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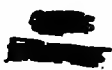


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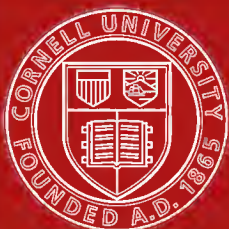
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MEMOIRS  
OF THE  
GEOLOGICAL SURVEY  
OF  
GREAT BRITAIN  
AND OF THE  
MUSEUM OF PRACTICAL GEOLOGY.

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THE GEOLOGY OF .  
THE COUNTRY AROUND OLDHAM,  
INCLUDING  
MANCHESTER AND ITS SUBURBS.

(SHEET 88 S.W., AND THE CORRESPONDING SIX-INCH MAPS 88, 89,  
96, 97, 104, 105, 111, 112 ; LANCASHIRE 259, 271.)

BY  
EDWARD HULL, B.A., F.G.S.  
WITH AN APPENDIX ON THE FOSSILS;

BY  
J. W. SALTER, A.L.S., F.G.S.

---

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

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## AUTHOR'S PREFACE.

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IN the survey of the northern portion of this Sheet, especially in the neighbourhood of Rochdale, and the mountainous tract around Delf and east of Staleybridge, I had the benefit of the assistance of my colleague, Mr. A. H. Green.

It is my agreeable duty to acknowledge, on the part of Mr. Green and myself, the assistance received from the colliery proprietors and managers in the neighbourhood of Rochdale, Oldham, Ashton-under-Lyne, and Manchester, without which it would have been impossible to carry out an accurate geological survey of the district.

Amongst so many to whom our acknowledgments are due, we may particularly mention Mr. Higson, Her Majesty's Inspector of Mines, and his sons, who were always ready to give us the benefit of their knowledge of the Coal-measures of Ashton-under-Lyne; Mr. Peace, manager of Lord's Field Colliery; Mr. Garside, manager of Mr. Buckley's colliery; Mr. Astley, proprietor, Mr. Charlton, manager, and Mr. Seddon, underlooker, of the Great Dukinfield Collieries; Mr. Wyld, of Staleybridge, who kindly accompanied me in examining the sections along the new road between that town and Ashton-under-Lyne; Mr. Fletcher, the trustee, and Mr. Bains, manager, of Haughton Colliery; J. Redfern, underlooker, who kindly assisted me in examining the river section in that district, with which he has a life-long acquaintance; Mr. Goodwin, of Hyde; Mr. Clayton, manager of Mr. Jowett's collieries; the proprietor and manager of Mottram Colliery; Mr. J. Hibbert, manager of Mr. J. Harrop's colliery Bardsley; Mr. Wyld and Mr. Collinge of Glodwick; Messrs. Baily and Marland of Cross Colliery, near Oldham. To the former gentleman I am specially indebted for personal assistance on several occasions. Mr. Butterworth, of Bent Grange Colliery; Mr. Mayall, of Oldham Edge Colliery; Mr. Bagnall, of Royton Colliery; Mr. Evans, of Edge Lane Colliery.

To Mr. Livesey and his son we are indebted for assistance both in the neighbourhood of Middleton and Manchester.

The proprietors and managers of the collieries of Moston, Middleton, Hopwood, Boarshaw, and Crompton, afforded us ready assistance in elucidating the structure of a rather obscure tract of country.

For information on the district around Rochdale our thanks are also due to Mr. Roscoe, of the firm of Messrs. Roscoe and Lord, Mr. W. Beswicke, the Messrs. Knowles, Messrs. Fishwick, Mr. Lomax, Mr. Stott, and Mr. Whitehead, mineral surveyor. Nor must we forget to name Mr. John Smith, of Bagslate, the underlooker of Bamford Colliery.

In our investigations on the structure of the Manchester Coalfield and neighbourhood we received much assistance from Mr. Mellor and son, the managers of the limestone pits of Messrs. W. Brocklehurst and Co., Mr. Bradbury and son, of Clayton Colliery, and Mr. Livesey and son, of Bradford Colliery. We have also had recourse to the publications of Mr. E. W. Binney, F.R.S., in the Transactions of the Geological, and the Literary and Philosophical Societies of Manchester, as well as the communications of other authors, which have thrown so much light on the structure of that interesting district.

From the Chamber Colliery Company no information could be obtained.

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# GEOLOGY OF THE COUNTRY AROUND OLDHAM, &c.

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## CHAPTER 1.

### *Physical Geography.*

THE district embraced by this memoir includes portions of the counties of Lancashire, Yorkshire, and Cheshire, the boundaries of the three counties meeting at a point on the river Tame, near Mossley. It comprehends also the following important towns:—Manchester at the south-west, Rochdale at the north, Ashton-under-Lyne and Staleybridge near the south, and Oldham in the centre. It is traversed by portions of several considerable streams:—The river Roch, which taking its rise in the high moorlands north of Rochdale, passes through that town, and after winding through some hilly ground, composed of Lower and Middle Coal-measures, and opening out several fine sections in these strata, joins the Irwell, south of Bury.

The Irk, which wanders through many miles of the central and western parts of the Sheet,\* except in the immediate neighbourhood of Manchester, is almost valueless for any light it throws on the geological structure of the district. After tracing this stream to its source, the geologist is disappointed in his hopes of finding sections cut down into the solid strata, and the only object which meets his eye at every elbow of the stream are banks of sand and boulder clay.

A similar statement is applicable to the Medlock, the sections which it affords being almost exclusively contained within a short distance of Manchester and the neighbourhood of Bardsley. These, however, are of such interest as somewhat to atone for the unproductiveness of the stream in a geological point of view throughout the remainder of its course.

The most interesting of all the streams which traverse this tract, both for the number and value of the geological sections it opens up, and the beauty of the scenery along its banks, is the river Tame. It takes its rise in the high moorlands at the north-east of the district, which form the watershed of this part of England. It then flows southward, gathering strength as it goes, by the confluence of several mountain streams, of which the principal are Diggle and Greenfield brooks, also having their sources at the watershed, and continues southward to Staleybridge, when it bends sharply to the west, crossing the whole of the Coal-series at Ashton-under-Lyne, and then turning again to the southward, flows into the Mersey near Stockport. Thus within a distance of about 12 miles, measured in a straight line along its course, and obliquely to the general strike of the strata, this river passes from the Limestone Shale or Yoredale Rocks, through the

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\* Sheet 88 S.W., one-inch scale, of the Ordnance and Geological Surveys.

Millstone Grit, Lower, Middle and Upper Coal-measures, and Permian formations up into the New Red Sandstone, in many places affording interesting and instructive views of the formations. These sections are often cut down through a thick covering of Drift deposits of clay and sand; and the river as it flows passes gradually from the mountainous tract of the "back-bone" of England into the rich and picturesque scenery of lowlands.

All the rivers here referred to ultimately flow into the Mersey, and thus reach the Irish Sea at Liverpool.

The scenery of the tract embraced by this Sheet is highly diversified, and corresponds more or less with its geological structure. As a general rule, the lowest formations form the highest ground. The tract composed of New Red Sandstone, Permian, and Middle Coal-measures, is for the most part flat, the hills are mere undulations, formed generally of drift sand. The highest ridge in the Coal-measures is Oldham Edge, formed of a very massive red sandstone, called the "blenfire rock," which there reaches an elevation of 800 feet, and in its extension southward to Glodwick Low, rises 745 feet; but these are exceptional elevations for this part of the Coal-series.

Beyond the margin of the Middle Coal-measures there is a tract of hilly country composed of Lower Coal-measures or Gannister beds. This extends along the northern edge of the map by Birtle and Rochdale to Helpet Edge, and southward to beyond Staleybridge. It generally consists of parallel ridges of flagstone and grit, divided by valleys of shale. Reaching higher elevations than the beds of the Middle Coal-measures, but lower than those of the Millstone Grit, the Gannister beds form, both in geological position and in their outward configuration, an intermediate group, distinguishable from, yet closely related to, both. Some of its hills reach considerable elevations. Thus Tunshill Hill reaches a height of 1,000 feet, Helpet Edge 1,287 feet, Besom Hill 1,150 feet, Count Hill 1,025 feet, Boardman's Edge 911 feet, May Hill north of Staleybridge, 800 feet. The same range of hills extends southward into Cheshire, by Marple, Disley, and Kerridge.

To the northward and eastward of the range just described, the high moorlands of Lancashire and Yorkshire commence. This tract is in reality a section of that central ridge which stretches from Derbyshire northward to the borders of Scotland, generally known as the Penine chain, or back-bone of England. It marks the position of a great anti-clinal axis, along which the Lower Carboniferous Rocks have been upheaved, and by means of which the Lancashire Coal-field has been disunited from that of Yorkshire. This tract extends along both sides of the wide valley of the Tame, from Staleybridge northwards; but its more elevated portion is to the east and north of this valley. Here the hills rise into an elevated table-land, intersected by deep valleys opening out into that of the Tame. The table-land terminates westward in a series of bold bluffs and declivities, of which Warlow Pike, Buckton Castle, and Harridge Pike are the most prominent, and which end off along the line of a great fault, presently to be described. It is covered with heather, and abandoned to the use of sheep and grouse. The edges of the escarpments and the sides of the valleys are often formed of cliffs of massive dark grit, which are remarkably fine when viewed from several points along the valley of Greenfield brook. These cliffs, when traced further into the uplands, give rise to rapids and waterfalls in the brooks which descend from the moors; the torrents often rush down with great violence after heavy rains, and leave their effects visible for years. The cliffs, which form the crests of the ridges, often afford good illustrations of denudation (*see* Fig. 1): fantastically shaped

*Fig. 1.*

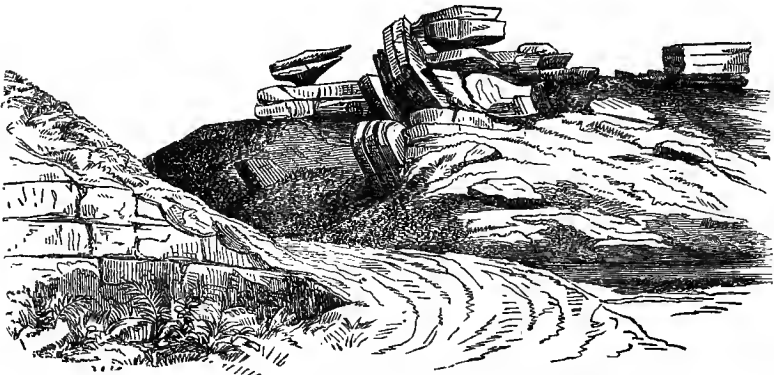
OLD COAST CLIFFS, OVERLOOKING CHEW VALE, BORDERS OF CHESHIRE AND YORKSHIRE.



portions of the rock standing out isolated from the main mass of the cliff, just as we often see in rocky coasts. Similar rocks are also seen on the upper surfaces of the moorlands, such as the "Rocking Stones," and "Pots and Pans,"\* near Greenfield. Whatever difference of opinion may exist as to the origin of the castellated projections along the edges of the escarpments, which might possibly have been produced by atmospheric agencies acting along the lines of jointage, there can scarcely be any, with reference to such cases as that shown in the woodcut (Fig. 2) as having been produced by the waves of the old Glacial Sea.

*Fig. 2.*

ROCKING STONE, BORDER OF LANCASHIRE AND YORKSHIRE.



\* Incorrectly marked as Druidical remains on the Ordnance Map.

The general structure of the district will now be easily understood. At the south-west corner is the highest formation, the New Red Sandstone, with a fringe of Permian beds, stretching about four miles to the north and east of Manchester, and containing within its area the small isolated tract of upper Carboniferous Rocks which form the Manchester Coal-field. Beyond the margin of the Permian strata (which owing to the deep covering of Drift overspreading the district is somewhat indeterminate) occurs a broad band of Coal-measures in the form of a semicircle, or rather of the two sides of a square with the corner rounded off, and sending off several projections towards the north. In point of fact, this district contains the extreme easterly margin of the great Lancashire Coal-field. It is here that the trend of the Coal-measures, which from their western border, towards Liverpool, has been on the whole from west to east, changes from north to south, and at Dukinfield passes into Cheshire. It is therefore a very interesting stage in its course; and it is remarkable to observe how this sudden bend of the strata has been accompanied by several large dislocations, which in the neighbourhood of Heywood and Rochdale repeatedly "throw in" the valuable coal known as the *Arley Mine* beyond its successive outcrops. Having crossed the belt of the Coal-measures, we then reach that of the Gannister series, rising from beneath the newer strata to the northward and eastward, and next in turn the Millstone Grit, which, as far as the valley of the Tame, for the most part dips rapidly towards the west.

Hitherto the dip of all the formations described has been invariably in the direction of Manchester. Along the northern part of the map it has been southward, further north-east it has been towards the south-west, and from Oldham southwards it has been westerly; but when we reach the valley of the Tame a change ensues. In consequence of a powerful upheaval of the beds along a line running north and south from March Hill to Harrop Edge, and visibly expressed by several lines of dislocation and sharp foldings of the strata, the dip here changes to the eastward, and continues so more or less constantly across the mountain tract of the Pennine chain into the Yorkshire Coal-field. We pass at this line from the *Lancashire dip* to the *Yorkshire dip*; and almost immediately after leaving this focus of subterranean energy the strata assume an arrangement of great regularity, and decline gently at first, more rapidly afterwards, towards the east.

In the following pages the rocks are described in ascending series, and are thus arranged in their order of super-position:—

FORMATIONS.	SUB-FORMATIONS.
Post Pliocene or Drift -	- { 1. Upper Boulder Clay. 2. Sand and Gravel. 3. Lower Boulder Clay.
New Red Sandstone or Trias	- Pebble beds, or Conglomerate.
Permian rocks -	- { 1. Upper Permian marls, with limestone. 2. Lower Permian sandstone.
Carboniferous rocks - -	- { 1. Upper Coal-measures. 2. Middle Coal-measures. 3. Lower Coal-measures, or Gannister beds. 4. Millstone Grit. 5. Limestone shale, or Yoredale rocks.



## CHAPTER II.

## GEOLOGICAL FORMATION.

*Upper Limestone Shale, or Yoredale Rocks.*

This series of beds,—the lowest part of the Carboniferous Group shown in this Sheet,—occurs as a narrow band, occupying the valley of the Thame from Millstone Edge to Harrop Edge, a distance of about 10 miles. In the direction of Saddleworth it occupies both sides of the anticlinal already described,\* and is surmounted by the basement beds of the Millstone Grit, which form the upper portions of the hills on both sides of the valley. It runs far up into the valleys of Greenfield and Diggle brook, and from Warlow Pike southward, extends along the edge of the great Penine fault to the southern extremity of Harrop Edge. The woodcut (Fig. 3) will show the position of these beds at Saddleworth, and (Fig. 4) their position east of Staleybridge.

Fig. 3.

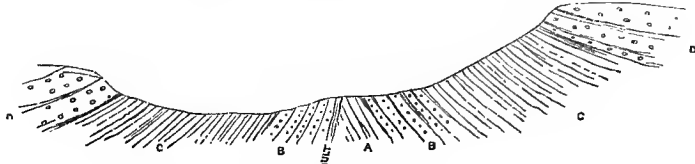
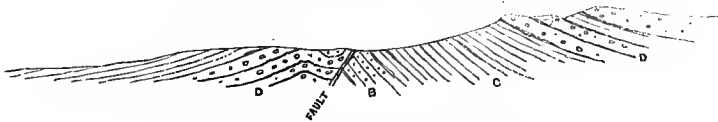
*Position of Fault at Saddleworth.*

Fig. 4.

*Position of Fault near Staleybridge.*

Millstone Grit—D. Kinder Scout Grit.

Yoredale Rocks { C. Grey micaceous shale.  
B. Fine-grained grits.  
A. Shale.

The base of this group nowhere appears in this district, and consequently we have no precise data for ascertaining the depth of the underlying Carboniferous Limestone. The lowest beds brought to light occur along both sides of the great fault near Upper Mill.

The succession of the Yoredale series, so far as they are represented in this district, is well shown in the brook courses along the flanks of the hill called "Pots and Pans," south of Saddleworth, and, with the exception of the lowest beds, is represented in the sections (Figs. 3 and 4). The lowest beds consist of flaggy sandstone and dark shales, about 60 feet in thickness (*a*, Fig. 3); then come a series of flaggy sandstones and grits, generally fine-grained, attaining a thickness of about 150 feet, and forming a well-marked band on both sides of the anticlinal axis (*b*, Figs. 3 and 4). Above these, grey micaceous shales, which in a section under Harridge Pike† are shown to be 600 feet in thickness. These shales are surmounted by the coarse massive grit of the Millstone series. We have therefore a thickness of more than 1,000 feet of strata without reaching the base. I have no doubt whatever, that

\* Page 5. Can the name of this valley have any reference to the saddle-shaped arrangement of the rocks?

† In a brook section of 220 yards in length, at Clough, under Buckton Castle Hill.

even the lowest beds here shown are several hundred feet above the Limestone, both from the fact of their being composed of sandstones, and also because a section of the whole series down to the Limestone, at Pendle Hill, near Burnley, gives a thickness of 1,800 or 2,000 feet. In this section the beds which *approach* the Limestone, throughout several hundred feet, are all composed of shales, with bands of black limestone appearing in their lower parts, and over these lie flagstones, which not improbably represent the lowest beds shown in this neighbourhood. Any attempts, therefore, to reach the Limestone by sinking in the valley of the Tame should be discouraged, as it is probable that the thickness of intervening strata may prove to be at least 500 feet, while the depth would be considerably increased by the steep angle at which the beds are inclined near the centre of the anticlinal.

The sandstones (*b*, in Fig. 3) form a narrow band on each side of the fault from Harrop Dale southwards.\* They are shown in the cutting at the entrance to Diggle Tunnel; in a quarry at Diggle Mill, dipping east at 50°, and on the opposite side of the axis, in the railway cutting, dipping west at 65°. They are again shown in quarries east of Saddleworth Fold, and at Heathfield, also on opposite sides of the axis; in brook sections at Cross Farm, near Upper Mill, already described; and in quarries above Waterside Mill and Greenfield Mill, along the flank of Alphin Brow. As a building stone they are of a very inferior quality, and only suited for the commonest work.

This series of beds, though often searched by fossil collectors and myself, have hitherto yielded no fossil remains, except small fragments of carbonized plants and annelide-tracks.

#### *Millstone Grit.*

This formation consists of a series of conglomerates, coarse and fine grits, flags, and shales, with several thin coal-seams. There are in this district four principal members of sandstone and two of shale, each subject to local variations, but, on the whole, preserving their identity from Pule Hill southward for many miles along the borders of Derbyshire and Yorkshire. The following is the order of super-position of the principal masses of grit with their underlying shales.†

1. *Rough Rock*.—*a*. Coarse massive grit of Brown Edge.  
*b*. Shale series, very thin, and generally absent in this district.
2. *Second Grit*.—*c*. Flagstones, close under the Rough Rock.  
*d*. Shale series, with thin coal at base, and a workable seam at Mossley and Mottram.
3. *Third Grit*.—*e*. Massive coarse grit, between two beds of flagstones.  
*f*. Shale series, with thin coal.
4. *Kinder Scout Grit*.—Massive coarse-grained grit and conglomerate, in several beds, with partings of shale.

These divisions are by no means so strongly marked in this sheet as they are in that to the south, where they form, as at Coomb Edge and Chinley Churn, a series of escarpments, each composed of its bed of sandstone and subordinate shale, rising in succession to the eastward,

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\* This band of sandstone in the Limestone Shale represents "the shale grit" of Farey, and is continuous all over this part of England, occupying a position about half way down from the Kinder Scout Grit to the Carboniferous Limestone. Around the Peak the shale grit is several hundred feet in thickness.

† The series given above differs from that of Mr. E. W. Binney, F.R.S., who makes the Millstone Grit series terminate upwards with the "Third Grit" in the above series, and throws the 1st and 2nd grits into the Lower Coal-measures. See Mr. Binney on the "Lancashire and Cheshire Coal-field." *Trans. Geol. Soc. Manchester*, vol. i., p. 78.

and, even when viewed from a distance, indicating to the observer the true nature and succession of the beds. There are, however, in the district under consideration, two nearly complete sections from the Limestone Shale to the Rough Rock, which will serve as guides to others less complete.

*Kinder Scout Grit.*—This term was proposed by my colleague Mr. A. H. Green and myself during our excursions over the Millstone districts where we conjointly worked together, to denote that group of massive grits and conglomerates which rests upon the Yoredale Rocks, and composes the greater part of the Yorkshire moorlands along the eastern border of the sheet. The name was suggested by the fact lately ascertained by Mr. Green, that it is the rock which forms the high table-land of Kinder Scout in the Peak country.\* It may be traced along both sides of the valley of the Tame, forming the ridge which stretches from Warmton Wood to Harrop Edge; also from Broadhead Noddle round by Millstone Edge, Diggle Edge, Ravenstone Brow, the escarpments of Greenfield and Chew Brook Valley, Buckton Castle Hill, Harridge Pike, and along the heights east of Staleybridge, to Roe Cross and Harrop Edge, in Cheshire, where it terminates against a large fault. It also forms the moorland of Tintwistle and the fine prominences of Peak Nab, Tintwistle Knarr, Ravenstones, and Charnel Rocks. The highest point attained within this sheet is at Long Ridge, 1,709 feet; but at Black Hill, only a mile or so to the east, the elevation attained is 1,909 feet. The cliffs of dark grit which form the heights along Chew Brook and Greenfield are remarkably fine, and above Ashway gap have somewhat the aspect of basaltic columns, owing to the vertical joints and fissures by which they are traversed. The scenery is here bold and impressive, and very refreshing to an inhabitant of a Lancashire town.

The Kinder Scout Grit is very well shown along the road to Huddersfield, where it crosses Millstone Edge. There are here three principal beds of grit, separated by two beds of shale, on one of which Stand Edge Reservoir is situated. Further on we reach a series of dark shales interposed between the Kinder Grit and the Third Grit (3, Fig. 5). Then the second shale with coal, forming the flat partially occupied by Redbrook Reservoir. Then a bed of sandstone, quarried for road material at Great Nab End, encircling the lower flank of Pule Hill. The steep slopes of the hill are formed of the first shale series, containing *Goniatites spiralis* and a coal-seam half a foot thick, formerly worked by tunnelling. At the top of the hill we reach what we suppose to be the Flagstone and Rough Rock, which form the upper limit of the Millstone Grit series. This section, which corresponds nearly with the course of the Stand Edge railway and canal tunnels, will give a general view of the succession in this part of Yorkshire.†

---

\* This is the principal Millstone rock of Farey, who with great perseverance tracked its course over a large part of the borders of Derbyshire and Yorkshire, and has tabulated its chief localities in his work on the history of Derbyshire. In the direction of Leek and Macclesfield, however, the Kinder Scout Grit is much reduced in thickness, and becomes finer in grain, so that it ceases to occupy that prominent position it attains in the Peak country. The Third Grit here plays the part of the older grit in the production of hills, and has thus been very naturally mistaken by Farey for the Kinder Scout rock.

† I confess, however, that there exists in my mind much uncertainty regarding the identity of the Pule Hill Grit with the "rough rock," from the fact, that if this is the case, the series is much thinner here than it ought to be considering the position of the hill, or than it is at Mossley, not any great distance from this point. From the isolated position of the hill, the stratigraphical position of the beds cannot be determined with certainty, and it is quite possible the Pule Hill Grit may be either the second or third members of the series.

*Fig. 5.*

## SECTION ACROSS MILLSTONE EDGE AND PULE HILL.



The thickness of the Kinder Scout Grit along this section is about 500 feet.

At Saddleworth the thickness is considerably greater, owing to the expansion of one of the beds of shale. There along the road from Greenfield to Sheply the upper bed of grit forms a second ridge, and judging by the contour lines the subdivision reaches a thickness of 600 to 700 feet.

