O'-Day, although nothing is seen of the bed in this region; the first section we get being at the stream a little beyond Swallows Nest, where marly sandstone is seen apparently striking in this direction. South of this it spreads out towards Easingwold and forms a strong feature below Rising Sun where the sandstones are exposed, as also they are in the little gully to the east; and just above at the foot of Howe Hill there are fragments of oolitic ironstone from the upper part of this formation.

At Halfway House and in the lane beyond beds of siliceous sandstone and ironstone are seen, the former containing *Rhynchonella tetrahedra*, *Cardium truncatum*, and *Avicula inæquivalvis**; east of this the Middle Lias is thrown up by a fault and forms an outlying mass surrounding the hill at Crayke.

At the side of Haverthwaites Beck a borehole was sunk in search of coal apparently in these beds, but of this we could obtain no account. Prof. Blake mentions having found *Rhynchonella tetrahedra* in fragments of oolitic ironstone from this boring.†

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* *See* Memoirs of the Geological Survey. Explanation of Quarter-Sheet 93 N.W., p. 13.

† Tate and Blake, The Yorkshire Lias, p. 142.

Upper Lias.

The Upper Lias in the area here described consists in its upper part of rather soft dark shale, containing a considerable quantity of finely disseminated pyrites. This character was formerly taken advantage of to burn the shale for the production of Alum, whence it is generally known as the Alum Shale. The chief characteristic fossils in it are *Ammonites communis*, *Am. bifrons*, and *Leda ovum*. Below this the shale becomes harder, platy, and more bituminous, and is known as the Jet Rock, from the occurrence in it of considerable quantities of jet. *Ammonites* of the type of *Am. serpentinus* and *Am. gracilis* and *Inoceramus dubius* are among the most typical of its fauna. Quite at the bottom of the Upper Lias is some 25 feet of soft shale, called the Grey Shale from its characteristic colour. Fossils in this division are rather rare, but *Am. annulatus* is to be found in the nodules about the middle of the bed. From its soft character the Grey Shale generally forms a hollow, and sections of it rarely occur; in fact, no really clear ones are known in this area.

The Jet Rock has been mapped only in the northern part of the area. Its outcrop is rendered very clear by the continuous line of drifts covering, or rather fringing, the entire district; which have been worked in every accessible place, and a reference to them is unnecessary.

There is, however, one point of special interest in connexion with these workings. The shale-tips show at a glance that fossils are much less common than on the coast about Whitby, Staithes, &c., while, on the other hand, there was a greater amount of jet obtained, and that in larger pieces. In the western escarpment there are only a few isolated workings, the chief of which are near West Field House, north-west of Osmotherley; in the banks above Thimbleby Lodge; and north of Over Silton. There are also two very interesting outcrops of the Jet Rock, which give conclusive evidence of the existence of large faults. Of these the first is in Cotcliffe Wood, where the Jet Rock which has been mined lies close against the *Gryphæa incurva* limestones of the Lower Lias. The second is in the railway cutting just south of Sessay Station, the platy shale being well seen even now, and the continuation of this outcrop under the drift was proved for some distance to the west by a large main drain driven to carry off the water. A few hundred yards to the north the country is composed of New Red Marl under drift deposits, while the Jet Rock has been worked close to the village of Kilburn, thus showing the presence of a very large fault.

Sections of the upper part of the Alum Shale are fairly numerous, as the water oozing from the Oolites causes landslips, which form great scars in the shales below, several of which occur in the face of Dromonby Moor.

In the nab-end of Carlton Bank there is an old alum quarry, in which many of the characteristic fossils may be found; but comparing this with similar quarries on the coast, there is the

same relative paucity of fossils as was noted in the case of the Jet Rock. The position of the outcrop of the Alum Shale in the northern area, and, in fact, all along the escarpment, is too clear to need a detailed description, but there are a few interesting points to be noted. Of these the chief is the local erosion of the Upper Lias to a depth of nearly 100 at the south end of Cold Moor, in Raisdale.

The channel formed by this erosion passes through into Bilsdale, and is filled up by the basement beds of the Oolite, showing a clear local unconformity. Another point of interest is the gradual thinning away of the Upper Lias, which, from being 200 feet thick at the north-east end of this area, diminishes to 160 feet at Swainby Mines, and to only 116 feet in the boring at Feliskirk; still further south this thinning continues, the Upper Lias being about 100 feet thick in the neighbourhood of Coxwold, and not more than about 80 feet in the extreme south-east, near Crayke.

The Alum Shale does not outcrop on the east side of the great faulted outlier of Borrowby, but on the west it is frequently seen.

South of Silton, in the main escarpment, the drift deposits creep up the hill, and in places entirely obscure the outcrop of the Upper Lias, the first clear exposure being on the hill side above Kepwick. In the pretty amphitheatre of Cowesby the drift rises well on to the Oolitic sandstone, but some sections are visible in the little pass between that village and Kirkby Knowle, as well as at intervals in the hill to the west.

The Alum Shale is seen again about Knowle Hill; in the bank just above the village of Feliskirk; and in the sides of Mire Beck, near Thirlby; but there are not many exposures in this neighbourhood.

On the north side of Hood Hill laminated shales are exposed just below the base of the Oolites, which must be near the top of the formation, and at Osgodby Hall shales are also seen, which cannot be far from the base; the upper portion of these shales is again seen round the Oolitic outlier at Stockings House, and in the road between here and Kilburn, but the best section about here is just west of Low Kilburn, where the Jet Shales have been worked, and show these beds dipping at rather a high angle slightly to the north of east. About 600 yards south of this point the beds are cut by the great Coxwold north fault, and by which they are shifted from 3 to 5 miles to the west; so that their next outcrop is about Highfield House, the well of which is sunk into Upper Lias shale, which might be seen a few years since close to the well, and a little north-west of the house the shale has been turned up in draining. The Jet Shales, as mentioned above, are exposed in the railway cutting south of Sessay Station.

South of Coxwold the Upper Lias comes in again at Newburgh Park, and may be easily followed along the escarpment to the south-west, where it forms the clayey slopes between the features made by the Middle Lias and the base of the Oolites.

In the lane above Husthwaite these shales are exposed, and have been penetrated in a well at Gibbet Hill just above to a depth of 40 feet. By the Husthwaite fault these shales are depressed, so that they outcrop in the low ground north of Providence Hill, and crossing the neck of alluvium are seen in the railway cutting at Thormanby Hill, where they contain *Inoceramus dubius* and a small *Ammonite*, and afford about the best section in the district. South of this they curve round with the base of the Oolite to the south of Oulston, but are not exposed anywhere in this direction. At Howe Hill, near Hanover House; at Easingwold; and at Mount Pleasant there are outlying patches of thin clay, which is exposed at all of these places.

CHAPTER VI.

LOWER OOLITES.

The principal area occupied by these rocks is that to the north of the Hambleton Hills, covering the wild district of Snilesworth and Whorlton Moors. Besides this there is a narrow belt flanking the western escarpment of these hills, which spreads out somewhat on Boltby Moor and about Coxwold, to the south of which it forms the western end of the Howardian Hills.

The Lower Oolite consists of a great series of estuarine and freshwater strata composed of sandstone and shale, with thin intercalated marine beds, which divide the whole into certain definite horizons.

The Dogger.—With the exception referred to in describing the Upper Lias that formation is conformably succeeded by this Estuarine Series. At the base of the whole is a calcareous ferruginous and siliceous bed, known as the Dogger or Top Bed, which according to the predominance of these three constituents is either a limestone, an ironstone, or a sandstone.

Where first met with in this area at the north-east end of Vittoria Plantation, it is a siliceous and ferruginous limestone some 6 feet thick. Towards the south it thickens rapidly to nearly 50 feet, and becomes a ferruginous echinital limestone, a species of *Acrosalenia* being extremely abundant. On the east side of the hill this limestone is lying in an eroded hollow of the Upper Lias, and at the extreme south end of Cold Moor a similar limestone is seen coming down to within a few feet of the Jet Rock. At the north end and west side of Vittoria Plantation a drift has been made into the Dogger, which is here 20 feet thick and quite a different rock, being more like the same bed on the coast, especially at the Peak, Robin Hood's Bay. It is so full of fossils as to be a marl, and rapidly disintegrates on exposure to the atmosphere. It contains vast numbers of little concretions, which contain a considerable proportion of phosphate of lime, and seem often waterworn.

The rock as a whole contains about 20 per cent. of iron. Owing to the rapid disintegration of the bed it is difficult to determine the fossils in it, but among the more abundant are the following:—

Ammonites. 2 species.
Pleurotomaria calix.
Eucyclus, sp.
Lima electra?
Modiola imbricata.
Ostrea gregaria.
Trigonia pulla.
Terebratula trilineata.
Acrosalenia, sp.
Thecosmilia, sp.
Vermetus, sp.

On the outlier of Dromonby Hill the Dogger is merely represented by a few bands of doggers or nodules, but on the little

outlier of Wath Hill to the south it is again a ferruginous limestone from 3 to 6 feet thick.

In Raisdale it is also merely represented by nodules at the east end, but in the centre of the dale it is a ferruginous limestone from 3 to 8 feet thick, which character it maintains as far as the fault. To the north of this it quickly thins away, a little band only of the somewhat phosphatic nodules representing it.

Towards the north end of Carlton Moor it is too thin to be traced, and a few doggers may represent it in the alum quarry, as well as along the west side of the hill, and in the outlier of Whorl Hill where nothing is seen of this bed.

A boring put down in a quarry over the entrance to Swainby Mine showed no distinct representative of the bed, and none can be seen (though it may exist in places) till the head of Thackdale is reached, where it is 3 feet thick, being shaly in the middle and very fossiliferous at base. It would appear to maintain much the same character and appearance round the head of Scugdale, for at Rank Crag it is 4 feet thick, while south of this, and at Blue Scar it is 5 feet.

The section at the latter place is—

	Ft.	In.
Sandstone - - - - - -	15	0
Shale - - - - - -	2	0
Dogger, impure ferruginous limestone - -	5	0

This Shale, which is very similar to the Alum Shale, generally succeeds above the Dogger, where the latter is a calcareous bed. In Harfa Bank there is no good representative of this part of the Lower Oolite, and it is not till approaching Limekiln Wood that exposures of the Dogger are again seen. Here it is an impure fossiliferous limestone, or rather a hard shelly marl containing a good deal of iron. It has been burnt for lime in former days, but had a tendency to run to a slag if not carefully watched. In the long scar about the centre of the wood the following section is seen:—

Sections in Limekiln Wood, Whorlton Moor.

	Ft.	In.
Thin sandstone, well-bedded - - -	10	0
Shale (like Alum Shale), with doggers -	12	0
Rather pure ironstone - - - -	1	0
Hard ferruginous marl - - - -	25	0

Towards the west end of the wood the section consists of thin sandstone and shale as above, succeeded by—

	Ft.	In.
Ironstone, very hard and fossiliferous *Myacites* sp., *Pholadomya Sœmanni*, *Ammonites* sp., *Belemnites*, *Terebratula trilineata* and many other fossils, difficult to extract whole - - - -	1	3
Very hard marl, siliceous at base - - -	4	9
	6	0

Between the faults at Scarth Nick nothing is seen of the Dogger, but it is exposed again along the north-west corner of the great escarpment, where it is about 4 feet thick.

Another fault brings this bed still further up the escarpment to Beacon Scar, where the following fine section is exposed:—

	Ft.	In.
Massive soft sandstone	50	0
Carbonaceous shale with sandy partings	15	0
Flaggy sandstone	2	0
Shale, like Alum Shale	15	0
Thin, carbonaceous, gannister bed	2	0
Shale full of nodules, contains *Ammonites* in lower part	5	0
Calcareous ferruginous bed with shaly parting	4	0
Alum Shale.		

