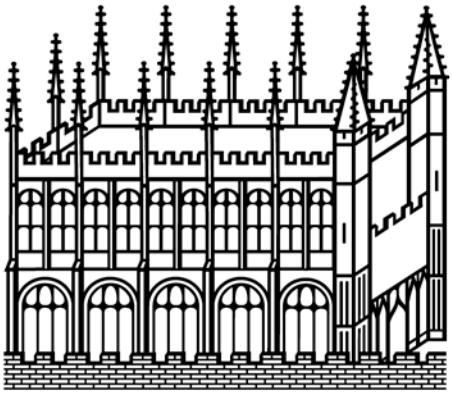

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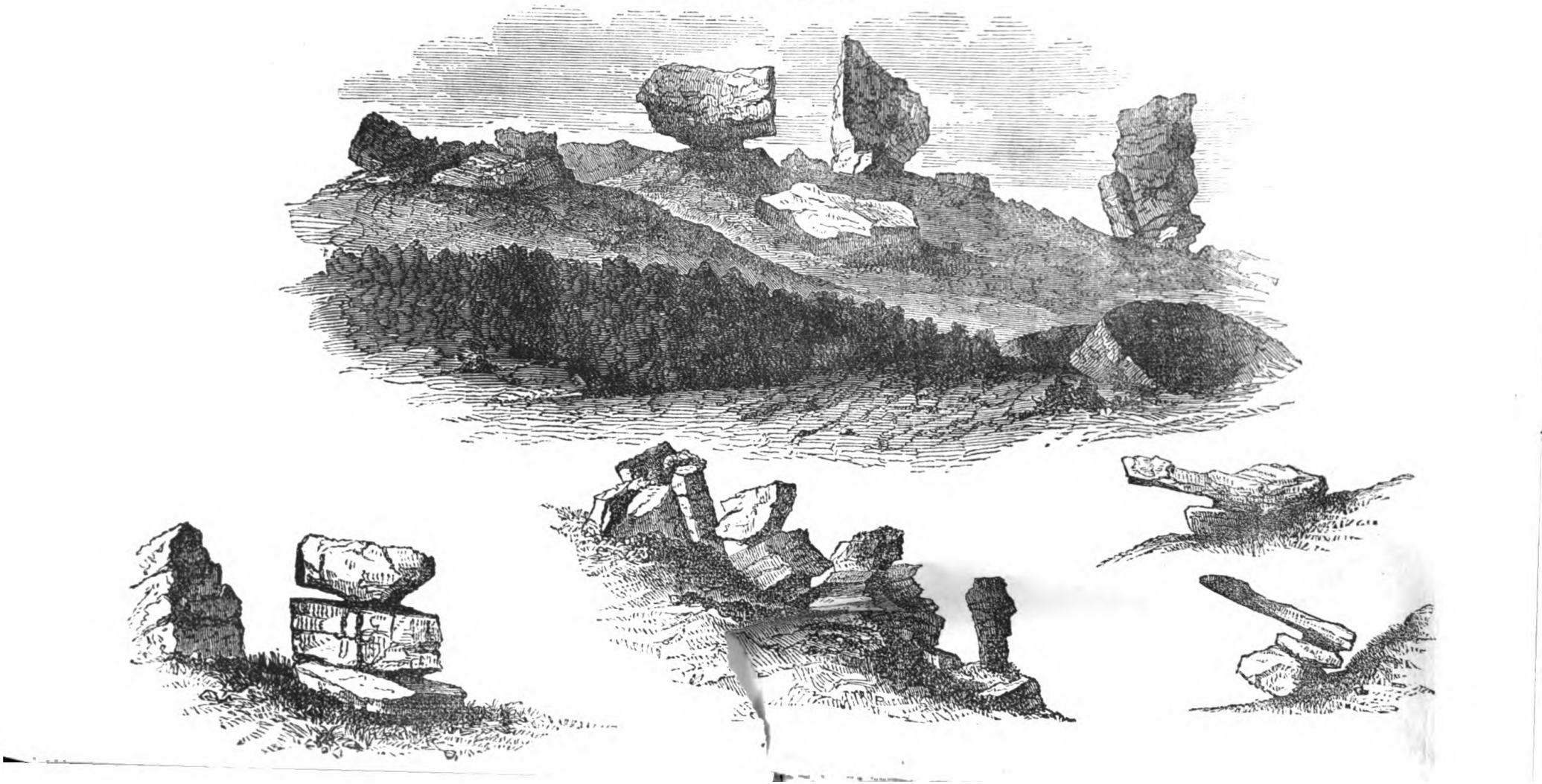

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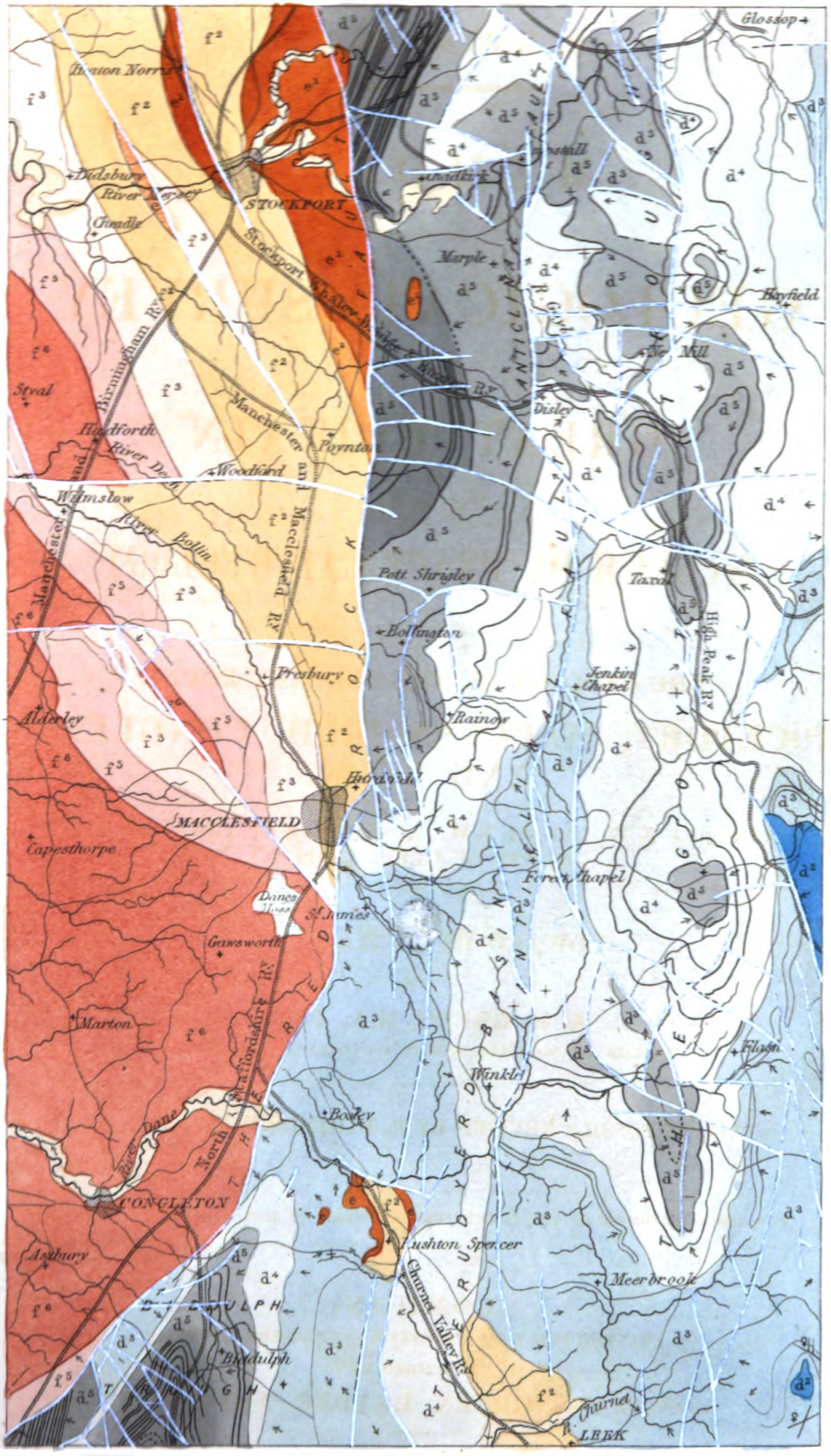
81 N.W AND S.W.



Coal Crops — White Lines. Faults _ . Upper'd Dips of Beds ↓ Beds Flat

81 N.W. and 81 S.W.

MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

GREAT BRITAIN

AND OF THE

MUSEUM OF PRACTICAL GEOLOGY.

THE GEOLOGY OF THE COUNTRY ROUND STOCKPORT, MACCLESFIELD, CONGLETON, AND LEEK.

(Sheets 81 N.W. and 81 S.W. of the Map of the Geological Survey of Great Britain.)

EDWARD HULL, B.A., F.G.S.,

AND

A. H. GREEN, M.A., F.G.S.,

FELLOW OF GONVILLE AND CAIUS COLLEGE, CAMBRIDGE.

LIST OF FOSSILS REVISED BY R. ETHERIDGE, F.R.S.E., F.G.S.

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NOTICE.

In the following description of the geological structure of the country around Stockport, Macclesfield, Congleton, and Leek, Mr. Edward Hull and Mr. A. H. Green have faithfully worked out all the details of the Lower Carboniferous rocks, and have clearly shown the age and relationship of beds hitherto imperfectly understood. They have very properly adopted as far as possible the terminology used by Professor John Phillips in his work on the Geology of Yorkshire, and there is good reason to hope, that the sub-divisions of the Yoredale group, which they have established in this southern region, will be found to agree with those laid down in that able work.

RODERICK I. MURCHISON,
Director-General.

September 19, 1865.

PREFACE.

In presenting this Memoir we have the pleasure of acknowledging our obligations to the proprietors and managers of the collieries and other mining works in the district, amongst whom we may particularly mention—Mr. John Fletcher, and his manager Mr. Bain, of the Haughton Green Collieries; Mr. Peter Higson, Her Majesty's Inspector of Mines; Mr. Jowett, and his manager Mr. Clayton, of Bredbury Colliery, and the managers of the collieries at Ludworth, Compstall, and Broadhurst Edge belonging to the same proprietor; Mr. Brocklehurst, of the Disley and Middle Cale Collieries; Mr. Legh, M.P., Mr. Clayton of Norbury Moor, and the late Mr. Mercer of Newton-in-Makerfield, together with the underlookers of the Lyme Park and Norbury Collieries; Mr. Greenwell, and Mr. Mattox, underlooker, of Lord Vernon's Collieries at Poynton; Mr. Gisborne and his manager, and Mr. Srigley, of the Collieries at Whaley; Mr. Livesley, of Shrigley; Mr. Kirk, of Winter Fold Colliery; Mr. Williams, owner of Kerridge Flagstone Quarries; Captain Osborne, of the Alderley Edge Copper Works; and the manager of the works at Mottram St. Andrew.

We have also to thank Mr. T. D. Sainter of Macclesfield, who not only placed at our disposal many facts bearing on the geology of the district, which a long residence in the town had enabled him to collect, but spared no pains to hunt up little out-of-the-way bits of evidence, many of which might well have escaped the notice of a stranger; the late Mr. Brodrick, chairman of the North Staffordshire Railway, was kind enough to use his official interest on our behalf; and information was given by Mr. Holland of Swanscoe, Mr. Stancliff, Mr. George Needham, and Mr. Jasper Hulley. Mr. R. D. Darbishire, who had given especial attention to the shells found in the Drift at Macclesfield, was good enough to place in our hands his MSS. notes, and allowed us to print his list of the species, with an abstract of his remarks thereon, in the Appendix. Mr. Willmott, late agent to the Duke of Devonshire

at Buxton, kindly allowed us the use of the plans of the collieries on the estate under his care. At Congleton most valuable information was supplied by Mr. Bradbury, of Bradley Green Colliery, and his bailiff Mr. W. Chadwick; and we have also to thank Messrs. Williamson of Tower Hill, Mr. Heath of the Biddulph Valley Ironworks, Mr. Goslin, Mr. Cooper, and Mr. Bateman, of Biddulph Grange. Mr. Thomas Wardle of Leek, who had given much attention to the geology of the country round that town, pointed out several places where fossils were to be found; and to him we owe the full list of fossils from the Mountain Limestone of Staffordshire given in the Appendix. From Mr. Sykes, also of Leek, we have sections of the Blue Hill Collieries.

Geological Survey Office,
28, Jermyn Street, London, S.W., 1865.

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THE GEOLOGY OF THE COUNTRY ROUND STOCKPORT, MACCLESFIELD, CONGLETON, AND LEEK.

CHAPTER I.

General Description and Physical Features of the Country.

The district to be described in the present Memoir is about 300 square miles in area, and lies in the quarter-sheets 81 N.W. and S.W. of the map of the Geological Survey of Great Britain.* It takes in parts of Lancashire, Cheshire, Derbyshire, and Staffordshire, the boundaries of which counties run for the most part along the rivers Tame, Etherow, Goyt, Dane, and Dove. Of these the Etherow and Goyt join at Water Meetings and form the Mersey, which receives the Tame at Stockport, and further down the waters of the Dane. The Dove rises on the eastern side of the watershed, and falls into the Trent.

The chief towns are Stockport, Macclesfield, Leek, and Congleton, all of which are built on the New Red Sandstone, hard by the uplands of the Lower Carboniferous series; such a situation has natural advantages, for while it is inconvenient for a manufacturing town to be hilly, it is beneficial for the purposes of drainage, water-supply, and health to have hills in the neighbourhood.

In outward look the eastern side of the district contrasts strongly with the western.

Except at Alderley Edge, which rises with an abrupt and picturesque escarpement on its northern side, the whole of the western half of the country forms a plain but slightly raised above the level of the sea, everywhere well wooded and highly cultivated: while the eastern half is varied by lofty hills with deep dells or wide valleys between, and the country is for the most part bleak and barren moorland, or where brought under cultivation yields but poor returns to the farmer.

The hills on the western side are, with the exception of Alderley Edge, rounded and soft in outline; while on the east they are steep and rugged, and mostly show a scarped rocky cliff on one side and a more gentle slope on the other.

On the east, moreover, the eye is at once struck by the long unbroken lines of terraced hills, which range through the country for miles, in directions nearly parallel to each other: while in the west we fail to trace any such systematic arrangement of hill and valley, and find merely a number of irregular mounds dotted hap-hazard over the plain.

The line parting these two tracts, so unlike each other, is well marked and clear throughout, running from the south-west corner of the district, by Congleton, Macclesfield, and Poynton, towards Stockport.

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* Although our main object is the description of the country mentioned, we have been obliged here and there to step beyond it, in order to give, as far as we can, a full history of the Lower Carboniferous Rocks on the west side of the Penning axis, from Staleybridge southwards to the New Red Sandstone plain of central England.

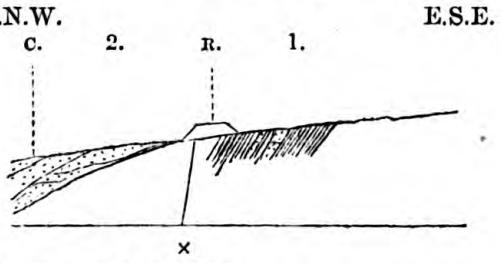
The striking contrast just described is directly owing to differences in geological structure: on the one side we stand on the eastern margin of the great Triassic Plain of Cheshire, the soft rocks of which have been planed down by denudation into a nearly level surface, and afterwards covered by a thick coating of clay, sand, and gravel; while on the other side we have the outlying heights, the advanced bulwarks, as it were, of the Pennine Chain, formed of Carboniferous rocks, which have been up-heaved, contorted, and bent into countless folds, and by their greater hardness have been better able to hold out against denudation, and thus stand up in bold relief. Throughout, the outcrops of the hard sandstones form the upper surfaces of the ridges, and determine their direction, while the valleys have been hollowed out in the softer shales.

This sudden change from the Permian and Triassic to the Carboniferous formations takes place along a line of fault known as "The Red Rock Fault;" and as this break plays so leading a part in the geology of the district, we shall at once mark out its line and give the evidence by which its position is determined.

The fault enters the district very nearly at its south-west corner, and is well shown in two sections; one where the railway crosses the brook at Ford Sprink, and the other in a lane on the south-west side of Grotto Wood. Sketches of these sections are given below.

Fig. 1.

BROOK SECTION, NEAR FORD SPRINK.