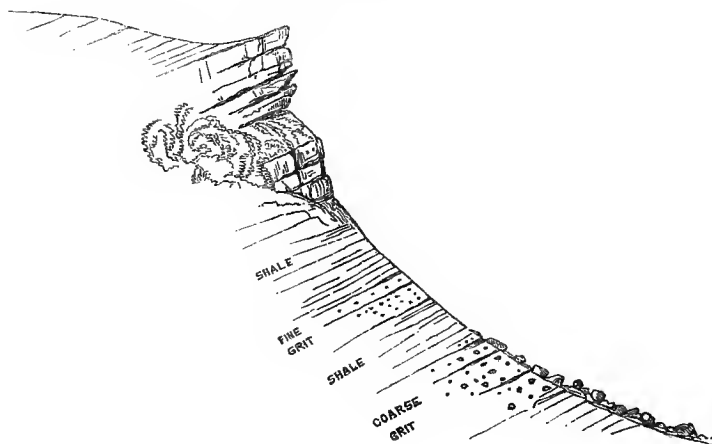
The rock is largely quarried on both sides of the Saddleworth Valley for millstones, engine-beds, and massive foundation stones. Some of the finer beds afford paving stones, and even flags, as well as ordinary building stone; and the rock generally retains its colour, and is not subject to discoloration by iron-stains. It is also quarried near Greenfield station at the foot of Warmlow Wood, where we find the beds thrown into a nearly vertical position, owing to a neighbouring large fault which branches out of the Penine fault. At Mossley the thickness is over 700 feet without reaching the base.

One of the finest sections in the Kinder Scout Rock is shown along the Mottram and Staleybridge road at Roe Cross. The beds here rest on the limestone shale which appears at the west end of the cutting. The dip is eastward at angles varying from 50 to 15 degrees, and the thickness of the subdivision is about 1,000 feet.

These measurements will afford a good idea of the variations in the development of these beds as regards thickness. It is not less remarkable as regards mineral character. The upper bed of grit, which forms the cliff on the south of Chew Brook at Slack Head Brow, is underlaid by shales which may be traced down one of the little gullies which descend from the heights into the valley (*Fig. 6*); the thickness of

*Fig. 6.*

## WHIMBERRY STONES.

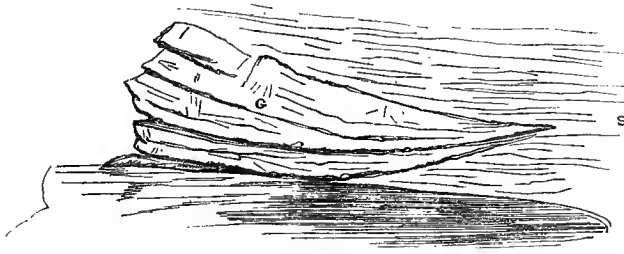


these shales is at least 250 feet. On the north side of the valley the same shales are partially replaced by a massive bed of coarse grit which occupies one-half of the thickness; and still further to the north-east these shales appear to be altogether replaced by massive grits, if we may judge by the section afforded by the brook which descends in a series of rapids or cascades into Chew Brook. The whole of these changes is effected within a distance of 2 miles.

One example of the kind on a smaller scale, taken from actual observation, is shown in Holm Clough along Greenfield Brook. Here a bed of coarse grit (g, Fig. 7) 12 feet in thickness, imbedded in

Fig. 7.

SKETCH IN HOLM CLOUGH.



shales (s.), thus out to a point within a distance of 30 feet. Many similar examples were observed by Mr. Green and myself during our explorations of the deep recesses of these Yorkshire moors.

The mineral character of this rock is generally that of a very coarse grit, passing into a conglomerate of white and coloured quartz. The pebbles of quartz are invariably rounded, and sometimes reach an inch in diameter. In the neighbourhood of Tintwistle the beds appear more than usually full of pebbles. Current planes are prevalent, and are generally found to dip westward at angles of about 30 degrees. Carbonized plants and impressions are to be found, but not so frequently as in the higher beds of the Millstone Grit series. The shales have afforded no fossils to the collector of the Survey.

*Third Grit.*—The shales which succeed the Kinder Scout Rock are shown in the section near Pule Hill already described (Fig. 5). They are there generally dark, and contain a coal-seam 5 inches in thickness, which overlies the lower beds of grit, more or less constantly, all over the district. They vary from 100 feet at the section to more than three times that amount near Mossley; and are exposed in the deep cutting of the Oldham and Greenfield Railway near Grass Croft. They sometimes becomes flaggy and micaceous. They are succeeded by the Third Grit, which is extremely well shown at Mossley, both in quarries and in the river-section at Scout Mill. The beds consist there of—

	ft.
1. Flaggy micaceous sandstone	70
2. Coarse-grained massive grit	- 80
3. Micaceous flags and shale	- 50

The dip is to the south-west at 15 degrees. This rock is also shown in quarries at Friar Mere, south-east of Staleybridge, where the rock-faces and planes of jointage exhibit remarkable examples of horizontal striation and polishing, somewhat resembling the effects produced by ice in other districts. The grit also appears west and south of Tintwistle, and at

Mouslow Castle Hill, where it is of a rusty aspect, and altogether unfit for building purposes. Traced southwards along the borders of Derbyshire, it becomes a very coarse red grit; and forms finely moulded escarpments from Glossop, by Matley Moor, Hayfield, Cracken Edge, and Eccles Pike. The average thickness is 200 feet; it is seldom a conglomerate, and in this respect differs from the underlying beds of grit.

*Second Shale series.*—Above the third grit is a series of shales, shown in a gully at Great Warcock Hill. They are sandy, of a grey colour, and contain a coal of 2 inches resting on a floor of fire-clay. In the brook near the Old Moorcock Inn I found *Goniatites* and *Aviculo-pecten* overlying the coal. The rock which overlies these consists of compact fine-grained grits used for road metal, and quarried at Great Nab End. It is also opened in quarries along the right bank of the brook west of Old Delf, and again in a cliff above Scout Mill, from which it takes the name of "Scout Rock." In all these places it underlies a coal-seam; and its thickness varies from 20 to 30 feet. Above this Rock is a thick series of black and dark grey shales, containing a coal-seam near the base, which has been worked at Pule Hill, also along the side of the valley from Old Delf to Junction, at Mossley, and at Mottram. At these last two places it varies in thickness from 2 to 3 feet, and contains a good deal of iron pyrites. The roof contains *Goniatites* of more than one species. It is the lowest workable coal of the district, and south of Glossop is known by the name of the "Simmondsley Mine." The shales which overlie it are 150 feet thick at Mossley.

*Second Grit.*—If we compare the Millstone series in this district with that further south, in the neighbourhood of Whaleybridge, we find a certain amount of variation between the two sections in the upper part, which has occasioned some difficulty in the way of showing their relationship to one another. After considerable hesitation, and many comparisons of sections, I believe I have now ascertained the cause of the variation. In the Whaleybridge district the rough rock, or first grit, is underlaid by 100 or 150 feet of shales, by which it is separated from the second grit or flagstones. This shale-series (*b* in the table p. 10), however; when traced northwards towards Mottram, gradually thins away, being only a few feet in thickness in that place, and thus the first and second grits approach each other, and actually meet at Broadbottom. When writing this memoir I had taken the Scout rock of Mossley as the representative of the second grit, but have since satisfied myself that it is only an accidental bed of sandstone, and is the same which occurs on the flank of Pule Hill.

*Rough Rock and Flags.*—This seems to be the grit which forms the escarpment of Pule Hill (*see* Frontispiece), one of the most striking landmarks in this part of Yorkshire. Seen from the south it rises as an isolated hill to a height of some 200 feet above the table-land of the Kinder Scout Grit; while its summit is fringed by a line of dark, serried crags, which gradually fall away towards the north and north-east. The escarpment is formed of coarse massive grit, traversed by two systems of joints, which cross each other at an angle of about 70 degrees, and divide the rock into a multitude of angular blocks, projecting from the ridge in a series of sharp edges, instead of the even wall of rock which more generally forms the crests of the hills. The thickness of the grit is about 15 feet, and it overlies beds of fine-grained flaggy sandstone, which form the ridge of the northern part of the hill. The same series also forms the conspicuous cliff of Hard Head, and the ridge of Shooters Nab, which reaches an elevation of 1,400 feet, exactly the same as that of Pule Hill.

The Rough Rock, in the form of a coarse grit, and conglomerate with rounded pebbles of quartz, shows itself all along the ridge, near the summit, from Brownstead Edge to Knob Hill above Old Delf. Here it terminates against a large fault which brings up the Kinder Scout Rock on the east. It again appears in quarries at Barn Edge, with the underlying flagstones, which are quarried near Grotton Hall; and from this we may trace it along the crest of Brown Edge above Mossley, gradually becoming thinner toward the south, till it actually thins out before reaching the valley of the Tame at Staleybridge. Its position however may be traced by the underlying flagstones, which are continuous, and cross the river at a cotton-mill about a quarter of a mile east of St. George's Church. The flags are overlaid by shales, which may be traced continuously upward to Staleybridge, so that the Rough Rock is here certainly absent. Further south the flags form the ridge of Early Bank Wood.

The Rough Rock re-appears at Mottram, and a continuous section from outcrop of the Mottram coal upwards into the Lower Coal-measures may be traced along the brook-course which crosses the railway a short distance west of the station. The grit is also very finely exhibited in the river cliff, at Broadbottom Bridge, it is there some 40 or 50 feet in thickness.

Throughout the greater part of its range, the Rough Rock is accompanied by a coal-seam, which from its peculiar fracture has been termed by Mr. John Hall the "Feather-edge" coal.\* This seam is largely worked north of Rochdale at Spotland and Woodhouse Mill.† It varies in thickness at these places from 20 to 30 inches, and is of good quality. Its floor is composed of sandy-micaceous under-clay, but its roof varies much, sometimes being coarse grit, at other times black shale with fossil shells. This variable nature of the roof obtains throughout the whole district extending from Rochdale to Whalley Bridge. Throughout the greater part of this sheet—I might almost say the whole of it—the Feather-edge coal is either absent altogether, or so thin as to be unworkable, its absence being compensated for by the presence of the Mottram or Mossley seam, already described (p. 14), which lies about 60 or 70 yards beneath it. This interchange of value between these two seams appears to be very general further south; for at Coomb Edge near Glossop, where the *Mottram* or *Simmondsly Mine* has been largely worked, there is no appearance of the *Feather-edge* seam; and at Whalley Bridge, where the latter is very thick and valuable, the former is just the reverse. The same is true at Mottram and Broadbottom.

The Feather-edge coal is worked in the valley at Birtle Dean, as mentioned by Mr. Binney, also at Pilsworth (6-inch Map 88) where its may be observed along the brook course, and in a quarry near a factory resting on the upper surface of the Millstone Grit. It is here much broken by faults, and its presence at the surface so far south of its general range is to be attributed to an upcast fault running east and west, to the north of its outcrop, somewhere in the neighbourhood of Pilsworth Moor. The coal breaks out to the surface at Green Bank Wood above Heywood Water-works, where it affords the following section:—

	Fect.
1. Coarse-grained flaggy grit	6
2. Feather-edge coal	2
3. Stony under-clay, about	2
4. Coarse massive grit	12

Its outcrop may be traced round Wind Hill, by Lower Red Lumb,

\* This seam is described by Mr. E. W. Binney in the *Trans. Geol. Soc. Manchester*, vol. i. A sketch of the outcrop, in a quarry of rough rock, is given in the "Geology of Bolton-le-Moors," *Memoirs of the Geological Survey*.

† These places are a little beyond the borders of this sheet.

round the base of Knowl Hill, a conspicuous elevation about 4 miles north of Rochdale, and along both banks of Green Brook at Rain Shore Mills and Bromleys Wood. It also crops at Shepherd's Mill Bridge, and along the turnpike road, till it is broken off against two large down-throw faults.\* The general name by which this seam is known in the neighbourhood of Rochdale is the "Three-quarters Mine." The seam may also be observed in the body of the grit along the edge of Badger Hill west of Old Delf, and in the road at Lugley north of Staleybridge, at which place it disappears in company with the Rough Rock, which it seems incapable of surviving.

#### LOWER COAL-MEASURES, OR GANNISTER BEDS.

This series of beds is included between the Millstone Grit and the *Arley* or *Royley* Mine, the lowest thick coal of the Middle Coal-measures. It is open to discussion whether it may not be preferable to call this series Upper Millstone Grit, rather than Lower Coal-measures, as it is more clearly connected with the former group than with the latter, by its fossil shells; and some of its beds of sandstone are in this district as coarse-grained as those of the underlying Millstone Grit. The following is the general succession of the beds, from the Royley Mine downwards. Some of the thicknesses of the beds are only approximations, and of course will not apply everywhere:—

	ft.	in.
1. Flaggy sandstone, in two beds	-	4 0
2. Grey shale and clay	-	10 0
3. <i>Coal-seam</i>	-	0 6
4. Hard flaggy sandstone	-	65 0
5. Grey and black shale	-	260 0
6. Micaceous rippled flags, sometimes coarse-grained, seen at Park Hall reservoir, Staleybridge, Knot Hill, and Ashton barracks, Barnpool woods, near Heywood	-	180 0
7. Grey and dark sandy shale	-	130 0
8. Flaggy sandstone, coarse-grained and massive, at Gorse Hall, Staleybridge	-	165 0
9. Black shale, with fossils	-	25 0
10. <i>Coal, 40-yards Mine</i>	-	1 4
11. Black shale, with fossils (Coal Brook Mill)	-	50 0
12. <i>Helpet Edge rock.</i> Coarse-grained flaggy sandstone, of Turishill, Helpet Edge, Austerlands, Besom Hill, Boardman's Edge, and Gorse Hall	-	130 0
13. Black shale, very fossiliferous, containing large calcareous nodules ("bullions"), with perfect <i>Goniatites</i>	-	10 0
14. <i>Bullion Coal, or Upper Foot Mine</i>	-	1 0
15. Black shales	-	36 0
16. <i>Gannister Coal, or Mountain Mine, from 18 in. to</i>	-	2 6
17. Hard siliceous stone (Gannister) and fire-clay, with <i>Stigmara ficosides</i> (variable)	-	2 6
18. Black shales	-	30 0
19. <i>Coal, Lower Foot Mine</i> (often absent)	-	0 8
20. Shale, with bands of flagstone	-	50 0
21. <i>Second coal, inferior quality, Lower Yard Mine</i>	-	2 3
22. " <i>Woodhead Hill Rock.</i> " Flaggy, current-bedded sandstone, often coarse-grained. Ogden Edge, Bowstead Edge, High Moor, High Knowls, Ridge Hill, and Glent quarries, Staleybridge, and Eastwood Hill	-	140 0
23. Sandy shales and flagstones; black shale, with fossils	-	60 0
24. <i>First Coal</i> (Turf Hill and Staleybridge)	-	0 6
25. Fire-clay and potters' clay (Staleybridge)	-	3 0
26. Sandy shales or flagstones (variable in character) resting on Millstone Grit	-	12 0
	1,375	5

\* Most of the above places are in Sheet 80, 6-inch Map, not yet published.



In the above section many of the details must be considered as approximations. There is not one place where an unbroken series is exposed to view throughout, and the beds of sandstone are especially liable to variations, both in quality and thickness. The coal-seams also vary in thickness, and are sometimes absent altogether. It will be seen, however, that when they are all present, there are seven in number; but only one of these, the Gannister coal, or "Mountain Mine," is ever worked to any considerable extent.

It has already been stated that some of the sandstones, though generally fine-grained, become as coarse in texture as Millstone Grit or the Rough Rock. This is particularly the case with the sandstone No. 12 in the above series, north of Rochdale, a fact referred to by Mr. Binney. In one quarry it was observed by Mr. Green to be so like Rough Rock, that it was only the fact of its overlying the Gannister coal that prevented his mistaking it for that formation. The same observation is applicable to these beds along their easterly outcrop, from Tunshill southward to Staleybridge. We find the Woodhead Hill Rock and the Helpet Edge Rock so coarse-grained and massive as lithologically to ally themselves more naturally to the Millstone Grit series than to the overlying Coal-measures. This is significant, as it falls in with the results of the palæontological evidence. Now, if we compare the sandstones of the Lower Coal-measures along the borders of Yorkshire, as shown in this sheet, with their representatives on the western side of the county, near Wigan and St. Helen's, we cannot fail to be struck with the change which has ensued in their lithological characters. In the latter, or western districts, they are invariably evenly-bedded, flaggy, and fine-grained; in the former often coarse-grained and obliquely laminated, evincing the prevalence of currents. These differences in petrological character, depending as they do upon differences in the conditions of deposition, point significantly to the direction of the land from which the materials were derived; and it is also worthy of remark that the composition of these sandstones is the same as that of the older Millstone Grits, consisting of particles of quartz, felspar, and mica, the detritus of granitic rocks.

We shall commence the detailed description of these beds in the ascending series:—

*First Coal.*—This little seam occurs immediately above, or within a few feet of, the Rough Rock. Its roof is black shale, with *Aviculopecten*, *Goniatites*, &c. It may be seen in a lane and brook-section, at a hamlet called Binns, east of Tunshill. Here, indeed, there appear to be two thin seams, which basset on the banks of the new reservoir, the upper 18 inches, the lower 6 inches in thickness. It also occurs at High Thurston Clough and Wall Hill, near Dob Cross, with a roof of black shale containing *Goniatites*. It is probably this seam which is worked for the sake of its under-clay a short distance above Staleybridge.

*The Woodhead Hill Rock\** is the first bed of sandstone of importance above the Millstone Grit. It lies about 60 or 80 feet above it, separated by shales, and forms the high ridges of Ogden Edge, Compton Moor, and Bowstead Edge. Here it occurs as a coarse-grained flaggy sandstone, full of current-planes, along which it is liable to split

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\* This name is taken from Mr. Binney's section, Trans. Geol. Soc. of Manchester, vol. i., p. 75. The "coarse-grained rock" with the "dark shale" mentioned in this section which lie above the "feather-edge" coal appear to me properly to be included with the "rough rock," as the shale frequently thins away, and the coarse rock then rests on the coal, and forms one mass with the underlying grit.

up. It also forms Badger Edge, and at High Moor yields very fine evenly-bedded flagstones. We find it largely quarried at Stone Breaks Hill, High Knowls, and Broad Car, where it consists of a rather incoherent, coarse-grained rock, not unlike the "Rough Rock" which underlies it. There are also large quarries at Hazelhurst, and Ridge Hill, and St. George's Church, Staleybridge, where it occurs as a micaceous flaggy rock, traversed by current-planes. It is used for paving and building.

This rock crosses the river Tame at Castle Hall House, and forming a ridge along the west side of Eastwood Park, may be traced due south by a line of quarries to Newton, where it is lost to view beneath the Drift.

*Lower Yard Mine.*—This seam is one of very inferior quality, and not always present. It overlies almost immediately the Woodhead Hill Rock last described, and in this position may be seen at the base of Tunshill and Helpet Edge. These are the only spots where it has been worked in this district. It has a roof of shale, and is itself split up by partings of the same material.\*

*Gannister Coal.*—Above the Yard Mine we find a series of shales with a bed of flagstone at Helpet Hill, about 50 or 60 feet in thickness, surmounted by a thin seam of coal, known as the "Lower Foot Mine," and this again by black shales, at the top of which is the Gannister Coal, or Mountain Mine. This latter is the most valuable in this district of all the coals below the Arley Mine, and it has been largely worked along the northern and central area of the map, in the neighbourhood of Heywood, Rochdale, Tunshill, Crompton, Barrowshaw east of Oldham, Broad Car, Hazelhurst, Staleybridge, and Newton. It is generally of good quality, suitable for coking, and varies in thickness from 18 to 30 inches. Its roof is strong black shale, sometimes, but not generally, containing fossil shells. Its most remarkable characteristic is its floor, which consists of a hard siliceous stone, called "Gannister,"† or crow stone, full of *Stigmaria ficoides*. The under surface of this bed is very irregular, and lies imbedded in softer under-clay.

I shall now record the places where the Gannister coal, or its floor, may be observed; and it may be as well to premise that, from its extreme hardness, the Gannister rock itself sometimes appears, cropping up in a brook, while the coal-seam lies concealed beneath the gravel or sand of the bottom. We find then the coal, or its floor, at Broadshaw Hill, and in a brook course east of Chesham, about 100 yards north of the Chesham fault, near Bury. It may also be found along the top of the banks in Cleggs Wood, which overhangs Birtle Brook, and at Pen Green Colliery it is worked at a depth of 63 yards. It crops out along the northern side of Bagslate Moor, near Rochdale, in company with the Lower Foot coal. The seam has been extensively worked under Tunshill and Helpet Edge; and the outcrop may be observed in many places along the eastern escarpment, as it has been excavated by "day-eyes" or tunnels entering the side of the hill. It breaks out at the banks of the reservoir, on Wey Moss, east of Crompton, and here the thickness is only 16 inches. Several tunnels have been driven into it at the north side of Besom Hill; and at Barrowshaw Colliery,

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\* Though so unimportant in this district, this seam is probably the same which is worked in several collieries near Broadbottom, south of Mottram, and in Mr. Jowett's colliery near Compstall Bridge.

† "*Gannister*." I found this term in common use amongst the colliers from Staley-bridge southwards.

near Oldham, it is worked at a depth of 140 yards. At Broad Car a tunnel has been driven from the outcrop along the dip of this coal to a distance of 500 yards, and the coal is pulled up the incline by a stationary engine. The inclination here is about 25°. At Hazelhurst the seam has also been worked close to the crop, and at Higher Fold, north of Staleybridge, in a pit about 100 yards in depth. On the south side of the river Tame the outcrop may be observed in the bank east of Gorse Hall, and from this point it has been worked as far as Tetley Fold Reservoir.\*

I may mention here that by far the finest exhibition of the Gannister which has come within my observation in this neighbourhood occurs in the bed of the river Spoddon, above Healy Hall Mill, north of Rochdale. The locality is beyond the limits of the map, otherwise it would have received a more detailed notice. Beyond the outcrop of the Gannister is a large fault bringing up the Millstone Grit and Feather-edge coal.

About 12 yards above the Gannister coal, and separated by black shales, there occurs a seam of about 12 inches ("the upper foot mine") chiefly remarkable for its roof, which is always extremely prolific of fossil shells. The roof consists of black shale, containing large calcareous nodules called "bullions," sometimes 2 feet in diameter, in which well-preserved specimens of *Goniatites* are plentiful. These shells, when found in the shales, are almost always flattened, but in the nodules they retain their natural form. The upper foot mine, although so thin, is wonderfully constant all over the district, and may be seen in the river bank, above Lomax Wood, near Bury, where it affords the following section:—

<i>Bullion Coal, Broadoak Mill, Bury.</i> †		ft. in.
1. Black shale, with large bullions containing <i>Goniatites reticulatus</i> , <i>G. Gibsoni</i> . In the shale are <i>Aviculo-pecten papyraceus</i> , <i>Orthoceras</i> , &c., about	-	10 0
2. Grey shale, with <i>Anthracosia</i> , <i>Posydonia</i> , and a small crustacean, probably <i>Beyrichia</i>	-	6 0
3. Coal (Upper Foot or Bullion seam)	-	0 10
4. Shaley fire-clay	-	0 6
5. Strong potters' clay (worked for pottery)	-	6 0
6. Flaggy sandstone (base unseen)	-	10 0

We find this seam again at Helpet Edge, Besom Hill, and Staleybridge, everywhere accompanied by its group of fossil shells.

Above the shales, which overlie the bullion coal, is a rock very variable in character, sometimes flaggy, at other times (as at Crow Knoll, near Crompton) a coarse-grained grit, passing into conglomerate. This rock forms the escarpment of Helpet Edge, and Besom Hill, and Austerlands, near Oldham, where it is extremely massive, and often as coarse as Millstone Grit, with pebbles of quartz. It is there fully 100 feet in thickness. It may now also be seen in a quarry on the north side of Gorse Hall, Staleybridge.

The highest workable seam of the Lower Coal-measures is the "40-yards mine," a term referring to the distance of this seam above the Gannister coal, but erroneously so for this district, as the distance is from 60 to 75 yards. This seam varies from 1 foot to 16 inches. It crops out on Helpet Hill, and in the bank north of St. James' Church, Ashworth. It is of inferior quality, and rarely worked.

\* It is remarkable that this seam thins out at Broadbottom, though the Gannister Rock remains, and is excavated by tunnelling for road material; on the other hand the Lower Yard Mine becomes valuable.

† The fossils have been determined by Mr. Salter, "Geology of Bolton-le-Moors." Memoirs Geol. Survey, p. 35.