Along Mount Grace Bank over Osmotherley, and for a considerable distance up the valley, there is no Dogger seen, and it certainly cannot be thick; for, above the west side of Osmotherley High Mill Oolite Sandstone and Alum Shale are seen within a few feet of one another.

Nothing is seen of the Dogger east of Osmotherley owing to downwash and talus, but near the head of Oak Dale is an opening marked as "old limestone quarry" on the Six-inch Map, which may have been an old working of this bed.

In the old Alum Works near Thimbleby Lodge the Dogger is about 18 inches thick, presenting the same ferruginous calcareous character; but in a trial-hole at the scar over Thimbleby it consists merely of a few nodules in shale and in the small hollows about Over Silton it is not seen anywhere. Near Kepwick at a trial-hole in Atley bank the following section may be seen:—

		Ft.	In.	Ft.	In.
	Ferruginous sandstone			6	0
	Shaly sandstone			5	0
	Grey shale			2	6
The Dogger.	Thin band of ironstone	0	6		
	Shale	2	0		
	Hard ferruginous limestone	5	6	11	6
	Shale	1	6		
	Ferruginous limestone	2	0		

In the interior of the Moorland there are several outcrops of the Dogger, the finest of which is in the upper branch of the Rye close under Snilesworth Shooting Lodge. A ferruginous limestone about 5 feet thick, passing at times into a calcareous ironstone, is seen in the bed of the stream; under which it sinks for about 50 yards, and then rises again some few feet above the river, having Alum Shale beneath it. A similar outcrop is seen in Arns Gill to the east, the Dogger being here from 2 feet to 3 feet 6 inches thick. The junction of the Lias and Oolite is seen again at High Farm, where there is a small inlier of the Alum Shale, but the calcareous bed is absent.

About the great faulted outlier there is no visible outcrop of the Dogger on the east side, but on the west it is comparatively clear. Close by Beacon Hill at the north end some 3 or 4 feet of ferruginous limestone is seen resting on Alum Shale, and from this point southward a similar bed may be found at intervals, slowly thickening in this direction, till at the hollow where the road crosses the hill at Cotcliffe Bank the Dogger is a ferruginous sandy marl with shaly partings some 20 feet thick. Its outcrop continues clear till it begins to turn south-east, when the drift creeps up the hill and obscures it. Around the little Oolite hill at Knayton the Dogger is similarly hidden.

Continuing along the main escarpment in the neighbourhood of Cowesby the drift reaches just up to the base of the Oolites and the Dogger is not seen, but an old slag heap not far from the Hall gives reason to suppose it was once worked there to a small extent. Round the outlier north-west of Kirkby Knowle it outcrops in several places, particularly in Low Wood and near New Buildings, where it is a ferruginous limestone about 4 feet thick. At Knowle Hill and in the main escarpment close by it is well seen, a trial-hole in the latter place showing it to be a calcareous ironstone some 5 or 6 feet thick. From this point past West Acre Lodge to close by Boltby the outcrop is very clear, an adit close by the village showing that it retains much the same character. On all the outliers about here the Dogger may be seen in some part of them; about Feliskirk Hill it is a ferruginous limestone 6 to 8 feet thick, and has been worked as a limestone to a small extent on the north-west face of the hill. North and east of Boltby the gravel that is so abundant about here obscures the outcrop, but it reappears north of Tang Hall having the same character, an adit having been made into it. Further south the position of the bed is fairly clear.

At Cleaves Quarries, where it has been largely worked and burnt for lime, it has a thickness of over 20 feet, as will be seen from the following details:—

Section at Cleaves Bank Quarry.

	Ft.	In.
Massive soft sandstone, very ferruginous at base	30	0
Blue clay and soft beds with calcareo-argillaceous balls	4	0
Massive false-bedded siliceous limestone	10	0
Thin band with *Ostrea*, *Pentacrinus*, and scattered pebbles, very pebbly at base	1	6
Oolitic limestone (base not seen)	6	6

In the next quarry at the side of the Thirsk road the shaly band between the sandstone and the limestone becomes thicker, there being over 20 feet of it; the limestone also becomes more pebbly in this direction and beyond Hood Grange appears to thin out, or is only represented by a ferruginous sandstone. The outcrop here shows how irregular this bed is, for whereas on the north side of the valley at Hood Grange it has a considerable

thickness, on the south side below Hood Hill, a distance of only 500 yards, it is not present, or is so thin as not to be traceable.

In the road between High and Low Kilburn there are some shales with thin ironstone nodules which may represent this bed, but it is too thin to be mapped anywhere in this area.

South of the Coxwold faults the Dogger comes on again very strong; it is here a massive ferruginous glance limestone and forms the fine feature of Beacon Banks, south-east of Husthwaite. Just south of this village it is thrown down by a fault, and outcrops in lower ground being well exposed in a quarry below Highthorne, and also at Providence Hill where it passes beneath the alluvium. South of these hills the Dogger again appears to have thinned out, for although the base of the Oolites makes a fairly good feature along part of its course this bed is not seen, nor is it of sufficient importance to map till we reach the neighbourhood of Terrington, a distance of nearly 10 miles.*

Lower and Middle Estuarine Series with Marine Bands.—Between the Dogger and the Grey Limestone Series along the north-west escarpment of the Oolites there is a series of massive and shaly sandstones with a little shale, which have a thickness of about 250 feet. These measures, which about here are much more sandy than they are in the next map, contain in the northern part of their outcrop one, and in the southern two, distinct marine beds. Of these two the lower consists of thin flags with shale below containing one or more bands of fossiliferous ironstone, and is known as the Eller Beck Bed, but further south these strata become more calcareous and a true limestone sets in, which has been mapped under the name of the Hydraulic Limestone.

The Eller Beck Bed and Hydraulic Limestone.—As the Eller Beck Bed is rather thin it is not easily found, unless the strata are cut through by stream sections, or when this bed occurs close under the bearing rock of a scar, as often happens in the great escarpment, where it has usually a thick ferruginous sandstone above.

In the long outlier of Cold Moor this brown sandstone is well seen, but there are no sections below, so that it was impossible to find the marine bed. On the roughly triangular area of Dromonby Hill the brown sandstone caps the scar, in the face of which the fossiliferous ironstone is seen, being from a few inches to a foot in thickness; the depth to the Dogger below being about 100 feet

At the north end of Carlton Bank it is not seen, probably owing to the accumulation of *debris* from the brown sandstone

* Memoirs of the Geological Survey. Explanation of Quarter-Sheet, 96 S.E., p. 6.

but passing south-east, a section is exposed in the road leading off the Moor to Staindale Farm, which is as follows :—

	Ft.	In.
Carbonaceous shale	0	9
Flaggy sandstone	6	0
Shale	0	6
Ironstone with fossils	0	6

From this point it can only be followed for a short distance.

On the south side of Raisdale and on Bilsdale West Moor the outcrop is fairly clear, fossiliferous ironstone fragments being seen in the Bridle Road leading down to Chop Gate and again further south in the scar called "The Clough" overlooking Bilsdale.

The small section of shale with little ironstone nodules above the sandstone quarry at the extreme north-west point of the main escarpment probably represents the Eller Beck Bed, but no mention of it is made in the following boring, put down some little distance to the south :—

*Boring on Osmotherley Moor.**

	Ft.	In.
Freestone	30	0
Blue plate	12	0
Red grit	6	0
Soft blue plate	2	0
Coal	0	6
Freestone	120	0
Total	170	6

After sinking to this depth they bored 150 feet further, and passed through many bands of sandstone and shale, and seem to have left off in some soft white freestone, but as they kept no good account the boring is doubtful. If they commenced just below the Grey Limestone Series, it would give the depth of the well-known Moor Coal as a little more than 50 feet below that series, and according to this boring there should be some 320 (!) feet of these estuarine beds, but as the whole is seen in the face of the escarpment to be clearly not more than 270 feet there must have been some mistake in the boring account, or else this coal does not represent the Moor coal at all, but is the thin upper seam, which was also found in the country to the south at Birdforth.

South of Osmotherley for a considerable distance the only evidence of the Eller Beck Bed is some fine-grained fossiliferous flags seen close by Hunter's Hill in the hollow north-east of Nether Silton.

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* Winch ; Trans. Geol. Soc., vol. v., p. 551, &c.

On Snilesworth Moor there are some very interesting inliers of the Eller Beck Bed. The first of these is in the uppermost reaches of the Rye, near Skelbeast Crag, a little below the coal workings on Coal Ridge. At the point where the stream divides a fine-grained flaggy sandstone may be seen having a few casts of fossils near the base; this is succeeded by shale and though not seen the thin ironstone seam is probably at the base of this. Following the outcrop round into Proddale Beck, the ironstone is 2 feet thick and contains a considerable number of fossils; further down on the east side of the stream there is no evidence of the exact outcrop, but on the west side of the Rye its position may be fairly well made out by the flaggy sandstone which makes a small but continuous feature. Passing up for a short distance into Wheat Beck the ironstone is seen again in the stream, being 1 foot 6 inches thick, and on the south bank may be followed till it sinks beneath the Rye at Burnt House, where the ironstone is somewhat thinner.

Along the south-east side of Arns Gill the fragments of ironstone seen at intervals mark the position of the Eller Beck Bed for a considerable distance up the dale, and drifts have been made into it.

Nearly a mile east of this, in Blow Gill, is another inlier of the Eller Beck Bed. It consists of thin flaggy sandstone with about 8 feet of shale below. Beneath the shale is a seam of light coloured, somewhat oölitic ironstone, containing a great number of fossils, of which *Pholadomya Murchisoni* is by far the most abundant. The section is—

	Ft.	In.
Flaggy sandstone.		
Shale - - - - -	8	0
Ironstone very fossiliferous - - - -	2	6

Near the lower end of the stream a third inlier of this bed is exposed, and just below Blow Gill Farm the following section was measured:—

	Ft.	In.
Sandstone.		
Shale - - - - - - -	5	0
Thin ironstone - - - - -	0	4
Shale - - - - - - -	3	0
Ironstone with fossils - - - - -	0	6
Shale.		

There appears to be four or more thin ironstone seams here, but they are not all exposed in one section.

At Coneygarth Hill on the outlier north-west of Kirkby Knowle this seam of ironstone is sufficiently thick to make a marked feature and strew the hillside with its fragments, but as soon as

the hill becomes steeper and the Oolite sandstones have a narrower outcrop this bed is again lost sight of.

A flaggy sandstone containing fossils, which is seen in two places in the main escarpment opposite this hill, is probably the upper part of the Eller Beck Bed, but from this point there is no evidence till Skipton Hill near Thirlby is reached.

Here the bed has considerably altered in character, and a thin limestone sets in, which gradually becomes thicker and more important towards the south, while the ironstone which accompanies it is less noticeable. This bed which we now describe under the name of the Hydraulic Limestone is a hard grey argillaceous limestone never more than a few feet in thickness, but which, from the fragments of it weathering to a whitish colour, is very conspicuous when it comes to the surface. This rock first becomes noticeable below Whitestone Cliff where it forms an outlier round Skipton Hill and may be followed along the escarpment below Gormire Lake. To the west and south of Hood Hill the bed is exposed at several places, having apparently been worked below Penfitt Wood; east of this it is seen at Acre House and between High Kilburn and Kilburn Thicket, but the outcrop in this direction is rather obscure.

In the Coxwold area there is a small outcrop of this bed close to the southern fault, fragments of the rock being seen in the beck below Angram Grange. South of this fault the Hydraulic Limestone is seen just south of Garbut Gill, but the outcrop along the southern escarpment and also on the faulted outlier south of Husthwaite is not good, although fragments of the rock are seen at a few places.

Between Garbut Gill and Newburgh the outcrop shown on the map is hypothetical, the rock not having been observed between these points.