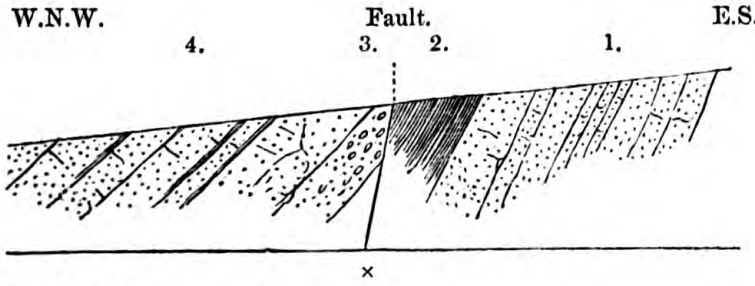
1. Black Shales, &c. Middle Coal-measures.
2. Soft red sandstone, with few pebbles. Base of the Waterstones.

× Fault.

R. Railway. C. Canal.

Fig. 2.

SECTION IN A LANE ON THE SOUTH-WEST SIDE OF GROTTO WOOD.



1. Hard fine sandstones. - } Coal-measures.
2. Dark shales. - - }
3. Soft mottled sandstone, with a few pebbles at the bottom. }
4. Red and white sandstone (a good building stone) with marl partings. - - - - - } Waterstones.

× Fault.

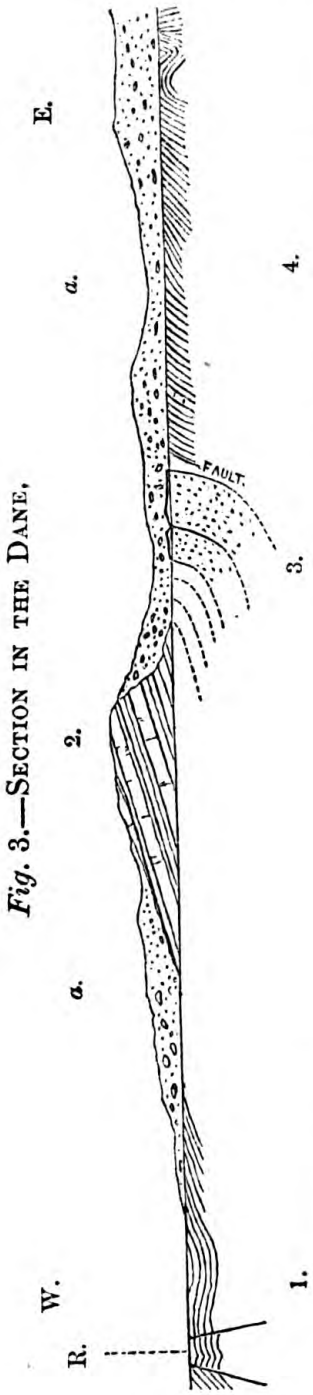


Fig. 3.—Section in the Dane,

In the limeworks at Astbury the limestone is said to have been found to abut on the west against sandstone like that worked in Grotto Wood, and therefore Lower Keuper Sandstone; but it will not be safe to infer from this that the throw of the fault is here equal to the thickness of the missing formations, as the Carboniferous Rocks were upheaved and denuded before the deposition of the New Red Sandstone.

The fault is again very clearly shown in the River Dane, by North Rode viaduct, as will be seen from the section below.

Fig. 3.

Section in the River Dane, near North Rode Viaduct.

1. Thin, red, marly sandstones, ripple-marked, bent, and faulted. - - - } Upper Keuper.
2. Red and white sandstones. - - } Lower Keuper or Waterstones.
3. Thick-bedded white sandstone. - } Lower Keuper or Waterstones.
4. Black shales and ironstone. Yoredale Rocks.

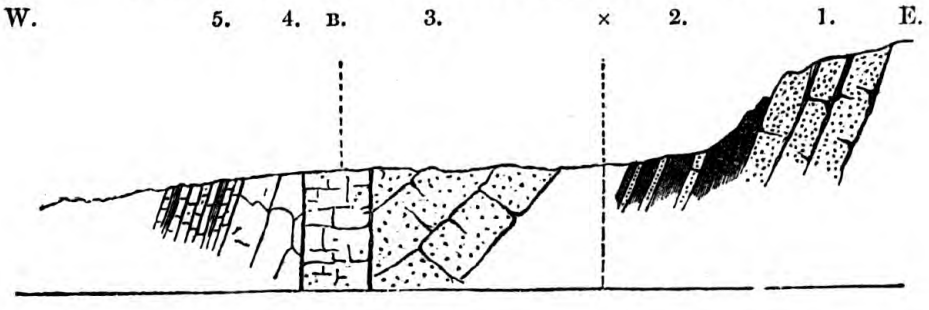
a. River-gravel.

R. Railway viaduct.

A number of sections between Stony Fields and Broad Oak Reservoir enable us to fix the place of the break with great exactness. A quarter of a mile east of Cow Ley we find the thin hard Upper Keuper Sandstones dipping west at an angle of 30°, on one side of the road, and large quarries in "crowstone," belonging to the Yoredale Rocks, close on the other side. The section at the west end of Ratcliffe Wood, of which a sketch is given below, gives the place of the fault to within a yard or two.

Fig. 4.

Section at the West End of Ratcliff Wood.



1. Hard quartz rock, "Crowstone." } Middle Group of the Yoredale Rocks.
2. Dark sandy shales. - - }
3. Soft, thick-bedded, white sandstone. Lower Keuper.
4. Lumpy red marl. - - - }
5. Thin-bedded red and white sandstones. } Upper Keuper.

× Red Rock Fault. B. Bridge, probably hiding a fault.

An equally good section is given by the Broad Oak Reservoir, if the observer be lucky enough to find it laid dry. At the west end are thinly bedded red and white sandstones, ripple-marked, with impressions and casts of salt crystals and plants (?), belonging to the Upper Keuper. These beds dip N.E. at 40°, in places plunging down at higher angles; above them come red marls, which may be followed for about three-quarters of the length of the reservoir, when we reach black and sandy shales with beds of hard sandstone, marked by slickenside, and dipping W.S.W. at 20°.

We next get evidence of the place of the fault at some old coal workings on Macclesfield Common. At a pit one quarter of a mile S.E. of St. Paul's Church the coal was followed for about 200 yards to the west of the shaft, and was there found so broken by a large fault as to be unworkable. Again, a shaft at Roewood Colliery, just on the "s" of the word Hurdsfield, was sunk to a depth of 60 yards, partly in a fault and partly in "red rock," and a tunnel driven from the shaft towards the canal was wholly in "red rock."*

A. H. G.

West of the village of Bollington we find the Pebble Beds of the New Red Sandstone on one side of the fault, and the hard grits of the Lower Coal-measures on the other. A section in the former occurs in the river bank west of the canal aqueduct, and quarries have been opened in the latter on both sides of the river, as the grit yields a valuable building stone.

At Poynton the position of the fault has been proved by several borings into the Lower Permian Sandstone, which is here brought down against the Middle Coal-measures. In Norbury brook we find the New Red Sandstone and Permian beds on the one side, and the Coal-measures on the other. Mr. Binney, who describes this section,† states that it was formerly more complete than at present.

The Fog Brook section, near Offerton Green, and the beds in the Mersey, into which the brook pours itself, enable us to mark the precise line of the fault. These sections have also been figured and accurately described by Mr. Binney,‡ though the author seems to have mistaken the age of the red sandstones, which certainly belong to the Lower Permian formation. The red sandstone abruptly terminates on the river bank, and at a short distance further up the hard grits of the Coal-measures rise above the surface of the river at angles of 70° or 80°, crossing from side to side in serried reefs, and climbing up the banks.

Fig. 5.

SECTION ALONG THE MERSEY NEAR GOYT HALL.

1. Permian sandstone.
2. Carboniferous grits and shales.
×. Position of Red Rock fault.

* For these particulars I am indebted to Mr. George Needham of Roewood Colliery.

† On the Permian beds of the North-west of England. Mem. Lit. and Phil. Soc. Manchester, vol. xii.

‡ Ibid., p. 7.

Each bed of grit incloses bands of shale with coal seams, and the old workings can be clearly made out in the bank, though the seams themselves are hidden from view.

The position of the fault has been approximately determined by a boring into the Lower Permian Sandstone west of Bredbury Colliery, and it has been proved in some colliery workings on the right bank of the Tame opposite Harden Hall, which have been described in a previous memoir.* The throw of the fault here seems to be very small, and we may infer that it is on the point of dying out.

E. H.

General Geological Structure.

To the west of the "Red Rock" fault the whole of the country is occupied by Triassic and Permian formations, dipping mostly westward, and traversed by longitudinal and transverse faults. A thick deposit of Drift sand, gravel, and clay covers the greater part of the country, and it is only at long intervals that we find sections even in the deep brook courses.

The general arrangement of the Carboniferous Rocks on the east of the "Red Rock" fault may be described in a few words. On the eastern side of the district lies a long synclinal, to the northern part of which Farey gave long ago the name of "The Goyt Trough." This hollow begins east of Mottram, and ranges southward by Ludworth Intakes, New Mills, Whaley, and the valley of the Goyt, whence it may be followed along Goldsitch Moss and by the east of Leek to Cheadle in Staffordshire. The trough is bounded for the most part on each side by ridges of the Millstone Grit, and is broken up into several subordinate basins, in which lie patches of the Lower Coal-measures. On the east side the beds rise to the eastward till they reach the district of the High Peak, where they lie flat, and afterwards roll over and dip steadily to the eastward, till they are hidden below the Coal-measures of Derbyshire and Yorkshire: the table-land of The Peak, which rises to a height of 2,000 feet above the sea, forms as it were the crest of the great saddle of Lower Carboniferous Rocks which parts the Coal-field of Lancashire from that of Yorkshire and Derbyshire.

On the west side of the Goyt Trough the beds rise into a sharp saddle, along the whole or greater part of which runs a line of fault, which we may call the "Saltersford," or "Anticlinal Fault." This line of disturbance is the prolongation of the great break which ranges through Saddleworth and along the valley of the Tame east of Staleybridge.† It enters the district at the eastern end of Werneth Low, and runs southwards by Compstall, Disley, and Saltersford valley, and onwards by the west of Shutlingslow, the river Dane at Bearda, and the west side of Gun Hill, till it is lost beneath a patch of New Red Sandstone near Leek. To the south of this outlier an anticlinal fault running along the east of Wetley Rocks (in Sheet 72, N.W.) is most likely a continuation of the same line of fracture.

Between the Anticlinal and the Red Rock faults we have on the north the south-eastern extremity of the Lancashire Coal-field. A long narrow strip of Coal-measures, branching off from the main field, runs down by Hyde and Poynton to Macclesfield. It is bounded

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* On the Geology of the Country around Oldham (Mem. Geol. Survey), p. 43.

† See Sheet 88 S.W. of the Map of the Geological Survey; and Memoir on "The Geology of the Country around Oldham," p. 57.

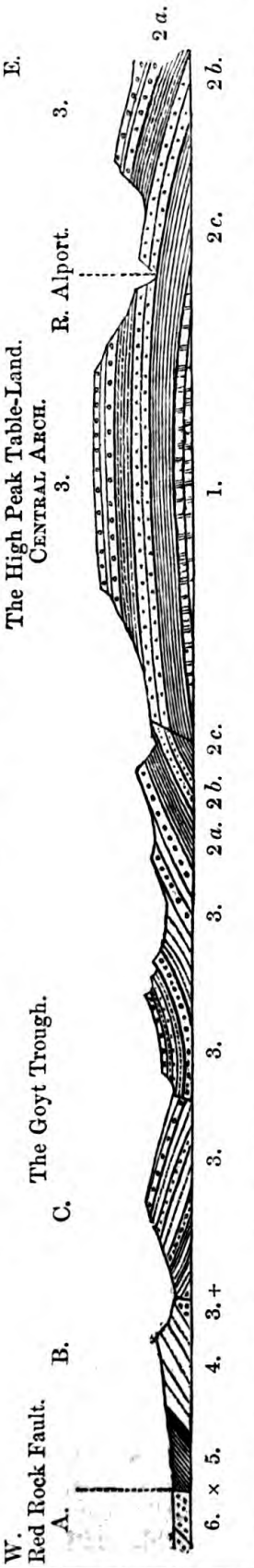

Fig. 6.—Section from Norbury across the Plateau of the High Peak.

on the west by the Red Rock fault, and on the east and south by ridges of the Millstone Grit, which rises in these directions from beneath the Coal-measures. These particulars will be understood from the section given below, which begins on the Permian Sandstone at Norbury (6), and after crossing the Red Rock fault reaches the Poynton Coal-field (5): from below this rise the Lower Coal-measures of Marple (4), at the base of which, in the bottom of the valley, is the Millstone Grit (3). After crossing the anticlinal fault the dip is reversed, and the beds slope toward the east as far as the axis of the Goyt Trough, which is here accompanied by a fault: on the other side of the trough the beds rise to the east as far as The Peak, where they flatten, and afterwards roll over and dip to the east.

Fig. 6.

Section from Norbury across the District of the High Peak.

1. Carboniferous Limestone (?).
2*c*. Shales, with sandstones and thin limestones at bottom. } Yoredale Rocks.
2*b*. Yoredale Grit. } Yoredale Rocks.
2*a*. Shale. } Yoredale Rocks.
3. Millstone Grit; five members.
4. Lower Coal-measures.
5. Middle Coal-measures.
6. Permian Sandstone.
×. Red Rock fault.
+. Anticlinal fault.
A. Norbury.
B. Marple.
C. Cobden Edge.

In the south-west corner of the district lies another deep synclinal, of Coal-measures, bounded on each side by ridges of Millstone Grit. It is known as the Biddulph Trough, and forms the northern end of the Coal-field of The Potteries.*

Between the Biddulph and the Goyt Troughs lies a shallower basin running down from the north of Rushton Spencer, through Rudyerd and Horton, and ending on the south in the little coal-field of Wetley and Shafferlong.† This we shall call the Rudyerd Basin.

The remainder of the country is mainly occupied by Yoredale Rocks, very much contorted and broken by faults.

* I use this name in preference to "The North Staffordshire Coal-field," because there are several coal-basins in North Staffordshire.—A. H. G.

† In Sheet 72 N.W. of the Map of the Geol. Survey.

The Carboniferous limestone comes to the surface at Mixon near Leek, and at Astbury near Congleton ; and a portion of the main mass of this rock runs into our district west of Buxton.

Drainage.—The main watershed of central England runs through the country ; and the drainage is carried off into the Mersey on the one side, and into the Trent on the other.

The course of the line dividing the districts drained by these two rivers is winding, and shows in places a marked disregard to the present surface configuration of the ground. It runs nearly due south over the table-lands of the High Peak and Combs Moss, and along the ridge of Axe Edge to a point about two miles south of the village of Flash. It then turns sharply to the west, and strikes straight across a valley bounded on the east, south, and west by lofty ridges formed by the outcrop of hard massive grit rocks. The only natural outlet from this hollow would seem to be on the north, and in this direction most of the brooks make their escape, and fall into the Dane : one stream, however, rising near Blue Hills, has chosen to cut a deep gorge through the bounding ridge at its southern end, and makes its way into the Churnet, though a much smaller amount of erosion would have carried its waters in the same direction as the rest of the brooks. The line now runs nearly due west till it strikes the ridge formed by the outcrop of the Millstone Grit on the east of the Biddulph Trough. This ridge forms in part the watershed between the two rivers ; but in spite of its height and the massiveness of its rocks, one brook rising to the west of it, whose easier course would have been into the Trent, has managed to cut through the barrier and make its way into the Dane. After following this ridge for about a mile and a half to the south of Biddulph, the line turns suddenly to the west, and strikes across the valley in exactly the same way as it crossed the hollow of the Goyt Trough on the south of Flash.

The chief feeders of the Trent are the Wye, the Dove, and the Churnet.

The Wye, rising to the west of Buxton, flows with an easterly course through that town, and joins the Derwent at Rowsley. It gives but few sections in the present country, but shows well the black shales at the base of the Yoredale Rocks at Buxton ; the remainder of its course is mainly in the Mountain Limestone.

The Dove rises on Axe Edge, and running with a south-easterly course forms for some way the boundary between Staffordshire and Derbyshire. It receives the brooks on the east side of Morridge and the continuation of that range by Flash to Axe Edge. In the upper part of its course are good sections of the Yoredale Rocks, and it afterwards runs for some time very nearly along the junction of that formation and the Mountain Limestone.

The Churnet is formed by the junction, a little above Leek, of several brooks running down from Bramcott and Meerbrook. Its course is upon the whole towards the south-east, and after joining the Dove at Rocester, the united streams take the name of the latter, and run on into the Trent near Burton. The Meerbrook and Bramcott brooks give good sections of Yoredale Rocks, and one of the feeders of the latter, as has been already mentioned, cuts through the range of the Millstone Grit south of Blue Hills, and shows well the different beds of that formation.