The higher beds of the Gannister series consist of flagstones, coarse grits, and shales, as stated in the tabular view (p. 16). They are represented near Wigan by the Up-Holland Flags, but a very marked change has supervened in their easterly extension towards the borders of Yorkshire. They are here much coarser, more massive, and less flaggy. This is certainly the case with the rock which I have called the "Helpet Edge Rock" in the tabular view, which is often as coarse-grained and massive as the Rough Rock or any of the inferior millstones. The best sections are along the banks of the Roch, and the road between New Hey and Ogden; also in the hills east of Crompton, the quarries at Austerlands, near Oldham, quarries at Ashton reservoir, Highfield Cottage, and Park Hall. On the south side of the river we find the same beds in some quarries on the east of Dukinfield and Newton.

#### MIDDLE COAL-MEASURES.

This series is the great repository of nearly all the thick and workable coals of the Lancashire Coal-field; and it includes all the strata from the Royley or Arley mine up to the Worsley or Pendleton 4-feet coal, reaching a total thickness of 1,000 yards.\* Owing to the want of exploration, and the presence of several large faults, which break the continuity of the strata, this latter seam is not capable of being traced continuously from the Pendleton district into the Manchester and Oldham district, but if we assume that it is identical with the Ardwick and Bradford 4-feet seam, the parallelism of the two districts will be complete.† The reasons which have induced us to adopt the *Arley mine* as the conventional base of the middle series, have been stated in a previous memoir,‡ and need be only here alluded to briefly. In the first place, the Arley mine (in this district termed the "Royley mine") is the first of the thick coals which we meet with in the ascending series, and is itself a seam of great value, so much so that its outcrop has everywhere been proved from actual exploration, except in the neighbourhood of Ashton-under-Lyne and north-west of Middleton. This circumstance is of very great value in enabling us to trace a true geological horizon, in those parts where the strata are concealed by deposits of Drift, and where our information has to depend entirely upon actual mining, as is the case over a very large part of the country around Oldham. Secondly, this conventional base of the Middle Coal-series seems to correspond very closely with a physical break in the succession of the strata, shown in a section of the river Irwell, a short distance above Bury, as also in a quarry near the same place, of which a sketch is given in the memoir already referred to.§ This physical break is also accompanied by a change in the character of the shells (mollusca) which are found in the beds above, as compared with those below, the Arley mine, for until we ascend through the whole series of the Middle Coal-measures (that is through 3,000 feet of strata) we find no recurrence of those genera of Cephalopoda and Brachiopoda, &c., which are found in the Gannister series, but only species of several closely allied genera of Myadæ, namely, *Anthracosia*, *Anthracoptera*, and *Anthracomya*. At or near the top of this series these genera again make their appearance, but with one exception

\* See "Geology of the country around Bolton-le-Moors," p. 8.

† The probabilities of the identity of these seams have been very clearly stated by Mr. E. W. Binney, F.R.S., in his papers on the "Lancashire and Cheshire Coal-field," and on the "Fossils of the Pendleton Coal-field." Trans. Geol. Soc. Manchester, vol. i. To these I shall frequently recur.

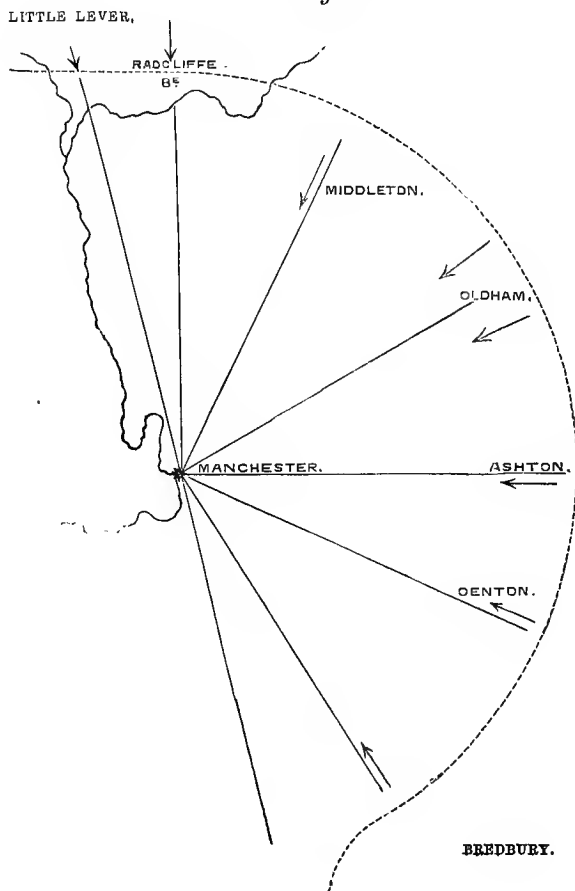
‡ Geol. of Bolton, p. 7.

§ Ibid, p. 7.

(*Aviculo-pecten papyraceus*) the species are all distinct from those of the Gannister series, as determined by Mr. Salter. (See Appendix, p. 64).

*General Arrangement of the Beds.*—It will be observed on comparing the strike or direction of the strata to the west of Manchester with that on the east, that the one is exactly at right angles to the other. From Wigan eastward by Bolton, Worsley, and as far as Middleton, the trend of the beds, as shown by the outcrop of the coal-seams, is on the whole from west to east. At the town of Oldham, however, a change ensues. Here the beds are bent round with a moderately rapid flexure, and henceforth trend due south, by Ashton-under-Lyne, till they cross the river Tame into Cheshire. South of Dukinfield a still further bend may be observed, and the strike of the beds through Hyde and Bredbury is nearly S.S.W. as far as the valley of the Mersey, where they begin to return to their original direction, and trend north and south towards Poynton. Thus we find that this band of productive measures has nearly passed through the curve of a semicircle, or at least  $165^\circ$ , between the valley of the Irwell and that of the Mersey, and if we draw a radius from the cathedral of Manchester to any point along this course, we shall find that the dip is everywhere very nearly along this line towards Manchester, and the strike at right angles thereto. (See fig. 8.) If from the more special

Fig. 8.



maps of the Geological Survey we turn to a general geological map of this part of England, we shall find that this change in the direction of the strike is by no means a local one, but that it is coincident with the general structure of the rocks in this part of England. The neighbourhood of Oldham may (without any play upon the words) be called the "turning point" of the geology of South Lancashire. At this point the beds come under the influence of that great upheaval which has resulted in the formation of the Penine chain.

GENERAL COAL-SERIES IN THE NEIGHBOURHOOD OF ASHTON-UNDER-LYNE, compiled from Pit Sections at Bardsley, Broad Oak, Lord's Field and Dukinfield Collieries :—

*Names of Strata.*

LORD'S FIELD COLLIERY.

	ft. in.
Red rock (sandstone), and blue shale	- 180 0
1. <i>Great Mine</i> { coal 2 ft. 6 in. dirt 1 ,, 6 ,, coal 3 ,, 6 ,, }	- - - 7 6
Strata, from 93 ft. to	- - - 105 0
2. <i>Roger Mine</i> - - - - -	- - - 4 6

DUKINFIELD COLLIERY.

Strata, principally shales - - - - -	109 9
3. <i>Furnace Hill Mine</i> - - - - -	- 3 3
Shale, with ironstone bands - - - - -	- 50 2
4. <i>Coal</i> , middling quality { coal 1 ft. 8 in. earth 1 ,, 8 ,, coal 2 ,, 2½ ,, }	- - - 5 6½
Rock and shale, with much water - - - - -	- 244 0
5. <i>Colonel's Mine</i> { coal - 0 ft. 10½ in. dark clay 1 ,, 0½ ,, coal - 3 ,, 3 ,, }	- - - 5 2
Strata, chiefly shale, with bands of coal and ironstone	74 3
6. <i>Hard Mine</i> { coal 0 ft. 8½ in. shale 0 ,, 6½ ,, coal 2 ,, 7 ,, }	- - - 3 10
Shale, with several bands of coal - - - - -	- 23 0
7. <i>Cook's Folly Mine</i> - - - - -	- 1 6
Shale, with "Huncliff Rock, 117 feet thick	- 149 0
8. <i>Mary's Mine</i> - - - - -	- 2 7
Rock and shale - - - - -	- 54 0
9. <i>Coal</i> - - - - -	- 2 2
Strong sandy shale - - - - -	- 42 0
10. <i>Town Lane Mine</i> { top coal - 1 ft. 0 in. earth - 0 ,, 10 ,, main coal 3 ,, 7 ,, earth - 1 ,, 6 ,, floor coal 1 ,, 3 ,, }	- - - 8 2
Strata, principally shales - - - - -	- 34 0
11. <i>Top Shuttles Mine</i> - - - - -	- 2 0
Shales and sandstone - - - - -	- 124 3
12. <i>Bottom Shuttles Mine</i> - - - - -	- 2 11
Sandstone and shale, with ironstone and shells - - - - -	- 195 0
13. <i>Oxycrow Coal</i> - - - - -	- 1 9
Strata, shales and sandstone - - - - -	- 70 9
14. <i>Coal</i> { coal 0 ft. 5 in. earth 0 ,, 7 ,, coal 1 ,, 0 ,, earth 0 ,, 9 ,, coal 1 ,, 4 ,, }	- - - 4 1
Shales - - - - -	- 39 11

		ft. in.	
15. <i>Fogs Mine</i>	{	coal 0 ft. 9 in.	} <i>Lower Chamber Mine</i> - 4 10
		clay 0 " 1 "	
		coal 1 " 0 "	
		dirt 1 " 11 "	
		coal 1 " 1 "	
Shales and sandstone (Blenfire rock) - - -		188 6	
16. <i>Rusty Mine</i>	{	coal 0 ft. 10 in.	} - - - - 3 8
		earth 1 " 6 "	
		coal 1 " 4 "	
Shales and grey sandstone - - - - -		74 0	
17. <i>Three Shreds Mine</i> (or "Great Mine" of Oldham)	{	coal 1 ft. 8 in.	} - 4 3
		dirt 0 " 3 "	
		coal 1 " 4 "	
		dirt 0 " 4 "	
		coal 0 " 8 "	
Fire-clay and shale, with seams of coal - - - - -		14 10	
18. <i>Salt Petre Mine</i>	{	coal 2 ft. 0½ in.	} - - - 5 4
		dirt 0 " 10½ "	
		coal 2 " 5 "	
Shale and sandstone - - - - -		30 8	
19. <i>Smithy Mine</i> , good quality - - - - -		2 2	
Shales, with a band of sandstone - - - - -		70 8	
20. <i>Black Mine</i> (at Bardsley 4 feet thick) - - - - -		4 8	

## BARDSLEY COLLIERY

Shales, with bands of sandstone, and coal 16 inches -		147 1	
21. <i>Stone Mine</i>	{	coal 0 ft. 11 in.	} - - - 3 1
		stone 1 " 1 "	
		coal 1 " 1 "	
Shale and sandstone - - - - -		33 10	
22. <i>Upper Bent Mine</i> (with cannel at Dukinfield)		2 2	
Seat stone and shale - - - - -		20 6	
23. <i>Lower Bent</i> , or <i>Peacock Mine</i> - - - - -		2 4	

## BROAD OAK COLLIERY.

Strong metal or shale - - - - -		60 0
24. <i>Lees Mine</i> - - - - -		1 6
Strata, principally sandstone - - - - -		62 3
25. <i>Hurst Old Mine</i> - - - - -		3 6
Very strong shale - - - - -		45 0
26. <i>Hurst New Mine</i> - - - - -		3 3
Sandstone and shales, from 300 feet to - - - - -		350 0
27. <i>Royley Mine</i> , or <i>Lower Woodley Mine</i> , not proved at Ashton-under-Lyne. Thickness supposed to be about 3 ft. 6 in., with partings of shale - - - - -		3 6

The Coal-series of Oldham and Middleton is, with some unimportant exceptions, similar to the above. The names of the same coals are often different, and it is very difficult, if not impossible, to identify many of the seams which lie *above* the Black Mine, as they occur in the pit sections of Bardsley and Dukinfield collieries. This fact is only another illustration of a phenomenon which may be observed throughout the Coal-series of Lancashire, that the higher you ascend in the scale, the more changeable do the coal-seams become; the lower coal-seams are, as a general rule, more constant than the upper. The following is the series as it occurs in the districts of Oldham and Middleton. I regret that, owing to the withholding of that kind of information respecting the Chamber Colliery which I usually received in other places, I am unable to give as much detailed information regarding this part of the coal-field as would otherwise have been the case.

## COAL-SERIES OF OLDHAM AND MIDDLETON.

## Names of Strata.

The numbers will show the identity of the seams in each section.

## BARDSLEY COLLIERY.

	ft.	in.
"Bardsley Rock" (sandstone) -	45	6
Shale -	31	7
<i>Stubb's Mine</i> (coal) -	1	5
Metal (shale) -	25	6
<i>Fairbottom Mine</i> -	2	0
Shale, with three thin seams of coal -	76	6
<i>Park Mine</i> (coal, with parting of clay) -	3	6
Shale 29 feet; Foxhole's rock, 79 feet 8 inches -	108	8
<i>Foxhole's Mine</i> -	2	4
Soft metal -	32	6
<i>Cannel</i> -	1	6
Strata, principally shales, with a coal seam 16 inches -	187	8
<i>Hathershaw Mine</i> -	2	2
Shale, with two seams of coal -	51	0
Rock and rock bands, with water (CHAMBER ROCK) -	88	6
Shale and sandstone -	38	3
14. <i>Nield or Upper Chamber Mine</i> (sometimes absent) -	2	0
Shale and sandstone -	54	6
15. <i>Lower Chamber Mine</i> {		
coal 1 ft. 5 in. }		
dirt 0 " 4 " }		
coal 1 " 2 " }		
dirt 0 " 8 " }		
coal 0 " 8 " }		
-	4	3

## GLADWICK COLLIERY.

Shale and bands of sandstone -	66	0
Red sandstone, with plants (BLENFIRE ROCK) -	146	9
16. <i>Blenfired Coal</i> {		
coal and cannel 1 ft. 11 in. }		
dirt - 0 " 6 " }		
coal - 0 " 11 " }		
dirt - 0 " 11 " }		
coal - 0 " 9 " }		
(very variable) -	5	0
Sandy shale and shale -	76	7
17. <i>Great Mine</i> {		
top coal - 1 ft. 11 in. }		
clay - 0 " 5 " }		
coal - 3 " 6 " }		
clay - 0 " 1½ " }		
bottom coal 4 " 0 " }		
-	9	10½
Sandstone and shale, with shells -	33	9
19. <i>Little Coal</i> -	2	3
Sandstone and shale, with fish remains -	66	9
20. <i>Black Mine</i> (the best seam in the district) -	4	2
Shales, sometimes strong, with two coal seams -	117	6
21. <i>Stone Mine</i> {		
top coal - 0 ft. 11 in. }		
stone - 1 " 2 " }		
bottom coal 1 " 3 " }		
(roof "dark stone") -	3	4
Soapstone (sandy shale), with a band of white rock -	21	4
22. <i>Upper Bent Mine</i> -	2	2
Hard soapstone, with ferns -	29	8
23. <i>Lower Bent Mine</i> -	2	8
Strata -	37	6
24. <i>Hollmgworth Coal</i> -	1	6
Strata -	234	0
26. <i>Neddy Mine</i> -	2	6
Strata, with several thin coals, about -	441	0
27. <i>Royley Mine</i> (with a parting of shale) -	4	0



*The Royley Mine.*—This coal, which is identical with the *Daub Hill*, or the *Arley Mine*, of the Bolton and Wigan districts, is a seam of great value all over the northern and central parts of the Sheet, as far as Lees, near Oldham, from which point it has never been worked until we pass southward into Cheshire, where it reappears, or is supposed to do so, under the new name of “Lower Woodley Mine.” In the neighbourhood of Heywood and Rochdale, this seam is repeatedly thrown in by large faults, so as to form four isolated patches, and two promontories jutting out northward from the general range of the middle Coal-measures.\* Over these areas, the seam has been almost entirely worked out, and but little of it now remains at a less depth than 100 yards. At Heywood we obtain the following series :—

		ft.	in.
<i>Coal</i>		-	-
	Strata	-	90 0
	<i>Coal</i>	-	0 4
	Shales, flaggy sandstone	-	110 0
	Grey shale, with ironstone bands	-	50 0
	Black shale roof	-	20 0
<i>Royley Mine</i>	}	coal, roofings	- 0 ft. 4 in.
		clay	- 0 „ 0½ „
		coal, little tops	0 „ 4 „
		coal, tops	- 1 „ 6 „
		dirt and coal	- 0 „ 9 „
		coal, bottoms	- 1 „ 8 „
	Soft underclay	-	3 0

At Middleton Colliery, the seam gives the following section ; the roof is black shale :—

		ft.	in.
<i>Royley Mine</i>	}	top coal	- 1 ft. 6 in.
		clay	- 0 „ 7 „
		bottom coal	2 „ 8 „
		-	4 9

The outcrop of the Royley Mine may be observed extremely well at Simpson's Clough, near Hooley Bridge, together with the strata which lie both over and under it. It may also be traced by a line of old workings along the banks of the Roch at Crimble Brow. It here dips so gently towards the south-west, that it requires a distance of nearly one-fourth of a mile to carry it down from the top of the cliff to the bed of the river. It occupies an area of about a square mile at Rochdale, and crops out a few yards below Spotland Bridge, but being concealed by drift is nowhere visible. It bassets again near Chadwick Fold, and also at Dig Gate ; but I could gain no information regarding the exact spot. It was also worked at Cowlshaw, and reaches the surface at Whetstone Hill. It was worked also under Broad Brent Mill, on the down-cast side of a fault of 180 yards throw, which passes a few yards to the S.W. of Barrowshaw Colliery. The outcrop is visible in a quarry at Spring Hill, near Watersheddings ; the thickness is 4 feet, and it dips very gently towards the south-west. The seam has been followed under a great accumulation of drift gravel as far as Lees, where it is being worked in a pit at a depth of 85 yards ; and it is known to crop out in the brook above the weir at Birch House. From this point southwards the seam (as already stated) has not been followed, owing principally to the great thickness of drift clay and sand, which overspreads the ground sometimes to a depth of 100 to 150

\* These areas, with the Royley Mine, are shown on the Map by the darker shading, and the edges of these patches show the outcrop of the seam itself.

feet. The deepest pit in the neighbourhood of Oldham down to this seam is that recently opened by Messrs. Mayall and Lees at Higginshaw to a depth of 280 yards. The shaft commences at the outcrop of the *Stone Mine*, underneath Oldham Edge.

West of the great fault which traverses Oldham from north to south, throwing down the strata on the east to a depth of 320 yards, the *Royley Mine* is worked at Mr. Butterworth's colliery, Bent Grange, at a depth of 222 yards. From this point the beds rise towards the north to the outcrop of the seam at Haggate and Royley, the spot from whence it derives its name. In the river Irk, near this place, there is a good section in the flaggy sandstone which overlies the coal.

*New Mine.*—This is a seam which is now of considerable importance in the neighbourhood of Ashton-under-Lyne, and southwards into Cheshire, and has only been recently discovered. It is supposed to lie about 100 or 120 yards above the Royley Mine, but the exact distance has never been ascertained in this neighbourhood.\* This is a good coal, and at Broad Oak Colliery, near Ashton, is 3 feet 3 inches in thickness. In the Oldham district this seam has not been identified, but it is probably either the *Neddy Mine* or one of the thin seams below it. The distance from the *Neddy Mine* to the *Royley Mine* at Oldham is about 140 yards.

*The Hurst Old Mine.*—This is a seam which is of importance in the Ashton district, but is not recognized at Oldham, unless it be the *Neddy Mine* aforesaid. At Broad Oak Colliery it is 3 feet 6 inches in thickness. In Cheshire, this seam goes by the name of the *Silver Mine*, and at Bredbury is of good quality, and 3 feet 2 inches thick.

*The Stone and Bent Mines.*—This is a group which is very constant over the whole district from Middleton into Cheshire. The *Stone Mine* is remarkable for a band of black stone which separates the seam into two parts. The *Lower Bent Mine* is generally superior in quality and thickness to the upper, and in Cheshire is called the "Peacock Mine," where it is highly esteemed. This seam has been successfully worked on the "long wall" system by Mr. Goodwin, at Newton. The Upper Bent Mine undergoes at Dukinfield a change of considerable importance to that district. It passes in its upper part into cannel of good quality, 18 inches in thickness, and is worked in the Victoria Pit, and also in the Astley Pit, by tunnelling from the *Black Mine*. The following view of the changes which this group of coals undergo in different localities may prove of use:—

THE STONE AND BENT MINES.

Coals.	Middleton.	Bardsley.	Broad Oak Hurst.	Chamber Colliery.	Bredbury, Cheshire.
	inches.				
Stone - -	11	{ Coal 11 ins. Stone 13 " Coal 13 "	Coal } 30 ins. Stone } Coal }	Coal } 35? ins. Stone } Coal }	{ Coal 15 ins. Stone 12 " Coal 12 "
Upper Bent -	21	26 ins.	24 "	21 ins.	16 "
Lower Bent -	29	28 "	Peacock 30 "	29 "	K. Willm. 30 "

The Bent Mines derive their name from Bent Grange, on the west side of Oldham, where the seams rise to the surface.

The *Black Mine.*—This is perhaps the most important seam in the whole district, for though there are one or two seams which attain a

\* Further south, at Middle Cale Colliery, Cheshire, the distance from the *New Mine* to the *Ridacre* has been ascertained to be about 90 yards, but it is not perfectly certain, though it is extremely probable, that the *Ridacre Mine* represents the *Lower Woodley* or *Royley Mine*.

greater thickness, they are scarcely equal in quality and persistency to the celebrated *Black Mine* of Oldham, Ashton, and Dukinfield. This seam is overlaid by black shale, which it is known forms the best possible roof, and it averages in thickness 4 feet. From this thickness it seldom varies by more than three or four inches, except at Dukinfield, where in the Astley Pit it was found to attain the thickness of 4 feet 8 inches, and justified the expenditure consequent on sinking what was at the time the deepest coal shaft in Britain, the depth to the *Black Mine* being here 687 yards. At Denton the thickness is 4 feet 6 inches. We shall commence at the southern edge of the Map, and follow this seam towards Middleton. The outcrop occurs in the river Tame, at the elbow opposite Glass House Fold, and runs along by the east of Haughton Green till it enters Cheshire, upon crossing the river at Haughton Dale Cotton-mill. The dip of the strata here is W.N.W. at  $25^{\circ}$  to  $30^{\circ}$ . At Glass House Fold it again enters Cheshire, and ranges through Gortley, Newton, and Dukinfield till it again enters Lancashire at Ashton-under-Lyne. At Mr. Ashton's collieries at Hyde and Newton the strata are very much broken by faults, and even bent and twisted in a manner quite unusual. In the most easterly of the three pits, the *Black Mine* is reached at a depth of 60 yards, the shaft itself passing through a fault. Several of these faults do not appear to affect the higher seams; and it is a curious fact\* with regard to the strata of this neighbourhood, that in the same mine, and under the same ground, the lower seams will often be dislocated by faults which do not enter the seams above them. Thus at Hyde a fault with a throw of 3 yards in the *New Mine* was not found in the *Old Mine*. At Dukinfield there is a fault which passes 500 yards on the deep of the Astley Pit, in the *Black Mine*, and, although the throw is 16 yards, it does not reach the *Great* and *Roger seams* above it. There is also at a shallower level a band of broken ground in the *Black Mine* which was not observed in the newer seams.

The outcrop of the *Black Mine* may be observed in the bank near the eastern end of Schoral Wood, on the south side of the Tame at Ashton-under-Lyne. The dip is here a little south of west at  $20^{\circ}$ . It ranges through Hurst, where it has been very largely worked, and at Hurst Brook its thickness is less than usual. In the interesting section of the strata in the banks of the Medlock in the Rocher Valley, we have a very clear view of the strata from the *Park Mine* down to the *Black Mine*; but this latter seam itself is not plainly visible, owing to the constant slipping of the muddy bank. The seam however crosses the brook a few yards above Old Rocher, where there is a pump at work turned by water power; the dip is here W.S.W. at  $30^{\circ}$ , and the depth of the seam at Park Bridge Colliery is about 300 yards. The outcrop of the seam ranges northward through Alt and along the base of Glodwick Low, and terminates against the Glodwick fault. The seam underlies, or more properly *did* underlie, Oldham Edge and the eastern part of the town as far west as the great fault, which throws it completely out on the west side. To the east of this fault the seam has been exhausted, and under the town are chambers on a small scale like the catacombs of Rome or of Paris.

On the west side of the great Oldham Edge fault, the seam shows itself just above the entrance to the railway tunnel at Primrose Hill; it then ranges by the north of Hunt Clough Colliery, where the depth was 94 yards. At this colliery a seam called the *Red Mine*, lying about

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\* Of which I was assured by the managers of Dukinfield and Hyde Collieries.