Moor Coals.—In the Estuarine Series there are one or more seams of coal which have been worked at several places, but, unfortunately, little appears to be now remembered about them.

In the inlier of these beds to the north of Hawnby the coal, which is 10 inches thick, outcrops about 50 feet below the Grey Limestone Series on either side of Ladhill Beck. There are also several old coal pits along Stonymoor Sike, the northern branch of the Rye near Coal Ridge; an adit has been made to the coal here, and fragments of it are seen in the road going to Skelbeast Crag. It again seems to have been met with, as we have mentioned in the boring on Osmotherley Moor and in the hollow to the north-east of Nether Silton, there being several old adits in the lower part of Swinestone Cliff Plantation. Some old coal pits may be observed in the bank east of Kepwick, and there are indications of a coaly seam at one or two places along the escarpment to the south. South of the Hambleton Hills this coal has been worked on the outlier above Kilburn; but the principal workings were between the faults near Burtree House north of Birdforth,

at Coxwold, and in Newburgh Park; at the latter place Mr. Winch gives the following section:—

Section of the Engine pit in Newbury Park Colliery, the seat of the late Lord Falconberg, near the village of Coxwold, Yorkshire.

	Ft.	In.
Soil	6	0
Blue metal	4	6
Soft blue metal	30	0
Strong grey metal with catheads	1	0
Coarse strong grey post	7	0
Coal	1	4
Total	49	10

The seam of coal is of irregular thickness, seldom under 10 or above 16 inches. It dips to the east 2 or 3 inches per yard. The coal is of an inferior quality.

At Birdforth, where the coal was worked about the year 1760, there were two seams, the lower of which is said to have been from 3 to 4 feet thick, and at about from 25 to 30 yards below the surface, but dipping rapidly in a north-west (east?) direction; it could only be found over an area of about a quarter of a mile.

Millepore Bed.—Forming a belt round the summit of the outlier of Kirkby Knowle is a curious bed of Sandstone, or white Grit, cemented together by crystalline carbonate of lime. It seems as if the lime in the stone had been entirely crystallised out by the slow action of solution and redeposition. The quarries in it show the extremely false-bedded character of the rock, and strikingly remind one of the Millepore Bed as seen on the coast. From its position in the hill above the Eller Beck Bed and below the Grey Limestone there can be no doubt that this does represent that bed; and it is certainly the same as the Oolite of Whitwell, which latter has been proved upon palæontological evidence to be the equivalent of the Millepore Bed.*

At the nab end called Wind Egg, to the south-east of Kirkby Knowle, a similar bed may be seen, but in this case there are little shell-masses at intervals, in small wedges, mixed up with fragments of Encrinites, &c. This curious rock is continuous only as far as the south point of the hill near Westow Hall.

With the exception of these isolated outcrops the Millepore Bed first becomes traceable as a separate horizon on the outlier of Hood Hill, where it is seen on the south side of that hill at High Ground Barns. The next exposure is in the lane above High Kilburn, where this rock forms the southern end of that outlier, being faulted against the Grey Limestone, and for which it might be easily mistaken. The third and last exposure north of the

* *See* Memoirs of the Geological Survey. Explanation of Quarter-Sheet, 93 N.E. p. 14.

Coxwold faults is on the three outlying patches at Scencliff Grange. The rock is here somewhat thicker and better exposed than it has been further north and contains the characteristic *Cricopora straminea*, which we have found at one or two places.

In the Coxwold area the Millepore Bed is not exposed, being hidden by drift, and the position of the outcrop is assumed between the other beds. South of these faults it comes on again, and is seen above Newburgh Grange. At Garbut Gill the outcrop is shifted by the fault, and being exposed in several quarries to the south forms a good feature, which may be traced along the escarpment to Oulston. In the quarry below the village here this limestone is worked and the following section was measured :—

Section in Oulston Quarry.

	Ft.	In.
Shaly beds	8	0
Siliceous sandstone	8	0
Shale	1	3
Hard oolitic stone in two beds	4	6
Softer and more shaly beds	2	6
Hard blue limestone partly oolitic on top, weathers brown, base not seen	6	0
Sandstone below.		

The limestone contains *Ceromya Bajociana, Isocardia cordata*, and other fossils similar to those from the Oolite at Whitwell.

In the faulted ground to the south of Husthwaite there are two outlying patches of this rock capping the hill at Highthorne and Sand Hill.

The Scarborough or Grey Limestone Series. — These beds, although mapped as one series, are capable of subdivision into three groups, each of which generally makes a distinct feature along the line of outcrop. At the base there is an alternating series of siliceous and calcareous beds with shales and thin sandy bands which are well seen in the road below Novey House on the west side of Ladhill Beck, where is the following section :—

	Ft.	In.
Shales with fossils.		
Grit.		
Hard, sandy, siliceous beds	3	0
Sandy shales	5	0
Siliceous and calcareous beds	4	0
Shales.		

Above this comes a considerable thickness of porous grit containing the casts of *Avicula braamburiensis* and other fossils in great abundance. This is the principal rock of the series, and being harder than either the beds above or below forms a good feature which spreads over a large area of the moorlands to the north. Lastly, above the grit is a band of shale forming a bank of wet ground beneath the Moor Grit above. The total

thickness of these beds is about 70 feet, but there is no clear section in which all the beds can be measured.

The blue flaggy limestone at the base of the series sometimes makes a clear outcrop, the ground being covered by fragments of it; as is well seen at the head of Ladhill Beck along the northern outcrop, where these beds must be very thick, and at the south end of Over Silton Moor.

At the northern end of the outcrop on Osmotherley Moor, just below Low Mossy Grain, a drift was put in to try and find the limestone; and the bottom bed was met with, being full of *Gervillia* and *Pecten*, but only a foot thick. The fossiliferous grit, which contains casts of Encrinites in great numbers, makes a series of little steps up the hill side.

At the head of Oak Dale, near Moor House, where the rock is quarried and partly mined for road-metal, a drift has been made into the basement limestone, which is here very hard, of a blue colour, and about 6 feet thick. It is quite evident from the above that going north the calcareous beds almost disappear in this area, and at the same time that the grit becomes thicker and coarser. This last fact is well brought out by the great detached mass of fossiliferous grit on the watershed between Scugdale and Raisdale; which is at least 40 feet thick, and contains quartz grains of the size of a pea, being by far the coarsest form in which this bed is known. These grits are very porous, and from their base give out powerful springs, some fine examples of which may be seen at the sources of the Cod Beck above Osmotherley, and again at Newfield House on Snilesworth Moor. At this last place the calcareous beds were worked for lime or cement, and some time ago in pulling down an old wall cemented with this lime, the bricks had to be broken to pieces before the lime showed any signs of giving way. In the next map, 96 N.E., the outcrop of these beds is well seen in Bilsdale, and may be traced from thence along the west side to the moors above Wether Cote, where they enter this district, and the blue sandy limestones at the base with *Gervillia acuta* and *Avicula braamburiensis* are exposed in the road at the side of the enclosures. Above this the gritty portion of the series spreads out over the summit of the moor and forms a band completely encircling the higher part of Ladhill Beck, so that the Estuarine beds exposed in this valley form an inlier.

On these moors the limestone has been worked and burnt for lime at one or two places. Near Hazel House there are some curious hollows called "Hell Holes," which have evidently been formed in the grit by the calcareous beds below being dissolved out.

Both in Ladhill Beck and the River Rye the Grey Limestone Series is well exposed, and west of the latter forms a good feature, which may be easily traced by Brewster Hill and Gate Cote to Dale Head, where it turns round the head of the valley by Stephen Thwaites and Newfield House. North of this these beds cross the higher waters of the Rye and may be traced across

the moors to the trigonometrical station 1,184 on Whorlton Moor. The outcrop now turns round to the west, and although broken by several small faults forms a considerable spread on Whorlton Moor.

East of Osmotherley the Grey Limestone follows the brow of the hill for some distance, running out in a broad tongue above Over Silton, where the limestone beds at the base have been worked. In Swinestone Cliff the three divisions become very distinct, and the fossiliferous grit, which is very ferruginous in its upper part, forms a bold crag in the plantation below the house.

In the neighbourhood of Kepwick the Grey Limestone forms the conspicuous promontories above Nab House and above Atlay Bank, being well exposed at these places, and also where the road crosses the outcrop east of the village at Rag Robin Turn. Above Cowesby Wood these beds follow the brow of the hill for some distance, and at Brockholes, near Kirkby Knowle, where a large landslip has taken place, the following section was measured :—

Section at Brockholes, Kirkby Knowle.

		Ft.	In.
	Grit, with a siliceous fossiliferous bed near the centre	16	0
	Shales passing up into sandstone	4	0
	Rubbly calcareous beds full of fossils	5	0
	Siliceous sandstone with fossils (*Ostrea*)	8	0
	Argillaceous limestone	0	6
	Sandstone	0	6
	Hard bluish grey limestone	1	0
Estuarine Beds.	Shales.		
	Massive sandstone.		
	Shales.		
	Massive sandstone, with shales and a little jet in the centre.		

East of Kirkby Knowle the Grey Limestone winds round the hill forming the two projecting nabs above Westow Hall and Boltby, and, turning up the valley of the Lunshaw Beck, is exposed in the bed of that stream for nearly a mile. Below Lunshaw House there are some trial-holes into the lower part of the limestone, but for whatever purpose these were made, it seems to have been a failure.

On the east side of Lunshaw Beck the outcrop is entirely hidden for some distance by large landslips of Calcareous Grit and other rocks which have come down from above, and it is only on the projecting points, as below Hesketh Grange, Little Moor, and near Garbutt Wood that we get sections in the rock.

South of Whitestone Cliff the outcrop is again hidden for some considerable distance, and it is not until the beds turn round to the east below Roulston Scar that they are again exposed. The Grey Limestone now becomes more easy to trace, and may be followed along the hillside to Snever Wood, where it forms a conspicuous bank in the lower part of that wood. The outcrop here crosses the beck, and after a somewhat obscure course round the hill to

the west of Oldstead, is again well exposed in the neighbourhood of Oldstead Grange, where it makes the low feature on the east side of the old fish pond. At the southern end of this pond the Grey Limestone meets the large east and west fault of the Coxwold valley, and is thrown down some hundreds of feet, the outcrop being shifted nearly four miles to the west.

Between Byland Abbey and Ampleforth there is an inlying outcrop of these beds which skirts round the hill at the back of Wass village; the bed which is not seen in this map is exposed at the corner of Burtis and Low Woods in Quarter-Sheet 96 S.E., just east of which it again meets the large fault.

On the southern side of the north Coxwold fault the Grey Limestone is first seen at Thirkleby Barf, where it has been extensively quarried for road-metal. The beds here, which are harder and more massive than is usually the case, are divisable into two portions, the lower part consisting of hard beds of blue fossiliferous limestone, while above this are soft massive sandstones with casts of fossils, which become more flaggy in the upper part. These beds, which at Thirkleby Barf dip about 15 degrees to the north-east, to the east of Burtree House curve round and above Barf Hill, dip at about the same angle slightly to the west of north, so that the outcrop is extended in an easterly direction by Wildon Hill to Coxwold; at all of these places the rock is exposed in old quarries, but is not seen along the intermediate ground, probably owing to the thick covering of Boulder Clay lying in the hollows between. In the beck to the south of the railway at Coxwold these beds are seen dipping to the south-east at an angle of 10 degrees, being bent over towards the second large fault by which they are thrown up so as to outcrop only in the south-east corner of Newburgh Park, as outliers at The Mount and Park House in the next map.