One brook rising to the south of Biddulph Moor flows directly into the Trent itself.

The Mersey is formed by the junction of the Goyt and Etherow, at Water Meetings; its feeders are the Dane, the Bollin, and the Tame.

The Dane rises on the western flank of Axe Edge, and runs at first with a south-westerly course along the hollow of the Goyt Trough: then turning to the west it cuts through the grit ridge of Back Forest, and flows past Congleton into the Weaver at Northwich; the latter river joins the Mersey at Runcorn. The course of this river from its source to Hug Bridge is in Lower Coal-measures, Millstone Grit, and Yoredale Rocks, and the sections given by it and its feeders are the chief data for working out the geology of the country through which it flows; among these may be noticed the admirable section given by the brook running past Goldsitch Houses (*see* p. 53), the pretty gorge cut by the river itself through the third bed of the Millstone Grit in Back Forest, and a fine group of vertical and contorted beds on the line of the anticlinal fault at Bearda. The river at Hug Bridge enters an outlying patch of Bunter Sandstone and Permian beds, both of which are well shown in its banks. After leaving these it runs over Yoredale Rocks till it reaches the Red Rock Fault at North Rode Viaduct (Fig. 3). From here to the edge of the map we have many sections, mostly in the red marls or thin hard sandstones of the Upper Keuper, among which we may notice that at Colley Mill as one of the best.

Several large brooks which rise to the south and east of Macclesfield, join about that town to form the Bollin, which runs with a north-westerly course into the Mersey, near Warburton. Throughout its course down to Wilmslow it shows no sections, except in drift deposits. A little below this point, however, near the mill, a cliff of New Red Sandstone makes its appearance, and further down at Quarry Bank there are several fine sections in the Keuper division of the Trias.

The river Goyt rises among the hills on the west of Axe Edge, and flows in a deep channel with a general N.N.W. direction, nearly along the axis of the Trough to which it has given a name. From Marple Bridge upwards to Strawberry Hill, the banks are formed of grits and shales of the Lower Coal-measures dipping westward. Here the anticlinal fault is passed, and we reach beds of Millstone Grit dipping east; owing to the drift covering, however, they are not very clearly shown. At Waterside, still higher up, Lower Coal-measures, with two coal-seams, are shown as far as the fault; one face of which forms a cliff of shale, while on the other side lies a mass of Boulder Clay. At New Mills the river cleaves its way between high cliffs of Millstone Grit with a slight dip to the east. At Furnace Bridge the Grits dip under the Lower Coal-measures, and the river runs in a trough of the latter, with few sections, to Whaley Bridge, where it again passes on to Millstone Grit. It flows over different beds of the formation till, near its source at Goyts Clough, it enters a small outlier of Lower Coal-measures. The upper part of this river, though little visited by the tourist, is of great beauty, specially the part above Goyts Bridge. On either side the beds of sandstone rise from the middle of the trough in sheets of heathery moorland, broken off abruptly along their upper edges. Beyond these are other expanses of moor terminated in like manner by steep descents; till a series of escarpments with sharp and gracefully curved sides is formed, with broad and gently rolling sweeps of moor between. Each ridge is formed by the outcrop of a sandstone bed, while the steep-sided valley below is hollowed out in shale; and each of these bands of grit and shale has its own place in the series, and can be traced and identified over the whole of the district.

The sources of the Etherow are in the watershed of England at Red Hole Spring and Wyke Head; it supplies the reservoir of the Manchester waterworks, and flows through Longden Dale: leaving this valley at Tintwistle it runs southwards by Compstall, and joins the Goyt at Water Meetings to form the Mersey.

The part of the Etherow within the present map flows over Carboniferous Rocks. From Compstall to Broadbottom all the sections are in shales and sandstones of the Lower Coal-measures, but at the point where the gorge is spanned by the viaduct of the Manchester and Sheffield Railway very fine sections are laid open in Millstone Grit, which rises on either side in lofty cliffs reaching nearly to Bank Wood Mill.

The bed and banks of the Mersey show Carboniferous grits and shales as far as Goyt Hall, east of Stockport; at this point the red rock fault is passed,* and from hence to a point above Heaton Mersey there is an almost unbroken section in Triassic and Permian sandstones: the remainder of the course of the river within our district is wholly in drift deposits, with the exception of sections in New Red Sandstone opposite Cheadle.

The river Tame joins the Mersey at Stockport, and for several miles flows at the base of high banks of Drift: sections in Lower Permian Sandstone are seen in a little watercourse west of Brinnington, and in an elbow at Reddish Wood. Farther up we find the same formation, at its junction with the Carboniferous rocks, on the right bank of the river below Beat Bridge. Above Beat Bridge the Coal-measures are opened up in many places along the river banks, the sandstones more conspicuously than the shales as far as Glass House Fold, and less frequently from this to Hyde Bridge. The sections along the rest of its course have been described in a former memoir.†

On pp. 263–270 of "The Ancient History of Leek, by J. Sleigh," (Leek, R. Nall, 1863,) is a good account of the springs in the neighbourhood of that town, by Mr. Wardle.

Hills.—The elevations of the country follow the general plan which has been already pointed out when treating of the district round Manchester.‡ The Trias forms a plain of an average height of 250 feet above the sea: then comes a tract of higher ground made up of Middle and Lower Coal-measures, stretching from Hyde to Macclesfield, with ridges which reach a height of 1,000 feet; while a third and still higher region is formed by the Millstone Grit series from Mottram southwards to Axe Edge, and thence towards Leek. The highest points reached by this formation lie a little beyond the eastern edge of the map, in the region of the High Peak.

The New Red Sandstone is somewhat freed from the charge of general tameness by the high ground of Alderley Edge, which at the Beacon rises to a height of 650 feet: but this is a remarkable exception, of which more hereafter.

The following are the heights in feet above the sea level of some of the chief points.

Lower Coal Measures.—Marple Church, 624; The Cage in Lyme Park, 882; Mellor Church, 739; highest point of Park Moor, south side of Lyme Park, about 1,350; Northern Nancy, north end of Ker-

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* See Fig. 5.

† "Geology of the Country around Oldham." Mem. Geol. Survey.

‡ Ibid., and "Geology of the Country around Bolton." Mem. Geol. Survey.

ridge, 930 ; Eddisbury Hill, near Macclesfield, about 1,000 ; source of the Goyt, about 1,600.

Millstone Grit.—Werneth Low (1st grit), 821 ; Coombs Edge (1st grit), 1,356 ; Chinley Churn (1st grit), 1,493 ; Eccles Pike (3rd grit), 1,225 ; Whaley Moor (1st grit), 1,347 ; Sponds Hill (1st grit), 1,357 ; Black Edge, highest part of Combs Moss (3rd grit), 1,670 ; The Cat and Fiddle (1st grit), 1,750 ; Axe Edge (4th grit), 1,809 ; The Roaches, north of Leek (3rd grit), 1,580 ; Shutlingslow (1st grit), 1,718 ; Tegg's Nose, near Macclesfield (3rd grit), 1,300 ; Cloud Hill, near Congleton (3rd grit), 1,190 ; Mow Cop (1st grit), 1,101.

The hard quartzose sandstones in the middle of the Yoredale Rocks form the group of hills about Bosley Minn, a ridge on the east side of Biddulph Moor, and Gun Hill near Leek ; the first of these is 1,210 feet above the sea, and the other two most likely slightly lower.

E. H.
A. H. G.

CHAPTER II.

Table and Description of the Geological Formations.

The following table shows, in descending order, the formations found in the district now under consideration.

Recent		Valley gravels and river terraces.
Post Pliocene	Boulder Beds or Drift	Upper Boulder Clay or Till. Sand and Gravel. Lower Boulder Clay or Till.
New Red Sandstone or Trias	Keuper	Red Marl. Waterstones or Lower Keuper Sandstone.
	Bunter	Upper Mottled Sandstone. Pebble Beds.
Permian		Upper Permian marls, with limestone bands. Lower Permian sandstones.
Carboniferous Rocks		Middle Coal-measures. Lower Coal-measures, or Gannister beds. Millstone Grit. Yoredale Rocks, or Upper Limestone Shale. Carboniferous or Mountain Limestone.

We will now give a short account of the mineral character of each of these formations beginning with the lowest, and afterwards describe their present positions at the surface.

Carboniferous or Mountain Limestone and Yoredale Rocks.

The Mountain Limestone is too well known to require much description, and is besides but little seen in the present country. It is a group of pure, pale-grey, thick-bedded limestones, with very slight traces of interstratified clay or shale, of very great but unknown thickness. Over the centre and north of Derbyshire two contemporaneous beds of igneous rock, called toadstone, are interbedded with the limestones.*

Above the Mountain Limestone lies a group of shales and sandstones with thin, black, earthy limestones at the bottom, which have been generally known hitherto in this country as the Upper Limestone Shale ; as, however, at least one-third of the group consists of sand-

* Jukes. Manual of Geology, p. 523, and Sheet 18 of the Horizontal Sections of the Geological Survey.

stones, and as it lies on the same horizon as the beds to which Prof. Phillips has given the name "Yoredale Rocks" in Yorkshire, the latter name seems to be the more suitable. In the present country the group shows us

1. Upper Group.
   - 1*a*. Greyish sandy and micaceous shales.
   - 1*b*. Thick bed of sandstone, for the most part not very coarse, but here and there coarse and massive. The "Shale Grit" of Farey.
   - 1*c*. Shales, with perhaps a few thin limestones.
2. Middle Group. A thick mass of hard, thin-bedded, fine sandstones, here and there taking the form of semi-crystalline quartz rock, with partings and thick beds of black shale.*
3. Lowest Group. Black shales, with thin, black, earthy limestones.

The "Yoredale Grit" is a massive sandstone, of finer grain than the Millstone Grits above it; the reasons for placing it in the Yoredale Group rather than with the Millstones will be given below. The sandstones of the middle division are known by their close grain and clean bright fracture, which seems to be due to a plentiful siliceous cement; they differ from the gritstones in this respect, for the freshly broken surface of the latter is always rough; and these sandstones do not, like the gritstones, become crumbly from weathering. The upper part of the third division is made up of black shale, but towards the bottom thin impure limestones come in, and seem mostly to become more plentiful and purer as we go down.

The Grit, the Sandstones, and the Black Limestones, which are the distinguishing features of the three groups into which we have divided the Yoredale Rocks, are noticed by Farey in his History of Derbyshire, p. 228. As instances of the two last he mentions the hard cank-like sandstones of Gun Hill near Leek, and the black limestones of Mixon, and he calls all three "anomalies," by which he perhaps meant that they are variations from the typical form of the formation, which in a broad sense may be said to be shale, as the typical form of the formations above and below are sandstone and limestone respectively.

A word as to the mapping of these beds. A dull blue has been taken for the general colouring on the map for Yoredale Rocks. The Yoredale Grit, which is for the most part well marked, is shown by a darker tint of the same colour; but the Yoredale Sandstones are too thin and changeable, and all too much alike, to allow of their being mapped separately; nor can a line be drawn with much accuracy between these beds and the group below, partly because the two pass into each other, and partly on account of the broken and contorted state of the country. Wherever either of the two lowest groups are largely and clearly shown, the words "Yoredale Sandstones," or "Thin Limestones," as the case may be, have been engraved on the map, and the blue Yoredale tint has been marked by yellow dots for the first and with bright blue lines for the second. This is done, however, only where the evidence is decisive; over doubtful ground the dull blue colour alone is spread, to show that, though we know the beds to be of Yoredale age, we cannot say for certain to which group they belong.

It is very difficult to form any trustworthy estimate of the thickness of the Yoredale Beds, on account of their contorted and faulted state. Sections under Congleton Edge, and on the east of the Pottery Coal-

* As we use the term Yoredale Rocks for the whole group, we venture to change the name "Shale Grit" into "Yoredale Grit;" and shall speak of the sandstones of the middle group as Yoredale Sandstones.

field between Ferneyhaugh and a large fault west of Endon,* would give about 2,000 feet of strata between the lowest Millstone Grit and the top of the third division of the Yoredale Rocks ; which latter are also shown by Section 42 of the Geological Survey to reach the same thickness.* This amount is rather startling, but I do not know of any fault or folding of the beds in the sections mentioned that would falsify the calculations.

Millstone Grit.

This is a group of thick-bedded, coarse, massive gritstones and conglomerates, between which lie shales, flagstones, and finer sandstones. The chief beds of gritstone, four in number, can be traced over the whole of the district, and have been laid down separately on the maps ; their outcrops form all the more striking hills and "edges," while the flanks of the ranges and the valleys are made up of the shales. The series is as follows :

1st Grit, or *Rough Rock.*
Shales, with a thin coal at the bottom near Buxton.
2nd Grit, or *Haslingden Flags.*
Shales, with two or three thin coals, one close to the bottom.
3rd or *Roaches Grit.*
Shales.
4th or *Kinder Scout Grit,* generally in two beds.

The Rough Rock is a coarse grit, here and there a conglomerate, containing a large proportion of felspar, the decomposition of which gives the rock a crumbly nature, which, though more or less common to all the gritstones is peculiarly characteristic of this bed. The thickness of the Rough Rock is from 80 to 200 feet.

A. H. G.

Either on the top of the Rough Rock, or a little way down in the bed, lies a seam of coal, known as the Feather-edge Coal, which may be here noticed. Of all the coal-seams in this district, none is so variable, we may even say, so excentric, in its distribution as this, the highest coal-seam of the Millstone Series. With the most extraordinary inconsistency, it will appear on one side of a valley and be absent on the other, though the rock may be the same ; or it may be covered by a thick mass of coarse grit in one spot, which within a few hundred yards may have entirely disappeared, and the roof of the coal be formed of black shale with fossils. The only hypothesis which appears sufficient to explain these irregularities is one which has been suggested by Mr. Binney, that after the formation of the coal, denudation has in some places swept away either the coal, or the grit, or both. We shall now proceed to trace this seam from north to south, noting its changes along our course.

The Feather-edge Coal does not appear in our district north of a line drawn east and west through Compstall, although the Rough Rock occurs at Romiley, Gee Cross, Werneth Low, Broadbottom, Charlesworth and Coombs Edge, and Ludworth Moor. Over this ground, however, its absence is compensated for by the presence of the Simmondsley and Mottram Mine, which lies on the top of the Third Grit. We find it, however, at Mellor, and all along Cobden Edge ; here the roof is generally black shale with Goniatites, in other places coarse grit of a few feet in thickness. It is worked in Mr. Jowett's pit at a depth of 120 yards, and is 3 feet in thickness.

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* See description of Horizontal Section of the Geol. Survey, No. 42, p. 3.

At New Mills very fine sections of the Rough Rock, and its included coal-seam, are opened in the river cliffs, and the Midland Railway cuttings. The coal here lies in the middle of the grit, which is at least 200 feet in thickness, and we have the following section:

Section at New Mills.

	Thickness. Feet.
1. Coarse massive grit	40 to 50
2. Black shales, with fossils	4
3. Feather-edge coal	3½
4. Dark grey sandy underclay	2½
5. Hard sandy shale	2
6. Hard coarse and fine grit, passing down into flagstones (about)	130

At Aspinshaw the Rough Rock and the coal form an outlier of nearly circular shape, and the roof of the coal is grit: the outcrop of the seam may be seen at Bank Head.

At Overlee, near Thornsett, on the south side of Sett Brook, the following section was passed through in a pit:

Pit Section near the Vine Tavern, Overlee.

	Ft.	in.
Coal	1	0
Black shale	36	0
Coarse grit (Rough Rock)	72	0
Feather-edge coal, with rock roof	2	4
Fire clay	3	0
Coarse grit (not gone through) about	36	0
	150	4

The rock which lies immediately above the coal may be seen in a quarry at the head of the turnpike road south of Thornsett.

At Chinley Churn and southward the upper bed of Rough Rock thins out, and the roof is a thick series of black shales. The outline of this range is very striking, and contrary to the usual course, the second grit forms the highest of the three escarpments. The section is as follows:

Lower Coal-measures of Ollerset Moor, penetrated by a colliery shaft to the Feather-edge coal.
First Grit, or Rough Rock, with the Feather-edge coal.
Shales.
Second Grit, forming at this part the highest point of the range.
Shales.
Third Grit.
Shales.
Fourth, or Kinder Scout Grit, in two thick beds with shale between.

Further south at Chinley Churn, the third grit assumes the pre-eminence, and the Rough Rock crops out at some distance down the western flank of the hill.