24 yards above the *Black Mine*, 25 inches thick, was worked. The *Black Mine* ranges into Chaddington Park, and then strikes against a fault, which throws out the seam as far south as Springs Brook Colliery, where it was formerly worked at a depth of 85 yards. The dip here is S.S.W. at  $18^{\circ}$  or  $20^{\circ}$ . The seam then ranges toward Middleton, and was found to reach the surface at the north pit of Tonge Colliery.\* At Middleton it strikes against another very large fault, which again throws the outcrop to the south side of Wince Brook. At Alkrington Colliery it was worked at a depth of 100 yards, and was first discovered in this district at the outcrop in the gully below the colliery. The dip is here nearly due south at  $10^{\circ}$  or  $12^{\circ}$ .

Though this valuable seam has already been heavily drawn upon, there probably still remains a considerable tract which it underlies, between Middleton, Heaton Park, and Blackley. A large unbroken tract also lies to the south and west of the present collieries of the Chamber Colliery Company. Upon crossing the large down-cast fault, which passes from N.W. to S.E. through Hollinwood, pits even deeper than that of Dukinfield will be necessary to reach this seam. If we suppose that the *Moston Mine* represents (as there is every probability that it does represent) the *Great Mine* of Dukinfield, the depth to the *Black Mine* at this pit would be no less than 850 yards or thereabout. This depth is great, but I am far from believing that it is inaccessible, especially in Lancashire, where coal-mining is already carried on with such marvellous energy, and in mines of such unusual depth.

*Great Mine of Oldham.* The next seam of value above the *Black Mine* is the Great Mine of Oldham, which yields there 8 feet of coal, split up by three bands of clay and bass. As a seam it is not held in much estimation, and at Ashton-under-Lyne and southwards becomes degenerated, and is known only as the "Dirt Mine." Its distance above the *Black Mine* is about 33 yards. The outcrop may be seen at Werneth Hill, and at Old Rocher in the valley of the Medlock. At Dukinfield it is termed "the three shreds" mine, and affords the following section. Its roof is blue "soapstone" or strong sandy shale.

	ft.	in.
Coal -	0	4½
Dirt or clay	0	1
Coal -	1	3½
Dirt -	0	3
Coal of good quality	1	4
Dirt -	0	4
Coal of good quality -	0	8

It crosses the River Tame north-east of Glass House Fold, and again at Haughton Dale, about 50 yards east of Harden Bridge. Below it are two seams, known as the *Salt Petre* and *Smithy* coals, each about 2 feet in thickness.

*Blenfire Coal and Rock.* The escarpment of Oldham Edge, which forms a very conspicuous feature when viewed from the north and east, and which reaches at South Moor an elevation of 800 feet, is composed of a very massive red sandstone called the "blenfire rock." This escarpment commences at Edge Lane, at a point where the blenfire rock is terminated against the great up-cast fault already alluded to. It

\* When I say *surface*, it must be understood that with respect to a coal-seam it may mean the actual surface of the ground, or the bottom of the drift, sand, gravel, or clay, which covers the solid strata. The term is here used in the latter sense.

thence trends southwards through the centre of the town, gradually falling till it disappears in a valley, which is filled with a thick deposit of gravel and Boulder clay. From this it emerges, and forms at Glodwick Low an escarpment only a little lower than that of Oldham Edge, being 749 feet in height. The ridge continues southwards, gradually falling towards the valley of the Medlock, where the blenfire rock may be observed on the banks of the river, but very much reduced in thickness, owing to a down-throw fault which crosses the river at Schoral Wood Cotton-mill, just at the point where the blenfire rock ought to appear: this bed is scarcely visible along that fine section. The two beds of red sandstone which occur at this point lie immediately above and below the Oxicrow coal, and therefore above the blenfire rock. This latter, however, is exposed to view in a quarry along the road which runs east and west between Dukinfield and Newton. It was found to be 42 yards in thickness at Victoria Colliery. It reaches the surface at Hyde Colliery, and is quarried at Glass House Colliery and Harden Bridge, at which point it enters Cheshire.

At Oldham Edge, and elsewhere along its course, this rock is remarkable for its deep red and purple colouring. It is traversed by planes of current-bedding and is full of stems of drifted plants. In places it is very coarse-grained, resembling Millstone Grit, and containing small pebbles of quartz. It seems to attain its greatest development towards the north and east, for on the south-west side of Oldham it appears to have almost thinned out, or at least to such a degree as to be scarcely recognizable. At Bardsley Colliery it is 40 feet thick, but this is a great falling off from its thickness at Glodwick, where it is about 150 feet in thickness. This amount of attenuation has occurred in a distance of  $1\frac{1}{2}$  miles from N.N.E. to S.S.W.

The Blenfire coal lies immediately at the base of the rock at Oldham and Glodwick.\* It is a seam of a very variable character, and is seldom workable. At Bardsley, it is known as the *Rusty Mine*, and is only 1 foot in thickness. At Dukinfield Colliery it gives the following section:—

		ft. in.
<i>Rusty Mine</i> {	top coal - - - - -	0 10
	earth - - - - -	1 6
	hottom coal - - - - -	1 4

Above the seam in this place, there are about 30 feet of shales, by which it is separated from the blenfire rock, and it is therefore by no means improbable that in other places, where these shales are absent, they have been removed by denudation, and perhaps part of the coal itself has in some places been so destroyed.

*Chamber Mines and Chamber Rock.* The two seams known as the *Upper* and *Lower Chamber Mines*, or as the *Nield* and *Pomphret Mines*, lie amongst a series of shales and flaggy sandstones bounded below by the Blenfire rock, and above by the Chamber rock. These seams crop out at Messrs. Baily and Marlands' Colliery, at Cross, near Oldham, and north of Chamber Dam Colliery, where the overlying sandstone may be seen in the quarry at Chamber Hall dipping S.S.W. at 8°.

The Chamber rock forms a fine cliff at Rocher, on the banks of the Medlock, and is largely quarried; it here consists of grey, iron-stained, flaggy sandstone, with plants. The outcrop of the Lower Chamber

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\* See section above, p. 24.

mine may be observed on the north bank of the brook, but not so the Upper Chamber mine. Mr. Baily, who kindly accompanied me, while examining this section, believes that this seam has here been denuded away, and states that similar disappearances of the seam have been observed in the underground workings. The Chamber rock may be observed in a quarry east of Hurst Knowl, and in the cliff at Schoral Wood, underlying the Oxicrow coal. Further south its importance diminishes.

The Upper Chamber mine is generally a solid seam from 2 feet to 2½ feet in thickness. The Lower is split up by partings of shale. At Coperas House Colliery it occurs as follows:—

		ft.	in.
Lower Chamber, or Nield Mine	}	Coal - - -	0 7
		Dirt - - -	0 10
		Coal - - -	0 8
		Dirt - - -	0 3
		Coal - - -	0 8
		Dirt - - -	0 3
		Coal - - -	0 3
		Coal - - -	0 8

At Dukinfield and Denton it is known under the name of the "Fogs Mine," as is generally supposed.

Above these seams there occurs a considerable thickness of strata, with the Oxicrow coal, a thin seam of little value. Over this lies a thick bed of red sandstone, shown at New Mill Iron Forge, Rocher Valley, at Hurst Knoll, and at Schoral Wood Cotton-mill.

Above this comes a seam of cannel, very local in its distribution, occurring at Hollinwood and Bardsley of a thickness of 20 inches, but thinning away towards the south. The outcrop of this seam may be observed east of Park Bridge, in a road cutting, and in the railway section north of Deanshut Farm. Mr. Baily states that it was here found to be 2 feet in thickness. Very little of this seam probably remains to be worked.

The *Foxholes* Mine next succeeds. At Bardsley it is about 2 feet 4 inches in thickness. The outcrop of this seam may be observed in the railway cutting at Deanshut Clough, underlying a thick bed of red sandstone, called the *Foxholes rock*. On this rock Deanshut Farm stands, and it also lines the sides of Fairbottom Valley, west of Park Bridge. I am disposed to think that this coal represents the Oxicrow mine of Dukinfield, but the identification of this and the following seams till we reach the Great and Roger mines, as they occur north and south of Ashton-under-Lyne, becomes very difficult, if not impossible.

If, in the endeavour to make these seams parallel, we take as guides the thick beds of sandstone, which are so conspicuous in our river sections, we may perhaps be led to sufficiently accurate conclusions. For this purpose I think we may take the *Foxholes rock* as a lower, and the Bardsley Bridge rock as an upper limit.

Now the *Foxholes rock* in all probability represents the sandstone of Hurst Knowl, of Schoral Wood Cotton-mill, and that which underlies the Lower Shuttles mine all the way to the banks of the river Tame, south of Haughton Green.

I think we may also with some confidence pronounce the Bardsley Bridge rock to be identical with the red sandstone of Dukinfield Lodge, and the "Huncliff Rock" of Dukinfield Colliery, which crosses

the River Tame at Harden Mill. Now between these two limits we find at Bardsley and at Dukinfield the following seams of coal :—

BARDSLEY.		DUKINFIELD.		
BARDSLEY ROCK.		HUNCLIFF ROCK.		
	ft. in.		ft. in.	
<i>Stubs Mine</i>	- - 1 5	<i>Mary's Mine</i>	- - 2 7	
<i>Fairbottom Mine</i>	- - 2 0	<i>Coal</i>	- - 2 2	
<i>Coal</i>	- - 1 0	<i>Town Lane Mine</i> {	<i>Top</i>	- 1 0
<i>Coal</i>	- - 1 0		<i>Main coal</i>	3 7
<i>Coal</i>	- - 1 5	<i>Top Shuttles Mine</i>	- - 2 0	
<i>Park Mine</i> (with partings)	3 6	<i>Bottom Shuttles Mine</i>	- 2 11	
FOXHOLES ROCK.		ROCK above the Oxicrow coal.		

At Denton the thickness of the *Bottom Shuttles Mine* is 2 feet 8 inches. *Top Shuttles Mine* 2 feet 4 inches. *Town Lane Mine* 3 feet 8 inches. *Mary's Mine* is very thin, and scarcely workable.

*Hard Mine.*—This seam lies about 68 yards above the *Town Lane Mine*, and is one of the best seams in the neighbourhood of Denton, Haughton, and Dukinfield. It consists of two seams, the lower of which is the principal bed of coal. At Dukinfield the seam occurs as follows :—

		ft. in.	
<i>Hard Mine</i>	- {	<i>Top coal</i>	- 0 8½
		<i>Black shale</i>	- 0 6½
		<i>Bottom coal</i>	- 2 7

At Denton the seam affords about 4 feet of coal. In this neighbourhood, however, it is subject to those unfortunate interruptions known as "*horse backs*" or "rock faults," where, in certain places, the coal is replaced by shale or sandstone. This is the case with regard to this seam in the level of the *Hard Mine* pit, between this colliery and the river Tame, where the whole of the seam passes into black shale for a distance of 200 or 300 yards. These changes necessarily result in great loss and unproductive expenditure, in rendering it necessary to tunnel in solid strata without any return.

Nearly all the seams in this neighbourhood which lie above the *Black Mine* are subject to similar vicissitudes. In Mr. Higson's colliery, near Moorfield House, these rock faults were so numerous in the seam there worked, as to cause the abandonment of the mine. A seam of coal 2½ feet thick, lying above the *Great Mine*, was reached at 175 yards. Levels were driven on this coal for a distance of 160 yards south, 200 yards north, and an up-brow of 40 yards. Throughout the whole of this area the coal was repeatedly cut out by shale or sandstone at intervals of a few yards, which made it impossible to continue the workings except at a great loss. It may be well to remark that these interruptions in the continuity of any one coal-seam, do not necessarily affect the seams either above or below it. Thus, while it may happen that the *Hard Mine* is injured by rock faults, the *Black Mine* underneath may be entirely free from them; and that while this Denton seam, which was worked in Mr. Higson's pit, is injured, the *Great Mine* below may be perfectly entire.

*Colonels' Mine.*—In the Dukinfield section this seam consists of two beds, the upper being 10 inches, and the lower 3 feet 3 inches in thickness, with a foot of dark clay between. At Denton Colliery this seam is of little or no value.

*Furnace Hill Mine.*—This coal is upwards of 3 feet at Dukinfield. At Denton it is known as the *double mine*, the thickness being 3 feet.

*Great and Roger Mines.*—These are the most important coal-seams of the district, and they lie near the top of the whole series of thick coals, though considerably below the position of the Ardwick or Bradford 4-feet seam. If we were to attempt to define their position in that part of the Coal-field which lies to the west of the valley of the Irwell, we should probably not be far wrong in stating it to be that of the *Crumbourke* and *Rams* (or 7-feet) *Mine* of Pendleton and Worsley.

The Great Mine lies exactly 576 yards above the Black Mine at Dukinfield. Its thickness there is 6 feet, and that of the Roger Mine 4 feet. At Denton the Roger Mine is 5 feet 6 inches in thickness, and is considered a good house coal. The distance between the two seams is 32 yards.

At Lord's Fields Colliery, Ashton-under-Lyne, the Great and Roger seams are worked at a depth of 138 and 170 yards respectively. The dip is there west at 25°, and the levels are driven north to a large up-cast fault, which throws out these coals. There still remains a considerable area on the deep of this colliery, over which these seams might be worked at a less depth than 500 yards.

The great fault, which forms the boundary of the mining ground of Lord's Fields Colliery, seems to range by Taunton, Valley Bridge, Warmley Wood Colliery, and Wroe's Cotton-mills, Hollinwood, in a general direction from south-east to north-west. Along the course of this fault the strata are much broken, at least towards Hollinwood; but at a proper distance to the south-west the Great Mine and all the underlying seams will doubtless be found at workable depths. This has been proved the case at Birchen Bower Colliery, near Hollinwood. There the Moston Mine is reached at a depth of 260 yards, dipping to the south. At Moston Colliery, which lies on the up-cast side of a very large fault, the same coal is reached at 210 yards in one pit, and 285 yards in another. The dip here is also to the southward, and the levels have been driven westward up to a large fault which passes through Shakerley Green. Beyond this fault the Moston Mine has not been proved; but near Moston Hall a 3-foot coal was formerly worked at 100 yards, and there can be no doubt that this seam overlies the 6-foot mine.

There is a considerable tract of ground stretching to the north of the border of Triassic and Permian Rocks, extending from Moston Hall, by Blackley, to Heaton Park, under which this valuable seam will probably be found at workable depths. Over this tract a great thickness of drift clay and sand is spread, which has served to deter attempts to open up its mineral treasures. It is to be hoped that the publication of the maps of the Geological Survey may stimulate further research.

Above the Great or Moston Mine there are several coals, such as the *Bland* and *Sod Mines*, but they are of inferior quality, and split up with partings of shale and bass. Above these is a seam 2 feet 6 inches in thickness; which crops out at Dunkirk Colliery, and is overlaid by a bed of fire-clay, 5 feet in thickness, which is there worked. About 50 yards higher still is a seam about 18 inches in thickness, which is overlaid by fossiliferous shales. These beds are shown in the banks of the River Tame, at the bend, west of Dunkirk Colliery. They contain large calcareous concretions, rich in fossil shells of several genera of Mollusca, discovered by my colleague, Mr. A. H. Green, during the progress of the survey. These beds may be placed near the top of the Middle Coal-measures, and are the highest strata exposed to view in this neighbourhood. The beds dip west at 40°, and are in close



proximity to a small fault visible in the bend of the river near the factory.

The *Yard Mines* of Moston Hall Colliery, and Moorfield House Colliery, Denton, both of which have already been referred to, may possibly be the same seam, and are, at any rate, very nearly on the same geological level; they are both of the same thickness, 2 feet 6 inches, and lie at a distance of something like 400 or 500 yards above the *Great Mine*. It is not at all improbable that they represent the Bradford *four feet* coal, or the seam next below it, called the *Yard Mine*. Should this identification be established, and could we ascertain the exact distance between these seams and the *Great Mine* at Denton and Moston, we should then know with certainty the distance to the thick coals under the east side of Manchester, a problem that all experiments have hitherto failed to solve.

The manner in which the Denton seam was found to be cut into, and thoroughly spoiled, by rock-faults has already been described. It appears to have been otherwise with the Moston seam, which has the character of having been a good coal. It was reached at a depth of 85 yards, and was 2 feet 8 inches in thickness; below this a seam was found of 2 feet, and another of 1 foot 8 inches. The dip is S.S.W. at about 20°.\*

#### UPPER COAL-MEASURES.

##### *The Manchester Coal-field.*

The Manchester Coal-field is an isolated tract of Upper Carboniferous rocks, surrounded on all sides by those of Triassic or Permian age. In shape it is somewhat oval; but runs to a point at its opposite extremities. Measured from S.S.E. to N.N.W. (that is in the direction of its longest diameter) it is a little over 4 miles, and at its centre it is one mile and a half across. It has a total area of about 4 square miles.

The dip of the strata is everywhere towards the south or south-west, so that the highest beds are found on the Manchester side of the field, and the lowest beds crop out along its north-eastern boundary.

This boundary is a very large fault, which throws in the New Red Sandstone, and may be seen in the banks of the Medlock at Bank Bridge Print Works. On the western side the Coal-measures appear in some places to be faulted against, and in others to dip in natural order under, the newer formations.

Near the centre of the Coal-field, at Collyhurst, a fault crosses from one side to the other, in a direction from south-west to north-east; and has been proved in the working of the coal-seams at Miles Platting. On approaching it the seams were found to bend round towards the south, and to end off in succession against its gradually sloping side, which is here formed of the Lower Permian Sandstone of Collyhurst. The coal-seams from this point trend across the field, dipping to the south-west, till they are broken off against the boundary fault at Bradford.

Very complete and interesting sections of nearly the whole series of the Manchester Coal-field are exposed to view in the banks of the Medlock and Irk, and have been faithfully described by Mr. Binney in his memoir "On the Geology of Manchester and its Vicinity."† We shall,

\* For these details I am indebted to Mr. John Stanley, of Moston Colliery.

† Trans. Geol. Soc. Manchester, vol. i. This paper was read in the year 1839, and it is probable that, owing to the increase of buildings, factories, &c., the sections at present are less perfect than they were at that time.

with this author, follow the course of these streams from Manchester upwards; and thus having crossed the strike of the beds, from the highest to the lowest, we shall become acquainted with the various minerals in their order of succession.

*Valley of the Medlock.*—At Ancoats Bridge and at the weir of Ardwick Dye-works, the pebble beds of the New Red Sandstone have been proved, though they are not now actually visible. A little further up, Lower Permian Sandstone has been found in a well which is now open. This well has been sunk near the junction of the Coal-measures; but it is a question of considerable uncertainty whether this junction is a fault or a superposition of the strata.

Upon crossing the boundary we enter upon the highest beds of the Coal-measures known in any part of Lancashire, consisting of reddish clays, shales, and sandstones, with six beds of limestone varying from a few inches to 5 feet in thickness. These limestones, with their accompanying measures, crop out between Holt Town reservoir and the bend of the river opposite All Souls' Church. Along with this limestone series are two thin seams of coal, a bed of black-band ironstone very full of a bivalve shell, *Anthracosia Phillipsii*, which appears to be exclusively confined to the higher stage of the Coal-formation, and a bed of calcareous hæmatite, considered by Mr. Binney, with great probability, to represent the ore formerly worked at Patricroft. These beds all rise and crop out towards the N. N. E., at angles varying from 18° to 25°.

Beyond these, opposite Beswick Lodge, the following strata may be seen in the bank, viz. :—

	ft.	in.
Red micaceous flagstone	-	5 0
Red, purple, and grey clays, with nodules of hæmatite	-	35 0
Dark blue shale	-	10 0

These beds dip to the S.S.W. at 18°, and underlie the lowest band of limestone.

Upon following the course of the river to the canal aqueduct, we reach sandstone, overlying the highest workable coal-seam, called the *Openshaw Mine*, and continuing our course we cross the outcrop of six seams of coal, most of them workable, with their accompanying measures of sandstone, shale, and clay. The lowest strata are shown at the elbow opposite the Grange, consisting of a coal-seam 10 inches thick, grey and black shales, underlaid by a bed of grit, upon which Mr. Wood's weir is erected. The beds here dip W.S.W. at 15°, and are cut off and thrown down by the great boundary fault of the Manchester Coal-field.

Of this fault Mr. Binney says, "In some places this rock" (the New Red Sandstone) "overlies the basset edges of the coals, and in others a bed of stiff red clay, of about a foot in thickness, intervenes between them and the sandstone. The fault is not vertical, but inclines to the east from one foot in two, to one in four, the inclination often varying."\*

*The Limestone Series.*—In no other part of Britain have calcareous beds been so strongly developed in the upper part of the Carboniferous rocks. In most other districts where they are represented, a single band

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\* *Trana. Geol. Soc. Manchester*, vol. i., p. 51. Mr. Binney holds, in this paper, that the original fault, or break, has disappeared, that the strata of the Coal-measures have been denuded as along a coast-line, and that against this surface the New Red Sandstone has subsequently been deposited.

of limestone a few inches in thickness is all that occurs. Here, however, there are at least six beds, with an aggregate thickness of about 15 feet of limestone; but it is to be recollected that this is not the entire amount that has been formed, for as the Coal-measures dip unconformably under the Permian sandstone, it is highly probable that still higher bands of limestone lie concealed under the Triassic and Permian rocks of Manchester.

The Ardwick limestone is of a grey, white, and reddish colour, unevenly bedded, and having often the appearance of breccia cemented by carbonate of lime. In the limestone are found *Anthracomya Phillipsii*, *Spirorbis carbonarius*, and fish, especially beautiful specimens of *Ctenodus*, now preserved in the Geological Museum in Manchester. The following is a section of the limestone pit at Ardwick, kindly furnished by Mr. Mellor:—

*Ardwick Limestone Series.*

	ft.	in.
Boulder clay and sand	36	0
Red sandy loam, shales, and clay	84	0
Limestone (Yard Mine)	3	3
Brown and shaley clay	4	9
Limestone ( $\frac{1}{2}$ Yard Mine)	2	0
Reddish shale and clay	18	0
Blue clay	4	0
Sandstone	24	0
Shale with joints	18	6
Black lias and black-band ironstone, with <i>Anthracomya</i>	0	6
Coal and bass	1	6
Strong clay	9	6
Limestone (Great Mine) in various beds	6	6

The band of calcareous hæmatite crops out near the bend of the river, south of Beswick Lodge. It is about 6 inches in thickness, with uneven surfaces, so that in some places it is probably thicker, and in others thinner, than at its outcrop on the river bank. It dips to the south-west at 25°, imbedded in shales, and overlying a thick series of soft reddish sandstones, which forms the elbow of the river. Beyond the bridge the lowest bed of limestone, 1 foot 6 inches in thickness, reaches the surface.

From the lowest limestone to the outcrop of the Openshaw mine there is a horizontal distance of 620 yards, representing 200 yards of strata. The following is the Coal-series at Bradford colliery, as kindly furnished by Mr. Livsey:—

*Bradford and Clayton Coal-Series.*

	ft.	in.
<i>Openshaw Mine</i>	- from 2 ft. 6 in.	to 3 0
Strata	-	(about) 135 0
<i>Charlotte Mine</i>	- from 1 ft. 6 in.	to 2 0
Strata	-	210 0
<i>Three-quarters Mine</i>	-	1 7
Strata	-	15 0
<i>Four-feet Mine</i> (main coal)	-	3 10
Strata	-	108 0
<i>Yard Mine</i> (variable)	-	1 ft. 5 in. to 4 0
Strata, with New Smut coal 1 ft. 4 in.	-	210 0
<i>Two-feet Coal</i>	-	2 0
Strata	-	120 0
Coal	-	0 10

The whole thickness of strata here shown is 271 yards, and the thickness of strata from the 10-inch coal up to the highest strata of the limestone series 671 yards, or about 2,000 feet, representing the development of the Upper Coal-measures of Lancashire.

The *Four-foot* and *Yard coals* above mentioned are worked at Bradford and Clayton collieries. They are already exhausted to a considerable depth. At Clayton Colliery the *four-foot* coal is worked by Mr. Bradbury on the "long wall" system, and to the late Mr. Bradbury belongs the credit of having introduced this mode of coal-mining into Lancashire.\*

Below the coals above named a great, but unknown, thickness of barren measures intervenes, separating the coals of the Manchester field from those of the main Coal-field of Lancashire. These beds crop out in the valley of the Irk, between Collyhurst and Smedley, and consist of reddish sandstones and shales, upwards of 450 yards in thickness.