Besides the main outcrop of the Grey Limestone there are several outliers. These occur as patches on the moors to the north, and fringing some of the hills in the neighbourhood of Kirkby Knowle and Kilburn to the south, the most northerly being that on Whorlton Moor, where the beds are depressed by small faults, and a patch of the fossiliferous grit has been preserved, forming a line of crags on its south side. In the north-west corner of the moors there are also some small patches of this rock which are much intersected by small faults, and to which, to a great extent, they owe their preservation.

Further south on Snilesworth Moor there are four of these outliers between the several tributaries of the Rye which, from the strong character of the grit and the absence of drift, are very distinct.

In the southern part of the district at Hood Hill, near Kilburn, and on the hill behind that village, there are also some outliers of the Grey Limestone; at the last of these places the outcrop is rather obscure, but a small portion of the limestone is seen on the northern side of the hill; at the southern end of the hill the Grey Limestone is thrown out by a fault, so that the limestone

which is there seen apparently on the same line of strike really belongs to the Millepore bed.

South of the great Coxwold faults the only outcrop of this bed is the outlier at The Mount to the east of Oulston.

Upper Estuarine Series.—These beds consist principally of shale, with thin irregular beds of sandstone, and at the base a thick bed of massive sandstone—the "Moor Grit." They have a total thickness of about 200 feet, but in many cases there does not seem to be so much as this, especially to the north-west, where there is not much more than 100 feet of these beds. The upper portion of this series, as a rule, makes wet clayey slopes, at the base of which the Moor Grit forms a distinct feature, often covering a considerable area of moorland. The outcrop of the Moor Grit follows that of the Grey Limestone so closely, that it frequently merely forms the upper part of that feature, and the description of one does for that of the other; but in a few cases, as on Bilsdale West Moor, Hawnby Moor, and over part of Snilesworth Moor, where this grit is partly of a gannister nature, it runs out in broad tongues, in a similar manner to the fossiliferous grit below, the ground being covered with large white siliceous blocks.

The shaly portion of this series does not generally afford good sections, their outcrop, which is principally below the steep escarpment of the Middle Oolites, being usually covered by the *débris* from that formation. The beds are, however, seen in some of the deeper valleys about Hawnby, and also on Osmotherley and Boltby Moors, where they run out from the overlying beds, and form their largest spreads.

Cornbrash.—The outcrop of the Cornbrash in this district is very uncertain, as the bed has not been anywhere observed, except in Northwoods Slack, above Boltby Moor, where is a little grey sandy limestone with *Ostrea*, which may represent this formation. On the strength of this the outcrop might be continued from the east and north as far as this point, there being a good line between the Estuarine Shales and the sandstone of the Kellaways Rock, although there are no sections exactly on this horizon. South of Boltby Moor, however, the base of the Middle Oolites is not so strongly marked, and, in fact, coming as it does in the midst of clays, it is impossible to say exactly where it should be drawn. There is certainly no evidence for carrying on the outcrop of this rock, and in the Howardian Hills, as we have noticed in the Explanation of Quarter-Sheet 96 S.E., it probably does not exist.

CHAPTER VII.

MIDDLE AND UPPER OOLITES.

Middle Oolites.

Kellaways Rock.—The Kellaways Rock in this district undergoes a considerable change both in character and position in its passage from the north to the south. In the northern part of the Hambleton Hills it is a thick-bedded massive sandstone, partly siliceous and partly sandy, with a ferruginous band towards the top, similar to what the rock has been further to the east, and having a thickness of about 60 feet; but in the southern part of these hills this rock, which is a soft red grit crowded with *Gryphæa* and *Belemnites*, comes in immediately below the Calcareous Grit, the lower part of the Kellaways Rock splitting up into shaly beds as if the clayey part of the Oxfordian series were setting in at the base instead of above this rock. As we trace this formation further to the east towards the Howardian Hills the normal position of the beds comes on again, so that it would appear that it is only to the extreme south-west that this peculiarity occurs.

The outcrop of the Kellaways Rock is continued from the next Map along the south bank of the Rye by Ristbrow and Dale Town; it also runs up the valley north of Old Byland, being exposed at Cadale Mill and other places.

West of Hawnby about Coum Hill and Arden Hall the rock is not so well seen being generally covered by landslips and the *débris* of the rocks above, but it is well exposed around the large outliers of Easterside and Hawnby Hill, especially towards their northern and southern ends.

Around the flanks of Black Hambleton the Kellaways Rock usually forms a good feature; it is easily followed as far as Kepwick, where the talus from the hill above again obscures everything.

On Boltby Moor above Cowesby the Kellaways Rock also forms a strong feature and running out in a long tongue is well exposed in several road-sections on that moor. South of this the outcrop is not seen till we get to Hesketh Grange, where it is exposed in the road; there is also a good section below Boltby Scar of red ferruginous sandstone with *Am. modiolaris, Belemnites, Ostrea,* &c.

Below Whitestone Cliff, where there is a fine scar exposing these beds, the lower part of the Kellaways Rock is seen to be getting much more shaly, and a bed of clay comes in which we have mapped with the Oxford Clay, and not with the Lower Oolites, as it seems to occupy the same horizon as the sandstones further north which here appear to be gradually dying out: in the next section we obtain the rock presents quite a different phase.

At the base of Roulston Scar there is a peculiar red ferruginous rock crowded with *Gryphæa subloba* and *Belemnites*, which although it lies immediately below the Calcareous Grit, must from the fossils it contains belong to the Kellaways Rock. It has a thickness of nearly 50 feet, as will be seen from the following section measured at the base of the scar :—

Section below Roulston Scar.

	Ft.	In.
Vertical cliff of lower calcareous grit, consisting of alternations of hard and soft sandstones with lines of curious forms, resembling fucoids and sponges, much eaten out by exposure to the weather, which has given the beds a very rough and irregular appearance.		
Soft sandstone, very full of *Belemnites*, contains also *Gryphæa, Avicula inæquivalvis*, and *Avicula ovalis*	1	6
Sandstone beds with lines of fossils *Gryphæa subloba, Belemnites Owenii, Placunopsis* - - -	5	0
Massive sandstone with *Gryphæa* - - -	20	0
Harder bed - - - - - -	9	0
Yellow sandy rock jointed becoming softer below -	8	0
Beds below hidden by talus.		
Total Kellaways Rock seen - -	43	6

Following round the outcrop to the east the rock is well seen in the several gullies coming down from the moor, especially in the third one known as Ravens Gill where the section is—

Section in Ravens Gill.

	Ft.	In.
Limestone - - - - - -	30	0
Red rock containing *Holectypus depressus* and great quantities of *Belemnites, Ostrea, &c.* - -	15	0
Massive yellow sandstone - - - -	20	0
Total Kellaways Rock - - 35 ft.		

The base is not seen, but it cannot be far below, as wet clayey ground very soon comes on. The limestone belongs to the measures above, as will be mentioned further on.

Beyond this the rock is not again exposed, and there is no evidence to say whether it really exists or not between here and its outcrop in the Howardian Hills to the south of Hovingham. The outcrop has, however, been carried on; as in Snever Wood and beyond, there is a sandy bank below shales, which seem to indicate that the Kellaways Rock is coming on again in its normal character below the Oxford Clay.

Besides the large outliers of Kellaways Rock near Hawnby, there is an outlying patch on Osmotherley Moor to the north of Black Hambleton, the rock here which is very fossiliferous in its lower part is divided into two portions by a shaly band; this is very often the case along its most northerly outcrop as we noticed

near Levisham, Saltergate, and Langdale End.* The only other outcrop of the Kellaways Rock, if we except that between the faults at Coxwold, of which nothing is known, is on Hood Hill; here, immediately below the Calcareous Grit, which caps the hill, there is a small exposure of sandstone with *Belemnites* which much resembles the rock seen at the base of Roulston Scar just opposite, and seems to occupy a similar position.

Oxford Clay.—The Oxford Clay, which in the northern part of this district consists of sandy shales, and has a thickness of about 50 feet, gradually thins out to the south; so that below Whitestone Cliff it is only 30 feet thick, and between there and Roulston Scar disappears altogether. At Whitestone Cliff, as we have noticed above, the lower part of the Kellaways Rock appears to be splitting up and turning into shales, and a lower bed of clay occurs, so that virtually in the extreme south-west the Oxford Clay is below the Kellaways Rock; as we trace the beds, however, eastwards towards Wass the clay comes on again below the Calcareous Grit, and if we follow the beds further east to the Howardian Hills, we find the Kellaways Rock below these shales in its normal position.

The outcrop of the Oxford Clay follows that of the Kellaways Rock round the Hambleton Hills forming in general a band of wetter ground between that rock and the Calcareous Grit above; but this is not always the case, as the great quantity of talus and the numerous landslips from the grit and limestone have frequently completely concealed the clays and entirely altered the character of the ground.

These shales may, however, be seen on the hillside to the south of Hawnby, and there are long tongues running up the valleys on either side of Old Byland.

Near Arden Hall they have been worked, and there are sections at a few places round the flanks of Black Hambleton, but they are not of much interest.

The best section is that below Whitestone Cliff, where there is a clear scar showing 30 feet of these shales between the Calcareous Grit and the Kellaways Rock, which latter is itself seen to be turning largely into shales, especially in its lower part. Beyond this the beds are very imperfectly exposed, except in the deep valley west of Wass, and the position of the Oxford Clay has to be chiefly inferred from the nature of the ground.

Between the Coxwold faults these beds are almost entirely obscured by Boulder Clay; sandy shales are seen in the railway cutting at the station, which probably belong to this formation, and shaly sandstones are exposed at one or two places between here and Wildon Grange, which must be near the base of the Calcareous Grit; so that the top of the Oxford Clay can be

* Memoirs of the Geological Survey. Explanations of Quarter-Sheets 96 N.E., p. 46, and 95 N.W., p. 45.

fairly well mapped, but there is no evidence to fix the base of the formation or to trace the outcrop of the Kellaways Rock.

Lower Calcareous Grit.—This, which is the principal rock of the Middle Oolites, forms in this district the great mass of the Hambleton Hills, which rising to the north and west in the great escarpment overlooking the Vale of York,* attains at Black Hambleton a height of 1,300 feet above sea level.

It consists principally of cherty sandstones with calcareous bands, which on the whole are harder and more massive than they have been in the country to the east, so that they are enabled to withstand the action of denudation better, and in a few places as at Peak Scar, Boltby Scar, Whitestone Cliff, and Roulston Scar to form grand vertical cliffs. At the former of these places the following section which shows the siliceous character of the beds was measured:—

Section at Peak Scar.

	Ft.	In.
Oolitic limestone	12	0
„ weathering sandy	2	0
Hard limestone	3	6
Hard white beds	1	0
	1	0
	1	10
	1	6
	1	0
Calcareous beds	1	6
	1	6
Hard siliceous bed, dark coloured	1	6
Siliceous beds, whitish	2	6
	1	10
	1	8
	1	0
Siliceous calcareous beds, become sandstones further on	2	2
	1	9
	1	6
	3	0
Cherty sandstones	4	6
	3	3
	3	2
	3	6
	2	6
	26	0
	2	2
	2	0
	3	4
	3	5
Total thickness exposed	97	7

* This northern part of the great central valley of Yorkshire is sometimes called the Vale of Mowbray.

The basement beds, which are softer and more shaly, are not exposed here.

As we trace the Calcareous Grit southwards along the Hambleton escarpment, we find that it becomes split up by calcareous bands and thin limestones; this is first seen at Boltby, where towards the top of the scar is a thin limestone which appears to be the same as the thick bed to the north at High Paradise and Kepwick, but is certainly not the same as that capping the hill at this spot and dipping eastwards to Cold Kirkby. The following section measured in the scar at Boltby shows this bed, which, however, soon appears to die out and cannot be traced much further to the southward, although there appears to be something of the same sort in the interior valleys:—

Section in Boltby Scar.