At Disley the Feather-edge Coal has been worked and has in general a rock roof. The outcrop of the coal may be observed in the cutting of the railway on the east side of the tunnel, and again in a cutting of the same line about half way between Disley and New Mills. This section is remarkable for the regularity of the joints by which the rock both above and below the coal is traversed, and which might easily be mistaken for bedding were it not for the coal-seams and shales, which

show the true dip of the rock to be nearly west at 20°. The section here is as follows :

Section in the Railway near Disley.

	Thickness. Ft.	in.
1. Coarse massive reddish grit (top not seen) -	50	0
2. Feather-edge coal - - - -	2	6
3. Micaceous underclay - - - -	2	0
4. Shale and thin grit - - - -	4	0
5. Coarse grit - - - - -	75	0
6. Coal - - - - - -	1	0
7. Thin-bedded fine reddish grits and shales -	30	0

The coal-seam No. 2 here shows the peculiar feathery fracture which induced Mr. John Hall to give this seam the name of "Feather-edge" coal. Notwithstanding that there is 50 feet and upwards of grit overlying the coal in the above section, the whole of this has disappeared within a mile of this spot, for at the head of Redmoor Lane we find the crop of the coal succeeded by shales, as follows :

Section in Redmoor Lane.

	Thickness. Feet.
Fine grit, seen at the barn - - - - -	10
Grey shales - - - - - -	38
Fine flaggy grit - - - - -	15
Grey sandy shales - - - - -	40
Black shale - - - - - -	70
Feather-edge coal - - - - -	4
Underclay and shale, about - - - -	6
Coarse flaggy grit (Rough Rock of Whaley Moor).	

The dip of the beds is here 20° to the east, and the coal forms the upper limit of the Millstone Grit series.

All along the western side of the saddle, which extends from Disley southward along Saltersford valley, there is no appearance, or at least only very slight traces of the Feather-edge Coal.

The case is different, however, on the eastern side, and on both sides of the Goyt Trough, as far south as Fernilee, the Feather-edge Coal has been gotten, and is of the average thickness of four feet. At Hockerley Colliery it is worked at a depth of 110 yards, and in Mr. Gisborne's pit, Whaley, a section of which will be found at page 25, at about the same depth. The outcrop of the seam at its southern termination may be seen in a little dell, which descends from Fernilee to the Goyt. Tunnels have here been driven into the bank, and in the shales which overlie the coal.

The Feather-edge Coal is worked also at Goyt's Clough near Buxton, and about Goldsitch Moss north of Leek ; notices of it will be found below, under the description of the Lower Coal-measures of the Goyt Trough.

E. H.

The Second Grit is a mass of fine-grained, brown or yellow, flaggy sandstone, from 100 to 120 feet thick. It would seem to be the equivalent of the Haslingden Flags of Lancashire, which further north lie immediately below the Rough Rock, but are here parted from it by 100 or 150 feet of shales.* This bed thins out somewhat suddenly about six miles to the north of Leek.

* See Memoir on the "Geology of the Country around Oldham," p. 14.

In the country further to the north the shales below the second grit hold two or three thin coals, called by Mr. Binney the Brooksbottom coals; one of these lying at the bottom of the shales, and often resting directly on the third grit, is found here and there over the whole of the present district; it is mostly about one foot in thickness, but near Buxton swells out to the thickness of 4 feet 6 inches.

The Third Grit is massive and well jointed, often a conglomerate, and is perhaps the most striking of the series, the fine edges formed by its outcrop being among the most noticeable features in the scenery, and often running for miles in an unbroken wall of rock: it might well be called "the escarpment grit." The rock is mostly red in colour, and from a thickness of 330 feet, which it reaches near Glossop, thins away to about 100 feet near Congleton, and still further south seems on the point of dying away altogether.

Below this bed, on the north of the district, lies a thick mass of shale with bands of flagstone, which mostly forms a broad valley beneath its escarpment. These beds grow thinner towards the south, and from Buxton onwards we find in their place about 100 feet of measures almost wholly shale.

The Fourth, or Kinder Scout Grit, has been so named by us because it forms the crags of Kinder Scout, the westerly edge of the table-land of the High Peak.* It is on the north made up of two or three thick beds of very coarse massive gritstone and conglomerate, with beds of shale between, the latter being very irregular.† It there reaches a thickness of from 700 to 1,000 feet. In tracing the bed southwards we find it becoming thinner and less coarse, and on the north of Buxton passing into two sandstone beds‡ with a thick shale between them. The upper is a soft red grit, rather coarse, about 150 feet thick; the shales about 130 feet; and the lower bed, a fine flaggy sandstone, about 50 feet thick. Farther to the south these beds grow still finer and thinner, and at last, a little beyond the southern edge of the map, die out altogether.

This Fourth Grit has been always looked upon from the time of Farey as the base of the Millstone series, and naturally so, for all the sandstones below it are thinner bedded and finer in grain; and besides, they associate themselves with the shales on the flanks of the great escarpments and edges, occupying a subordinate position in the features of the country to the Kinder Scout grits and other millstones. We have been unwilling to alter so good and long established a classification, otherwise the Shale Grit of the Yoredale Rocks might well have been placed among the Millstones, for it is in places massive, sometimes a conglomerate, and mostly wants the close siliceous cement which distinguishes the Yoredale Sandstones from the true Gritstones.

The Grit series reaches, on the Chinley Hills near Hayfield, in the north of our district, a thickness of 3,000 feet. It thins away step by step southwards, and where it is covered up by the New Red Sandstone of central England, a little beyond the southern edge of the map, it is not more than 300 or 400 feet thick.

A. H. G.

Lower Coal-measures.

Under the head of the Lower Coal-measures are included all the beds between the Redacre Mine, the supposed equivalent of the Arley Mine

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* "Geology of the Country around Oldham" (Mem. Geol. Survey), p. 11.

† Ibid., p. 13.

‡ These beds we will speak of in their place as the Fourth and Fifth Grits.

of Lancashire, and the Rough Rock. These measures consist of shales and micaceous flagstones, with a few thin seams of coal.

1. *Lower Coal-measures of the tract between Hyde, Poynton, and Macclesfield.*

At Hyde this series forms a narrow band, between the outcrop of the Lower Woodley Mine and the Millstone Grit of Gee Cross. One or more of the coals have been worked here, probably the Gannister seam, but no information could be obtained regarding them. At Romiley there are large quarries in the flagstone, which dips west at 15° or 20°. Many sections in the flagstones and shales of the series are shown along the Mersey, between Otterspool and Compstall, and coal has been worked on the river bank below the canal aqueduct. Purple and red massive grit, probably the same as the Marple rock, is finely opened out in the railway cutting at Hyde Bank, and flagstones in High Lane, near Wibbersley Hall, rising to the eastward from below the Middle Coal-measures of Norbury. The ridges of Lyme park, with their intervening valleys, especially to the south of the Hall, open out to view the entire series with great regularity, as ridge after ridge rises in succession to the eastward from the outcrop of the Redacre coal to the Rough Rock of Park Moor.

The section at Pott Shrigley is still more instructive, as we have the advantage of the openings along the banks of Shrigley Brook. The highest bed of flagstone appears to be that which is so largely quarried in Stypherson Park. This is a grey, flaggy, and evenly-bedded stone, rippled and micaceous, and containing in places large rusty concretions. The dip is W. 10° S. at 20°. Descending from the ridge towards the east, we cross a valley of shales, and then commence ascending the hill of Shrigley Park. This is formed of flagstone, opened out in a quarry on the south side of the Park. We then descend into the valley of Shrigley Brook, formed of shales, and then, above the mill, reach a quarry in massive hard gritstone, dipping west at 10°. Beyond this quarry is a coal-pit, 80 yards in depth, to the Bakestone Dale coal.

From the pit, and for a distance of about 350 yards the section in the bank, is principally in shale; and we then reach the outcrop of the *Gannister coal*, here only 5 inches thick, but underlaid by its peculiar flinty floor with impressions of *stigmariæ*. Beyond the outcrop are more shales, dipping west at 10°, and then we reach the crop of the Bakestone Dale coal, 14 inches thick, and the most valuable seam in the district. Beyond this are shales, then a very hard grit, then shale again, resting on the Rough Rock of the Millstone series. At a short distance south of this section the whole of these strata are thrown out by a large upcast fault ranging eastward from the village of Shrigley.

The coal-seams above described crop out south of Shrigley, and dip under the Bollington Grit. This is a very massive white and grey grit, in places rather coarse, and about 150 feet in thickness. It is largely quarried on both sides of the town, and is in all probability the same bed that is shown in the quarry east of Pott Mill, lying about 120 yards above the Bakestone Dale coal, and occurring on the top of Kerridge in a small patch above the Endon quarries. The difference in its position on the top of the ridge and in the quarries at Bollington is due to the presence of a downcast fault, ranging north and south along the western base of Kerridge, which may be traced southwards into the North Staffordshire Coal-field. (*See* p. 66.)

The most remarkable seam in this series, though not the thickest in this district, is the Gannister coal above mentioned. In South Lanca-

shire it is the most valuable of all the seams of the Lower Coal-measures; but here it is very thin, and at Broadbottom is absent altogether. The floor of the coal, however, retains that unique character, which distinguishes it from the floors of other seams. It consists of an extremely hard or flinty rock of variable thickness, penetrated by rootlets, and generally imbedded in soft fire-clay. The stone is valuable for road metal, and is made use of in the "Bessemer process" of manufacturing steel for lining the inside of the "converters." It is of the same nature over an area of at least 2,500 square miles.

E. H.

About Macclesfield, where the little coals have been largely gotten, the general section is as follows:

		ft.	in.		ft.	in.
1.	Kerridge rock, a thick mass of sandstones of various qualities: flaggy and micaceous, hard and close grained, and in some of the upper beds a coarse gritstone. Thick shale partings.					
2.	Shales.					
3.	Coal, *Great Smut.*	2	6			
4.	Measures, shales, &c.	100	0	to	140	0
5.	Coal, *Little Smut.*	0	0	„	1	1
6.	Measures.	36	0			
7.	Coal, *Shore* or *Sweet Seam.*	1	6	„	2	0
8.	Measures.	12	0	„	24	0
9.	Coal, *Stinkard.*	0	3	„	1	0
10.	Measures.	39	0	„	54	0
11.	Coal, *Ribbon.*	0	0	„	0	10
12.	Measures.	90	0	„	120	0
13.	Coal, *Big Mine.*	4	0	„	6	0

The above general section is drawn up from the accounts of old colliers. The following section of Roewood colliery, Hurdsfield, for which I am indebted to Mr. George Needham, gives a few further particulars:

	ft.	in.		ft.	in.
Drift.	33	0			
Shale.	57	0			
1st Coal (No. 5 of above Section).	0	10			
Hard Rock.	24	0			
Shale.	12	0			
2nd Coal, No. 7.	1	1	to	1	5
Rock.	36	0			
Shale.	12	0			
3rd Coal.	1	6	to	1	8

The Kerridge Rock may be the equivalent of the great flagstone series which in Lancashire, Yorkshire, and Derbyshire parts the Lower from the Middle Coal-measures.* The Great Smut may represent the "40-yards Mine" of Lancashire, while the four coals below hold the place of the Gannister and its fellow seams. The Big Mine, which rests directly on the Rough Rock, is the Feather-edge coal.†

A. H. G.

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* This is the opinion of Mr. Binney; Mr. Hull thinks that the Kerridge beds are lower down in the series than the flags of Rochdale and Upholland.

† For an account of the Lower Coal-seams of Lancashire, see Mr. E. W. Binney's most valuable papers, Trans. Geol. Soc. Manchester, vol. i., p. 76; Mem. Lit. and Phil. Soc. Manchester, vol. viii., p. 160; vol. x., p. 187; and "The Geology of the Country around Oldham" (Mem. Geol. Survey), p. 16.

2. *Lower Coal-measures of the Goyt Trough.*

In the lesser hollows into which this great trough is broken up lie patches of Lower Coal-measures, whose seams bear a general likeness to those of the Lancashire Coal-field.

A considerable tract is composed of these beds at the northern part of the district lying between Broadbottom and New Mills. Over this area the Lower Yard Mine, the equivalent of the Bakestone Dale Coal, is, and has been, extensively worked. The outcrop of the seam may be observed in Ernocroft Wood, where a tunnel has been driven into the side of the hill near the outcrop. It is also worked at Chisworth. The thickness of the seam is about 3 feet. The following is the section at Rose Grove.

Section at Rose Grove, near Broadbottom.

	ft.	in.
Black shale	10	0
Coal — from 1 ft. to	1	2
Principally shales, thickness uncertain.		
Coal (Gannister seam)	0	4
Principally shales	180	0
Coal (Lower Yard Mine) — from 3 ft. to	3	6

The next section was obtained from the underlooker of Mr. Jowitt's colliery, the Inkerman Pit, at Ludworth.

Section at Ludworth Colliery.

	ft.	in.
Sandstone	36	0
Coal (Forty Yards Mine?) — 1 ft. 2 in. to	1	4
Coarse flaggy sandstone	44	0
Shale	40	0
Coal (Gannister seam) — 1 in. to	0	6
Gannister rock	2	0
Shale	60	0
Hard fine grit ("Five feet rock")	5	0
Black shale	25	0
Hard grey shale ("Dun bed")	12	0
Dark shale	12	0
Shale ("Little Dun bed")	2	0
Black shale roof	4	0
Coal (Yard seam)	3	0
Hard floor and fire-clay	4	0

At Compstall the Yard Coal is worked by Mr. Jowitt at a depth of 112 yards, on the downcast side of the large anticlinal fault which traverses the country from north to south.

On the east the tract of Lower Coal-measures just described is bounded by a large upcast fault which occupies the line of "the Goyt Trough" and on the south by the up-rising of the Millstone Grit at New Mills. A second basin, more irregular in outline and of smaller extent, occupies the valley of the Goyt from Furnace to Fernilee, the village of Whaley being nearly in the centre. From this two arms project in the form of narrow troughs, one towards the north-east in the direction of Ollerset Moor, the other towards the north side of Disley. In the southern part of this tract, and around Whaley, the Lower Coal-measures lie in a bed formed of the Feather-edge Coal, which has a roof of black shale of 12 yards in thickness. In the northern part, however, the upper bed of the Rough Rock, absent in the south, reappears, capping the coal, and appearing in considerable force at Disley. To this subject we shall again return.

At Whaley there are four seams, including the Feather-edge Coal, all of which have been worked, and are given in the following section of Mr. Gisborne's colliery.

Section at Whaley.

	ft.	in.
Shale	180	0
Coal (Red Ash Mine)	1	6
Sandstone	18	0
Shale	12	0
Coal (Gannister Mine)	1	0
Rock	12	0
Shale	36	0
Coal (White Ash or Lower Yard Mine)	1	6
Sandstone (7-yards stone)	21	0
Shale	36	0
Coal (Big, or Feather-edge Mine)	4	0
MILLSTONE GRIT.		

The Gannister Coal, and also the Lower Yard Mine, are, or have been, both worked north of Disley, and the outcrop of the latter may be observed in a deep dell which is cut in the bank above Waterside. The outcrop of the Gannister Coal, or its floor, may be seen in the brook north of Hockerley, on the west side of the basin, and in the lane above Upper Barn on the east.

The following is the section in Mr. Srigley's pit, about half a mile north of Whaley.

Section in Lower Coal-measures North of Whaley.

	ft.	in.
Marl (Boulder Clay)	60	0
Shale, with bands of flag	80	0
Black shale, with *Aviculo-pecten* and *Goniatites*	10	0
Coal (Red Ash Mine)	1	6
Rock (with vein of Galena)	24	0
Shale, with fish remains, *Cypris*, and plants	36	0
Coal (Smithy Mine)	1	6
Strata, principally rock	30	0
Coal (Cannel Mine, bad quality)	1	4
Rock and shale	30	0
Coarse grit (Woodhead Hill Rock)	21	0
Shale	39	0
Coal (Big Mine)	3 ft. to	4 0

The Whaley basin is traversed from east to west by a large fault, which passes by Hockerley, and is a downthrow on the north side.

The effect of this fault in bringing the third Millstone Grit against the second, and the second against the outcrop of the Gannister Coal, will be better understood by a reference to the map than by a written description. To this fault the Black Brook Valley, which crosses the Millstone series transversely and opens into that of the Goyt, is perhaps due.

Lead Veins.—I may here mention the somewhat unusual occurrence of veins of galena in the strata of the Lower Coal-measures which have been observed at Whaley. According to the information of Messrs. J. and W. Srigley, veins of galena have been worked in the measures both above and below the *Red Ash Mine*, specimens of which I was shown on the spot; but the largest quantity of ore has been obtained in Mr. Gisborne's colliery in the rock below the *Red Ash Mine*, although the lode itself has been traced through all the strata down to the *Big Mine* roof, in which it was pointed out to me.