Attempts have been made by Mr. Livsey to reach the thick coals which undoubtedly lie below the *Yard* and *Four-foot* mines of Bradford. If we assume the four-foot seam to represent the *Worsley four-foot*, the distance to the *Crumbourke mine* ought to be about 300 yards, and to the *Rams* or *Seven-foot mine* 345 yards; yet Mr. Livsey has penetrated, by sinking and boring, considerably beyond this distance, and has not met with any seam of workable thickness. It is certain, however, from the section of the strata shown in the valley of the Irk, that no coal-seam of sufficient thickness for working will be found at a less depth than 616 yards below the Bradford four-foot mine. This will be evident from the following considerations. If we take the grit of Bank Bridge to represent a part of the Delf Fold Rock, Collyhurst, the least depth will thus be found:—

	ft.
Thickness of strata from the Bradford 4-foot coal to the grit of Bank Bridge Print Works - - -	500
Thickness from the Collyhurst (Delf Fold) rock to the lowest beds of Smedley, in the valley of the Irk, all of which are barren of coal - - -	1,350
Least thickness of strata without coal - - -	1,850
or 616 yards	

*Valley of the Irk.*—An almost continuous section of the strata may be observed along the valley of the Irk, from Collyhurst Sand Delf up as far as Smedley Old Hall. The strata thus exposed to view must be considered (as already stated) to underlie those just described in the valley of the Medlock, containing the coal-seams of Bedford. The highest beds shown in the Irk river-section consist of massive purple and brown sandstone, the upper part passing into purple shales, which are unconformably overlaid by Permian sandstone. The former of these has been somewhat largely quarried for building. Below this are a series of brown and purple sandy shales, on the top of which is a 10-inch coal, which crops out near Smedley Bridge. From below this the "Smedley Grit," a thick bed of purple sandstone, rises towards the north at 15°, and has been quarried opposite Mount House. Sandstones, and shales with ironstone, are shown in the Fire Brick Works, and below these two seams of coal, 16 inches, and 3 feet in thickness, are reported to have been found.† A little beyond this, at Messrs. Jonathan Andrews' works, the New Red Sandstone has been proved.

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\* For the sake of consistency it will be preferable to take the *Four-foot Mine* as the base of the Upper Coal-measures, as this seam is supposed to represent the *Worsley* and *Pendleton Four-foot*, which forms a convenient line of demarcation. See *Memoir* of "The Geology of the country around Bolton," pp. 12-15.

† Stated by Mr. Binney, on the authority of Mr. Bradbury, "Geol. of Manchester," p. 58.

Coal-measure sandstone may be observed at Green Mount Dye-works, dipping south at about 20°, alongside Moston Brook. It is, however, very uncertain how far west of the River Irk the coal-field extends. It is likewise uncertain whether the boundary is here a fault, or whether the Coal-measures are covered over by New Red Sandstone, with or without the intervention of Permian beds. Our ignorance on these points is owing to the thickness of the Drift.

I have already stated the great depth at which we may expect the thick coals of Ashton, Middleton, or Clifton to lie under Miles Platting, but, whatever this depth may be, it will be considerably less in the valley of the Irk at Collyhurst. The depth to any of these coals would probably be less by 200 yards at Smedley Bridge than under the Bradford 4-foot coal. I am of opinion that an attempt to reach the coal in the valley between the bridge and Smedley would be attended with a fair prospect of success; and, considering the closeness of the market, and the demand arising from the factories and dye-works around, would probably turn out a profitable speculation.

We have now concluded the description of the Carboniferous series of this part of Lancashire. It may be interesting to give a view of the vertical development of each of its members:—

*General View of the Carboniferous Series.*

		Feet.
Upper Coal-measures (Manchester), 2,013.	{	Limestone series - - - 600
		From the limestone to Open- shaw coal - - - 600
		From the Openshaw coal to the <i>Yard coal</i> - - - 485
Middle Coal-measures 4,247.	{	Barren strata (Irk Valley) - - - 1,678
		Unknown strata - - - -
		Sod Mine to Black Mine - - - 2,000
Lower Coal-measures 1,370.	{	Black Mine to Royley Mine - - - 897
		From the Royley Mine to the Rough Rock - - - 1,370
		From the Rough Rock to the Limestone shale (measured at Mossley) - - - 2,000
Millstone Grit - - -	{	Limestone shale (measured at Mossley) - - - 2,000
Limestone Shale, or Yoredale series - - -	{	Thickness uncertain, but probably falling little short of 2,000
Total thickness of sedimentary strata - - -		11,630

Thus it appears that the Upper, Middle, and Lower Coal-measures combined amount to no less than 7,630 feet, and the Millstone Grit to 2,000 feet.

Now, as to the thickness of coal. If we add the thickness of all the seams, from 2 feet and upwards, of the Middle Coal-series, to that of the Upper Coal-series of Manchester, we find the amount of workable coal to be in round numbers 100 feet, which is more than that of the Worsley district by 39 feet, and about 15 feet more than in the Wigan district.\*

PERMIAN FORMATION.

This formation is well represented in the immediate neighbourhood of Manchester, skirting the borders of the main Coal-field by Denton, Droylsden, Failsworth, and Blakeley, and appearing along the western margin of the Manchester Coal-field, from Rushford to Ancoats Bridge, and still more strongly at Collyhurst.

\* "Geol. of Wigan," 2nd Edit. p. 22.

It consists of two members, the lower composed of red sandstone, and the upper of red marls, with bands of fossiliferous limestone. The formation rests unconformably on different parts of the Coal-measures, and so great is this unconformity that, in the immediate neighbourhood of Manchester, it reposes in one place on Coal-measure strata which are at least 2,000 feet below those on which it rests in another. The places here referred to are Collyhurst and Ardwick.

*Collyhurst Section.*—The two members of the formation are here open to view; the red marls in the right bank of the Irk above Travis Isle, and in the opposite bank behind the houses. These beds were once much more accessible to examination than at present, and have been very fully described by Mr. Binney, who, in company with Mr. Leigh, investigated their characters, and established their position in the Geological scale.\* From the marls, and thin bands of limestone which were found interbedded with them, these gentlemen collected a considerable number of shells, nearly all of small size, belonging to the genera *Rissoa*, *Turbo*, *Natica*, *Avicula*, *Axinus*, and *Lucina*. Some of the species being new, were figured and described by the late Captain Thomas Brown.† These marls are stated by Mr. Binney to dip regularly under the New Red Sandstone of Newtown, which may be seen in the bed of the river at Mr. Clemson's Dyeworks. They, in turn, repose upon the red and variegated sandstone of the lower division, and the junction may be very clearly seen at the bend of the river above Travis Isle. Near the point of junction there occurs a bed of coarse-grained grit, with small pebbles of quartz.

The lower red sandstone is opened out into very fine sections in Mr. Buckley's quarries. A section is shown at least 100 yards in length, and sometimes 60 feet in depth. Here we see a bed of boulder clay, sometimes 20 feet in depth, resting on a nearly uniform mass of bright red, orange, and mottled sandstone, soft and friable, and

*Fig. 9.*

SECTION AT COLLYHURST.



B. Boulder Clay.

S. Permian Sandstone.

generally fine-grained. There are no pebbles in this sand, and it is in great request for moulding at the iron foundries. The whole formation is extremely like the "lower mottled sandstone" of the Trias, from which it would be impossible to separate it, were it not that it under

\* "On the Geol. of Manchester." Trans. Geol. Soc., vol. i., p. 54.

† *Ibid.*, p. 63.

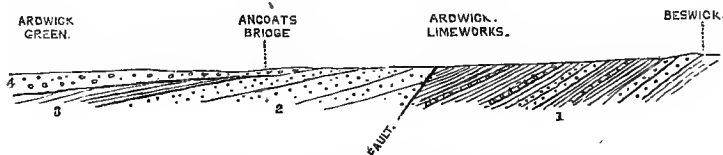
lies the fossiliferous marls of Permian age, as already stated. The rock is traversed by planes of current-bedding, generally sloping towards the south at angles of  $25^{\circ}$  to  $30^{\circ}$ , but the true stratification of the rock is indicated by long white or coloured bands, or lines, which divide the different tiers of current-planes, and dip towards the south-west at  $5^{\circ}$  or  $10^{\circ}$ . One of these bands is shown in the above woodcut (Fig. 9), and I am persuaded, after several examinations, that the angle of dip does not exceed this amount. The thickness of the sandstone here is therefore, I believe, about 200 feet. Mr. Binney, however, considers it to be 350 feet thick.\*

The base of the formation is very clearly shown in the bank of Moston Brook, near its confluence with the Irk. The red sandstone rests unconformably on the purple shales and sandstones of the middle part of the Coal-measures.

The amount of discordance, with reference to the *direction* as well as amount of the dip, is considerable. The dip of the Coal-measures is about  $10^{\circ}$  east of south; that of the Permian, about  $10^{\circ}$  west of south, the difference being  $20^{\circ}$ ; while with regard to amount, the difference is  $10^{\circ}$  or  $12^{\circ}$ , the dip of the Permian sandstone being  $10^{\circ}$ ; that of the Coal-measures,  $20^{\circ}$  or  $22^{\circ}$ .

Fig. 10.

SECTION ALONG THE MEDLOCK AT ARDWICK.



4. New Red Sandstone, resting unconformably upon Permian beds.
3. Upper Permian Marls, dipping at a higher angle than the New Red Sandstone.
2. Lower Permian Sandstone, faulted against Coal-measures.
1. Upper Coal-measures with Limestone.

*Manchester Sections.*—The greater part of the city is built upon New Red Sandstone, which stretches westward from the boundary of the Coal-field at Ardwick, dipping probably at a small angle towards the south-west (Fig. 10). Below this formation the Upper and Lower Permian beds, together with the underlying Coal-measures, extend in regular order, as has been proved by several borings in search of water. These sections have been carefully collected and published by Mr. Binney, to whose memoirs I shall frequently have recourse in treating of these beds.

One of the most interesting sections was that obtained in the well of Dr. Joule, near Albert Bridge, Salford,† which is as follows :—

	ft.
Trias.—New Red Sandstone, about	470
Upper Permian.—Red clays, with bands of limestone	120
Lower Permian.—Hard red sandstone (Collyhurst sandstone), total thickness proved not stated	10
	600

\*Mem. Lit. and Phil. Soc. Manchester, vol. xiv., p. 5.

† On the Permian beds of the north-west of England, by E. W. Binney, F.R.S., Mem. Lit. and Phil. Soc. Manchester, vol. xii.

On the opposite side of the river the New Red Sandstone was perforated at a much less depth, as may be seen by the following section, obtained at Messrs. Lomas and Bradbury's works, Strangeways:—

	ft.	in.
Post-Pliocene, or Drift sand, clay, &c. - - -	21	0
Trias, or New Red Sandstone - - -	273	0
Upper Permian Beds.—Red clay (raddle), with two beds of limestone - - -	44	4
Red clay, containing magnesia - - -	30	0
	<hr/>	
	368	4

The following section gives the succession of the beds near the centre of the city, and was obtained at the works of Messrs. T. Hoyle & Co., Mayfield\*:—

	ft.	in.
Trias, or New Red Sandstone - - -	143	4
Upper Permian.—Red and variegated marls, with beds of limestone and impure ironstone	150	0
Conglomerate - - -	1	2
Lower Permian.—Red soft sandstone - - -	59	4
	<hr/>	
	356	5

The last section to which I shall refer is the most valuable, as it actually passes through the New Red Sandstone and Permian beds, and enters the Upper Coal-measures, which rise to the surface at Ardwick. The Lower Permian Sandstone was found thinner than could have been expected, only 70 feet, whereas we have already seen that at Collyhurst its thickness is nearly 200 feet. These rapid variations are, however, everywhere characteristic of the lower division of the Permian beds in Lancashire.

This section was obtained in a boring for water, at the works of Messrs. Fryer & Co, Chorlton-on-Medlock, and was as follows†:—

	ft.
Trias, or New Red Sandstone - - -	114
Upper Permian.—Red marls, with limestones - -	237
Lower Permian.—Coarse red sandstone, with pebbles -	45
Coarse red sandstone - - -	24
Upper Coal-measures.—Red shaley marls, with limestones	126
	<hr/>
	546

The limestones in the red shales contained *Spirorbis carbonarius* and scales of *Palæoniscus*, clearly proving them to be of the age of the Coal-measures of Ardwick. This fact, however, is not likely to prove of economic value, for although the Coal-measures are thus found to lie at a comparatively small depth under the south side of Manchester, yet the depth to even the highest workable seam of coal, the *Openshaw Mine*, would be not less than 1,800, or probably 2,000 feet,‡ together with 350 feet more to the *Four-foot seam*; such being the case it is questionable whether seams of such moderate thickness will ever prove sufficiently tempting to induce persons to penetrate for them to the depths above stated.

\* The full details of this boring are given by Mr. Binney, but a synopsis, as given by the author himself, is probably sufficient in this place.

† Mr. E. W. Binney, Proceedings Lit. and Phil. Soc. No. 5, 1861, p. 137.

‡ This depth is estimated by adding the thickness of the Trias and Permian to that of the strata at Ardwick, lying above the Openshaw coal, together with an allowance for the dip of the beds towards the south-west; the thickness may be even greater than that here stated.



*Valley of the Medlock.*—Crossing the band of New Red Sandstone which lines the eastern side of the Manchester Coal-field, we find Permian beds rising from below the Trias, and spread out, through the agency of several faults, over a band of country above a mile in width, and stretching from Failsworth to the banks of the Mersey at Stockport.

There have been several borings in search of coal along this valley, but they have never penetrated sufficiently deep to reach a workable seam. It is principally from the knowledge of the strata obtained from these borings that the geology of that part of the district has been brought to light to a degree which admits of being represented on the maps of the Survey. We are not, however, altogether deprived of ocular assistance, as the Trias and lower Permian sandstone are opened out in several places along the banks of the river.

The New Red Sandstone, seen at Bank Bridge, has been proved by the late Mr. Bradbury to extend up the river beyond Clayton Vale.\* The sandstone at Clayton Bridge was found to be 59 yards thick, lying upon red marls.† This sandstone may be seen at intervals for 400 yards, from above the bridge nearly to the weir. It dips to the westward at an angle of about 5°. In every particular it resembles the Permian sandstone of Collyhurst, and not that of the Trias, as represented in this neighbourhood. It consists of soft bright red sandstone, fine-grained, and free from pebbles. Its base may be seen near the weir, and from beneath it rise, at a steeper angle, certain beds of purplish grit and clay, which I consider, with some hesitation, to be referable to the Upper Coal-measures. If the red sandstone of Clayton Bridge be of Permian age, of which (judging from lithological character and stratigraphical position) there is every probability, then these beds of grit and clay must be Coal-measures. This may prove a most important point in reference to the discovery of coal along this valley; but unfortunately the extent of these beds exposed to view is insufficient to determine their true age beyond the possibility of a doubt.

Above the weir there is every reason for supposing a large fault crosses, though the exact spot cannot be ascertained, because the Permian, and even the Trias, occurs again in force at Medlock Vale Print-works, and also because this spot lies in the direction of a great fault, which has been found at Moston Colliery.

In Jericho Clough borings were made by the late Mr. Bradbury, but I have been unable to obtain information as to the exact spot, and the clough is 600 yards in length. From the account of these borings given by Mr. Binney, it is extremely difficult to tell to what formation the beds belong. Mr. Binney seems to consider them as of Upper Permian age, for he says "It is doubtful to me whether the lower red sandstone has been perforated, and the Coal-measures reached, especially as the former has been since proved to be of much greater thickness than the whole of the sandstones in the lower part of the section in Jericho Clough."‡ My own impression is that 129 feet, consisting of clays with bands of limestone and grit, belong to the Upper Permian formation, and the remaining 103 feet, consisting of

\* Mr. Binney, in his account of the sections in the valley, states that the "Upper Red Sandstone" has been proved up to Jericho Clough. It seems probable, however, that the Triassic and Permian sandstones have been confounded together in the borings, as there can be no question, I think, that the red sandstone at Clayton Bridge is Permian.

† Mr. Binney, *Geol. of Manchester*, *Trans. Geol. Soc.*, vol. i., p. 52.

‡ "On the Permian Beds, &c." *Mem. Lit. and Phil. Soc., Manchester*, vol. xii., p. 15.

various kinds of sandstone, to the Lower. Mr. Bradbury abandoned the boring as not being favourable for coal.

Very recently a deep and instructive boring has been completed at Medlock Vale Print-works by Mr. Wood, but unfortunately without reaching coal, the object of his search. This section was kindly supplied to me in detail; but perhaps the synopsis, as prepared by Mr. Binney, will prove sufficient here. It is as follows\* :—

	ft.	in.
<i>Drift</i> , or alluvial gravel	-	26 0
<i>Trias</i> (red sandstone)	-	23 0
<i>Upper Permian</i> .—Red marls, with beds of limestone and 5 thin beds of gypsum	-	246 3
<i>Lower Permian Sandstone</i>	-	375 11
<i>Coal-measures</i>	-	90 0
		761 2

There can be no question that the Coal-measures were reached here, as the beds consisted of grey, blue, and dark shales, alternating with beds of grey and red sandstone; but it is difficult to say whether the measures are those which lie over or under the Bradford 4-feet coal. I am inclined to think, after much consideration, that the first workable coal which would be found would be the Yard seam, formerly worked in Moston Hall Colliery. From the thicknesses of the Permian beds as ascertained by the boring at Medlock Vale, and allowing for the rise of about  $15^{\circ}$  towards the east, the base of the Permian would probably reach the surface about  $\frac{1}{4}$  of a mile further up the valley, below Ash Bridge Farm; but there is great reason for supposing that the large fault, which has been proved at Moston Colliery under Broad Lane, and which has a downthrow to the north-east of about 60 yards, crosses the river a short distance east of Medlock Vale House, and again throws down the Permian beds, and thus spreads the Permian strata over a wider extent of ground than would otherwise be the case. The position of this fault is further indicated by the boring which was made at the corner of a field at Pole Lane End, Failsworth, where the Permian sandstone was pierced to a depth of 333 feet without having been passed through.† The section, as given by Mr. Binney, is as follows ‡ :—

	ft.	in.
Drift deposits	-	120 0
Red marls		5 4
Red sandstone	-	333 0
		458 4

This fault probably throws the Permian Sandstone as far east as a line drawn from Wrigley Head, Failsworth, southward by Woodhouses, Cinderland Hall, Cross Gate (Audenshaw), and Taylor Lane Farm, to the banks of the Mersey, a little west of Beat Bank Bridge, where the red sandstone may be seen in close proximity to the purple grits and shales of the Coal-measures.

The position of the Permian beds at this point on the River Thane is difficult of comprehension. I agree with Mr. Binney in thinking that the Permian sandstone occupies a trough in the Coal-measures in one

\* "*Additional Obs. on the Permian Beds.*" Proc. Lit. and Phil. Soc., No. 5, 1861–62, p. 138.

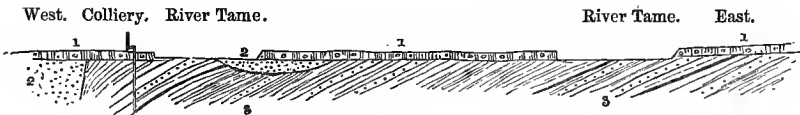
† The author visited the spot, and ascertained the precise position of the bore hole from the manager of Mr. W. Walmsley's mill.

‡ Mem. Lit. and Phil. Soc., vol. xii., p. 15.

place, while it is faulted against them in another. In a pit 60 yards in depth, sunk on the north bank of the river above the bend, a seam 3 feet thick was worked; and, according to the statement of Mr. Peter Higson, the levels were driven south for a distance of 100 yards in the direction of Harden Hall, under the red Permian sandstone. A seam 2 feet thick, lying 30 yards above the Yard coal, crops out in the river bank (under the Drift), and west of this the beds were found in a vertical position, indicating the presence of a large fault, along which the main mass of the Permian beds is thrown in. The section here may be somewhat as shown in the following woodcut.\*

Fig. 11.

SECTION ALONG THE RIVER MERSEY WEST OF BEAT BRIDGE.



1. Terraces of Drift-sand and clay.
2. Lower Permian Sandstone resting in a trough in the Coal-measures in one place, and faulted against them on the other.
3. Coal-measures, with seams of Coal.

Reviewing the general course of the Lower Permian Sandstone, it becomes evident that this rock, although extremely variable in its distribution, yet has a general tendency to thicken out towards the north-east. The section afforded by the boring at Seedley Print-works, west of Salford, proves that it is there only 12 feet in thickness, and at Patricroft only 21 feet.† At Collyhurst, however, which lies E.N.E. of these places, the thickness is at least 200 feet. Again, under the south part of Manchester, as we have just seen,‡ the thickness is under 70 feet, while at Medlock Vale, lying about 4 miles E.N.E. of this, the thickness is 375 feet, and at Failsworth, still in the same direction, 333 feet, without being penetrated. Thus we see a gradual increase in vertical measurement as we proceed easterly and northerly. These facts point to the north-east as the source from whence this sandy sediment has been originally derived.

Another point of interest is the position of these beds with reference to the Coal-formation which underlies it. In the memoir "On the Geology of Bolton-le-Moors," I have drawn a diagrammatic plan to illustrate the discordance between the two groups of strata. This discordance is shown to be least at Manchester, and to increase as we proceed westward, till it becomes a maximum towards St. Helens; our guide in the determination of the amount of discordance being the particular part of the Coal-measures on which the Permian beds rest. At Ardwick, as we have already seen, the Permian beds repose on the upper part of the Limestone series; at Patricroft they overlap the whole of this series, and rest on the hæmatite still farther down in the series; and at Bradford and Leigh the amount of overlap is still greater. Now, just as the discordance increases as we proceed westward from Manchester, so, I believe, it also increases as we proceed

\* The geology of this part is a little south of the 1-inch Map 88 S.W. See 6-inch Sheet 112.

† "Geology of the Country around Bolton." Mem. Geol. Survey. pages 20-21.

‡ Page 40.

eastward, and that the Permian beds along the valley of the Medlock, at Clayton Bridge and Medlock Vale, &c., rest on constantly descending beds of the Coal-measures, and certainly on considerably lower beds than those on which they repose at Ardwick. The measures proved in Mr. Higson's colliery at Denton must have been close to the border of the Permian beds, but there was no appearance of the Ardwick limestones, and there can be no question they were below this horizon. The same proposition applies to the Coal-measures, which skirt the Permian formation at Moston and Failsworth; they are all lower down in the series than the Ardwick limestones, and are probably near the position of the Bradford 4-foot coal. I have no doubt, therefore, that the Permian sandstone rests continually on lower beds of the Coal-measures as we proceed eastwards and northwards from Manchester, and that on this account there is a prospect of finding workable coal at a less depth than might otherwise have been expected beneath this formation.

#### NEW RED SANDSTONE, OR TRIAS.

The lower portion of the Trias is alone represented in this map, consisting of the Pebble beds belonging to the Bunter division. These beds are very well shown in several places around Manchester. They are everywhere similar in character, consisting of coarse-grained red sandstone, rather soft, and containing numerous pebbles of coloured quartz, grits, and hornstone or chert, the first-named rock predominating. It is seldom that these beds are sufficiently compact in this neighbourhood to be used as building stone, though they are largely quarried for that purpose in the neighbourhood of Liverpool.

The finest natural section in this district is that exposed to view in the river cliff which overhangs the Irwell at Broughton. There are also good sections in the same river at Hulme, extending along the banks from above Cornbrook to the railway bridge; and also for some distance along the banks of the Medlock, from its confluence with the Irwell. The dip of the beds here is south-west, at angles varying from  $10^{\circ}$  to  $20^{\circ}$ . At Oldsall, Messrs. Worrall penetrated these beds to a depth of 460 feet, without going through them. At the bottom of the bore the water became so salt that they discontinued the work, it being no longer fit for dyeing and bleaching purposes.\*

Another section is shown in the river bank at Waterloo Bridge. The dip is here north-west; and near this point, at Strangeways, the rock was found to be only 273 feet in thickness. At Broughton Bridge it was penetrated to a depth of 402 feet; and at Wheat Hill, to 345 feet.