		Ft.	In.
Sandstones, 15 ft. 6 in.	Siliceous beds	1	2
	Sandstone, with curious markings	3	2
	Siliceous bed	1	2
	Sandstone	1	4
	,,	4	6
	,,	1	0
	Siliceous bed	1	4
	,,	1	0
	Siliceous sandstone	0	10
Limestone, 16 ft.	Siliceous limestone	1	6
	Sandy limestone	1	6
	Oolitic limestone	13	0
Sandstones, 23 ft. 8 in.	Sandstone	1	6
	Siliceous bed	0	8
	Rubbly bed	1	0
	Sandstone with nodules	2	2
	Siliceous band	1	0
	Sandstone with fuciods	4	6
	Sandstone	0	11
	Massive sandstone with bands of nodules in centre	3	7
	Soft sandstone	1	4
	Sandstone with bands of flint nodules	7	0
	Total beds seen	55	2

Along the southern escarpment a band of limestone comes in quite at the base of the formation which is 30 feet thick at Ravens Gill below Shaws Moor, but cannot be traced for any distance, and there is no means of saying whether it is the same band as that mentioned above or not.

The Lower Calcareous Grit forms, as we have said, the main mass of the Hambleton Hills, which are the western end of the great tabular range of hills extending from the coast at Scarborough to this district. It presents a bold escarpment to the north, west, and south, and fringes the valleys which have cut through the rock in the neighbourhood of Old Byland.

It also forms the main mass of the remarkable outliers of Easterside, Hawnby Hill, and Coum Hill near Hawnby, and just caps the summit of Hood Hill near Kilburn.

In the faulted mass at Coxwold the rock is seen in quarries near Wildon Grange, Coxwold, and Newburgh Park, but it does not make a good feature; and, as there is no evidence as to where the limestones and grits above come on, no lines have been drawn to separate these various divisions.

Lower Limestone.—The Lower Limestone covers a much larger area than any of the other Oolites, and although it has not so great a thickness as it has further to the east, it is still considerable in the northern part of its outcrop: towards the south, however, it becomes thinner, and about Wass entirely disappears. In the northern area between Kepwick and Hawnby there is probably from 50 to 80 feet of this limestone, but about Cold Kirkby there cannot be more than about 30 feet or so, and south of this on Byland Moor it is merely represented by an oolitic band of sandstone rather than a true limestone.

In the district between Hawnby and Kepwick this limestone is fairly massive, but a much more barren rock than it was to the east; in fact, the paucity of fossils is remarkable; as we trace the rock to the south it becomes more flaggy, and on Boltby Moor is so fissile that some of the quarries have been marked on the Ordnance Map as "Slate Quarries."*

The outcrop of this limestone covers the summit of all the high ground to the south and west of Hawnby, and stretches away to the north as far as Arden Moor, its exact northern limit being rendered somewhat obscure by the great thickness of peat on that moor. From the most northerly point the beds dip rapidly to the south, falling over 100 feet in less than a mile, so that at Kepwick Quarries and on a line east of them we appear to get the maximum thickness of the limestone.

South of High Paradise the limestone becomes split up with sandy bands so that if we trace the base along the escarpment we find only a thin band of limestone, which gradually dies out; on the other side, however, at the head of the deep valley north of Old Byland, the base of the limestone is continuous and the sandstone dies out, so that the limestone of Cold Kirkby to the south is not really a separate bed from that of Kepwick to the north; the Lower Calcareous Grit and the limestone being dovetailed together in a manner that renders the stratigraphy about here rather intricate. In the valley below Cold Kirkby there is also a lower band of limestone, which, although excessively thin, may be traced eastwards along the valley of the Rye as far as Duncombe Park where it becomes the principal limestone, and is the bed that is mapped about Carlton to the north of Helmsley and thence eastwards. The upper band of limestone, which forms a fairly good outcrop north

* "Flag Quarry Plantation" on Scawton Moor is also probably so called from the fissile character of the limestone.

of Cold Cam, rapidly dies out to the east and south, so that it cannot be traced beyond Sproxton Moor and Wass respectively; above the latter place it turns into a band of sandstone or impure limestone with oolitic grains, which may be followed as far as Ampleforth.

We have already mentioned the occurrence of a limestone 30 feet thick at the base of the Calcareous Grit along the southern escarpment; this bed is only seen for a short distance along the bank below Shaws Moor; it is very possibly the same bed as that occurring in the valley below Cold Kirkby and Scawton, although it occupies a slightly different position.

The principal outliers of this limestone are those occurring on the great Calcareous Grit outliers about Hawnby; there are also several patches on Arden Moor and about Scawton, which are but slightly separated from the main mass.

Middle Calcareous Grit.—The Middle Calcareous Grit, which occupies only a small area in this district, comes on over the limestone of Cold Cam; and, covering the greater part of Byland Moor, may be traced eastwards till, from the dying out of the limestone, it becomes amalgamated with the sandstones of the Lower Calcareous Grit below, and the two, as at Ampleforth and beyond, have to be mapped as one formation.

The Middle Calcareous Grit consists of soft reddish sandstones, which are not so hard or cherty as the beds of the Lower Calcareous Grit, and which, at the base, are rather shaley, or at any rate decompose into a red clayey sand.

Upper Limestone and Coral Rag.—This rock does not anywhere form a natural exposure. The low ground between the Coxwold faults is its only outcrop, and here it is so completely buried beneath the thick covering of Boulder Clay that it is hopeless in such disturbed ground to attempt to trace it out. The only place that the rock is seen is at the bottom of the deep quarry in Snape Wood close against the northern fault, where from 30 to 40 feet of higher beds have been removed; and, as these dip over into the fault and surround the limestone on all sides, it is evident that it cannot have a natural outcrop here. Nearer Kilburn Park, Wildon Grange, or towards Coxwold, where one would expect this limestone to appear, there is no evidence whether the bed really outcrops or is cut out by other faults.

The limestone which has been preserved in this unique section at Snape Wood is very crystalline with *Thecosmilia annularis*, *Ostrea gregaria* and spines of *Cidaris florigemma*, and, although there is not much of the bed seen, it is a true Coral Rag very

similar to the main outcrop of this bed at Beacon House above Ampleforth, nearly six miles to the east.

Upper Calcareous Grit.—In the quarry at Snape Hill, immediately above the Coral Rag just mentioned, the following section in beds of this age was measured:—

Section at Snape Hill.

	Ft.	In.
Sandstone with *Am. triplex*, *Bel. abbreviatus*, *Pecten lens*, and *Astarte ovata*? - - - -	10	0
Calcareous series with alternations of sandstone and shale - - - - - -	13	0
Shaly series with bands of semi-argillaceous limestone (Throstler?) - - - - -	13	0
Shaly beds hidden by talus - - - 8 ft. to	10	0
Coral Rag with *Thecosmilia annularis*, *Cidaris florigemma*, and *Ostrea gregaria*. Base not seen -	4	6

From this section it is seen the Upper Calcareous Grit consists of soft fossiliferous sandstones that become more calcareous lower down and towards the base turn into more shaly beds, which very much resemble the more shaly part of the cement-stone of North Grimston.

In this section there are about 40 feet of strata exposed, and this may be nearly the full thickness of the formation; for, although the Kimeridge Clay does not come on for some little distance, the sandstones dip with the slope of the hill and appear to pass directly under it.

Besides the exposures at Snape Hill the Upper Calcareous Grit is not seen anywhere this side of Ampleforth; and, there being no evidence by which to fix its base or the boundaries between the limestones and sandstones below, the whole of these from the Lower Calcareous Grit to the Upper Calcareous Grit have been mapped together. The line drawn between these beds and the Kimeridge Clay above is entirely hypothetical and may be a faulted boundary or not.

UPPER OOLITES.

Kimeridge Clay.—There is only a small area of this clay let down between the faults to the north-east of Coxwold. In this region the beds are less obscured by Boulder Clay than they have been further to the west, and the Kimeridge Clay is exposed at several places about Brink Hill and Low Pasture House, where it forms a low ridge extending into the next map.

From these sections it is seen to be a dark blue or black shale with *Discina latissima, Ammonites,* and other fossils in a bad state of preservation, and containing excessively hard bands, which are of a yellow colour when weathered.

Although only a small area of this clay is seen its thickness must be considerable, for in a boring at Low Pasture House, the particulars of which are given below, 400 feet of this clay were pierced without reaching the bottom.

Boring at Low Pasture House, Wass.

	Ft.	In.
Kimeridge Clay* - - - - -	90	0
Stone,† water rising to the surface - -	2	0
Blue shale - - - - - -	186	0
Hard blue shale - - - - -	120	0
Total - -	398	0

* These are the names used by Mr. Owston, to whom we are indebted for the above particulars. It is probable that all the shale is Kimeridge Clay, but we have no means of ascertaining this.

† Probably one of the hard bands in the Kimeridge Clay.

CHAPTER VIII.

SUPERFICIAL DEPOSITS.

Glacial Beds.

Boulder Clay, Sand, and Gravel.—With the exception of the high range of hills forming the western end of the Oolites, the whole of this area is more or less covered by superficial deposits. These beds attain a considerable thickness in the northern part of the district, and about Thirsk.

In the neighbourhood of Northallerton they are much thinner, and to the west of that town the Keuper Sandstone almost appears at the surface, while on the east the low bank of the Rhætic Beds and the more lofty hill formed by the outlier of Oolite just east of Cod Beck project through the great mass of Boulder Clay.

There is also no great thickness of drift along the low range of hills formed by the Keuper Sandstone which the Roman road follows between the Swale and the Ure, nor over the Magnesian Limestone in the south-west corner between Well and Ripon.

Besides the above area there is not much drift over the Trias west of Thirsk, nor over the Oolites and Lias about Cox-wold, which frequently protrude through the Boulder Clay and are exposed at the surface.

Taken as a whole, the glacial deposits never rise much above the 600-ft. contour line, and only attain this elevation along the northern escarpment of the Oolites; in the south they are not usually more than 400 feet above sea level, except at Oulston, where the gravels rise to nearly the 500-ft. contour.

In the neighbourhood of the Tees and along the Leven there is pretty clear evidence that the Boulder Clay consists of an upper and lower division separated by intermediate sands and gravel, which are seen cropping out between the clays in the steep banks formed by these streams; but whether this holds good over the whole of the district there is not sufficient evidence to say.

In the right bank of the Tees near Eryholme there is the following striking section, which shows the character of the drift remarkably well:—

*Section in the Tees, Rawcliff Scar, near Eryholme.**

		Ft.	In.
Upper Boulder Clay with some sand	about	35	0
Bluish laminated clay without stones	8 ft. to	10	0
Reddish Upper Boulder Clay with few stones	15 ft. „	20	0
Sand	6 ft. „	7	0

* This section has been supplied by Mr. W. Gunn.

	Ft.	In.
Bluish laminated clay with no stones - -	7	0
Reddish Upper Boulder Clay with fewer stones than clay below - - 10 ft. to	12	0
Lower Boulder Clay, hard blue clay with many foreign stones well striated. Base not seen - -	10	0

Further south there appears to be 30 or 40 feet of sand in the middle; the top of the sand is very irregular.

The line at the bottom of the lower reddish Upper Boulder Clay was very distinct, and the section clearly showed that all the beds of sand and laminated clay were merely episodes in the deposition of the Upper Boulder Clay.

From several boreholes and well sections, principally to the north of this area, it appears that there is frequently more than one stratum of sand, so that at the outcrop it is impossible to say whether we always have the same bed or not.