The ore, however, was almost entirely confined to the rock below the *Red Ash Mine*, in which the lode was as much as 24 inches in width, and yielded 60 or 70 lbs. weight per dish of ore. The lode "perished" in the centre of the basin, but southward became very rich, and has

now been worked out. In the Big Mine the lode occurs as a small fault, and contained small pieces of ore.*

E. H.

In a little patch of Coal-measures at Goyt's Clough, west of Buxton, we have the following beds :†

	ft.	in.
Shales - - - - - - -	40	0
Sandstone (*The Woodhead Hill Rock* of Lancashire) -	20	0
Shales - - - - - - -	15	0
Goyt's Coal (the *Feather-edge Coal*) - { Coal 1 0 / Bat 0 3 / Coal 3 7 }	4	10

In the trough of Coal-measures lying round Goldsitch Moss the section is as follows :

		ft.	in.		ft.	in.
1.	Coarse red grit rock.					
2.	Shales.					
	Coal, *Silver seam.* - - -	1	4	to	1	6
	Measures. - - - -	130	0			
	Coal, *Thin seam.* - - -	1	4	„	1	6
	Measures. - - - -	45	0	„	60	0
	Coal, *Thick seam.* - - -	2	0	„	2	3
	Measures. - - - -	60	0	„	72	0
	Coal, *Cannel seam.* - - -	0	6	„	2	0
	Shales. - - - - -	9	0	„	12	0
	Coal, *Bassy*, black shale with thin layers of Coal. - - - -	5	0	„	6	0
3.	Sandstone (*Woodhead Hill Rock*). -	57	0			
4.	Black shales, Ironstone, and Flags. -	267	0			
5.	Coal, *Feather-edge Coal.* - -	4	0	„	6	0

In this series No. 1. may represent a rock in Lancashire called by Mr. Binney‡ the "Ending Common Rock," and the "Helpet Edge Rock" by Mr. Hull :§ group No. 2. will be the Gannister and its companion coals. No. 3 is a bed called by Mr. Binney the "Woodhead Hill Rock;" it is in this country very variable, sometimes showing as a soft, thick-bedded, crumbly grit, and at others as a very current-bedded flagstone. The lowest coal, No. 5., which is only separated from the Rough Rock by a few feet of underclay, agrees well with the Feather-edge Coal. The above section is drawn up from the accounts of old colliers at Goldsitch Moss: in Robin's Clough, where the same coals are wrought, I was told that the thicknesses are as follows :

	ft.	in.		ft.	in.
Coal, *Silver seam.*					
Black shales.					
Coal, *Thin seam.* - - - -	1	8			
Shales and flagstone. - - - -	42	0			
Coal, *Thick* or *Rock seam.* - - -	1	8	to	1	10
Red flaggy sandstone. - - }	48	0	„	54	0
Shales and flags. - - - }					
Coal, *Cannel seam.* - - - -	1	0	„	1	2

* These lodes are noticed by Mr. E. W. Binney in a paper read before the Literary and Philosophical Society of Manchester. See their transactions, 2nd series, vol. 9, p. 125.

† The thicknesses are from a tunnel driven through these beds by the Duke of Devonshire, a section of which was kindly given me by the late Mr. Willmott.

‡ Trans. Geol. Soc. Manchester, vol. i., p. 75.

§ "Geology of the Country around Oldham" (Mem. Geol. Survey), p. 16.

Both the "Thick" and the "Cannel" seams have hard, Gannister-like floors.

In the map to the south of our district, 72 N.W. lies the Cheadle Coal-field, the last of the little coal basins of the Goyt Trough; an account of its measures will be found in Part IV. of "The Iron Ores of Great Britain" (Mems. of the Geol. Survey), p. 277; and in a paper by Mr. E. W. Binney, Mems. of the Lit. and Phil. Soc. of Manchester, vol. xii., p. 34.

3. *Lower Coal-measures of the Biddulph Trough.*

In the lower part of the Coal-measures of the Pottery Coal-field we find about 300 feet of beds, with a few coals containing marine fossils in their roofs. These are looked upon as the equivalents of the Lower Coal-measures of Lancashire;* but as we cannot point to any seam as the representative of the Arley Mine of that county, and as the Upper Flagstone of Lancashire is wanting in North Staffordshire, it is not easy to say exactly where the line between the Lower and the Middle Measures is to be drawn.

In an old colliery at Lea Mill Forges the following beds were passed through:

	ft.	in.		ft.	in.
Coal.	1	8			
Warrant. Thin bed of sandstone. Shales.	130	0			
Coal, *Crabtree*, or *Four-foot*.	3	0	to	4	0
Warrant. Thin sandstone. Shales.	61	0			
Coal.	1	0			
Shales.	59	0			
Coal, *Little Row* or *Two-foot*.	2	3	to	3	0
Warrant. Fine-grained thick-bedded sandstone. Dark sandy shales, with a little coal.	55	0			

In the roof of the Crabtree seam were large calcareous nodules, with *Goniatites Listeri, Orthoceras, Aviculopecten papyraceus.* The thick sandstone at the bottom of the section holds about the same place as the Woodhead Hill Rock of Lancashire, but otherwise the Coal-measures of that county do not show any close resemblance to those of the district of the Potteries.

The Crabtree and Little Row coals have been largely gotten around Biddulph, but I do not know of any pit now at work, and the section above was the only one that I could lay hands on. In his general account of the Coal-measures of North Staffordshire, Mr. J. Bradbury gives the following section of the lower beds:†

	ft.	in.
Coal.	1	5
Strata.	141	0
Coal, *Crabtree*.	4	0
Strata.	42	0
Coal, *Little Row*.	2	3

* See "Iron Ores of Great Britain" (Mem. Geol. Survey), part iv., p. 263.

† Trans. Manchester Geol. Soc., 1862.

The lower coals have been worked farther to the south on Wetley Moor, and similar beds are found in the little Wetley basin. For sections see "The Iron Ores of Great Britain," Part IV., (Memoirs of Geological Survey,) pp. 264–276.

A. H. G.

Middle Coal-measures.

These are the beds which contain all the chief workable coal-seams. They are found at Haughton, Hyde, and Poynton, and in the Biddulph Trough.

1. *Denton, Bredbury, and Poynton Coal-tracts.*

Regarding the outcrop of the *Redacre Coal* as the margin of the Poynton Coal-field in one direction, and the Red Rock fault as its limit in the other, the shape of the Coal-field would be somewhat that of a segment of a circle, of which the fault is the chord. At its northern extremity, however, it does not terminate against the fault, as it does on the south; but at Offerton Green and Bredbury is connected with the Coal-field of Lancashire by a narrow band of measures containing a few of the lower seams. At Haughton nearly all the seams of the Middle Series are present, and they rise and crop out rapidly to the eastward. The base of the series is the *Lower Woodley Mine*, which is considered to represent the *Royley Mine* of Oldham and Rochdale on the north, and the *Redacre Mine* on the south. But while, from the general range of the coal-seams, this supposition appears in the highest degree probable, it must be admitted that it has never been actually proved by experiment. This arises from the fact that there is a gap of unproved ground between the *Royley Mine* at Oldham and the *Lower Woodley Mine* at Hyde; and there is another similar space between the *Lower Woodley Mine*, where it has been worked on the north bank of the Mersey at Otterspool, and the *Redacre Mine* at Windle Hurst; and until the country lying between these three points has been opened up, the identity of the seam in the three places must remain in uncertainty.

At Haughton the whole of the Middle Coal-measures is present, though, from the thinning away of some of the seams, and the splitting up of others, there are only about six of them of any considerable value. The banks of the river from Beat Bank Bridge upwards afford a very fine section of the measures, but it is seldom that the outcrop of the coals is visible. The following is the general series at Haughton and Hyde:

Coal Series at Denton, Haughton, and Hyde.

	ft.	in.
Coal, Sod Mine, bad quality	5	8
Strata	99	0
Coal	1	7
Strata	33	0
Coal	1	8
Strata	189	0
Coal, Big Mine, good quality	6	0
Strata	96	0
Coal, Roger Mine, good house coal	5	6
Strata	84	0
Coal, Double Mine	3	0
Strata	414	0
Coal, Hard Mine, good quality	4	6
Strata	204	0

	ft.	in.
Coal, Town Lane Mine	3	8
Strata	30	0
Coal, Top Shuttles Mine	2	4
Strata	144	0
Coal, Lower Shuttles Mine	2	8
Strata, with Red Rock	615	0
Coal, Saltpetre Mine, bad quality	5	0
Strata	120	0
Coal, *Black Mine*, good quality	4	6
Strata	24	0
Coal	0	10
Strata	27	0
Coal and dirt	2	0
Strata	105	0
Coal, Stone Mine — Coal 1 3; Stone 1 0; Coal 1 0	3	3
Strata	45	0
Coal, Cannel, or Upper Bent Mine	1	4
Strata	96	0
Coal, Peacock, or King William Mine	2	6
Strata	75	0
Coal	0	10
Strata	76	0
Coal	1	10
Strata	45	0
Coal, Silver, or Hurst Old Mine, good quality	3	2

The seams below these are—

Water Mine — Coal 3 0; Shale 1 0; Coal 1 0	5	0
Coal	1	4
Rosemary Coal	1	6
Upper Woodley Coal	2	0
Lower Woodley Coal	2	6

The six seams from the Silver Mine downwards crop out in the bed of the Mersey near the Red Rock fault, below Goyt Hall.

The coals at Haughton and Denton are often "troubled" by rock faults and other irregularities, such as the local disappearance of the coal by the junction of the roof and floor. At Haughton Colliery the Hard Mine is frequently cut out by shale or sandstone for many yards, occasioning much profitless outlay in driving in barren ground. Several of the other seams are equally unfortunate.*

Further south, at Bredbury Colliery, all the seams from the *Black Mine* downwards have been worked or proved. The *Black Mine* there is 4 feet in thickness.

Most of the Coal-series at Denton reappear at Norbury and Poynton, only in a somewhat altered state. A very fine section of the beds may be observed along Norbury Brook, which flows in a deep channel across the whole series. The railway cuttings have also laid open the beds to some extent. For the following section, somewhat condensed, we are indebted to Mr. David Clayton, of Norbury Moor.

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* Much of my information is due to Mr. Bain, manager for Mr. Fletcher.

Coal-series at Norbury.

	ft.	in.
Coal, Chapel Mine	5	6
Strata	26	0
Coal	2	3
Strata	17	0
Smithy Coal	2	0
Strata	70	6
Coal	0	4
Strata, with several thin seams	99	5
Coal, Mill Mine	4	6
Strata	45	0
Coal and Cannel	1	0
Strata	19	10
Coal	2	3
Strata, principally sandstone	92	0
Coal	2	3
Strata	15	1
Coal	2	9
Strata	10	2
Coal	2	3
Shale	36	1
Reddish sandstone	163	0
Shale	6	0
Coal and dirt, Sheepwash Mine	10	0
Blue and red shale	24	0
Coal, Cannel Mine, with partings	8	0
Blue and red shale	19	0
Great Mine Rock (sandstone)	120	0
Coal, Great Mine, with two partings	6	6
Strata, with a thin coal seam	90	6
Coal	2	0
Strata	30	0
Coal, Four-feet Mine	3	8
Shale	120	0
Coal, Five-feet Mine	4	6
Strata	181	0
Coal, Silver Mine — Coal 2 0; Dirt 1 1; Coal 1 4	4	5
Strata	31	0
Coal, Water Mine — Coal 2 0; Dirt 0 6; Coal 0 10	3	4
Strata	74	5
Coal, New Mine, with partings of shale	9	8
Strata	270	0
Coal, Redacre Mine — from 1 6 to	2	6

The *New Mine*, near its outcrop, consists of two seams, the upper one of which may be seen in the railway cutting by the canal aqueduct. It is here separated from the lower by 16 yards of strata, nearly the whole of which thins out in the distance of a quarter of a mile westward. The section at the two points is as follows :

Sections of the New Mine, Norbury.

WEST. — *Towards the Deep.*	One-fourth mile.	EAST. — *Towards the Outcrop.*
Coal, 27 inches.		Coal, 27 inches.
Clay, 12 „		Strata, 48 feet.
Coal, 36 „		Coal, 36 inches.

Under Marsden House the New Mine is cut through at a depth of 70 yards from the surface by a "sand-fault," or ancient channel hollowed down through the strata, and filled in with sand.

The series at Poynton is similar to that at Norbury; and here, in a position intermediate between the Lancashire and North Staffordshire Coal-fields—in the former of which the clay-ironstones are so poor, and in the latter so rich—we find them working the ironstone nodules which occur in the roof of the 4-feet and 5-feet seams. The stone is calcined on the spot, and then sent off to the Staffordshire furnaces. See Appendix II., page 97. E. H.

2. *Middle Coal-measures of the Biddulph Trough.*

The account of these beds I have been able to draw up is somewhat meagre, and I am sorry that I have no fuller description to offer of a district of such great mineral wealth. It is, however, very difficult to get at trustworthy information. For the most part, no records of the workings have been kept, and the colliers and underlookers have seldom any good knowledge even of their own ground. Among the few exceptions that I met with I would mention Mr. W. Chadwick, bailiff at Bradley Green Colliery: to him and to Mr. Bradbury I owe by far the greater part of the information I have been able to obtain.

The collieries now at work are Mr. Bradbury's, at Bradley Green, Messrs. Williamson's, at Tower Hill, and Mr. R. Heath's, at the Biddulph Valley Ironworks. The sections of the first two, corrected for dip, are as follows:

Bradley Green Colliery.

	ft.	in.
Coal, *Magpie*	5	0
Measures	43	0
Coal, *Hollylane*	4	0
Measures	158	0
Coal, *Bowling Alley*	6	0
Measures, with irregular 2-ft. coal	70	0
Coal, *Stinking*, in three seams	3	0
Measures	100	0
Coal, *Ironstone Mine*	2	3
Measures	185	0
Coal, *Froggery* (1 ft. 6 in. bad at the bottom).	5	0
Measures	145	0
Coal, *Cockshead*	9	0
Measures, with *Lime-kiln* or *Sudden* Coal	220	0
Coal, *Bulhurst*	6	0
Measures	53	0
Coal, *Winpenny*	3	0
Measures	170	0
Coal, *Brick-kiln Row*	1	6
Measures	200	0
Coal, *Silver Mine*	3	0

Tower Hill Colliery.

	ft.	in.
Coal, *Rough 7-foot*	6	0
Measures, with little coal	90	0
Coal, *Stony 8-foot* 6 ft. to	7	0
Measures	60	0
Coal, *10-foot*	5	6
Measures	189	0
Coal, *Top two row*, or *Magpie*	5	0
Measures	5	0
Coal, *Under two row*, or *Hollylane*	3	0
Measures	100	0
Coal, *Bowling Alley*	5	0
Measures	160	0
Coal, *7-foot Banbury*, or *Froggery*	2	3
Measures	140	0
Coal, *8-foot Banbury*, or *Cockshead*	7	6
Measures	185	0
Coal, *Bulhurst* - 2 ft. to	6	0
Measures	70	0
Coal, *Winpenny*	3	0

The thickness of the measures between the Magpie and Winpenny Coals is twice as great at Bradley Green as at Tower Hill: this change is most marked in the distance between the Magpie and the Hollylane, which at Bradley Green are 43 feet apart, and at Tower Hill are near enough to each other to be worked as one seam, under the name of the Two Rows. In the southern part of the Coal-field the beds show a

marked thinning away to the west,* but not to so large an extent as that just mentioned.

The following account of the nature and quality of the coals is taken mostly from a paper by Mr. J. Bradbury, jun., read before the Manchester Geological Society, in April 1862.

"The Rough seven-foot and the Stony eight-foot are now acknowledged to be choice coals for blast furnaces." At a distance of about 40 feet below the 10-foot coal lies a bed of red sandstone, about 50 feet thick, known among the miners as the *10-foot rock*. The Magpie, which is also sometimes called the Sparrow Butts around Biddulph, is known over the portion of the coal-field south of Norton as the Bowling Alley. And the Bowling Alley of Biddulph takes the name of Sparrow Butts in the south. The mine has a hard gannister-like floor at Bradley Green. "The Hollylane is the best house coal in the district, but free burning. The Bowling Alley is a very strong coal, and very similar to the splint coal of Scotland; it is used in Biddulph by Mr. R. Heath, and others, for the manufacture of pig iron, for which it is found admirably suited; it is also one of the best coals for locomotive purposes. This seam often lies on a very strong rock, without the slightest appearance of anything like fire-clay. The two Banburys are largely used for coking, and are both of good quality for household uses. The Bulhurst is in general two seams of coal, of 3 feet each, parted by four inches of soft dirt; it often happens that the top coal is altogether absent, or only 9 or 10 inches in thickness, without the quality of the lower seam being impaired." The roof of this seam is a thick sandstone rock, of a bluish grey colour, weathering red; it may be seen between White House End and the Hay Hill, where it forms a small ridge, and on the west of Mow Cop. "The Winpenny lies upon a bed of Ironstone, containing a large quantity of siliceous matter, and having the property of smelting at a very low temperature." The Silver Mine is now nowhere worked; about Tower Hill it is a cannel.