The New Red Sandstone is nearly everywhere covered by Drift, except along the banks of the rivers which traverse Manchester, so that it is a rare occurrence to get a glimpse of the rock on which the city is built. A few months since, however, I was fortunate enough to find, very much to my surprise, a considerable opening excavated for the foundations for some houses on the north-east side of the London Road, near Cornbrook Little Bridge. It consisted of soft red sandstone, with pebbles of quartz, dipping to the W.S.W. at  $5^{\circ}$ . It was overlaid by only 6 feet of Drift.

The New Red Sandstone is a most valuable source of water-supply, and is penetrated by probably one hundred wells in Manchester and Salford, some of them yielding several thousand gallons of water per

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\* Mr. Binney, Proc. Lit. and Phil. Soc., No. 5, 1861-62.

day, for the factories, dye-works, &c. There can scarcely be any doubt that a large quantity of the water finds its way by percolation through the strata from the rivers Irwell, Irk, and Medlock; for it is almost impossible to conceive that so large a supply can be derived directly from the atmosphere alone. If we estimate the quantity raised from the New Red Sandstone and the Lower Permian Sandstone at 5,000,000 gallons a day, we shall probably make no exaggeration, and recollecting that this supply is cut off along the east side of Manchester by the Coal-field, and that the greater part of the hydrographical area is built over, or sealed against the infiltration of rain by a covering of boulder clay, there appears to me to be no other way of accounting for so large a supply. If this is the case, the New Red Sandstone must be considered as a most admirable filter, when it is capable of transforming the polluted streams of the Irwell, the Medlock, and the Irk into clear water, fit for bleaching, dyeing, and similar purposes.\*

Along the eastern side of the Manchester Coal-field, but few sections of the New Red Sandstone can be observed. The district around Heaton Park, Blackley, and Harpurhey is at present unexplored ground with reference to its geological structure. Nowhere do the rivers and brooks cut their channels down to the rock, and no light has been thrown on their nature by borings, except in two instances. One of these is the well at Crumpsall workhouse, which enters the New Red Sandstone, and the other a boring in the same formation at Mr. Jonathan Andrews' works, in the valley of the Irk.† This last boring must be close to the great fault which forms the boundary of the Coal-measures. At Newton this formation has also been reached in a well,‡ which gives us some data for estimating the breadth of the formation at this point.

The only section now open to view is that shown in the banks of the Medlock at Bank Bridge, close to the fault which bounds the Manchester Coal-field. The beds consist of soft red sandstone, with pebbles and bands of marl dipping W.  $10^{\circ}$  S. at  $25^{\circ}$ . Just above the weir, a boring of 98 yards has been sunk into the same formation without passing through.

From this point, the boundary fault turns towards the south, and passes by Clayton Colliery and Openshaw, where the New Red Sandstone was penetrated to a depth of 148 yards.§

The breadth of the New Red Sandstone east of the southern extremity of the Manchester Coal-field, is nearly 2 miles, as its easterly margin extends beyond the Gorton Waterworks. At the engine-house one of the wells passes into the New Red Sandstone, a depth of 70 yards, and is capable of yielding 600 gallons of water per minute; which is remarkable, considering that the greater part of the district is covered by Boulder clay, which must to a great degree prevent the descent of the rain. That the sandstone in which the well is sunk is Triassic, I have no doubt, from the samples shown me by the manager, which I was able to identify by the pebbles of quartz.

From this district southward the strata are concealed by a deep deposit of Drift, which overspreads the country in one nearly level

\* Dr. Angus Smith, F.R.S., informs me that the water drawn from the Trias in Manchester yields 14 grains of lime in a gallon, 8 grains of sulphate, and 6 of carbonate. This is probably an excess of salts above that usually given by this rock, and may be owing to the impure source of the water, as already stated.

† Mr. Binney, *Trans. Geol. Soc. Man.*, vol. i., p. 58, and vol. iii., p. 356.

‡ At the Shears public house, *ibid.*, p. 40.

§ *Ibid.*, vol. i., p. 40.

sheet as far as the banks of the Mersey. Along the banks of this river, both above and below Stockport, very fine sections in the Triassic and Permian beds are shown, the description of which properly belongs to a future memoir.

#### POST-PLIOCENE, OR DRIFT DEPOSIT.

I propose to give a short sketch of the succession of the Drift and more recent deposits in the neighbourhood of Manchester, to which I have recently paid a considerable share of attention.

When treating of this subject in a former memoir, "On the Geology of the country around Bolton-le-moors," I had merely given a sort of passing attention to the subject, without any attempt at mapping the divisions of the northern Drift. I was, therefore, under the impression, generally shared I believe by the geologists of the neighbourhood, that the high-level gravels which occur at Cheetham, Crumpsall, and Pendleton, were the uppermost members of the Drift, and had no immediate successors belonging to the Post-Pliocene period. It having been determined, however, that in addition to the ordinary geological maps, others showing the Drift and diluvial deposits should be prepared, I commenced, with the sanction of Professor Ramsay, a systematic survey of these beds, which speedily convinced me that the high-level gravel is surmounted by a second formation of Till or Boulder clay, quite as important, both in extent and thickness, as the lower, though often denuded from the tops of the high grounds composed of the gravel referred to.

In Mr. E. W. Binney's memoir "On the Drift Deposits of Manchester and neighbourhood,"\* in which a very detailed account of the subject is given, the existence of this second bed of Boulder clay is not distinctly stated as a component member of the series, but is alluded to as occurring in one part of Cheetham Hill, and gradually approaching the lower Boulder clay, until it actually comes in contact (or nearly so) with it, owing to the thinning away of the sand. In this paper "On the Drift Deposits of Blackpool,"† however, the same author describes two thick beds of Till, separated by an intermediate formation of sand and gravel, the whole presenting very much the appearance of the Drift-series of the country around Manchester. The coast section here was lately visited by myself in company with Professor Ramsay and Mr. A. H. Green of the Geological Survey, for the purpose of obtaining a clearer conception of the nature and arrangement of the beds along the fresh sections of the cliffs than could be obtained inland, and of making a comparison of the general series with those we had been tracing in the neighbourhood of Manchester. We could not fail to be struck with the similarity in the arrangement of the beds; but we considered it prudent to reserve any positive opinion regarding their parallelism *in time*, until the fact should be proved, or otherwise, by an actual survey of the intermediate tract of country.

The western half of the map is for the most part covered with a thick deposit of sand and clay, through which the more ancient strata seldom appear except in the deeper river channels. The eastern and more hilly tract is generally bare of such a covering, though erratic pebbles and boulders occur at considerable elevations. The thickness of this formation is often very great around Manchester. The banks of the Irwell at Whitefield are composed entirely of drift, and are

\* Lit. and Phil. Society Trans., vol. viii., new series, p. 194.

† Ibid., vol. x.

140 feet in height. At Mr. Stott's colliery, Prestwich, the drift was found to be 150 feet thick. At Kersall Moor the drift is 160 feet, judging from the height of the hill, and the level at which the rock appears in the valley below. In the neighbourhood of Ashton it is probably thicker than anywhere else; thus at Broad Oak Colliery it was found to be 174 feet; at Mr. Kenworthy's Colliery, 130 feet; at Copperas House Colliery, 78 feet.\*

On approaching the highlands along the borders of the counties, occasional hills of Coal-measures appear rising from below the Till; islands of rock surrounded by a sea of drift, giving promise of land; but in all probability these hills, of which Oldham Edge and Glodwick Low are the most remarkable examples, were themselves once overspread by the deposit, and owe their present bareness to denudation.

The Boulder clay sometimes runs very far up into the hills along the bottom of the valleys. It occurs in Greenfield Brook in the form of fine laminated sandy shale. There is also a patch of it along the left bank of the Tame, above Staleybridge. At Lees, near Oldham, the thickness of the drift must be about 200 feet in the valley of the Medlock, for I was informed that the level in the *Arley Mine*, at a depth of 85 yards, was driven into drift gravel in the direction of Nether Lees.

The general succession of the Post-Pliocene deposits around Manchester, appears to be as follows:—

1. Upper Boulder Clay, or Till - Reddish-brown clay with glaciated pebbles and boulders, sometimes containing bands of sand, and showing more or less distinct traces of stratification.
2. Middle Sand and Gravel - Fine sands, or gravel composed of waterworn pebbles, the whole distinctly stratified.
3. Lower Boulder Clay, or Till - Reddish-brown stiff clay with glaciated pebbles, presenting faint traces of stratification.

Below this third member a bed of gravel sometimes occurs, which is mentioned by Mr. Binney as having been proved in borings and sinkings at Barton Moss, and St. George's Colliery, Manchester; but I have nowhere been able to observe any such stratum in contact with the rocks and beneath the Lower Boulder Clay, and am inclined to think that it is merely a more stony form of this latter deposit, or a bed of sand resulting from the immediate decomposition of the underlying geological formation. In the case of St. George's Colliery,† where this lower bed of sand and gravel is stated to be 10½ feet in thickness, it is remarkable that no such bed is visible in the section, not more than 150 yards distant from the pit, shown in the Collyhurst sandstone delf, where the Lower Boulder Clay may be seen resting directly upon the Permian sandstone. I therefore feel inclined to omit this gravel bed from the general series of the Drift of this neighbourhood, as being either of local occurrence, or arising from the well-known uncertainty of such terms as used by miners and pit-sinkers;—and to assume the Lower Boulder Clay as the earliest stage of the Drift series.

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\* In addition to the above, I may mention a few more cases which have been collected by Mr. Binney. At St. George's Colliery, Manchester, the depth was 55½ feet; at Victoria Park, 58; at Mr. Williams' fire-clay pit, Berwick, 53; and at the industrial school, Swinton, in sinking a well, the bottom of the Drift was not reached at a depth of 93 feet. At Crumpsall Workhouse, the depth is 125 feet.

† This colliery has been closed for some years.

*The Lower Boulder Clay.*—On this bed the greater part of Manchester and Salford is built, and it may be traced almost continuously from the banks of the Severn, between Didsbury and Heaton Mersey, round by Heaton Norris, Openshaw, Clayton and Bradford, Collyhurst, Red Bank, and the Eccles road west of Salford. Thence we trace it westward by Monton, Ellenbrook, Tyldesley, Atherton, and Hindley; and northward of Manchester we find cropping it out along the banks of the rivers Irwell and Roch at the base of the high banks of sand. Owing also to the fact that it rises in the direction of the hills, it sometimes appears at the bottom of the valleys and brook courses: in this manner it may be traced along the borders of the Tame, between Stockport and Hyde.

The aspect of the Boulder Clay is so familiar to all of us that it scarcely requires description; at the same time there are few formations which require closer scrutiny in order to arrive at a true notion of the phenomena attending their deposition.\* The colour and general composition of the Till appears to be independent of the nature of the underlying geological formation, as it is nearly the same whether it rests on New Red Sandstone or Coal-measures; on the other hand, the nature of the pebbles and blocks of rock which it contains varies with the locality; but one almost constant feature applies to them from whatever district they are gathered. They are all more or less polished, striated, and scratched:—in a word, glaciated. The arrangement of the pebbles in the clay is also peculiar,—sometimes we find them lying on their flattest surface, and in nearly horizontal lines; but more generally they are imbedded pell-mell, some standing on end, others resting obliquely, or in all possible positions. The stones are seldom very large, and, taken as a whole, boulders of large size are by no means numerous: these are for the most part found scattered over the surface of the country, but there can be no doubt they have come for the most part from the Boulder Clay.

The thickness of the Till varies with the locality. It is probably greatest along the valley of the Mersey, and thins away, or entirely disappears, in the direction of the hills. Having been deposited over an uneven and generally inclined surface of the older rocks, these latter rise from beneath it and the two succeeding members of the Drift in the hilly districts of Bolton, Bury, Oldham, and Staleybridge. Around Manchester and Salford it is largely employed in the manufacture of bricks, of which the greater part of these towns is built; and it is in the brick-yards that almost all the sections are found.

It has sometimes been a question whether or not the Till is stratified. To this point Professor Ramsay on a recent visit directed my special attention. We visited together several sections in the neighbourhood, and everywhere discerned traces of bedding. These were sometimes very faint and rude, but were indicated either by partings of sand, a change along a definite line in the colour and aspect of the clay itself, or by a certain horizontal arrangement of the stones; and we could come to no other conclusion than that the formation is rudely stratified. This remark applies equally well, or rather with greater force, to the Upper Boulder Clay, in which we were so fortunate as to find a deep and fresh section in the railway cutting above Strines' Print Works, near New Mills.

*Sand and Gravel.*—This series is very distinct from either of the Boulder Clays, and consists for the most part of clean running sand

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\* I use the word as not necessarily implying stratification or bedding.



and gravel, often varying much in thickness, and resting on an uneven surface of the lower Till or of the older rocks. It may be traced from the banks of the Mersey at Stockport northward by Reddish, Gorton, Moston Hall, Harpurhey, Blackley, Cheetham, Prestwich, and along the banks of the Irwell and Tonge beyond Bolton and Bury. Then westward by Pendlebury, Swinton, Worsley Stocks, and Wharton Hall, in the direction of Wigan. It also occupies a large tract by Heywood, Middleton, Rochdale, and Royton. It appears also in the valley of the Tame, and may be generally traced lying between the two beds of Till from Stockport to Staleybridge. At Chadderton Park and Tandle Hill it forms conspicuous elevations.

At Mr. Stott's colliery at Prestwich it was 50 yards thick; and in a pit north of Great Nathurst Hall it was not passed through at 60 yards from the surface.\* Notwithstanding, however, its great thickness in some places, in others it almost disappears. Thus at Gorton it is not more than 15 or 20 feet thick; and at one or two places at Cheetham Hill the Upper and Lower Boulder Clays almost meet each other,—a fact noted by Mr. Binney. I am inclined to think, however, after having followed the outcrop of the sand for many miles, that such a phenomenon is attributable in some degree to the undermining of the sand, and the consequent falling over of the clay. During the denudation of the Drift there would be a constant tendency to the formation of running sand, such as would easily be washed out of the cliffs or hill side, and thus allow of the subsidence of the upper clay.

The gravel is not only stratified, but also frequently obliquely laminated or traversed by current-planes. The pebbles are waterworn, and are not scratched or ground in the manner of those imbedded in the Till. At Bourton, Hyde, and Bredbury,† shells for the most part in a fragmentary state have been discovered; but it must be confessed that their occurrence is very rare in this neighbourhood, though in similar deposits at Blackpool they are abundant. Besides pebbles it contains great quantities of drifted coal, which have doubtless been washed out of the Carboniferous strata of the neighbourhood. The following list of pebbles was made from the gravel of Heaton, north of Manchester, and they are here stated in the order of their numerical abundance.

1. Carboniferous grit. 2. Carboniferous shale and pieces of coal. 3. Hard greenish Silurian grit. 4. Trap and porphyry. 5. Red granite. 6. Red and white quartz. Further toward the hills, at Bolton and Bury, the gravel is formed almost exclusively of Carboniferous grits.

It is seldom that bands of clay appear in the middle sand, but it so happens that between Whitfield and Rochdale a bed of reddish clay in all respects similar to the ordinary Till makes its appearance in the very centre of the sand. It is probably not more than from 5 to 10 feet in thickness, but from the fact of its occurrence in a sandy country it is largely worked for bricks, and assumes an appearance of greater importance than really belongs to it. This bed of clay may be seen in the railway cutting at Clough Side, in a brick-yard near Outwood Park, and in several others west and south of Heywood and Hopwood Park.

The sand has been subjected to a considerable amount of denudation previous to the deposition of the upper Boulder clay; this may be one way of accounting for its thinness in some places. We find the upper surface frequently much eroded and worn into hollows, and filled

\* Some 5 or 6 yards of the top of this pit was composed of upper Till.

† By Mr. John Taylor, *Trans. Geol. Soc. Manchester*, 1862.

with the upper Boulder clay, which has then the appearance on the surface of lying at a lower level. Several very interesting sections showing these phenomena came under my notice while tracing the outline of the upper Till. The most remarkable was observed in a sand-pit at Heyside, near Oldham, where the sand rises on one side several feet above the Till which is shown inside of the pit to rest on the eroded surface of the sand. The next section was observed in an excavation on the west side of Oldham, near Chadderton Workhouse. In cutting the new road from Altrincham to Bowdon, a section was exposed showing what I now recognize as the upper Boulder clay, resting upon an eroded surface of the middle sand. I was informed that here this latter has been proved to be upwards of 20 yards in thickness, and the water level is 15 yards from the surface at the upper part of the town. These, with several others, combine to show that the two formations are to a certain extent distinct from each other, and are separated by a period of time represented by that necessary for the amount of deundation. At the same time there are other sections, such as that at Gorton, already alluded to, where the line of junction is perfectly even and regular.

*The Upper Boulder Clay.*—This subdivision of the Drift is so like in all respects to the lower Boulder clay, that a short description of its range will alone be necessary. It is this stratum which ascends the highest flanks of the hills, capping the gravel, or resting upon the surfaces of the older rocks. In either of these positions we find it on the moors north and east of Bolton, on the western slope of Oldham Edge, and filling in the valleys of the lower Carboniferous rocks of the Penine Chain. From these elevations it slopes downward towards the plain of Cheshire, and here it tends to form flat terraces, capping the sand, along the banks of the Bollin, at Wilmslow, as also Bramhall Brook, the river Tame between Stockport and Staleybridge, and the Medlock east of Clayton. It also caps the high gravelly hills above Harpurhey and Crumpsall. It forms the flat moorland of Clifton and Linnyslaw Moss, and extends westward by Little Hulton to West Houghton. Along the western banks of the Irwell and Tonge, it caps the sand all the way from Pendlebury House to Bolton, and in this position it may be observed in a pit above Dewhurst Clough, near Dunscar Bridge; in a brick-yard opposite Mr. Scowcroft's colliery at Bolton, and in a sand-pit on the north bank of the canal, near Black Cat Colliery, Radcliffe Bridge.

I have already stated, that the various members of the Drift above described slope from the hills downward towards the plains; thus we often find the base of the upper Boulder clay keeping the same height above the bed of a brook for several miles, or even rising more rapidly than the brook, and in tracing their boundaries by means of the 6-inch ordnance map, I found them frequently crossing the contour lines. Thus, if we take the level of the base of the upper Boulder clay at Pendlebury we find it is there about 270 feet above the sea; at Halshaw Moor 275, at Bolton 300, at Little Bolton 370, and at Sharples it rises nearly to 500 feet:—so much for the slope from north to south, along the northern margin of the plain. But the inclination is not less perceptible along the eastern margin; thus, if we trace the base of the upper Till from Gatley, near Cheadle, in the direction of Poynton, we find that at the former place it descends almost to the level of the Mersey, while at the latter it is higher than one of the tributaries of this same river. It is therefore evident that the beds of Drift rise from the plains towards the hills in at least these two directions.\*

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\* Mr. Binney notices this fact at Pendleton.—Proc. Geol. Soc. 1843, p. 18.

In order to account for this, I was for some time inclined to believe that the slope of the beds was a true dip, arising from the elevation of the land at the close of the Glacial period, and that this elevation had taken place along the old lines of upheaval, dating as far back as the close of the Palæozoic period. However, Professor Ramsay does not consider that so speculative a theory is required to account for the phenomena above stated, but suggests that the deposition upon a previously inclined surface is a sufficient explanation; and in that opinion I reluctantly concur.

The following list of rock-fragments, with their per-centages, have been determined by Professor Ramsay at Gorton.

Silurian grits	-	-	-	37 per cent.
Felspar porphyry	-	-	-	31 "
Felstone	-	-	-	2 "
Carboniferous grits	-	-	-	14 "
Granite	-	-	-	6 "
Porphyritic conglomerate	-	-	-	4 "
Carboniferous Limestone	-	-	-	3 "
Ironstone	-	-	-	2 "
				99 "

These may be compared with a list taken from the cliffs of the Mersey at Eastham, near Birkenhead.

Silurian grits	-	-	-	43 per cent.
Felspar porphyry	-	-	-	5 "
Felstone	-	-	-	7 "
Carboniferous grits	-	-	-	1 "
Granite	-	-	-	8 "
Greenstone	-	-	-	8 "
Carboniferous Limestone	-	-	-	4 "
Quartz rock	-	-	-	9 "
New Red Sandstone, or Permian	-	-	-	12 "
Ironstone	-	-	-	1 "
				98 "

Similar lists have been tabulated by Mr. Binney\* from the Till of Salford, Cheetham, and Openshaw, near Manchester, the last place being not far distant from Gorton; but there is considerable difference in the percentages, as he makes a larger proportion of Carboniferous grits, and a smaller proportion of Silurian rocks.

The Boulder clay in the immediate vicinity of Manchester has hitherto yielded no shells; but in the Vale of Mottram, on two occasions, shells of the species now living in the Irish Sea have been discovered. The first by Mr. J. F. Bateman, C.E., during the construction of the Hollingworth reservoir, when he met with a considerable number of the common cockspur shell (*Turritella terebra*). In the second, Mr. J. Prestwich, F.R.S., and Mr. Binney, in the summer of 1862, were fortunate enough to discover near the same spot several recent species, imbedded in a deposit of brown sandy clay, which had just been cut through to the depth of about 4 feet for the purpose of forming the goit. The elevation of the spot, as furnished to Mr. Binney by the City Engineer, Mr. J. G. Lynde, is 568 feet above the level of the Irish Sea. The species found on this occasion were *Turritella terebra*, *Fusus Bamfius*, *Purpura lapillus*, *Tellina*, and *Cardium edule*.† Recent shells have also been found by Mr. John Taylor in the Drift of Bredbury and Hyde.

\* Trans. Geol. Soc. Manchester, vol. iii., p. 358.

† See account by Mr. Binney, Proc. Lit. and Phil. Soc., No. 3, 1862-63.

*Boulders.*—We frequently find very large boulders of granite, porphyry, and other rocks, either imbedded in the Till, or lying in spots, frequently the summit of a hill. I shall here refer to a few of these which are specially deserving of notice, as representatives of erratic blocks from distant and local sources.

1. The first of these blocks occurs a little east of Chamber Colliery, near Oldham, at a height of 670 feet above the sea. It has recently been disinterred from its bed of Boulder clay, where it lay entombed, and is composed of felspar porphyry, a rock which can have no nearer birthplace than the Lake District. It is about 8 feet in diameter, and probably weighs about 12 or 15 tons. Its extreme hardness has hitherto enabled it to resist all attacks, and every geologist will join in sincerest good wishes that it may withstand every attempt at its destruction.

2. The second example is of more local origin, but is worthy of notice from its great size, and the elevation at which it lies. It is called the "Way Stone," and is one of a group of large blocks, lying on Buckstones Moss, on the borders of Yorkshire, at an elevation of 1,550 feet above the sea. The name has been given to the largest of a group of blocks which lie on the crest of a ridge amongst the dreary moorlands, and has probably served as a landmark for ages back. The boulders are composed of very coarse massive grit or conglomerate, while the ridge on which it stands is formed of fine-grained flaggy sandstones and shales. From the base of the ridge stretches a wide plain looking

*Fig. 12.*



towards the north and west, and it would appear that this great block of grit had been stranded on this ridge by an iceberg while on its voyage towards the south. That the Way Stone is an erratic block is beyond question, as it is altogether dissimilar in mineral character from the strata on which it lies. The largest of the group will probably weigh from 15 to 20 tons.

3. A boulder of granite lies on the summit of Nicholas Pike near Butterworth, at an elevation of 1,050 feet, and near this hill the Drift in Hanging Lees Clough contains many large boulders of rocks not occurring in the neighbourhood.

4. A boulder of indurated slate rock occurs on Brown Edge above Mossley, at a height of 1,012 feet above the sea.

5. The last instances which I shall notice occur near Disley, and are, therefore, rather out of the district embraced by this memoir; but it may be as well to note their occurrence while on this subject. The long valley of Saltersford is lined by Boulder clay, which extends on either side about half way up its flanks; but on the crest of the ridge which divides this valley from that of the Goyt, near a farm called Black Hill Gate, and at a considerable elevation above the upper edge of the Drift, lie two boulders of transported rock; one of these is composed of granite, the other of dark blue felspar trap, and their position is at a height of 950 feet (approximately) above the sea, as determined by Professor Ramsay with an aneroid barometer. From the general form

of the valley we came to the conclusion that these blocks had been carried over a ridge or pass which crosses the head of the valley, called Dissop Head, which lies northward of that of Black Hill Gate, and is itself of nearly the same elevation.