The Boulder Clay which occurs in this district is a portion of that vast accumulation which extends from Durham through the great central valley of Yorkshire. It is confined entirely to this valley, and the low hills on its flanks, the more lofty range of the Cleveland and Hambleton Hills being entirely free from it. Throughout this region it maintains its usual character of a stiff clay having a dark blue colour when unweathered; and containing rounded and subangular pebbles and boulders of rock, principally derived from the sandstones and limestones of Carboniferous age as well as of the Oolite and Lias, with a large proportion of granite and igneous rocks, and occasionally a few flints. So great is the amount of limestone in the gravel above Osmotherley, that it is cemented together and makes quite a cliff above the corn-mill. These foreign rocks occur principally in the Lower Boulder Clay, the upper clay is almost stoneless.

The Upper Boulder Clay never rises to more than 400 feet above sea level, but the Lower Clay occurs at a much greater height, and the gravel which is found above this reaches an elevation of 670 feet.

The gravel forms a distinct fringing line to the great escarpment, running a long way up the dales opening off it, but keeping usually to about the same level; and from the fact of the hinges of *Tellina balthica* being very plentiful in this gravel, while the whole shell is by no means uncommon, it is clear that the water must have reached to this height.

The Lower Boulder Clay is only cut into by the Tees and the Leven, but it has been proved in several of the boreholes and well sections, given in the Appendix.

The sands, besides being seen in these sections, are exposed in the Wiske and Staindale Stell, and over those areas where they form larger spreads.

The drift in the south, especially about Thirsk and between there and Ripon, contains much more gravel and sand than the country to the north of Northallerton.

The low ground in this latter region is nearly all clay, except about Stokesley, along the flanks of the Oolites, and a small patch near Cowton Station.

To the west of Ripon the Glacial Beds, which, however, are not very thick, consist largely of gravel. These gravels frequently form long ridges similar to Eskers, which run in a north-west and south-east direction; the most remarkable of them being the "Roman Ridge" near Lindrick Farm. There is also a good deal of gravel about Studley Park, which in many cases has been washed into hollows and caverns in the Magnesian Limestone.

Warp and Lacustrine Clay and Sands.—In the country to the south of Thirsk a large spread of flat sandy land comes in; this, which is the northern limit of a great plain stretching away from York and beyond, consists of sands and laminated clay. These beds are best seen in the neighbourhood of Isle Beck and near Pill Moor, where the laminated clay comes nearly to the surface and has been worked for brickmaking. At the latter place there is said to be over 100 feet of clay, but it is not stated whether the lower part of this was clean clay or Boulder Clay.

Boring at Pill Moor.

	Ft.	In.
Soil and sand - - - - - -	3	0
Clay - - - - - - -	115	0
Total - -	118	0

The age of these sands and clays is somewhat doubtful. In certain cases they appear to be overlaid by Boulder Clay and are therefore glacial; but in tracing them to the south they join on without any apparent division to similar beds at York, which have previously been considered post-glacial, and to the warp beds of the Humber, which are certainly of quite recent date.

Post-Glacial Beds.

Peat.—The principal area of hill peat is on that part of Arden Moor called "The Mosses," where it covers the summit of the hill, but as there are no sections in it except at the edges we cannot judge of its thickness. There is also a small patch having a thickness of about 6 feet on Bilsdale West Moor, near the Ordnance Station, 1294. In the low ground several of the hollows in the Boulder Clay are filled with peat or dark peaty soil. The largest of these is at Snape Mires, where a ditch section shows 3 feet of peat.

River Terraces.—The Swale west of Northallerton, the Ure north of Ripon, and its tributary the Laver west of that town, have terraces of river gravel along their flanks. These, although now above the reach of the highest floods, mark the levels at which these streams formerly flowed at different periods.

Those on the Swale are not far above the level of the modern alluvium, and consist principally of sand, which has probably been washed out of the glacial beds and redeposited by the action of the stream. The terraces flanking the Ure are mostly composed of gravel and are of three ages, the highest of these being from 25 to 50 feet above the present level of the river.

Alluvium.—The largest areas of river alluvium are along the courses of the rivers Swale and Ure. These form low-lying flats liable to be flooded, and therefore are generally devoted to pasture. Besides the above there are numerous patches of alluvial soil filling hollows in the Boulder Clay, the age of which it is not always possible to make out. They give rise to flat, clay, peaty or loamy lands, which are more often arable.

CHAPTER IX.

PHYSICAL STRUCTURE.

The general structure of this district divides it into two distinct areas. The low ground in the centre and on the west, which is occupied principally by the Trias and lower part of the Lias, forms a flat or gently undulating surface, rising gradually to the flanks of the Oolite hills on one side, and to the Carboniferous on the other; while the Oolites themselves, which rise in a bold feature, form the elevated land on the eastern side.

The former of these areas might, for agricultural purposes, be further subdivided into a north-east and south-west region roughly divided by a line running from the Swale near Langton through Northallerton and Thirsk to Raskelf and Easingwold. North of this line it will be found that the Boulder Clay occupies the greater part of the surface, causing a cold heavy soil, while to the south-west gravel, sand, and alluvium cover the larger portion of the ground, forming light porous land of a much dryer and warmer character. With the exception of a portion of the Oolites the general dip of all the formations is easterly at low angles, usually not more than 5 degrees; thus causing the Millstone Grit and Permian Beds, outcropping in the west, to pass gradually beneath the several members of the Trias and Lias, which in their turn pass beneath the steep bank of the Oolites.

Taking the two main areas separately we find that the Oolites may be divided into three regions having a slightly different character. The northern portion, which comprises the Cleveland Hills, is composed principally of the sandstone and shales of the Lower Oolite with the Lias clays cropping out around its flanks and in the deeper valleys. These form an elevated tract of wild moorland country, very desolate, and of little value either for its minerals or for agricultural purposes.

The central region is the elevated table land of the Hambleton Hills, which are the western end of the great tabular range extending from the coast at Scarborough by Hackness and Lastingham to this district. These hills are composed of the different members of the Middle Oolite, and form around their flanks a steep escarpment, which is particularly bold along the west; where it sometimes, as at Boltby, Whitestone Cliff, and Roulston Scar, rises in grand vertical cliffs of rock. The great charm, however, of this country are the deep ramifying valleys of the interior, which the Rye and its tributaries have cut through these beds, causing numerous projecting spurs and deep gorge-like valleys, the sides of which, being usually well wooded, have a very picturesque effect. The surface of these hills is composed of grit and limestone, and is partly moorland and partly enclosed, the lime-

stone forming good land, which is usually enclosed when the elevation is not too great. The highest limit of cultivation seems to be between 1,100 and 1,200 feet above sea-level; the northern part of these hills which rise above that level are entirely moorland.

The southern region comprises the Oolites about Coxwold, in the south-east corner. The rocks at the village have been let down between large faults; and, outcropping in comparatively low ground, are mostly covered by glacial deposits. To the south of these trough faults they form a bold hill, which is the western end of the Howardian range, described in the Memoirs on Quarter-Sheets 96 S.E. and 93 N.E. The beds throughout the whole of this district are very faulted; and, as we have shown in previous Memoirs, the disturbance extends from one end to the other of this range of hills. In this Map the evidence for the position of the larger faults is more exact, and they can be traced into older formations; in fact, to the base of the Secondary Rocks altogether.

Faults.—The northern part of the Oolites is traversed by several faults, mostly in a north and south direction; though some large ones also occur, having the east and west trend so often met with in the Cleveland Ironstone Mines.

The first fault we have to describe is one of these, which runs from the east end of Raisdale across into Scugdale. Its effect is first noticed at West Cote, where it begins to fault out the Middle Lias. In the bed of the stream shales of the Ironstone Series are seen within a few feet of Lower Lias beds, while in the road up the hill going to Scugdale the base of the Oolites is at a lower level than the Main Seam of Ironstone; the throw being more than the whole thickness of the Upper Lias, or nearly 200 feet. From this point it rapidly decreases, and seems to die out in the Upper Lias in the higher part of Scugdale, though it is possible that it may join a similar fault lower down the dale.

This, which is also a nearly east and west fault, begins just south of the spot at which the first leaves off near Scugdale Hall; and is well shown at Rakes, where the sandstones of the Middle Lias lie against the shales of the Upper Lias. Still further west it just cuts out the whole of the Middle Lias, having over 100 feet of throw; beyond this it is lost under drift, but undoubtedly runs into the north and south fault, near Hollin Hill. The little east and west fault north of this is concealed by drift, but was proved in the mines, where it has a throw of 30 feet.

The north-west face of the outlier of Grey Limestone Grit between Scugdale and Raisdale is clearly faulted; and the fault is well marked by the sudden fall to the south of the base of the Oolites above Staindale, but beyond this its course is not very clear.

Whorl Hill, near Whorlton, may be considered as a piece of ground let down between two faults. Of these the more easterly is well seen at the north-east face of the Hill, where the Lower Lias comes to the surface within a few feet of the Jet Rock, cutting out the whole of the Middle Lias for a short distance. Its course to the north is inferred only, but it probably extends some distance in this direction, as it decreases rapidly southwards. The clearest evidence of its position in the main escarpment is where it cuts the base of the Oolites, these sandstones being nearly 50 feet higher on the east side than on the west. The little parallel fault to the west of the last was proved in the mines, where it has a downthrow to the west of 14 ft. 6 in.

The fault that bounds the Whorl Hill area on the west may be inferred about Potto Hill and the Castle, from the fact that beds far down in the Lower Lias are seen here, which could not be at the surface unless the dip at Whorl Hill increases considerably to the west. Southward its effect is well shown by the much higher level at which the Middle Lias stands in Limekiln Wood than at the Swainby Mines. In the escarpment its effect is very clear where it cuts the Dogger, and lets this bed down on the east side; further south still it brings down the Grey Limestone some 40 or 50 feet, making the outcrop considerably north of the main mass. A little east of this last place is another small fault having the opposite throw, which brings the limestone back level with its former position.

Another north and south fault occurs along the outcrop of the Grey Limestone Grit, in the valley east of High Mossy Grain, which raises the base of that bed on the west side above the level of its top on the east, and consequently has a throw of about 50 feet.

A pretty example of the effect often produced by a fault is seen in Scarth Nick, where there is clearly a considerable break in the beds. The Dogger, which can be followed very easily through Limekiln Wood, evidently outcrops just above the east side of the road at the entrance to Scarth Nick; while some 56 feet above the west side of the road at the same place is the Grey Limestone Series, the Dogger and all underlying beds being thrown so far down the escarpment on the west side as to be lost under the drift and detritus. The fault probably attains its maximum throw here, which cannot be much under 200 feet. Proceeding southwards the outcrop of the fossiliferous grit on the west side is somewhere between 70 and 100 feet below the corresponding outcrop on the east side of the fault, but in following the latter still further it appears to die out before reaching "Solomon's Temple."

Another fault, having an opposite throw to the last, brings the Dogger again into view in the face of the escarpment, while it throws out the Grey Limestone on its west side, causing a break of some 50 feet.

Near the north-west point of the escarpment is another large fault, which must have an upthrow to the south-west of over

100 feet, in fact, not far short of 150 feet. The fossiliferous grit caps the hill just south of Coploaf Cottage, the Dogger being well exposed more than 200 feet below; while on the west side this bed is just below the base of the massive sandstone of Beacon Scar, rather more than 75 feet down the face of the hill. It continues to have approximately the same throw for some distance, for after sharply bounding the west side of the outlier of Grey Limestone and Moor Grit, the base of the former is again seen to be no great distance above the Dogger, in the valley above Osmotherley Mill; the relative position also of these two beds cannot be much different on the east side of the valley, but the ground is somewhat obscured by drift. From this point the fault rapidly diminishes in throw till it seems to die away a little north of Trenholm House.

A little to the west of Moor House a small fault cuts the outcrop of the Grey Limestone Series, throwing it down slightly to the east, but on the opposite side of the valley the throw is much larger, the outcrop being abruptly broken and shifted a long way to the south; beyond this it soon dies out, or is lost in the general obscurity below Black Hambleton.