For the sake of comparison, I add the section at Mr. R. Heath's Biddulph Valley Ironworks, and that part of Mr. Bradbury's general section which applies to the present district.

General Section of the Lower Part of the North Staffordshire Coal-measures.—Mr. J. Bradbury.

	ft.	in.
Coal, *Rough 7-foot*	6	6
Warrant, coal, metal, and rock	165	0
Coal, *Stony 8-foot*	7	0
Linsey, grey rock, and shale	94	6
Coal, *10-foot*	6	6
Grey metal and rock	90	0
Coal, *Magpie*	4	0
Strong metal	45	0
Coal, *Hollylane*	5	0
Strong grey rock and metal	165	0

Section at the Biddulph Valley Ironworks.

	ft.	in.
Coal, *10-foot*	4	11
Measures	45	0
Sandstone, "*10-foot Rock*"	45	0
Measures	68	0
Coal, *Magpie*: Coal 3 10; Parting 0 6; Coal 1 3	5	7
Measures	29	0
Coal, *Hollylane*	4	6
Measures	103	0

* See "Iron Ores of Great Britain" (Mem. Geol. Survey), part iv., p. 271.

	ft.	in.
Coal, *Bowling Alley* -	6	0
Warrant, metal, and rock - - -	45	0
Coal, inferior, in three beds - - -	3	3
Metal and warrant -	39	0
Coal, inferior, in four beds - - -	3	7
Shale and black bass -	144	0
Coal, *Ironstone Mine* -	2	8
Grey metal, rock, and bass - - -	114	0
Coal, *Frogrow* - -	5	0
Strong rock and blue metal - -	114	0
Coal, *Cockshead* -	9	0
Rock and Ironstone binds - -	93	0
Coal, *Lime-kiln* - -	2	3
Rock binds, rock, and strong metal - -	144	0
Coal, *Bulhurst* - -	6	0
Rock metal and bass -	60	0
Coal, *Winpenny* -	3	0
Rock, bass, and Ironstone bands - -	183	0
Coal, *Brick-kiln Row* -	1	6
Shale and black bass -	216	0
Coal, *Silver Mine* -	4	9
Coal, *Sparrow Butts, Bowling Alley* of Biddulph - -	5	0
Measures, with thin coals - - -	380	0
Coal { Coal - 4 4; Black bass 0 6; Coal - 2 9 }	7	7

A. H. G.

Permian Beds.

Stockport District.—The Lower Red Sandstone of this formation is very largely developed in this neighbourhood, stretching along the western side of the Coal-measures as far south as Poynton, and overlaid by the Pebble Beds of the New Red Sandstone. At Stockport it occupies a breadth of country of over a mile and a half, with a steady dip to the west, and is terminated by the Red Rock fault (see Fig. 5, p. 10) without its base being brought to the surface: we may, therefore, estimate the thickness as over 1,500 feet at this place, and throughout it is everywhere similar in composition and aspect. (See Hor. Section of the Geological Survey, Sheet 65.)

The Lower Red Sandstone consists of bright red, sometimes striped and mottled sandstone, very soft, and crumbly, and without pebbles, which are to be found in abundance in the overlying beds of the Trias. Planes of current-bedding on a large scale frequently occur, and the rock resembles in every respect its contemporaneous sandstone of Collyhurst, near Manchester. There are many sections in the Mersey, and when the water is low a fine spring may be seen bubbling up in the bed of the river below Goyt Hall.

The section shown in the bend of the river below Brinnington Hall is interesting, as the rock is capped by two members of the Drift, and is as follows:

Fig. 7.

SECTION IN THE BANK OF THE MERSEY ABOVE STOCKPORT.

A. Upper Boulder Clay or Till - - 50 feet.
B. Sand and gravel - - - - 25 „
C. Lower Red Sandstone, current-bedded - 35

The sections in the River Tame are few, although the river wanders over these beds for a distance of three miles above Stockport. The rock, however, may be seen in a little dell that descends into the valley from Brinnington, and at the foot of the bank at Reddish Wood. At Beat Bank, below the bridge, an interesting though very small section occurs, referred to by Mr. Binney.* The sandstone is here properly described by this author as lying unconformably on the middle Coal-measures ; and the thin coals worked in a pit belonging to the late Mr. Fletcher, on the north bank of the river, were followed for a distance of 100 yards under the sandstone, in the direction of Harden Hall. Having described this section at greater length in a previous memoir, I shall not further dwell on it now.†

On the west side of Stockport, the Permian Sandstone, and a few feet of overlying marls, are brought to the surface by a large fault, with an upcast of probably 500 feet on the west. Another fault, which is a continuation of the Boundary fault of the Manchester Coal-field, was formerly visible in a piece of open ground west of the railway viaduct, on the north bank of the river ; but I fear that the works of the new railway to Altrincham will conceal it. The Permian Sandstone is worked for moulding sand in a deep pit at Hope Hill, and a section where the Pebble Beds of the Trias rest upon the Permian marls, occurs at Travis Brow. The dip of the beds is westerly from Travis Brow, down the river as far as Heaton Mersey Bleach Mills. Here the Permian beds are again brought to the surface by a large upcast fault, which I believe to be a prolongation of the great Irwell Valley fault, north of Manchester. At Heaton Mersey, the throw of the fault is about 1,000 feet, and the section which was found by a boring for water is thus recorded by Mr. Binney.‡

Section at Heaton Mersey.

	feet.
Soil and (valley) gravel, a few feet.	
New Red Sandstone - - - - -	45
Red marls containing beds of hard stone - - -	129
Lower Red Sandstone, proved - - - -	402
	576

* On the Permian Beds of the North-west of England (Mems. Lit. and Phil. Soc., Manchester, vol. xii.), p. 8.

† Geology of the Country around Oldham, p. 43, with woodcut.

‡ On the Permian Beds, &c., p. 9.

The author observes, "The last-named deposit, which I examined on the spot as it came up from the bore, consisted of a coarse grained sand of deep red colour, similar to that at Collyhurst. How much thicker this deposit might be it is impossible to say, but it is quite evident that the Permian beds extend under the Trias of Cheshire." The Permian beds must here form a very narrow strip running along the line of the fault for an unknown distance on both sides of the river, as represented in the map, but the strata are much hidden by Drift.

If we compare the sections at Heaton Mersey, Hope Hill, and Stockport, we cannot fail to observe that the New Red Sandstone is unconformable to the Permian beds, and gradually passes over so as to rest on lower beds of the latter formation as we proceed from west to east. In order to illustrate this, we shall place the three sections in juxtaposition.

WEST.	CENTRE.	EAST.
HEATON MERSEY.	HOPE HILL.	E. SIDE OF STOCKPORT.
New Red Sandstone.	New Red Sandstone.	New Red Sandstone.
Permian marls, 129 ft.	Marls, 25 ft.	Absent.
Lower Permian Sandstone.	Sandstone.	Sandstone.

Thus we see that between Heaton Mersey and the east side of Stockport, a distance of nearly three miles, the two sandstone beds, which in one direction were separated by a thickness of 129 feet of marls, are brought in the other immediately in contact.

Norbury Section.—The section in the brook near Norbury Hall has also been described by Mr. Binney,* who was fortunate enough to visit it at a time when it much more clear than at present. The New Red Sandstone may be followed for a long distance up the brook, and, when it runs out, certain red clays with bands of stone appear, dipping at a higher angle than the New Red Sandstone, but the nature of their junction does not appear. Mr. Binney considers it to be a case of unconformable superposition. Further on the Coal-measures set in, on the east side of the great Red Rock fault. (See Appendix II.)

Torkington.—A curious little patch of Permian beds occurs at Torkington, near Hazel Grove. The beds are only to be seen in two brook courses, and, as far as it is possible to make out their relationship to the Coal-measures, they appear to lie in a trough formed in the lowest beds of the Middle series, in fact over the Redacre Coal.

The patch appears to be about one-fourth of a mile in breadth from east to west, and is bounded on both sides by carboniferous grits and shales. If we follow the brook eastward from Torkington, we find the following series in descending order, all the beds dipping westward.

Permian Beds.
1. Red marls.
2. Soft red breccia in a sandy matrix, containing angular fragments of Coal-measure grits, shales, and pieces of earthy hæmatite.

Coal-measures.
3. Soft purple grits, red shales, with bands of earthy hæmatite.

Owing to the amount of Drift over this part of the country, it is impossible to determine the exact northern and southern limits of this little outlier of Permian beds.

E. H.

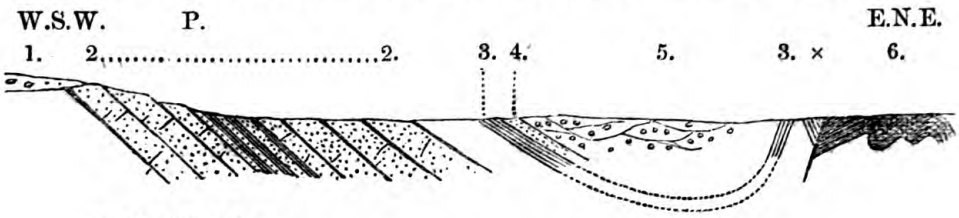
* On the Permian Beds, &c., pp. 6, 7.

Permian of Rushton Spencer.—Strata, which are most likely of Permian age, crop out round the patch of Pebble Beds at Rushton Spencer. They consist of sandstones, red and mottled, or of a pepper and salt colour, with partings of red, sandy, micaceous marl. Some of the sandstones are thick-bedded, but flaggy beds lie among the marls: a hard sandstone with a calcareous cement is seen near Peck's House.

Above these, in the bed of the Dane, are chocolate-coloured and white marls, full of lenticular-shaped concretions. These marls, I am told by Mr. Binney, closely resemble the Permian marls of Manchester, in which like concretions are found. Above the marls is a bed of soft reddish sandstone, with a few pebbles. The section below shows these beds.*

Fig. 8.

SECTION ACROSS THE VALLEY OF THE DANE, NEAR HUG BRIDGE.



1. Boulder Clay.
2. Sandstones and red sandy marls
3. Mottled red and white marls, full of concretions } Permian.
4. Soft red Sandstone, with few pebbles
5. Pebble Beds - - - - - New Red Sandstone.
6. Black Shales - - - - - Yoredale Rocks.

×. Fault.
P. Peck's House.

A. H. G.

NEW RED SANDSTONE OR TRIAS.

With the exception of the strip of Permian already described, the whole of the country west of the Red Rock fault is composed of New Red Sandstone and Marl. The sub-divisions of this group have already been given (pp. 7, 16), and the general character of the country which they underlie.

Pebble Beds.—This sub-division consists of brownish-red pebbly sandstone, sometimes current-bedded, and it is sufficiently hard to be used as a rough building stone, but much inferior in durability to the Carboniferous grits. The great majority of the pebbles contained in it are liver-coloured quartz; but white quartz, hornstone, and grit are also to be found.

The finest section in these beds is that which occurs in the banks of the Mersey at Stockport; the greater part of the town being built

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* The section at Hug Bridge is described by Mr. Binney, in his Memoir "On the Permian Beds of the North-west of England." (Mem. Lit. and Phil. Soc. Manchester, vol. xii.) The following is his section:—

	ft.	in.
Soft red sandstone (New Red Sandstone) - - -	4	0
Red marl, parted by layers of red and variegated coarse sand -	2	0
Soft red sandstone, containing layers of red marl - -	2	0
Brownish sandstone - - - - - -	9	2
Red and variegated marls, with small lenticular marks, similar to those seen at Cheetham Weir - - - -	18	0
Red and variegated sandstone, containing beds of conglomerate in the middle of it - - - -	45 0 to 60	0

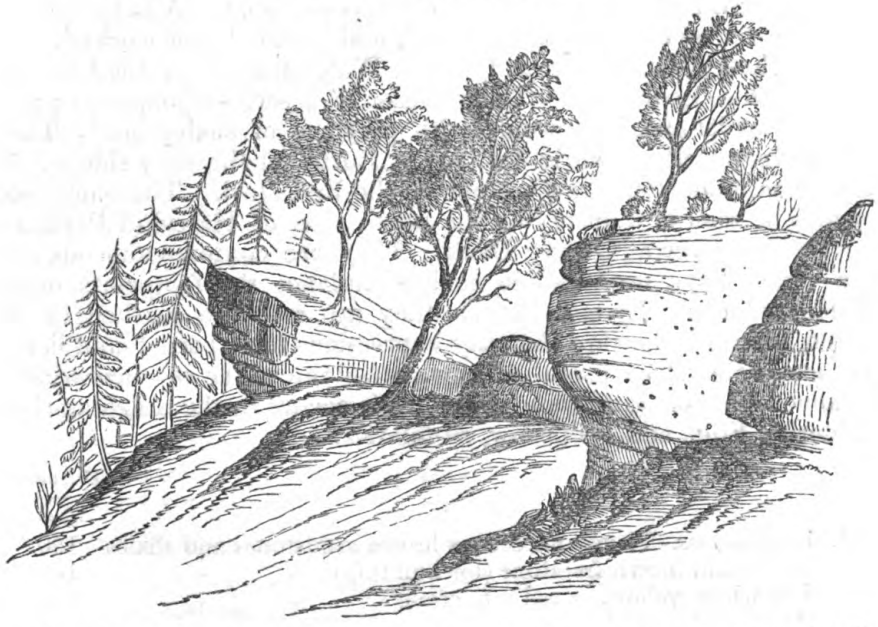
upon this rock. The basement beds consist of a coarse breccia of small angular pieces of grit, chert, and other rocks, and form a little cliff on the north bank of the Mersey below its junction with the Tame. The same beds are again visible in Travis Brow, on the upcast side of the large fault; and the beds which succeed are shown in the river banks almost as far as Heaton Mersey. The thickness of the sub-division is 750 feet. Sections are also shown in Bramhall Brook, from the top of Great Reddish Wood upwards, the stream for the most part flowing in a deep channel scooped out of the rock. Another small section is shown in the River Dean, west of Dean Water, and further up in the cliff west of Bollington, close to the great Red Rock fault.

Upper Mottled Sandstone.—This sub-division has a thickness of about 600 feet, and rests on the Pebble Beds. It consists of soft, fine-grained sandstone, of bright red, or variegated colours, and in some parts of Lancashire and Cheshire is used as moulding sand. There are several good sections in this sub-division, occurring chiefly in the brooks. Of these we may mention that in the brook near Withington Old Hall; the banks of the Mersey, east of Heaton Mersey Bleach Mills, where the beds may be seen resting on the Pebble Beds; Bramhall Brook at Cheadle, and the banks of the Mersey at Didsbury Mill; the banks of the River Bollin below the factory at Wilmslow; and several sections in the banks and lanes on the northern flank of Alderley Edge and Clockhouse Wood. The chief differences whereby this sub-division may be distinguished from the Pebble Beds, lie in the entire absence of Pebbles, and the brighter colouring and finer grain of the particles of sand.

Lower Keuper Sandstone, and Waterstones.—The base of this sub-division, forming the lower member of the Keuper series, is the massive quartzose conglomerate which forms the crest of the escarpment of Alderley Edge (Fig. 9). This conglomerate is formed of rounded peb-

Fig. 9.

CLIFFS OF CONGLOMERATE ON ALDERLEY EDGE.



bles of white and coloured quartz, very similar to those of the Pebble Beds of the Bunter sandstone; and I have long been of opinion that,

as the Keuper lies unconformably on the Bunter division, the conglomerate of the former is simply the re-constructed materials of the latter. In looking at the Alderley Edge rocks we are strongly reminded of the cliffs of white conglomerate which form the base of the Keuper series along the valley of the Churnet at Alton in Staffordshire, and which are really not very far distant from this point, but are separated by a tract of Carboniferous ground. At Alton, however, the conglomerate of the Keuper rests on the Pebble Beds of the Bunter, here on the Upper Mottled Sandstone, and the contrast is the more striking. Near the spot from which the above sketch is taken, the junction of the two members of the Trias may be traced along the cliffs, and is shown in the sketch at the point where the rock juts out from the hill side.