*River Terraces, Valley Gravel.*—The river terraces in the neighbourhood of Manchester have already been fully described in previous memoirs.\* On one of these terraces Lower Broughton is built. It rises about 6 feet above the present alluvial flat, which is liable to floods. The edge of the terrace is marked by a sudden rise of the ground, and may be traced from Grove Place, by Talavera Place, and round by Irwell House to the Suspension Bridge. The inward boundary of the terrace is formed by the steep bank of Boulder clay which runs from the river cliff, by Great Clowes Street and the Grove Inn, to Strangeways.†

On the north side of Lower Broughton a pit has been opened in the Valley Gravel, affording the following section :—

	ft. in.
Soil and turf	0 6
Sandy and clayey loam	- 4 0
Sand and gravel, or rounded pebbles, sometimes iron-stained, and similar to those found in the Drift	6 0

At this pit I made a diligent search for shells, or any objects affording a clue to the age of these gravels, but without success, not even a flint arrow-head has as yet been found, though they are certainly not more ancient than those gravels which afford these relics of early human art.

Persons who have crossed the ground on both sides of the Mersey, from Old Trafford to Altrincham, cannot fail to have observed the extreme flatness of the country. I had frequently remarked it myself, and was aware that on some parts of it there was a layer of gravel or sand; but was unaware whether this gravel belonged to the northern Drift, or was of more recent origin. Not long since I commenced to trace its margin, and found that it occupies a considerable extent of country, and is either an estuarine deposit, at a period when the land was at a lower level, or, as Professor Ramsay supposes, is an old river terrace of a period when the rivers Irwell and Mersey had a much wider range than at present. Failing the discovery of shells, which would of course settle this point, we must leave it in abeyance for the present.

The gravel lies for the most part on the lower Boulder clay, and is composed of small pebbles, well rounded, and generally evenly bedded; sometimes it passes into fine sand, white or ochreous. It is exposed to view in a brick-yard at Urmston, near Stretford, resting on Boulder clay, and forming a terrace about 30 or 40 feet above the alluvium of the Mersey. It may also be seen in pits at Cheadle, Didsbury, Bromyhurst, near Barton-upon-Irwell, at Barton Old Hall, and Barton Grange; at this latter place it underlies the peat of Barton Moss, and rests on Boulder clay.

The gravel may be traced from Didsbury, through Withington, Hulme, Old Trafford, Trafford Park, Patricroft, and Winton to Barton Moss; and it occupies all that flat country lying between the banks of the Irwell and Mersey, and extending into Cheshire as far as Timperley and Altrincham.

\* Geology of Bolton, p. 29. Geology of Altrincham, p. 6.

† On the Geology of the country around Bolton-le-Moors.

*Warp*.—At the base of Grundy Hill, east of Didsbury, is shown a very interesting section in the large brick and tile works there in operation, and presenting the following series in descending order :—

- |   |   |   |   |              |
|---|---|---|---|--------------|
| 1. Fine white sand, laminated   | - | - | - | 2 feet.      |
| 2. Layer of peaty matter, composed of the stems and branches of a tree with a shining bark, either birch or hazel | - | - | - | 3 inches.    |
| 3. Dark brown fine laminated sand, without pebbles (warp?)  | - | - | - | 5 or 6 feet. |
| 4. Boulder clay with striated pebbles   | - | - | - | 5 feet.      |

On visiting this section I was struck by the remarkably laminated aspect of the clay No. 3 ; but seeing that it passed down into genuine Boulder clay, and was surmounted by sand, apparently the same as that which forms the hill, I concluded that this was the junction of the middle sand on the lower Boulder clay, and that the bed of decomposed wood represented a land surface of the Drift period.

Professor Ramsay, however, on subsequently visiting the spot with me, at once recognized the laminated clay as “warp,” or alluvial mud of a river, similar to that of the valley of the Humber, which he had only lately visited ; and in this opinion he was confirmed by the rather fresh aspect of the wood, and the fact that the whole lies in the river valley of the Mersey, though at an elevation of 50 feet above the ordinary level of that river. If Professor Ramsay’s opinion is correct, the position of this warp will show a former much more extended over-spread of the river, including on either side a wide tract of flat country, covered with fine sand and gravel, and extending from Didsbury for many miles in the direction of the sea. The junction of the Warp with the Till is not very apparent, but from the rapidly increasing thickness of the former from its edge towards the base of the hill, it seems to rest in a hollow formed in the Boulder clay.

## FAULTS.

**FAULTS IN THE TRIAS AND PERMIAN ROCKS.**—The western boundary of the Manchester Coal-field, north of Ancoats Bridge, appears to be a fault, both on account of the absence of the Permian beds and the manner in which the Coal-measures run up and terminate against it. Mr. Binney, on the other hand, who, in company with Mr. Mellor, has had an opportunity of examining the junction from a tunnel driven in the limestone, considers this a case in which the Permian beds rest unconformably on an eroded surface of Carboniferous strata. He says, “The Carboniferous strata present every appearance of having undergone considerable erosion by water, the shaly clays showing a very irregular surface, on which lay rounded boulders of Ardwick limestone, and the hollows in such clays being filled with Lower Red Sandstone.\*

The fault which bounds the Collyhurst sandstone along the south-east, and which runs for some distance along the side of the Rochdale Road was proved in the workings of the 4-feet coal, of which I have had an opportunity of seeing the plans. The coal-seams, on approaching the fault, bend round towards the west, and as the fault slopes very much, in some places as much as  $1\frac{1}{2}$  vertical to 1 horizontal, the coal has been worked considerably under the upper surface of the Permian beds.

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\* Mem. Lit. and Phil. Soc., vol. xii., p. 12.

The fault which forms the eastern boundary of the Coal-field may be observed at Bank Bridge Works. Of this fault Mr. Binney states\* "that in some places the red sandstone overlies the basset edges of the coals, and in others a stiff red clay, of about a foot in thickness, intervenes between them and the sandstone. The fault is not vertical, but inclines to the east from 1 foot in 2 to 1 in 4. Great blocks of stone and coal recline on its sides, exhibiting appearances similar to what would be seen on a shelving bank of Coal-measures at the surface. The grit rocks project towards the sandstone further than the shales, forming little terraces, and bear marks of the action of water on a coast line; no fractures or flexures appears in the sandstone to indicate the formation of the fault since its deposition." The author of the above description considers that the Carboniferous beds have been worn away by marine action to a distance from the original line of dislocation, and that upon the surface thus formed the Trias has been deposited.

The fault which is marked on the Map with a dotted line as crossing the Medlock east of the weir at Clayton Bridge Print-works, has previously been referred to. It is evident, from the general arrangement of the beds as proved by the river-sections and borings, that a large fault must cross the river between Clayton Bridge and Medlock Vale. In the borings at the latter spot, as also in Jericho Clough, Trias and Permian beds have been found beyond the outcrop of the Lower Permian Sandstone, and the supposed Upper Coal-measures at Clayton Bridge weir.† This fault also appears to be in the same line with one found at Moston Colliery.

The strip of New Red Sandstone, 23 feet thick in the boring at Medlock Vale, is probably let in by a small fault.

That the Permian beds, which were found in the boring near Fails-worth mill, have been thrown in by a large fault, there cannot be a question, as they are considerably on the rise of the general strike of the Coal-measures of Moston Colliery. The fault which I have drawn, in order to account for their presence here, is in a line with a very large dislocation which ranges through Middleton, throwing down the strata towards the north-east about 100 yards.

*Faults in the Coal-measures.*—The greater number of the faults in the Coal-measures range north by west; and nearly all those marked on the Map have been either proved in the mines, or observed in sections.

Of the faults marked at Middleton, the whole have been taken from mining plans. One of these passes by Alkington Colliery, and has a down-throw to the east of 30 yards. The next passes by Tonge Hall, and ranges for several miles, passing through the west part of Heywood. The throw at Middleton is about 100 or 120 yards down to the east; and from this point it seems gradually to lessen in amount, and to die out on the north side of the Roch. It may be seen in a little gully on the north side of Heywood. Several small faults, north and east of Middleton, do not require special notice.

The fault which passes by Hilton Fold is said to pass under Middleton junction, and is probably a continuation of the large dislocation which ranges by Coalshaw Green, Hollinwood, Warmley Wood Colliery, and has been found to pass by Valley Bridge, Waterloo, and to the north of Lord's Field Colliery. Ashton-under-Lyne. Owing to the

\* Trans. Geol. Soc., vol. i., p. 51.

† See *ante*, p. 41.

refusal of the manager of Hollinwood Colliery to give me information, I cannot say that the details regarding this fault south of Hollinwood are very precise; but I am informed that the strata for some distance south of the fault were found to be very much broken, and thrown into steep inclinations, so that the coals were unworkable. The fault has a down-throw towards the south-west.

The faults which are marked as passing through the top of Hollinwood and Werneth Lodge have been obtained from information on the spot, and I have every reason to believe in their accuracy.

The faults which traverse the town of Oldham have been taken from working plans. The largest of these commences south of Fairbottom House, crosses the Medlock at Fairbottom Bobs, and ranges by Fitton Hill and Sheepwashes. Here it has a slope of  $45^{\circ}$  east. It then ranges by Oldham parish church, and at Edge Lane has a throw of 320 yards down to the east. It has been traced northward by Royton, High Gate, and Hathershaw, in the workings of the Royley mine, which is thrown out on the west side of the fault. Northward of this, it continues its course west of Rochdale, by Oakenrod Hall, bringing in the Royley mine in the isolated area already described.\*

The faults which bring in the patches of the Arley mine north-east of Heywood, have been taken from working plans. Some of them, however, may be seen in the river banks; one which passes south of Bamford Hall may be seen in the bank at Gelder Brow, and in the bank of the Roch at Grimble cotton-mill; another at Broadhaigh fulling-mill; and another west of Hill House mill, in the south bank.

The faults at the east side of Oldham have been traced with the assistance of Mr. Mayall, of Barrowshaw Colliery; one of these, immediately on the deep of the pit, brings in a strip of the Royley mine, and has a down-throw to the west of about 180 yards.

The faults which cross the whole Coal-series, from west to east, at Hurst, have been proved in the workings of several collieries. One of them may be seen in a quarry near the railway bridge at Heyrod. The fault which ranges from Dukinfield and passes under St. Michael's Church, Ashton-under-Lyne, is indicated in the road-section under Schoral Wood by the shattered state of the rock. It is a down-throw of uncertain amount towards the south-west. Another fault, which seems to run into the last-mentioned south of Dukinfield, passes by Dunkirk Colliery, and may be seen in the river bank at the bend near the railway bridge. At Hyde the beds are very much disturbed and broken by faults, which I have drawn from the plans as fully as the small scale of the 1-inch map would allow. The Black mine, and all the underlying seams of the Middle series, appear to be thrown out to the east by a large fault, which passes a little east of Newton railway station, as the Gannister coal has been worked near this spot, and there is not room for all the beds between the Black mine and Gannister seam to rise and crop out in regular succession.

The "Curren Lane fault," which passes by Hurst Brook and Park Hall, appears to die out eastward at Staleybridge, as there is no appearance of it in the banks of the Tame at St. George's Church.

The faults in the Lower Coal-measures and Millstone Grit need scarcely be described in detail, as they seldom involve any question of economic value. Most of these are actually visible at one or more points of their course. I shall confine myself therefore to the description of the Great

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\* I have received much assistance from Mr. Roscoe, of the firm of Roscoe and Lord and Mr. John Smith, of Bagslate, and Mr. Whitehead, mineral surveyor, of Rochdale, in working out the structure of this district.

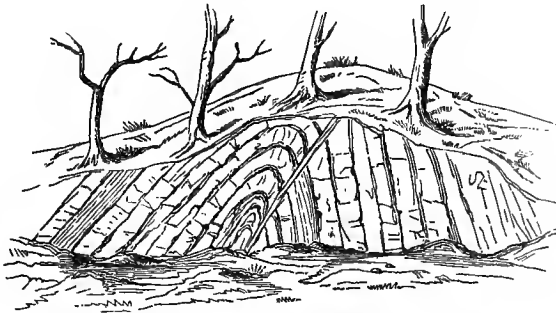


Penine fault, which produces such important changes in the geological structure of the district. This fault ranges nearly due north and south, sometimes splitting into several branches and generally reversing the dip of the beds.

The fault shows itself at Denshaw, at the north of the Map, and may be very clearly observed along the section in the road at Wragstone, where a little patch of the limestone shale is brought up on the west side. The fault crosses the western end of Millstone Edge, and may be seen in a gully at the head of the valley, at a spot where a cliff of the Kinder Scout Grit is terminated. Further south it is seen reversing the dip of the beds in a quarry north of Car; and again near the entrance to the tunnel, where the beds may be seen nearly erect. All along its course, as far as Greenfield Brook, the position of the fault may be ascertained by the verticality of the beds and the change of dip. At this part it is joined by several branches, which radiate from the neighbourhood of Warlow Pike, and show that at this spot enormous disturbing influences have been concentrated. One of the most important branches passes by the west side of Warmton Wood, and ranges northward by Old Delf. It joins the main line at the base of Buckton Hill, and henceforward the whole amount of disturbance is expressed by a single line of fracture. The disturbed state of the strata occasioned by proximity to the great fault may be seen in Car Brook, east of the turnpike road. A remarkable folding of the grits and shales is shown a little east of the fault itself, in a bank behind some bleach-works, of which a

*Fig. 13.*

CONTORTION OF THE STRATA ALONG CAR BROOK NEAR THE PENINE FAULT.

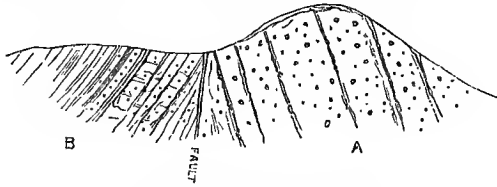


sketch is annexed (Fig. 13). I at first thought that the small fissure there seen was the fault itself; but on subsequent examination became satisfied that the real fault is further down the bank. The grits are extremely hard and compact, and, though bent in the manner shown in the figure, are but slightly broken. The effect of the fault west of Harridge Pike is to bring down the Millstone Grit against the Limestone Shale; this may be very clearly made out at the base of the hill at Buckley's Farm, where the dip is very suddenly reversed (Fig. 4). Further south, at Harpley, the second grit is brought down against the shale, as the beds on the west side of the fault sweep round to the east and are ended off against it.

At the western entrance to the cutting at Roecross, the beds are seen rearing up at an angle of  $50^{\circ}$ , but the fault itself is not visible. At the southern end of Harrop Edge the fracture is very well shown at the entrance to a quarry of the Kinder Scout Grit (Fig. 14), on both sides

*Fig. 14.*

## PENNINE FAULT AT HARROP EDGE, NEAR MOTTRAM.



A. Massive, very coarse Grit.

B. Fine Grits and Shales.

the beds dip at high angles away from the fault in opposite directions. From this point the line of disturbance may be traced southwards into Cheshire and the borders of Derbyshire, producing similar changes in the geological structure of the country.

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## APPENDIX ON THE FOSSILS,

By J W. SALTER, F.G.S., A.L.S.

I am sorry that circumstances, over which I have no control, prevent my filling up the following lists from data in the Manchester and other museums. I can but give those collected by the Survey; adding a few observed by myself in the collection of the Manchester Geological Society, or supplied to me on certain authority. This can therefore only be considered as a contribution to the palæontology of the eastern portion of the Lancashire Coal-field; not as a full illustration of it.

## MILLSTONE GRIT.

Name.	Locality.	Position.
<i>Lepidodendron Sternbergii</i> }	St. Paul's Church, Staleybridge	{ Middle of Millstone Grit.
<i>Stigmaria ficoides</i>	Do. - - -	
<i>Sternbergia</i> - - -	Do. - - -	
<i>Halonina</i> - - -	Do. - - -	
<i>Næggerathia</i> - - -	North of Mottram - - -	{ Deep in Millstone Grit.
<i>Calamites Suekowi</i> }	Quarter of a mile east of Red Brook Reservoir, 10 miles N.E. of Staleybridge.	{ ———
<i>Neuropteris</i> - - -	Bottersley Clough, Yorkshire,	
<i>Ulodendron majus</i> - - -	North of Mottram - - -	{ Deep in Millstone Grit.
<i>Athyris ambigua</i> , or <i>planosulcata</i> - - - <i>Aviculopecten</i> - - -	Hattersley, 1 mile S.W. of Mottram Do. - - -	{ Over the Mottram Coal. Do.
<i>Aviculopecten papyraceus</i> - - -	Dry Clough, 8 miles north of Dob Cross. Hoarstone Edge, 6 miles north of Dob Cross.	{ ———
<i>Posidonia Gibsoni</i> ? - - -	Dry Clough, 8 miles north of Dob Cross.	
<i>Monotis ? obtusa</i> - - -	Forestone Edge, 6 miles north of Dob Cross.	{ ———
<i>Monotis ? lævis</i> ? - - -	March Hill, 5 miles north of Dob Cross.	{ ———
<i>Modiola</i> , sp. - - -	Road Cutting, Roe Cross, near Mottram - - - - -	{ Near bottom of Millstone Grit.
<i>Goniatites Listeri</i> - - -	Hattersley, 1 mile S.W. of Mottram Pule Moss, 3 miles N.E. of Diggle.	{ Over the Mottram Coal. Shales in Millstone Grit.
<i>Goniatites striatus</i> - - -	Hoarstone Edge, 6 miles north of Dob Cross. March Hill, 5 miles north of Dob Cross.	{ ———
<i>Goniatites Gibsoni</i> - - -	Pule Moss.	
<i>Goniatites truncatus</i> - - -	Hoarstone Edge, 6 miles north of Dob Cross.	{ ———
<i>Goniatites reticulatus</i>	North of Mottram.	{ ———
<i>Goniatites spiralis</i> - - -	South side of Pule Hill, Yorkshire.	{ ———

Name.	Locality.	Position.
<i>Goniatites (bilinguis,</i> <i>Fig 14.)</i>	Pule Moss, 3 miles N.E. of Diggle.	} Shales in Millstone Grit. — — —
	Dry Clough, 8 miles north of Dob Cross.	
	Horestone Edge, 6 miles north of Dobcross.	
	March Hill, 5 miles north of Dob Cross.	
<i>Orthoceras</i>	Pule Moss.	—
<i>Palaeoniscus</i>	March Hill.	—

It is almost necessary to give a figure and description of the very uncommon *Goniatite* above quoted, and which, from the exaggerated processes on the edge of the mouth, I have called *G. bilinguis*, n. sp.

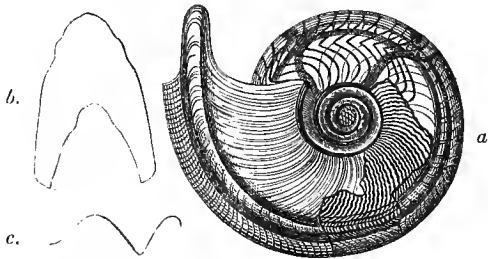


Fig. 14. GONIATITES BILINGUIS. N. SP.

a. Full-grown specimen.

b. Section of mouth.

c. Septum.

*Description.*—Involute, an inch and a half diameter, and a good deal compressed, with a double concentric furrow near the periphery, and the sides from thence flattened as far as the steep-edged umbilicus. Surface reticulate. Mouth with two strong projecting tongue-like lobes near the outer margin. Septa-lobes very open and angular, one on each side. Aperture blunt sagittate. Umbilicus moderate, one-fourth the diameter of the shell.

Ratio of outer whorl to the whole diameter, in a shell 16 lines diameter, 5:12,—in younger specimens 5:10; of thickness to width in the last whorl, as 14:13. Immersion of the inner in the outer whorl about one-half.

The above characters may serve to distinguish a rather common shell in the Millstone Grit of Yorkshire and Lancashire. The general aspect is a good deal that of *G. reticulatus*. Nor do I see very much difference, except in the great lengthening of the oral processes in *G. bilinguis*; the deep sulcation of the margin, and the more open angle and straight sides of the lateral lobe. But these differences are quite sufficient to establish the species.

*Localities.* See above. Also in several Millstone Grit localities in Yorkshire and Derhysire.

#### LOWER COAL-MEASURES.

Name.	Locality.	Position.
<i>Pecopteris arborescens</i>	Ashworth Moor -	} Featheredge Coal. —
<i>Neuropteris flexuosus</i>	Ashworth Moor, below Pottery.	
<i>Noggerathia</i>	Redlumb, 5 miles W. by N. of Rochdale -	} Do. Do.
<i>Sphenopteris latifolia</i>	Do. - -	
<i>Sphenopteris acutifolia</i>	Roadfield, east of Rochdale - -	} Gannister. Featheredge Coal.
<i>Sphenopteris acutifolia</i>	Redlumb, 5 miles W. by N. of Rochdale -	
<i>Asterophyllites foliosa</i>	Do. - -	} Do. Do.
	Ashworth Moor, below Pottery -	

Name.	Locality.	Position.
<i>Asterophyllites</i> , sp. inc.	Broad Car, Mossley, Staleybridge - Roadfield, east of Rochdale - -	Gannister Coal. Do.
<i>Sigillaria hexagona</i> -	Redlumb, 5 miles W. by N. of Rochdale - -	} Featheredge Coal.
<i>Sigillaria mammillata</i>	Do. - -	
<i>Sigillaria reniformis</i> -	Do. - -	Do.
<i>Sigillaria</i> , sp. inc. -	Two miles N.W. of Rochdale Helpet Edge, Ogden Mill, 4 miles north of Oldham - -	} Above Gannister Coal.
<i>Calamites Suchowii</i> -	Redlumb, 5 miles W. by N. of Rochdale - -	
<i>Calamites</i> , sp. inc. -	Roadfield, east of Rochdale Long Grains, 4 miles north of Dob Cross - -	} Gannister Coal. Gannister Beds. Coal above the Lower Yard Mine.
<i>Lepidodendron Sternbergii</i> -	Helpet Edge, Ogden Mill, 5 miles north of Oldham - -	
<i>Lepidodendron dilatatum</i>	Ashworth Moor, below Pottery - Two miles N.W. of Rochdale	} Upper Foot Mine. Featheredge Coal. Gannister Coal.
<i>Lepidodendron obovatum</i> -	Roadfield, east of Rochdale	
<i>Lepidodendron</i> , sp. inc.	Two miles N.W. of Rochdale Bagslate Moor, 1½ miles north of Rochdale - -	} Do. Do.
<i>Lepidostrobus</i> -	Broad Car, Mossley, Staleybridge - Roehuck Low, 1½ miles N.E. of Oldham - -	
<i>Uladendron majus</i>	Roadfield, east of Rochdale Ashworth Moor, below Pottery Do. - -	} Do. Featheredge Coal. Do.
<i>Halonia</i> - -	Bagslate Moor, 1½ miles north of Rochdale - -	
<i>Stigmaria ficoides</i> -	Roadfield, east of Rochdale - Two miles N.W. of Rochdale	} Gannister Coal. Do. Do.
<i>Stigmaria</i> , sp.	Helpet Edge, Ogden Mill, 4 miles north of Oldham - -	
<i>Fruit of Calamite</i> -	Long Grains, 4 miles north of Dob Cross - -	} Lower Mine Foot, below the Gannister Coal. Gannister Beds. Coal above the Lower Yard Mine. Gannister Coal.
<i>Aviculopecten papyraceus</i> -	Broad Car, Mossley, Staleybridge - Roadfield, east of Rochdale - -	
<i>Anthracosia ovalis</i> -	Roebuck Low, 1½ miles N.E. of Oldham - -	} Do. Do.
<i>Anthracosia acuta</i> -	Ogden Mill, 5 miles north of Old- ham - -	
<i>Anthracosia</i> , sp. inc.	Shore Edge, 4 miles north of Old- ham - -	} Do. Do.
<i>Anthracosia</i> , (Halifax species) -	Count Hill, N.E. of Oldham - Sholver, 2 miles N.E. of Oldham -	
<i>Monotis</i> ? ( <i>Gervillia obtusa</i> , Brown)	High Marcroft Gate - - Dog Hill, Oldham - -	} Bullion Coal. Above Featheredge Coal. Over Gannister Coal.
	Bagslate Moor, 1½ miles north of Rochdale - -	
	Roadfield, east of Rochdale - -	} Do. Do.
	Helpet Edge, Ogden Mill, 4 miles north of Oldham - -	
	Bagslate Moor, 1½ miles north of Rochdale - -	} Little Mine, next be- low the Gannister. Gannister.
	Crompton Moor, 4 miles north of Oldham - -	
	Count Hill, N.E. of Oldham - -	Gannister Coal.