The great outlier of Oolites on which Borrowby village stands is clearly let down between two great faults, which unite at their two extremities. The eastern of these is mostly inferred, but the throw must be nearly 400 feet, as the ground between the outlier and the main escarpment is evidently all Lower Lias, there being only room for a few feet of the Upper Lias to come on before the Oolite is reached. The displacement in the outcrop of the Rhætic Beds caused by this fault is noticed in the description of those strata. On the west side of the hill, under Landmoth, the *Bucklandi* limestones of the Lower Lias are seen resting against the Jet Rock, which has been mined here; consequently the whole of the Middle Lias, some 25 feet of the Upper Lias, and more than 200 feet of the Lower Lias, are faulted out, the throw being also about 400 feet.

A well-marked fault passes through the outlier close by Upsall Castle. Its effect is best seen in the outcrop of the curious crystalline calcareous grit that caps the hill, which is clearly faulted down at the west end. The beds to the north of this give no very clear evidence, except the Dogger, which seems slightly shifted above Fox Hall. On the south side of the hill, however, just above Upsall Castle, the outcrop of this bed shows the break well, and similarly the Middle Lias is at a much lower level along the roadside going up to the castle than it is a little further east.

Throughout the Hambledon Hills there are no faults, and it is remarkable how entirely free from faulting and disturbance of any kind this range of hills is; especially when we notice the excessively faulted character of the ground that sets in immediately below their southern termination.

In this southern region, below the great escarpment of the Middle Oolites at Kilburn, there is a small fault, which is first

observed just north of the village. Here the base of the Oolite, which forms Headsty Bank, is thrown up about 50 feet on the south side, and outcrops close below the houses in High Kilburn; the shales of the Upper Lias and the ironstone above being seen just at the entrance to the village. On the top of the hill the evidence is somewhat clearer, for in tracing the outcrop of the Grey Limestone round this outlier it is found to abut against the Millepore Bed exposed in the lane above the village; and similarly on the east side, the Millepore Bed is nearly on the same level as the Hydraulic Limestone. In the little valley south of Oldstead this fault may be again observed, the Grey Limestone at the village being at the same level as the Millepore Bed on the outlier to the south. Beyond this the fault appears to curve round to the south and join the large fault at the south end of the old fish pond below Oldstead Grange.

Just south of Kilburn we have the northern of the two great east and west trough faults, which have depressed the beds at Coxwold, and along the long strip running by Topcliffe to the Ure. The line formed by this fault is very clear where it enters the map to the south of Wass and Byland Abbey; the soft sandstones of the Estuarine Series and the black shales of the Kimeridge Clay are seen within a short distance of each other on either side. The deep boring at Low Pasture House * also shows that there is a considerable thickness of these shales close to the fault. A little to the west of Byland Abbey the line is rendered very apparent by the good outcrop of the Grey Limestone south of Oldstead Grange and the conspicuous hill of Kimeridge Clay known as Brink Hill, which abut against each other. At Kilburn Thicket the line is not quite so well defined, and it is possible the fault does not make so great a bend as shown on the map; although from the little evidence afforded, the Lower Oolite seems to occupy the greater part of this wood.† The next clear evidence of this large fault is to the south of Kilburn, where we get beds below the Jet Shales of the Lias thrown against the Upper Calcareous Grit and Coral Rag which have been worked in the quarry at Snape Hill. Judging from the thickness of strata that have been removed, the throw of the fault at this spot cannot be much less than 1,000 feet; and to anyone standing on Snape Hill and looking at the great escarpment towering above to the north, the effect is very striking; and gives a good idea of the throw of this fault, and the amount of denudation that has taken place. At Thirkleby the Rhætic Beds are on a level with the Grey Limestone which has been quarried on the hill at Thirkleby Barf; so that here, allowing 200 feet for the Lower Oolite and 500 feet for the Lias, which are probably under estimates, the amount of throw will be at the very least 700 feet. Further

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* *See* page 52.

† It is just possible that there is a branch fault starting from here and running in a south-east direction; there is no evidence to say whether the line separating the Upper from the Middle Oolite is a fault or not.

west the throw of the fault is probably lessening and its exact position cannot be fixed, but it may be approximately determined from the following evidence:—At the village of Dalton and further to the west the wells are all in red marl and gypsum, while in the railway just south of Sessay Station, the Main Seam of Ironstone and the Jet Rock crop out. The Middle Lias Ironstone is also seen at Barf Hill, and the Lower Lias in the bed of the Swale, near Topcliffe, while the Red Sandstone crops out along the Swale to the north, and was proved in a well at the west end of Baldersby Park. Further west there is no evidence till we get to the Magnesian Limestone, the top of which formation is shifted from the neighbourhood of Wath to the west side of Ure, the junction beds of marl and gypsum being much twisted and contorted by these dislocations.

The southern main fault, which encloses the long strip running through Coxwold and Topcliffe, is portion of a great dislocation bounding the north side of the Howardian Hills. This line of disturbance has been traced from the vicinity of Malton to near Ripon, a distance of over 30 miles. It enters our present district in Newburgh Park, where the Calcareous Grit is seen on the northern side; while to the south, although the beds are hidden by drift, it is pretty evident that the lower part of the Lower Oolite outcrops at no great distance. Nearer Coxwold the evidence is more marked, and on the north side we have a complete succession of beds from the Calcareous Grit downwards, the coal having been worked near the station close to the fault; on the south side the different members or the Lias come up, the base of the Oolite is seen on the hill at Newburgh Grange, and the Dogger forms the fine feature of Beacon Banks. At Carlton Husthwaite, from the covering of drift, the exact position of the fault is not so clear. The Grey Limestone is seen on the hill above, and wells at the village are said to go into grey shale, which will probably belong to the Lower Lias; but it is just possible that the line of fault may be further to the south, and that these shales are part of the Oolite. On the next hill, as we have observed, the Grey Limestone is exposed at Thirkleby Barf, while the Middle Lias with *Cardium truncatum* is seen in the road at Hutton Sessay; it is therefore apparent that the line runs between these two places. At Highfield House Upper Lias was turned out of the well, while at Sessay Rectory, a short distance to the south, the well is in red marl. Further west marls and gypsum have been met with at several places between Sessay Park and Elmire, which are only a little way south of the sections in Jet Shales and ironstone in the railway cutting, and at Barf Hill respectively. The outcrop of the Lias in the Swale near Topcliffe gives similar evidence of a large break to the south as it does to the north, and white sandstones are proved in the wells at Rainton, which cannot be far from the line of fault. In the neighbourhood of the Ure the line is well marked by the relative position of the gypsum beds on the west side of the river, and the Magnesian Limestone which is exposed at Hall Garth Ponds on the east side.

Between these two main dislocations there is a small fault parallel to them in the village of Coxwold. The chief evidence for this fault is that the Calcareous Grit upon which the greater part of the village stands is thrown up to the south so as to outcrop at Holmtop Quarry, while the Oxford Clay which is exposed in the railway cutting at the station, and the Lower Oolite to the south are brought against it. South of Husthwaite is another east and west fault, the effect of which is very marked near the village. On the north side of this fault the Dogger forms the fine feature of Beacon Banks and the Upper Lias was proved to a depth of 40 feet in a well at Gibbet Hill, the Middle Lias being also seen at the village. On the south side the Dogger is exposed in the quarry below Highthorne, the difference in level between the two outcrops being about 100 feet. The Middle Lias is thrown forward to Thormanby, and must abut against Lower Lias beds, although the exact line of junction is hidden beneath the alluvium. Further in this direction it cannot be traced. East of Husthwaite this fault is rendered apparent in mapping the subdivisions of the Oolite at Garbut Gill and at Oulston, but it is dying out in this direction, and the ground being more or less covered with drift, the outcrop of the beds along the line is not very clear.

A branch of this fault runs down the valley from Garbut Gill, the effect of which is to throw down the beds on the west, so that the Hydraulic Limestone does not outcrop on this side, although quarried on the other; the base of the Oolite is also over 100 feet lower near Flower of May than it is on the hill opposite.

In the corner of the map at Mount Pleasant just below Crayke Hill are a group of small faults, the principal of these, which has an east and west direction running from the Oolite beyond Brandsby, has a downthrow to the north.* In this map the amount of throw is about 100 feet, by it a small patch of Upper Lias is brought against the Lower Lias of Crayke Hill; and in the town of Easingwold, just south of the edge of the map, the Middle Lias abuts against the Rhætic Beds and Keuper Marl.

On either side of this fault are two small branches, the northern of which brings the Lower Lias outcropping south of Hanover House against the Middle Lias, which was proved in the boring at Haverthwaites.† The southern branch repeats the outcrop of the Upper and Middle Lias on the south side of Crayke Hill, and there being no drift just here the line is fairly clear.

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* *See* Memoirs of the Geological Survey. Explanation of Quarter-Sheet, 96 S.E., p. 36.

† *See* page 26.

APPENDIX I.

WELL SECTIONS.*

Stokesley Brewery.

	Ft.	In.
Made ground	1	2
Beck silt	2	0
Sand and gravel, with many pebbles of Magnesian Limestone	30	0
Clay	30	0
Sump and sand	8	0
Brown clay	16	0
Sand	3	0

Picton Junction.

	Ft.	In.
Boulder Clay into yellow sandstone	130	0

Borehole in Coalpit Wood, Crathorne.

	Ft.	In.
Superficial deposits to Red Rock	30	0

Crathorne.

	Ft.	In.
Boulder Clay	75	0
Sand	39	0
Clay	6	0
Loam	15	0
Rock clay	12	0

Crathorne Grange.

	Ft.	In.
Boulder Clay	40	0
Red sandstone.		

Half-Round Plantation, Deighton.

	Ft.	In.
Clay and red marl	135	0

West Thorpe, near Great Smeaton.

	Ft.	In.
Clayey loam	34	0

Cowton.

Deep wells in clay.

Pepper Hall, near East Cowton.

	Ft.	In.
Clay	66	0

Birkby.

	Ft.	In.
Clay	30	0

* Other Well Sections are noted in the text.

HUTTON BONVILLE.

	Ft.	In.
Solid clay	100	0
Hard slabby shale	6	0
Fine gravel, having a large stream of water	5	0

LOVESOME HILL.

	Ft.	In.
Clay	32	0

LANGTON-HALL.

	Ft.	In.
Clay and sand	120	0

HOPE NURSERY, LEEMING LANE.

	Ft.	In.
Clay	15	0
Red sandstone with water	12	0

YAFFORTH.

	Ft.	In.
Sand	24	0
Hard grey sandstone.		

NORTHALLERTON; HIGH BARN, NORTH-WEST OF.

	Ft.	In.
Clay	36	0
Red rock	24	0

NORTHALLERTON; STATION WELL.

	Ft.	In.
Chiefly marl, with gypsum	29	0

NORTHALLERTON; FACTORY.

	Ft.	In.
Gravel and clay	27	0
Blue shale (marl?)	57	0

ROMANBY; NEW CHURCH.

	Ft.	In.
Gravel and strong clay	20	0
Clean, black, laminated clay.		

THORNTON-LE-MOOR; BREWERY.

	Ft.	In.
Red clay with pebbles	18	0
Hard red and green marl with gypsum	21	0
(Water stands in the well 12 feet from surface.)		

THORNTON-LE-MOOR; WELL, AT EAST END.

	Ft.	In.
Red and blue marl with gypsum	11	0
(Water stands 8 feet from surface.)		

THORNTON-LE-STREET.

	Ft.	In.
Blue marl	24	0

THE HALL.*

	Ft.	In.
Red marl, except a few feet at the surface	50	0

* Called *Wood End* on the Map; but this name seems not to be locally known.

THE HALL GARDENS.