In some places, at the junction of the Keuper and Bunter divisions, a band of marl occurs, giving origin to springs. One of these may be seen on the north side of the edge ; but the same band occurs in much greater strength at the old copper mine on the east of the edge. The conglomerate here is but slightly consolidated, and assumes the appearance of a white quartzose gravel or pudding-stone. The same bed occurs in the escarpment above Clockhouse Wood Farm, and north of Hareshill, resting on the Upper Mottled Sandstone, being repeated by a large fault, and at the copper works of Mottram St. Andrew. Sections in the same beds also occur in the banks of the Bollin at Quarry Bank, near Wilmslow, the beds dipping westerly at angles varying from 15° to 30°.

The beds which succeed the conglomerate are formed of soft whitish and variegated sandstone, from which the copper on Alderley Edge is extracted. At Quarry Bank this rock is bright red, and very similar to the Upper Mottled Sandstone of the Bunter, but is distinctly separated from that formation by the quartzose conglomerate. Above this comes a white freestone, which produces an excellent building material, both on account of its hardness, uniform texture, and absence of colour. There is an old quarry in this bed, by the side of the lane which crosses the Edge from Alderley Old Hall, and from which it is very probable the stone for the old church and cross was obtained. A little further south a newer quarry has been opened, and is now being worked.

The highest beds are properly "the Waterstones" of the Cheshire and Lancashire geologists. They consist of a series of flaggy, rippled, brownish sandstones, micaceous, with partings of shaley marl. These beds are very well shown in the lane at Butts, on the west side of Alderly Edge, underlying the bottom of the Red Marl. The same beds may also be seen in a quarry on the north side of Hareshill Park, and south of the river at Quarry Bank. They are contemporaneous with those which have produced in such abundance the footprints of the Labyrinthodon at Lymm, but as they are nowhere worked in this district, we are not aware that any impressions have been found here.

It may probably be useful to summarise the order of succession of the Lower Keuper Sandstone group, as it occurs in the neighbourhood of Alderley Edge and Wilmslow, as follows:

	Thickness.
	feet.
1. *Waterstones.* Flaggy micaceous brown sandstones and shales	150
2. White and brown freestone (for building) - - -	100
3. Soft white, yellow, or red sandstone - - - -	100
4. White and reddish conglomerate - - - -	100
Thickness about - -	450

Copper Mining at Alderley.—This seems the proper place for a short account of the process by which copper and other minerals are now being extracted with success from the sandstone of Alderley Edge and Mottram St. Andrew.

At the former of these places the minerals are disseminated in the soft sandstone which lies above the conglomerate (No. 3 in the above list) ; and at the old copper works on the east side of the Edge, and at Mottram, in the conglomerate itself. The ores are diffused in varying quantities, but in some degree along the planes of bedding, throughout the entire mass of the rock, which at the western end of the excavations at Alderley Edge Works, presents the following section :*

Section at the Alderley Edge Mines.

	ft.	in.
1. Thin sandstone	4	0
2. Shaley clay, with band of copper ore at bottom	2	6
3. Ferruginous sandstone, with large nodular masses containing carbonate of lead	6	0
4. *Cobalt bed.* Laminated sandstone, with cobalt ore	4	6
5. White compact sandstone, with carbonate of lead	5	0
6. Ferruginous sandstone, with ores of manganese, cobalt, and iron	12	0

The sandstone containing the principal supply of copper lies at the bottom of the above series, in which, it ought to be stated, each bed is not sharply marked off from its neighbour, but only by some slight variation in character. The copper occurs as green and blue carbonate coating the particles of sand, and in quantities varying from $1\frac{1}{2}$ to $2\frac{1}{2}$ per cent.

The process by which it is obtained is somewhat as follows :—The rock containing the ore is ground, and macerated in a solution of muriatic acid. By this process the copper is dissolved, and "the liquor," which is of a fine sap-green colour, is pumped into reservoirs of wood. Into these reservoirs old scrap iron is thrown, and the acid of the liquor seizing the iron, dissolves it, and precipitates the copper in the metallic state. At the conclusion of the process there is a solid residue, composed of 80 per cent. copper, and 20 per cent. iron, which is sent to St. Helen's and other places, where it is mixed with other ores of copper for smelting into ingots.

When operations were first commenced on this spot, the rock was extracted in open work, and a very large excavation, with a proportionably large accumulation of waste sand, has been formed. Now, however, the bed containing the principal quantity of ore is followed by tunnelling downwards in the direction of the dip of the strata.

Carbonate of lead, and galena, occur, in some places as much as 40 per cent. of the matrix ; on an average, 30. They are separated by washing. Cobalt is also obtained. In the centre of the works occurs a deep hollow cut in the sandstone, and filled with boulder clay. This is 40 feet in depth, and 180 across at the top. It is turned into the purpose of a reservoir.

At Mottram St. Andrew, cobalt and copper are extracted in precisely the same manner. They are, however, obtained from the conglomerate at the base of the Keuper, and raised by shafts a few feet in depth and worked by a windlass. The rock reaches the surface in a quarry, and the green carbonate of copper may be observed colouring the sur-

* I am indebted to Captain Osborne for his assistance and information regarding the process of extracting the metals at these works. For a very full account of the nature of the ores at Alderley Edge, and the process of extraction, see account of Mr. W. Henderson, *Mining Journal*, 1860, p. 686.

faces of the pebbles and pieces of the rock, which dips westward at 5°. The stone here seems richer in ore than at Alderley, and the captain of the works* informed me that some pieces yield as much as 22 per cent. of copper ore, the average being 5 per cent. There can be no doubt the rock at both places is the same, and the position of the conglomerate at Mottram, which is down in the plain, and several hundred feet below its equivalent beds at Alderley Edge, is due to the large downcast fault which ranges east and west through Chorley.

The number of minerals accumulated in these beds is surprising. At the old works on Alderley Edge, the following kinds were determined with the assistance of Señor Berruti of the Royal Geological Survey of Italy, whose company we were favoured with for a few days :—galena, carbonate of lead, green and blue carbonate of copper, phosphate of copper, earthy black oxide of manganese, sulphate of barytes, sparry iron ore, peroxide of iron.

The elevated position of Alderley Edge is owing, partly at least, to the existence of a large fault, alluded to above, which runs along the base of the hill on the north side, and somewhere to the south of Mottram Copper Works. At Chorley, the conglomerate of the Keuper and the Upper Mottled Sandstone are upheaved above the Red Marl on the north side of the fault, and this latter having been easily denuded away, has left the sandstone rocks rising above the plain in a conspicuous cliff. At the same time it is difficult to understand why the sandstone rocks of Alderley have been so favoured, while their contemporaneous beds of Mottram, Wilmslow, and other places should have been denuded down to the level of the Red Marl and Bunter Sandstone.

E. H.

Beds belonging to this division are also seen at the following spots.

A strip of thick-bedded red sandstone is brought up, close to the Red Rock Fault, at the west end of Ratcliff Wood, 3 miles south of Macclesfield ; it is more like Lower Keuper Sandstone than the thin-bedded sandstones of the Upper Marls, against which it seems to be faulted on the west. The position of this bed is shown in Fig. 4, p. 9.

In the River Dane, a little to the east of North Rode Viaduct, we meet with sandstones most likely belonging to this group ; they are shown in Fig. 3, p. 9.

Lastly, in the south-west corner of our district we have a patch of Lower Keuper Sandstone abutting against the Red Rock Fault. The rock may be seen in the brook running by Ford Sprink, between the canal and the railway (Fig. 1, p. 8) ; on the road leading up the hill east of Mow Cop station ; and in a lane on the south-west side of Grotto Wood (Fig. 2, p. 8). In all these sections we find thick-bedded red and white sandstones with beds of marl resting on soft mottled sandstones with a few pebbles. The latter are the equivalents of the conglomerates of Alderley Edge, but without the calcareous cement that there hardens the rock and enables it to make so bold a feature.

The sandstone is largely worked in Quarry Wood, where it yields a good building stone ; here and there it is a fine conglomerate, and some of the beds have a calcareous cement.

A. H. G.

* At both the works in Alderley and Mottram the managers are Cornish men, who are there called "captains" of the mine; and the miners, being also from the same country, were at first very much puzzled and perplexed at finding the ore lie in beds instead of in lodes.

Red Marl.—This formation consists of a thick series of finely laminated red and grey marls or shales, with bands of grey or white micaceous sandstone, which in this district do not seem to be confined to one definite horizon. Seams and lenticular masses of gypsum are also present,* and at Alsager and Northwich beds of of rock salt.

Owing to the covering of Drift which is spread over the tracts occupied, or supposed to be occupied, by this formation, it is seldom visible within the limits of this district. In the adjoining parts of Cheshire, to the west, it may be observed in some of the brook courses, especially along the banks of the Bollin from Quarry Bank to Bowdon. Sections, however, may be observed in the lane leading up towards Alderley Edge from the Old Cross, and in some of the little dells which descend into the Bollin on the south side of the river opposite Quarry Bank.

E. H.

Sections in this formation may be seen around the Broad Oak Reservoir, 3 miles south of Macclesfield, and in the deep valley that runs by Cow Brook. The River Dane also gives an almost unbroken section from North Rode viaduct to the western edge of the map. A little cliff at Colley Mill shows well the thin hard sandstones that lie in the marl, and some thin seams of gypsum. The former are often blue internally, very fine grained, and ring under the hammer. All along the beds roll very much, and are broken by small faults, but upon the whole there is a slight dip to the west. Red marl may also be seen in the Buglawton Brook near Congleton.

In conclusion, I give a section of a boring made in this formation on the Howford Bridge estate, Buglawton, near Congleton, belonging to Mr. T. Cooper, for a copy of which I am indebted to Mr. Binney.

	ft.	in.
1. Red marl	5	0
2. Grey sandstone	2	0
3. Red marl	3	3
4. Grey marl	7	0
5. Red marl	10	0
6. Red stone	0	4
7. Grey stone	2	0
8. Red marl	0	8
9. Grey marl	4	0
10. Red marl	3	0
11. Red stone	0	1
12. Red marl	0	2
13. Grey marl	20	0
14. Red marl	6	0
15. Red stone	0	2
16. Red marl	4	0
17. Gypsum	7	0
18. Red marl, with 4 in. of ironstone	1	6
19. Gypsum	4	0
20. Red marl	6	0
21. Red stone	0	1
22. Grey marl	5	0
23. Grey stone	0	6
24. Red marl	3	0
25. Grey stone	0	3
26. Do.	0	6
27. Red stone	0	6
28. Red marl	5	0
29. Grey stone	0	4
30. Red stone	3	0
31. Red marl	4	0
32. Grey stone	0	4
33. Red marl	0	8
34. Red stone	0	2
35. Grey stone	0	6
36. Red stone	0	3
37. Red marl	2	0
38. Do.	0	3
39. White marl	0	2
40. Grey stone	0	1
41. Red marl	2	2
42. Do.	2	0
43. Grey marl	2	1
44. Grey bass shale	6	0
45. Grey marl	2	0
46. Grey bass shale	2	0
47. Dark rock	0	6
48. Grey stone	0	6
49. Red marl	5	0
50. Black bass	1	10
51. Grey stone	2	2
52. Grey rock	26	0

A. H. G.

* See Memoir on the Geology of the Country around Altrincham (Mem. Geol. Survey).

CHAPTER III.

Detailed Account of the Geological Structure of the Country.

Having in the last chapter described the general mineral character of the different formations, we will now give an account of their position at the surface, of the faults, rolls, and other disturbances which affect them, and of their local lithological changes.

(A.) *The Country to the East of the Red Rock Fault.*

This district, with the exception of outliers of the New Red Sandstone, is wholly occupied by Carboniferous rocks ; it is divided by the Anticlinal Fault, already mentioned, into two parts, which it will be convenient to handle separately. On the east lies the great hollow of the Goyt Trough ; while on the west are the Coal-measures of Hyde, Poynton, and Macclesfield, the Rudyerd Basin, and the Biddulph Trough. Before proceeding to the detailed description of each of these great natural geological districts, we will mark out the line of the Anticlinal Fault.*

This fault, accompanied as it is almost all along by a reversed dip of the beds, is a continuation of the fracture which extends southwards along the valley of the Tame at Saddleworth, and the base of the range of moorlands east of Staleybridge. It may be observed at the southern end of Harrop Edge, where the beds are thrown into a vertical position, and it enters our district at the eastern termination of Werneth Low. Here the Rough Rock, and the underlying flags, are suddenly terminated against beds belonging to the Lower Coal-measures. Following the line south, we observe the fault in the banks of the Etherow at the foot of Ernocroft Wood ; again, in the bed of the Goyt below Marple, where it brings the Rough Rock against the Third Grit. At Disley it crosses the railway about 200 yards west of the station, for we find the flagstones of the Lower Coal-measures in a quarry by the side of the line dipping west at 25°, while in the tunnel, at the opposite side of the fault, the Rough Rock and underlying shale dip in the opposite direction.

At the edge of Lyme Park the fault appears to be shifted considerably to the eastward by a transverse fracture, which crosses the new reservoir from north-west to south-east, but it reappears very clearly along the Saltersford Valley. Notwithstanding its displacement, we can have no doubt that the fault in Saltersford Valley is one and the same with the great disturbance which has caused the fracture in the valley of the Tame.

The brook of Saltersford Valley very nearly coincides with the axis of the saddle and the line of the fault. It runs due south, and immediately on crossing it we find ourselves on beds dipping in opposite directions. The lower part of the valley is in the Yoredale beds, and on either side the grits of the Millstone series dip to the east and west, the Third Grit forming on the eastern side the most conspicuous ridge, and the Fifth Grit on the western. In the bottom of the valley, near Jenkin Chapel and Crabtree Knowl, we find the fine-

* As this fault has been unluckily spoken of as "The Great Pennine Fault," in the Memoir on the country around Oldham (p. 57), it may be as well here to say that it is *not* a continuation of the Pennine Fault of North Yorkshire.

grained siliceous grits which mark the middle group of the Yoredale Rocks.* E. H.

We next get evidence of the break in the stream near Lower House, but we cannot here fix its place exactly, as the shales are folded and broken for the space of nearly one-eighth of a mile. We again find signs of the fault in the brook by White Hills; at Forest Chapel, where the beds are vertical, and dip steeply to the east and west on opposite sides of the fault; and in a very broken patch of ground on the south-east of Lower Hollin Tongue. In the brook on the west side of Shutlingslow the Second Grit is brought by this fault against shales and sandstones, most likely of Yoredale age. The fault is again seen in the section given by the brook north of Alders, where chocolate-coloured shales and sandstones belonging to the Yoredale Rocks are brought by it against the Third Grit. It runs along the face of Castle Cliff, where the shales in the bed of the river are vertical, and crosses the Dane a quarter of a mile south-west of Dane Bridge. Hence for the space of one mile a perfectly straight line of vertical beds can be traced, the beds near being often violently contorted. The line seems to pass close to the west of Gun Stone Pits, and is again found in the brook one-eighth of a mile south-east of Rudyerd Hall. It is here lost under the Pebble Beds of the Churnet Valley, but on the south of this outlier the line produced falls into a fault on the east side of Wetley Rocks,† which therefore belongs most likely to the same line of fracture.

A. H. G.

I. *Country east of the Anticlinal Fault. The Goyt Trough.*

We may now pass to the description of the Goyt Trough.

This trough has its origin in the moorlands north of Hollingworth, where the beds begin to dip gently towards a central axis which passes exactly through the village. South of the village of Mottram we find in a brook course the outcrop of the Mottram coal; then shales, succeeded by flags, and the rough rock of the Millstone series, dipping towards the south-east; and on the other side of the trough the same grit dipping towards the west from the crest of Coomb's Edge. The trough-like form of the district is also seen in the arrangement of the beds north of New Mills. On the eastern side we find the first, second, and third Grits rising to the east, and ending off in a series of fine escarpments at Matley Moor, Lantern Pike, Ollerset Moor, and Chinley Churn; and on the western side the same grits, cropping out, though less conspicuously, from Mellor, by Cobden Edge, New Mills, and Whaley Moor. From this point southwards the trough becomes more contracted, and regular in form, and the River Goyt very nearly coincides with the axis. The appearance of the hills formed by the ridges of grit, as they crop out in succession on both sides of the trough, has already been described.