Name.	Locality.	Position.
<i>Monotis laevis</i> , Brown	Shore Edge, 4 miles north of Oldham	Gannister Coal.
	Ogden Mill, 5 miles north of Oldham	Do.
<i>Posidonia Gibsoni</i> , Brown	High Marcroft Gate	Above Featheredge Coal.
	Shore Edge, 4 miles north of Oldham	Gannister Coal.
<i>Posidonia laevigata</i> , Brown	Sholver, 2 miles N.E. of Oldham	Bullion Coal.
<i>Goniatites Listeri</i>	Shore Edge, 4 miles north of Oldham	Gannister Coal.
	Ogden Mill, 5 miles north of Oldham	Do.
	Roebuck Low, 1½ miles N.E. of Oldham	Do.
<i>Goniatites paucilobus</i> <i>Goniatites</i> , sp. near <i>truncatus</i>	Sholver, 2 miles N.E. of Oldham	Bullion Coal.
	Roebuck Low, 1½ miles N.E. of Oldham	Gannister Coal.
<i>Orthoceras</i> , sp. inc.	Do.	Do.
	Shore Edge, 4 miles north of Oldham	Do.
<i>Discites</i>	High Marcroft Gate	Above Featheredge Coal.
	Do.	Do.
<i>Megalichthys Hibberti</i>	Count Hill, N.E. of Oldham	Lower Foot Mine.
	Baggsdale Moor, 1½ miles north of Rochdale	Gannister Coal.
<i>Palæoniscus Egertoni</i>	Helpet Edge, Ogden Mill, 4 miles north of Oldham	Little Mine, next below the Gannister.
<i>Palæoniscus monensis</i>	Baggsdale Moor, 1½ miles north of Rochdale	Gannister Coal.
	Helpet Edge, Ogden Mill, 4 miles north of Oldham	Little Mine, next below the Gannister.
<i>Rhizodus granulatus</i>	Crompton Moor, 4 miles north of Oldham	Do.
	Kenyon Fold, 2 miles north of Rochdale	Gannister Coal.
<i>Celacanthus</i>	Kenyon Fold, 2 miles north of Rochdale	Do.

I add (as they are so near the district) fossils from the following localities, just out of quarter sheet 88 S.W.

Name.	Locality.	Position.
<i>Stigmaria ficoides</i>	Rose Grove, Broadbottom, south of Mottram	Gannister Beds, above the Lower Yard Seam.
<i>Sigillaria</i>	Do.	Do.
<i>Palæoniscus monensis</i>	Rose Grove, Broadbottom, south of Mottram	Gannister Beds above the Lower Yard Seam.
<i>Palæoniscus Egertoni</i>	Do.	Do.
<i>Megalichthys Hibberti</i>	Do.	Do.
<i>Rhizodus granulatus</i>	Do.	Do.

## MIDDLE COAL-MEASURES.

Name.	Locality.	Position.
<i>Neuropteris Loshii</i> -	Dukinfield - -	{ New Mine, lower part of Middle Coals.
<i>Neuropteris heterophylla</i> - -	Tibbs Street, Denton	Town Lane Mine.
<i>Pecopteris muricata</i> -	Do.	Do.
<i>Sphenophyllum erosum</i> -	Dukinfield - -	New Mine.
<i>Sphenopteris</i> , sp. inc.	Tibbs Street, Denton	Town Lane Mine.
<i>Sphenopteris</i> ( <i>Pecop.</i> )	Dukinfield, Staleybridge -	New Mine.
<i>latifolia</i> - -	Do. - -	Do.
<i>Asterophyllites grandis</i>	Do. - -	Do.
<i>Lepidodendron</i> , sp. -	Do. - -	Do.
<i>Lepidodendron Sternbergii</i> -	Do. - -	Do.
<i>Lepidodendron obovatum</i> -	Dukinfield Colliery	Black Mine.
<i>Lepidodendron elegans</i> - - -	Hayes Colliery, Oldham.	
<i>Adiantites</i> , sp. - -	Natt Bank and Meadow Croft Mill, near Rochdale - -	{ Under Arley Mine.
<i>Lepidophyllum</i> - -	Do. - -	Do.
<i>Poacites</i> - -	Do. - -	Do.
<i>Calamites</i> - -	Do. - -	Do.
<i>Calamites Suchowii</i> -	Dukinfield - -	New Mine.
<i>Calamites decoratus</i> -	Tibbs Street, Denton	Town Lane Mine.
<i>Calamites cannaeformis</i>	Dukinfield Colliery -	Black Mine.
<i>Calamites undulatus</i> -	Do. - -	Do.
<i>Calamites</i> , with narrow ridges - -	Do. - -	{ Black Mine and Town Lane Mine.
<i>Calamites</i> , 2 sp. - -	Ashton-under-Lyne - -	Over Great Mine.
<i>Ulodendron majus</i> -	Natt Bank.	
<i>Ulodendron minus</i> -	Oldham.	
<i>Stigmaria ficoides</i> -	Hayes Colliery.	
<i>Sigillaria reniformis</i>	Dukinfield Colliery.	
<i>Sigillaria oculata</i> -	Tibbs Street, Denton	Town Lane Mine.
<i>Favularia nodosa</i>	Dukinfield - -	New Mine.
<i>Limulus trilobitoides</i>	Dukinfield - -	Town Lane Mine.
<i>Estheria</i> - -	Do. - -	Do.
<i>Pygocephalus Cooperi</i>	Do. - -	Do.
<i>Serpulites</i> , wavy sp.	Oldham (Manchester Geological Museum).	
<i>Aviculopecten fibrillosus</i> , n. sp. -	Natt Bank - -	Royley Mine.
<i>Aviculopecten</i> , pl. 1, f. 2 - -	Park Bridge, Ashton	{ Probably from Black Mine.
<i>Aviculopecten payrauceus</i> , pl. 1, f. 1 -	Ashton-under-Lyne -	Over Great Mine.
<i>Anthracosia</i> , sp. inc.-	River Section, Ashton-under-Lyne-	Do.
<i>Anthracosia acuta</i> -	Do.	Do.
<i>Anthracosia ovalis</i> -	Do.	Do.
<i>Anthracomya modiolaris</i> - - -	Do.	Do.
<i>A. dolabrata</i> -	Do.	Do.
	Mill Lane, 3 miles N.W. of Stockport	Black Mine.
	Dukinfield - -	Do.
	Banker's Hill, north of Rochdale -	{ Shales, 30 feet below Royley Mine.
	Dukinfield - -	Black Mine.
	Mill Lane, 3 miles N.W. of Stockport	Do.
	Natt Bank.	
	Oldham.	Do.
	Do. - -	Do.

Name.	Locality.	Position.
<i>Anthracoptera</i> , sp. -	Mill Lane, 3 miles N.E. of Stockport	Black Mine.
<i>Anthracoptera</i> , like	Dukinfield -	Do.
<i>A. quadrata</i> -	Banker's Hill, west of Roehdale -	{ Shales, 30 feet below Arley Mine.
<i>Anthracoptera modio-</i> <i>laris</i> -	Do. -	Do.
<i>Ctenodonta</i> , sp., pl. 1, f. 3 -	Ashton-under-Lyne	Over Great Mine.
<i>Nautilus præcox</i> , sp., pl. 1, f. 5 -	Do.	Do.
<i>Discites rotifer</i> , pl. 1, f. 6 -	Do.	Do.
<i>Discites</i> , sp., pl. 1, f. 2 -	Do.	Do.
<i>Goniatites</i> , sp., pl. 1, f. 4 -	Do.	Do.
<i>Rhizodus granulatus</i> -	Dukinfield Hall	Black Mine.
<i>Rhizodus</i> , sp. inc.	Peoples' Bridge, Manchester	{ Bottom of Upper Coal-measures.
<i>Megalichthys Hibberti</i>	Ashton-under-Lyne -	Over Great Mine.
<i>Pleuracanthus gib-</i> <i>bosus</i> -	Peoples' Bridge, Manchester	{ Upper Beds. Bot- tom of Upper Coal-measures.
<i>Palæoniscus Egertoni</i>	Do. -	Do.
<i>Cælacanthus</i> -	Do. -	Do.

The following are the contents of the marine bed at Ashton-under-Lyne :—

*Ashton-under-Lyne*.—In large concretions in shales (about 150 yards over the Great Mine). In river bank.

<i>Calanites</i> , narrow ridges.	—	—
Wood, long strips.	—	—
<i>Serpulites</i> , wavy spe- cies.	—	—
<i>Aviculopecten fibril-</i> <i>losus</i> , n. sp. -	Pl. 1, f. 2	{ Like <i>A. alternatus</i> , Ph.
<i>Aviculopecten papy-</i> <i>ræceus</i> , Sow. -	Pl. 1, f. 1	A Lower Coal species.
<i>Ctenodonta</i> , sp.	Pl. 1, f. 3	{ Allied to <i>C. tumida</i> , Phillips?
<i>Nautilus præcox</i> , n. sp. -	Pl. 1, f. 5 -	{ Allied to <i>N. con-</i> <i>cavus</i> ? Sowerby.
<i>Discites rotifer</i> , n. sp.	Pl. 1, f. 6	—
<i>Discites</i> , sp. 2 -	Pl. 1, f. 7	—
<i>Discites</i> , sp. 3 -	Pl. 1, f. 8 -	{ Like <i>D. tetragonus</i> , Ph.
<i>Goniatites</i> , sp.	Pl. 1, f. 4 - -	Imperfect.
<i>Orthoceras</i> , thin sp. -	Not figured.	—
<i>Megalichthys Hibberti</i>	—	—

#### DESCRIPTION OF THE NEW SPECIES FROM ASHTON-UNDER-LYNE.

This small series of marine shells, discovered by Mr. A. H. Green in the upper part of the Middle Coal-measures, has been adverted to in the previous memoir on the Bolton district,\* and is referred to in a previous part of the present memoir.† The species found are included in the foregoing lists.

\* On the Geology of the country around Bolton-le-Moors, by Mr. E. Hull. 1862.

† See *ante*, p. 32.



But a short special notice should be given of this marine band, containing as it does a small peculiar fauna, comparable with that of the Lower Coal-measures of Shropshire, and yet wholly distinct. It is true the common marine shell, *Aviculopecten papyraceus*, occurs in this remarkable band. But even this is dwarfed, and except this species, the fossil contents are wholly different, both from those of the Lower Coal-measures, and those of the beds among which they occur.

As a test of the relative age of the beds, this evidence, scanty as it is, is very valuable. It shows clearly that the change from the fauna of the Lower to that of the Upper Coal Measures was one of great extent. So much so, that, as the species of *Cephalopods*, *Brachiopods*, &c., of the Lower Coal-series differ widely from those of the Mountain Limestone, and yet belong to the same genera, so in like manner, the fossils of the Upper Coal-measures, where deep-sea bands occur, show that sufficient time had elapsed to present us with new and distinct species, though all nearly comparable with those of the Lower Coal-measures.

*Aviculopecten fibrillosus*, Salter, sp. n. Pl. 1, f. 2.

*A. parvus*,  $\frac{3}{4}$  uncia longus, valvis æquiconvexis, elongato-ovatis, striato-radiatis; umbonibus prorsum curvis. Auriculæ valde inæquales, antica recta magna, postica minor obliqua, sublinearis. Superficies lævigato-striata, rugis concentricis nonnullis, lineisque minutis, crebris, interlineatis, sæpè abbreviatis radiata.

This, the most abundant shell of the deposit, is not like any of the coal species yet described, nor quite the same with any of the mountain limestone forms, though allied to several elongated thin-shelled species with slight superficial ornaments. The fine fibrillose striæ, which cover every part except the ears, are very characteristic. They do not divaricate, but radiate directly from the beak, interrupted and frequently duplicated in their course.

*Ctenodonta*, sp. inc. Pl. 1, f. 3.

All that can be said about this smooth form, with a few concentric lines of growth, is that it does not belong to either of the common mountain limestone species, such as *C. attenuata*, *C. tumida*, *C. brevisrostrum*, &c. But it is too imperfect to name.

*Goniatites*, sp. inc. f. 4.

A single contraction, marking the usual varix at the mouth of the *Goniatite*, determines the genus of this fragment.

*Nautilus præcox*, Salter, sp. nova. Pl. 1, f. 5.

*N. latus hexagonus*, ore transverso; dorso planato, vix concavo; lateribus obliquis, subplanis; umbilico profundo.

A fine species, at least two inches across the mouth, and about the same in diameter. The general form is that of the Oolite species, *N. hexagonus*, &c., the sides sloping away from the flattened back at an angle of about 120°, and the umbilicus being (as usual in Carboniferous forms of the genus) steep, and broader than in the Oolite forms.

*N. chitellarius*, Sow. (Trans. Geol. Soc. 2nd series, vol. v, pl. 40, f. 5.), has a rounded back. *N. concavus*, id. f. 6., has far too narrow whorls. Yet this Colebrook Dale species has a certain resemblance to our fossil. *N. pinguis*, M'Coy (Carb. Foss. Ireland, pl. 2), has some characters in common, but has not the flat oblique sides, which gives so much the aspect of an Oolite shell.

*Discites rotifer*, Salter, sp. n. Pl. 1, f. 6.

Whorls 4-5 (the outer rather more than twice the width of the preceding), compressed (or flat?) on the sides, with a marginal ridge on either side of the narrow flat (or concave?) back.

It is so crushed and imbedded that we cannot be sure of the section. The markings, however, are clear: the sides have numerous close rounded ribs of a sigmoid form, fainter both at the inner and outer margins of the whorl, and only strong in the middle. The breadth of the ribs as great as the interval between them.

The ribs in *D. falcatus* (Sow. in Trans. Geol. Soc. l. c. f. 9) have a much greater bend forward, and are as strong at the outer margin as at the middle.

There is no ridge, either at the outer margin, and the section of the whorl is squarish. Nevertheless the species are much alike, and at one time I thought them identical.

*Discites*, sp. inc. Pl. 1, f. 7.

This shell has flat discoid whorls, more rapidly increasing than in the last species. They are gently convex over the sides, then concave, ridged externally and flat on the back. The lines of growth are tolerably strong and equidistant, and have a strong sigmoid bend along the middle of the whorl, almost amounting to a lobe or process on the edge of the mouth. Section flattened, square on the back.

So far as can be seen from our very imperfect specimen (which nevertheless is not crushed), *N. latidorsatus*, M'Coy, is nearest to it in form, having the outer ridges raised; but is too square in section, and has not a sufficiently rapid increase of the whorls. *N. discors*, or *N. mutabilis*, of the same author, are both like ours, but want the raised border.

*Discites*. Pl. 1, fig. 8.

This giant species may be but the full-grown portion of fig. 7, and is only figured to show the great size these Cephalopod shells attained in the upper part of the Coal-measures.

UPPER COAL-MEASURES.

Name.	Locality.	Position.
<i>Pecopteris Miltoni</i> -	Ardwick, Manchester.	Above the 4-foot Mine.
<i>Pecopteris abbreviata</i>	Ardwick (Mr. Binney's cabinet).	Do.
<i>Poacites</i> -	Do.	Do.
<i>Cyclopteris flabellata</i>	Do.	Do.
<i>Neuropteris cordata</i> -	Do.	Do.
<i>Neuropteris tenuifolia</i>	Bradford, Manchester	Under 4-foot.
<i>Neuropteris flexuosa</i>	Do.	Over Yard Mine.
<i>Sphenopteris latifolia</i>	Ardwick, Manchester.	Over 4-ft Mine.
<i>Sphenopteris obtusiloba</i> -	Bradford, Manchester	Do.
<i>Sphenophyllum</i> -	Do.	Under 4-foot.
<i>Lepidodendron obovatum</i> -	Ardwick, Manchester.	Do.
<i>Lepidodendron elegans</i>	Bradford, Manchester	Over Yard Mine.
<i>Lepidodendron Sternbergii</i> -	Do.	Under 4-foot.
<i>Lepidostrobus</i> -	Do.	Over Yard Mine.
<i>Asterophyllites longifolia</i> -	Ardwick, Manchester	Under Bassey Mine.
<i>Calamites Suchowii</i>	Bradford, Manchester	Over Yard Mine.
<i>Calamites cannaeformis</i> -	Do.	Do.
<i>Calamites decoratus</i> -	Ardwick, Manchester	Under Bassey Mine.
<i>Sigillaria elegans</i> -	Bradford, Manchester	Over Yard Mine.
<i>Sigillaria</i> , sp. inc. -	Do.	Under 4-foot.
<i>Stigmaria ficoides</i>	Do.	Under Yard Mine.
Abdomen of a new insect* -	Ardwick (Mr. Binney's cabinet)	—
<i>Estheria</i> -	Bradford, Manchester	Over Yard Mine.
<i>Cythere</i> or <i>Leperditia</i>	Do.	Do.
<i>Leperditia inflata</i> -	Ardwick, Manchester.	—
<i>Spirorbis carbonarius</i>	Do.	In limestone.

\* I think this is an Orthopterous insect.

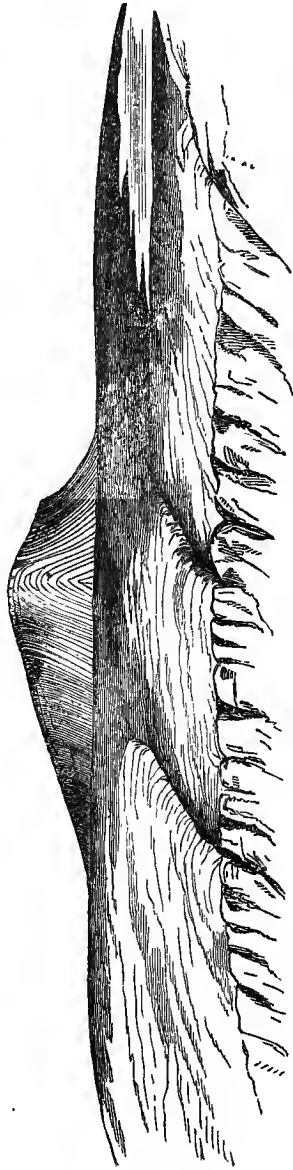
Name.	Locality.	Position.
<i>Anthracopectera Browniana</i> - - - }	Ardwick, Bradford, &c.	—
	Do.	—
<i>Anthracomya Philipsii</i> - - - }	Bradford, Manchester -	Over Yard Mine.
	Clayton - - -	{ Over the thick Limestone.
<i>Anatina</i> -like shell -	Do. - - -	Do.
<i>Pleuracanthus gibbosus</i> - - - }	Bradford, Manchester -	Over Yard Mine.
	Ardwick, Manchester.	—
<i>Palæoniscus Egertoni</i>	Do.	—
<i>Palæoniscus</i> , sp. -	Clayton - - -	{ Over the thick Limestone.
<i>Rhizodus granulatus</i>	Bradford, Manchester -	Over Yard Mine.
	Ardwick, Manchester.	—
<i>Rhizodus</i> , sp. - - - }	Clayton - - -	{ Over the thick Limestone.
<i>Amblypterus</i> - - -	Do. - - -	Do.
<i>Megalichthys Hibberti</i>	Ardwick, Manchester.	
<i>Ctenoptychius cristatus</i> .		
<i>Platysomus</i> , <i>Gyracanthus</i> , &c., &c.		

For a better list of these Ardwick fishes the reader may consult the 1st volume of the Manchester Geological Transactions.

#### PERMIAN BEDS.

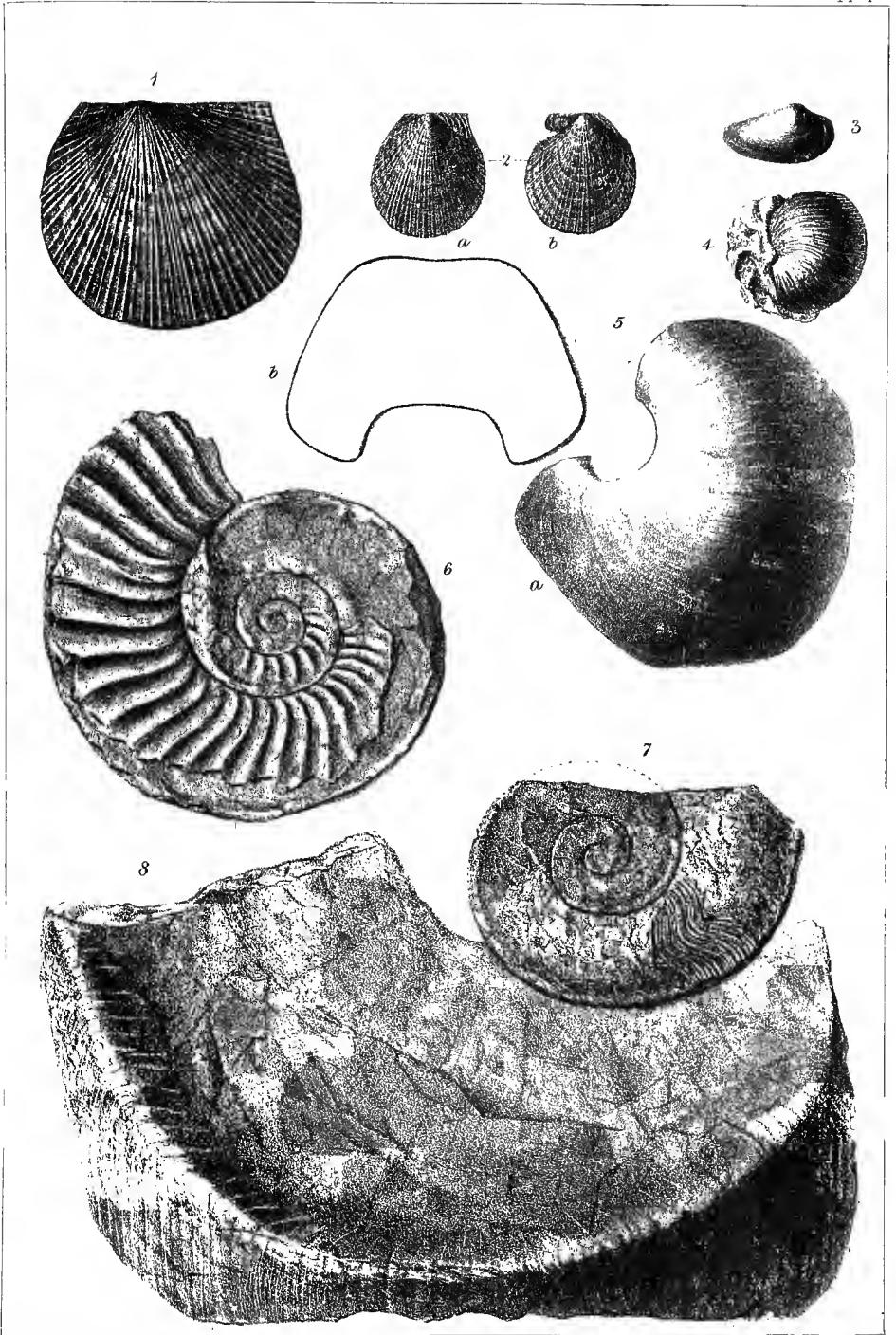
The marls at Collyhurst, &c. contain *Bakevellia antiqua*; *B. tumida*; *Pleurophorus costatus*; *Schizodus obscurus* and *S. rotundatus*; *Turbo man-cuniensis*; *T. helicinus*; *Rissoa obtusa*; *R. Leighi*; *R. Gibsoni*; *Natica minima*; and some others. These fossils were originally figured and described by the late Captain Brown, in his appendix to Mr. Binney's paper, "On the Geology of Manchester."—Trans. Geol. Soc. Manchester, vol. 1.





Pule Hill, Millstone Grit, Yorkshire, near Marsden, seen from the South.





A.H. Cowan fec. J.W. Salter del.

Day & Son, Litho to the Queen.

MARINE SHELLS, ASHTON UNDER LYNE.





# LIST OF GEOLOGICAL MAPS AND SECTIONS OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM,

PUBLISHED BY MESSRS. LONGMAN & Co. FOR HER MAJESTY'S STATIONERY OFFICE,

The Maps are those of the Ordnance Survey, geologically coloured by the Geological Survey of Great Britain and Ireland, under the Superintendence of Sir ROBERT IMPEY MURCHISON, K.O.B., F.R.S., Director-General. The various Formations are traced and coloured in all their Subdivisions.

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