	Ft.	In.
Red marl	21	0

MANOR HOUSE FARM.

	Ft.	In.
Marl and clay	17	0

PASTURE FIELD HOUSE.

	Ft.	In.
Soil and clay	16	0

BRICKYARD HOUSE.

	Ft.	In.
Soil and clay	15	0

BEAL HOUSE.

	Ft.	In.
A few feet of clay.		
Red marl	40	0
Gypsum, streaked with blue and red veins	44	0

OTTERINGTON STATION.

	Ft.	In.
Clay (drift)	18	0
Red marl	36	0

ABEL GRANGE.

	Ft.	In.
Drift	5	0
White and red shale (marl)	34	0

SOLBERGE* (SOWBER HILL ON MAP).

	Ft.	In.
Clay and sand	21	0
Red sandstone	30	0

SNAPE MIRES.

	Ft.	In.
Clay, with some sand in lower part	33	0

BALDERSBY FARM.

	Ft.	In.
Red sand	8	0
Red sandstone	50	0

Water stands 30 feet in the well.

BONDGATE BREWERY, RIPON.

	Ft.	In.
Sand and gravel	30	0
Limestone	2	0

MARTON-LE-MOOR.

Sandstone at 70 feet.

HIGH BROOMS.

Sandstone at 75 feet.

* Dr. Fairley gives an analysis of this water. Proc. Yorksh. Geol. Soc., vol. vii., p. 409, 1882.

APPENDIX II.

LIST OF SOME OF THE WORKS REFERRING TO THIS DISTRICT.

1782.

WILLAN, R. Observations on the Sulphur-Water at Croft, near Darlington. 8vo. *Lond.* Ed. 2, under a different title, in 1786.

1794.

TUKE, J. General View of the Agriculture of the North Riding of Yorkshire. (Map and Account of Soils.) 4to. *Lond.*

1821.

SMITH, W. Geological Map of Yorkshire. 4 sheets.

WINCH, N. J. Observations on the Eastern Part of Yorkshire. *Trans. Geol. Soc.*, vol. v., p. 545.

1822.

WINCH, N. J. On Blocks of Granite, Syenite, &c., embedded in Diluvium. *Ann. of Phil.*, Series 2, vol. iii., p. 373.

———— On the Geology of the Eastern Part of Yorkshire. *Ibid.* p. 374. (For reply and counter reply, *see* vol. iv., pp. 247, 339.)

1831.

ANON (T. E. L.) A Sketch of the Flora of Richmond, Yorkshire, as compared with that of Thirsk, in the same County. *Mag. Nat. Hist.*, vol. iv., pp. 34, 467 (*see also* p. 276).

1832.

MURCHISON, R. I. On the Occurrence of Stems of Fossil Plants in Vertical Positions in the Sandstone of the Inferior Oolite of the Cleveland Hills. *Proc. Geol. Soc.*, vol. i., p. 391.

1853.

PHILLIPS, JOHN. A Map of the Principal Features of the Geology of Yorkshire (scale, 5 miles to an inch). *York.* Ed. 2 in 1862.

1857.

MARLEY, J. Cleveland Ironstone. Outline of the Main or Thick Stratified Bed; its Discovery, Application, and Results, in connexion with the Ironworks in the North of England. *Trans. N. Engl. Inst. Mining Eng.* vol v., p. 165. Discussion, vol. vi., pp. 7, 187. (1858.)

1858.

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1861.

BEWICK, J. Geological Treatise on the District of Cleveland in North Yorkshire, &c. 8vo. *Lond.*

1864.

MARLEY, J. On the Discovery of Rock Salt in the New Red Sandstone at Middlesborough. *Trans. N. Inst. Mining Eng.*, vol. xiii., pp. 17, 92; and *Geologist*, vol. vi., p. 387. (1863.)

1868.

TUTE, J. S. The Geology of the Country near Ripon. *Proc. Yorksh. Geol. Soc.*, vol. iv., p. 555.

————. On certain Natural Pits in the Neighbourhood of Ripon, *Geol. Mag.*, vol. v., p. 178; and *Proc. Yorksh. Geol. Soc.*, vol. v., p. 2, 1870.

1870.

PEACOCK, W. H. On the New Red Sandstone of Cleveland and the Rock Salt discovered in it. *Trans. Cleveland Lit. and Phil. Soc.*, vol. ii.

1873.

HUDLESTON, W. H. The Yorkshire Oolites. Part I. *Proc. Geol. Assoc.*, vol. iii., No. 7, p. 283–333.

1875.

PHILLIPS, JOHN. Illustrations of the Geology of Yorkshire. Part I. The Yorkshire Coast. 3rd ed. Edited by R. ETHERIDGE. 4to. *Lond.*

1876.

HUDLESTON, W. H. The Yorkshire Oolites. Part II. The Middle Oolites. *Proc. Geol. Assoc.*, vol. iv., No. 6, p. 353.

TATE, R., and J. F. BLAKE. The Yorkshire Lias. 8vo. *Lond.*

1877.

BLAKE, J. F., and W. H. HUDLESTON. The Corallian Rocks of England. *Quart. Journ. Geol. Soc.*, vol. xxxiii., p. 315.

DAVIS, J. W. Unconformability of the Permian Limestone to the Red Rocks west of its escarpment in Central Yorkshire. *Proc. Yorksh. Geol. Soc.* vol. vi., p. 280.

1878.

HUDLESTON, W. H. The Yorkshire Oolites. Part II., section 2. The Coralline Oolites, Coral Rag, and Supracoralline Beds. *Proc. Geol. Assoc.*, vol. v., No. 8, p. 407.

1882.

CAMERON, A. G. Subsidences over the Permian Boundary between Hartlepool and Ripon. *Proc. Yorksh. Geol. Soc.*, vol. vii., p. 342.

FAIRLEY, T. On the Blowing Wells near Northallerton. *Ibid*, p. 409.

1884.

TUTE, J. S. On the Sequence of the Permian Rocks near Ripon. *Proc. Yorksh. Geol. Soc.*, vol. viii., p. 218.

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GENERAL MEMOIRS OF THE GEOLOGICAL SURVEY—*continued.*

The CARBONIFEROUS LIMESTONE, YOREDALE ROCKS and MILLSTONE GRIT of N. DERBYSHIRE. By A. H. GREEN, DR. C. LE NEVE FOSTER, and J. R. DAKYNS. (2nd Ed. in preparation.)

The BURNLEY COAL FIELD. By E. HULL, J. R. DAKYNS, R. H. TIDDEMAN, J. C. WARD, W. GUNN, and C. E. DE RANCE. 12*s.*

The YORKSHIRE COALFIELD. By A. H. GREEN, J. R. DAKYNS, J. C. WARD, C. FOX-STRANGWAYS, W. H. DALTON, R. RUSSELL, and T. V. HOLMES. 42*s.*

The EAST SOMERSET and BRISTOL COALFIELDS. By H. B. WOODWARD. 18*s.*

The SOUTH STAFFORDSHIRE COAL-FIELD. By J. B. JUKES. (3rd Edit.) (*Out of print.*) 3*s.* 8*d.*

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The LEICESTERSHIRE COAL-FIELD. By EDWARD HULL. 3*s.*

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Scale, one inch to a mile.

Anglesey, 78 (SW).
Bristol and Somerset, 19, 35.
Coalbrook Dale, 61 (NE & SE).
Clee Hill, 53 (NE, NW).
Flintshire and Denbighshire, 74 (NE & SE), 70 (NE, SE).
Derby and Yorkshire, 71 (NW, NE, & SE), 82 (NW & SW), 81 (NE), 87 (NE, SE), 88 (SE).
Forest of Dean, 43 (SE & SW).
Forest of Wyre, 61 (SE), 55 (NE).
Lancashire, 80 (NW), 81 (NW), 89, 88 (SW, NW).
Leicestershire, 71 (SW), 63 (NW).
Northumberland & Durham, 103, 105, 106 (SE), 109 (SW, SE).
N. Staffordshire, 72 (NW), 72 (SW), 73 (NE), 80 (SE), 81 (SW).
S. Staffordshire, 54 (NW), 62 (SW).
Shrewsbury, 60 (NE), 61 (NW & SW).
South Wales, 36, 37, 38, 40, 41, 42 (SE, SW).
Warwickshire, 62 (NE SE), 63 (NW SW), 54 (NE), 53 (NW).
Yorkshire, 88 (NE, SE), 87 (SW), 92 (SE), 93 (SW).

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Scale, six inches to a mile.

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Sheet.
15. Ireleth.
16. Ulverstone.
17. Cartmel.
22. Aldingham.
47. Clitheroe.
48. Colne, Twiston Moor.
49. Laneshaw Bridge.
55. Whalley.
56. Haggate.
57. Winewall.
61. Preston.
62. Balderstone, &c.
63. Accrington.
64. Burnley.
65. Stiperden Moor.
69. Layland.
70. Blackburn, &c.
71. Haslingden.
72. Cliviger, Bacup, &c.
73. Todmorden.
77. Chorley.
78. Bolton-le-Moors.
70. Entwistle.
80. Tottington.
81. Wardle.
84. Ormskirk, St. Johns, &c.
85. Standish, &c.
88. Adlington, Horwick, &c.
87. Bolton-le-Moors.
88. Bury, Heywood.
89. Rochdale, &c.
92. Bickerstaffe.
93. Wigan, Up Holland, &c.
94. West Houghton, Hindley.
95. Radcliffe, Peel Swinton.
96. Middleton, Prestwich.
97. Oldham, &c.
100. Knowsley, Rainford, &c.
101. Billinge, Ashton, &c.
102. Leigh, Lowton.
103. Ashley, Eccles.
104. Manchester, Salford, &c.
105. Ashton-under-Lyne.
106. Liverpool, &c.
107. Prescott, Huyton, &c.
108. St. Helen's, Burton Wood.
109. Winwick, &c.
111. Cheedale, Stockport, &c.
112. Stockport, &c.
113. Part of Liverpool, &c.

Durham.

1. Ryton.
2. Gateshead.
3. Jarrow.
4. S. Shields.
5. Greenside.
6. Winlaton.
7. Washington.
8. Sunderland

Durham—*continued.*

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53. Winston.

Northumberland.

44. Rothbury.
45. Longframlington.
48. Broomhill.
47. Coquet Island.
54. Longhorsley.
55. Ulgham.
56. Druridge Bay.
63. Netherwitton.
64. Morpeth.
65. Newbiggin.
72. Bedlington.
73. Blyth.
80. Cramlington.
81. Earsdon.
82. NE. of Gilsland.
83. Coadley Gate.
87. Heddon.
88. Long Benton.
89. Tynemouth.
91. Greenhead.
92. Haltwhistle.
93. Haydon Bridge.
94. Hexham.
95. Corbridge.
96. Horsley.
97. Newcastle.
98. Walker.
101. Whitfield.
102. Allendale Town.
103. Slaley.
105. Newlands.
106. Blackpool Br.
107. Allendale.
108. Blanchland.
109. Shotleyfield.
110. Wellhope.
111. Altenheads.
112. ——

Cumberland.

55. Searness.
56. Skiddaw.
63. Thackthwaite.
64. Keswick.
65. Dockraye.
69. Buttermere.
70. Grange.
71. Helvellyn.
74. Wastwater.
75. Stonethwaite Fell.

Westmorland.

2. Tees Head.
8. Dufton Fell.
12. Patterdale.
18. Near Grasmere.
25. Grasmere.
38. Kendal.

Yorkshire.

7. Redcar.
9. ——
12. Bowes.
13. Wycliffe.
20. Lythe.
24. Kirkby Ravensworth.
25. Aldborough.
32. Whitby.
33. ——
33. Marske.
39. Richmond.
46. ——
47. Robin Hood's Bay.
53. Downholme.
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