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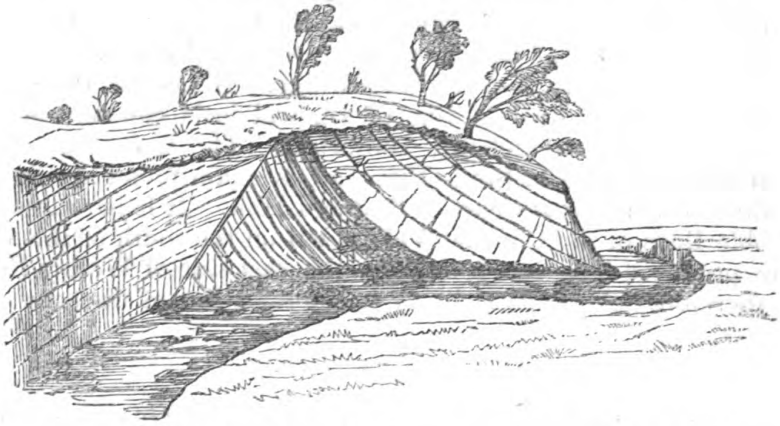
* The coal which overlies the Third Grit is generally present along the line of country on both sides of the anticlinal fault. We find it at Longhurst, near Mellor, cropping out on the bank, and covered by black shales containing Goniatites and other fossils. It has been worked in the valley west of Dissop Head, near Disley, and from this point southward to Rainow, and again at Tegg's Nose, near Macclesfield. At Spond's Hill it is 16 inches thick; at Harrop Wood, near Shrigley, 14 inches, and of good quality. On the eastern side of the saddle it has been traced continuously from the reservoir south-west of Whaley up to the neighbourhood of Flash. At the outcrop in Ladbatch Plantation it is 16 inches in thickness, but farther south, near Buxton, it reaches a thickness of 4 feet 6 inches.

† In Map 72 N.W.

The banks of the Goyt above Whaley Bridge offer several sections of faults, accompanied with much disturbance of the beds. One of these is seen below Knipe, and shows us certain dark and grey grits thrown into a vertical position against a nearly horizontal bank of grit. Another case occurs near the Powder Mills, where the basement beds of the second Grit and the underlying shales are brought up with a curve against other beds of shale which dip gently away from the fault. (See sketch, Fig. 10.)

Fig. 10.

Sketch of Fault in the Banks of the Goyt, at the Powder Mills, South of Taxal.



The escarpment of the third Grit forms a very marked feature along the eastern margin of Sheet 81 N.W. The rock itself is often extremely coarse, as at Matley Moor, and from the Chinley Hills southwards is generally of a red colour, and very coarse and massive. It forms the fine cliff of Cracken Edge, and the summit of Eccles Pike, 1,225 feet. At Bugsworth this red grit is finely opened out in the quarries. Beyond the base of the steep bank of shales which descends from the ridge of the grit, the moorlands of the Kinder Scout Grit rise gradually to the eastward till they culminate in the table-land of the High Peak. In this district the Kinder Scout Grit consists of two thick beds, separated by shales, the whole being of a thickness of 1,000 feet in the neighbourhood of Glossop, at the north-east extremity of the district. Between Glossop and Hayfield there are many good sections in quarries, as the rock produces excellent foundation stones, as well as rough flags and paving stones. South of Hayfield the beds begin to diminish in thickness, and become less coarse, and would scarcely be recognized as the representatives of the grits of the Yorkshire moorlands. One of these grits may be seen in the quarry north of Combs Head; and the same grits crop out along both sides of the Saltersford Valley, and are shown in the section which crosses the east side of the valley at Pym Chair. (See page 47.)

E. H.

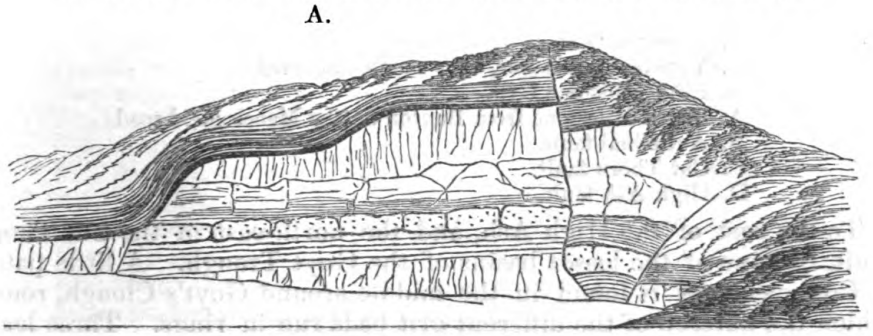
We will next take in hand the country from Whaley Bridge southwards as far as a fault crossing the basin, which may be called the Cut Thorn fault.

The fault branches from the anticlinal fault near Bull Greave. It is beautifully shown in the valley from Greenaways to Bottom-of-the-Oven, the beds along the lower part being everywhere vertical, or nearly so. It is seen in the brook one-eighth of a mile south of Bottom-

of-the-Oven, bringing black Yoredale shales against the Fifth Grit, and again near High Ash and by Clough House. Good evidence was found in the coal workings at Robin's Clough. The beds worked are the Lower Coal-measures, lying in the valley; while the high ground hard by, on the north-east side of Cut Thorn, is formed by the Third Grit. The beds in the headings driven in this direction were very much broken. In the bed of the Dane the rocks were much tossed about, and in the next brook to the south-east we have the section below.

Fig. 11.

SECTION NEAR THE LINE OF THE CUT THORN FAULT.



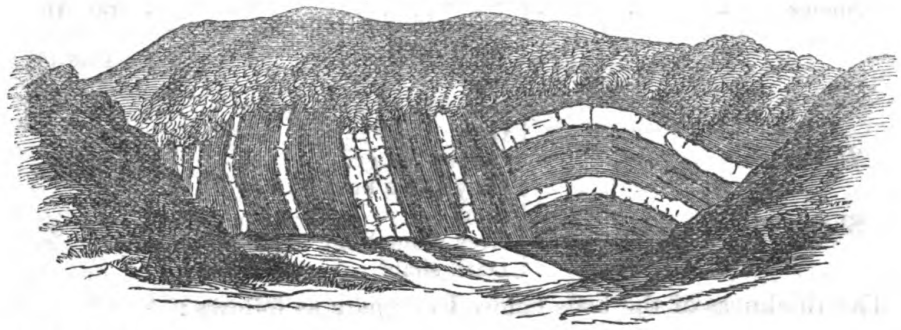
Section at A.

Black shale.
Coal, 6 inches.
Soft underclay, passing into clunch.
Sandstone.
Grey shale.
Hard underclay.

The fault crosses the stream from Flash Bottom a little to the west of the outcrop of the Feather-edge Coal, which is thrown nearly on end by it; and it seems to end off against a cross fault by Little Hill End.

Another large fault runs nearly due north from High Ash; it brings about a sudden change of dip in the brook running down from Bleak Knowl, in the brook immediately to the north, and in the brook one-fourth of a mile south-east of Brook House. Where it crosses Wild Moor Bank Hollow the shales are violently contorted for more than 100 yards. The sketch below shows a part of the broken beds.

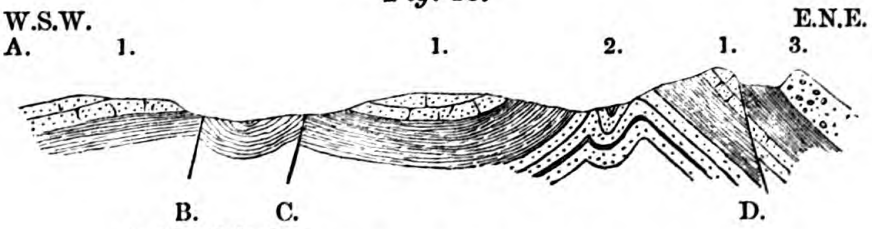
Fig. 12.



The fault then seems to run along a high ridge formed by a sandstone, most likely the Yoredale Grit, which dips east at a very high angle, and is in places vertical. Hence the break seems to run up to a line of vertical beds at Saltersford Hall, and afterwards to pass into a very sharp saddle. This fault we will call the High Ash fault.

The country between this and the anticlinal fault is occupied by Yoredale Rocks, mostly of the middle division. A section across it, a little south of Anchor Knowl, would run as under :

Fig. 13.



1. Yoredale Grit.
2. Yoredale Sandstone, very much contorted.
3. Fifth Millstone Grit.

A. Third Milestone from Buxton on the Macclesfield road.
B. Anticlinal fault.
C. Cut Thorn fault.
D. High Ash fault.

To the east of the High Ash, and the north-east of the Cut Thorn fault, lies one of the lesser basins of the Goyt Trough. A little patch of Coal-measures is found in the middle around Goyt's Clough, round which the outcrop of the different grit beds run in rings. Three leading faults cross the district : the Cumberland fault running north-west by Cumberland Farm House ; the Quainford fault running N.N.E. by Quainford ; and the Lower House fault running east and west by the farm of that name.

A tunnel driven on the estate of the Duke of Devonshire from near Clough House, Buxton, gives the following section of the beds from the Woodhead Hill Rock to the fourth Grit :*

		ft.	in.
Sandstone - - -	*Woodhead Hill Rock* - -	20	0
Shales - - -	- - - -	15	0
Goyts or Feather-edge Coal	Coal 1 0 Bat 0 3 Coal 3 7	4	10
Rough Rock - -	- - - -	100	0
Shales - - -	Strong dark shale - 80 0 Clunch - - 20 0 Thin Coal - - -	100	0
Second Grit - -	Flaggy sandstone -	140	0
Shales - - -	Stone bind - 40 0 Cank - 30 0 Stone bind - 70 0 Black shale 120 0	260	0
Coal - - -	Coal 1 1 Bat 0 6 Coal 2 11	4	6
Third Grit - - -	Coarse red grit -	140	0
Shales - - -	Grey stone bind - 42 0 Rock - - 8 0 Grey stone bind - 70 0 Dark shale - 60 0	180	0

The thickness of the beds below I estimate as follows :

	ft.
Fourth Grit, soft red grit - - - - -	150
Shales - - - - - - - -	130
Fifth Grit, flaggy sandstone - - - - -	50

* A copy of this section was kindly given me by Mr. Willmott, late agent to the Duke of Devonshire at Buxton.

This will give 1,250 feet for the thickness of the Grit series at Buxton.

The crops of the *Fourth* and *Fifth Grits*, the equivalents of the Kinder Scout beds, may be easily traced on the west of the Goyt Trough from past Jenkin Chapel up to the Cumberland fault. For the most part these beds are fine thick-bedded sandstones, but on the south of High Ash the Fifth Grit becomes very coarse and massive. The section below, given by the lane leading down from Pym Chair to Jenkin Chapel, shows these and the underlying Yoredale beds well, and they may also be seen in a brook course running down from Bleak Knowl.

Third Grit of Pym Chair			Millstone Grit.
Shales and flags			
Fourth Grit, fine grained		Representatives of the *Kinder Scout Grit.*	
Grey sandy shale			
Black shale			
Grey sandy shale			
Fine flaggy sandstone	*Fifth Grit*		
Sandy shale			
Fine sandstone			
Black shale			
Fine flaggy sandstone			
Sandy micaceous shale		Upper Group.	Yoredale Rocks.
Black shale			
Grey shale			
Flaggy sandstone			
Grey shale			
Fine massive sandstone.	*Yoredale Grit*		
Shale and flags		Middle Group.	
Dark shale			
Shale (?)			
Sandstone (?)			
Flaggy, pepper and salt, sandstones and shales			
Sandstone and shale			
Shale, with bands of stone			

On the east side of the trough the *Fourth Grit* forms a ridge, of which Axe Edge is the highest point; it is a soft, red, grit rock, not very coarse. By the "G" of Axe Edge Green a little coal has been worked on the top of this grit, with a sandstone floor, and a black shale roof containing *Goniatites*. The fifth is a finer rock. It is largely quarried at Nithen End, where it shows as a thick-bedded, concretionary sandstone.

The Third bed, which is a very coarse, massive, red grit, makes the fine escarpment from Windgather Rocks by Pym Chair and along the Tors, and thence runs with a good line to Dane Thorn Colliery. The crop of the little coal on the top of this rock may be traced along the whole of its upper boundary. At Castage the coal is one foot thick, and of fair quality; *Goniatites* were seen in its black shale roof. At Dane Thorn Colliery I learned from an old collier, and from a report furnished by Lord Derby's agent, that it varied from 1 foot 6 inches to 2 feet 3 inches.

On the east the line of the *Third Grit* is also good. The overlying coal is found along the whole of the outcrop of this bed, and has been largely worked, both on the north and south of Thatch Marsh Colliery; it is there 4 feet 6 inches in thickness, of which at least 2 feet 6 inches is good coal.

The *Second Grit*, which is a fine-grained brownish sandstone, forms a broad spread in the middle of the trough about Goyt's Bridge, north and south of which its outcrops run regularly on each side of the basin.

It is largely quarried for tiles and flags on the flanks of the Chinley Hills, at Dane Slate Quarries, near Thatch Marsh Colliery, and at Goyt's Clough. A little coal lies here and there on the top of this grit. It was found in the Buxton Tunnel (p. 45); and in the brook by the "G" of Stonaway T. G., a hard floor with *Stigmaria* and a black shale roof with *Goniatites* and *Aviculopecten papyraceus* crops out, but the coal is absent. The same floor and roof, and about a quarter of an inch of coal, are seen in a brook half way between here and Dane Slate Quarries, and in the brook above these quarries there were traces of old coal workings.

The Rough Rock, which keeps its usual coarse crumbly nature, crops out on the east, south, and west of the Whaley Bridge Coal-measures. Outliers of it lie at Norman Wood near Bunsal, and on a long hill half a mile south of Goyt's Bridge. A ring of it, in places of some breadth, runs round the patch of Coal-measures at Goyt's Clough. A well at the Cat and Fiddle, which most likely went through nearly the whole of the bed, was 40 yards deep; the dip is 10°, and this would give 118 feet for the thickness.

Lastly, on the top of all comes a little patch of *Coal-measures*, with the *Feather-edge Coal*, 4 feet 6 inches thick, at the bottom. The crop of this coal is well shown in the brook below Moss Houses; it is there from 4 to 5 feet thick, and parted from the Rough Rock only by an underclay. In the roof Mr. Molyneux found *Rhizodus*, *Palæoniscus*, *Lingula mytiloides*, and plants.*

Faults.—A fault, a little north of the Buxton and Congleton road, was drawn from working plans in Mr. Willmott's office; its line is somewhat uncertain; it throws down to the north 18 yards. The fault laid down on the map, a quarter of a mile south of Thatch Marsh Colliery, has been proved at the point where it crosses the lane, but nothing is known for certain about its direction; it throws down to the north 34 yards.

Yoredale Rocks.—The *Yoredale Grit* makes a good ridge through Beet Plantation till it abuts against a fault near the tunnel on the High Peak railway; it is thick bedded, but not very coarse. The outcrop of the same bed forms a steep ridge west of Thorns Cliff, shows well in the brook above Fair Thorns, runs by Dove Head, and after being shifted by a small fault abuts against the Cumberland fault at Nield Lye.

Beneath the Yoredale Grit the *Yoredale Sandstones* come out in the brook below Fair Thomas and in the Dove; beyond these, to the east, a fault passing by Coldshaw throws in again the Yoredale Grit, and hence eastward this bed plays a very important part in the geology, covering the greater part of the country as far as Longnor. The beds are, upon the whole, flat, but roll considerably, and are often repeated by faults. A section across the country is given below (Fig. 18, p. 58).

Beyond this tract of Yoredale Beds the *Mountain Limestone* is brought up by a fault, ranging N.N.W., along the line of which the beds dip steeply to the west; they soon, however, flatten, and in the Grin Hill quarries the dip has fallen off to 5°.

It may be as well here to mention that the boundary of the Mountain Limestone southwards by Longnor and Hartington must be either itself a fault or have a fault very near it, for the reasons given below. The steep westerly slope of Chrome Hill looks like the face of a fault,

* From information kindly furnished by Mr. Ward, of Longton.

and where its line produced crosses the River Dove there is a sudden change of dip. The dips in the Dove south of Park Hill are very high, and in the lane by Glutton Mill the black shales are vertical. Again, the Yoredale Grit makes the top of a long steep ridge, running from the north-west of Longnor to the south-east, and the space between the base of the Grit and the limestone seems to be far too small to allow room for the remainder of the Yoredale group. And besides, in places, as at Ludwell Mill, Bank Top, and Hartington, the limestone close to its boundary has an easterly dip steep enough to carry it *over* the Yoredale shales on the west unless some fault ran between. We must not forget, however, that the fault may not be at the actual junction of the Limestone and Yoredale Rocks, but a little to the west of it: which we cannot say, but a fault there must be.

On the north side the boundary of the limestone runs from the house called The Pecks west to Buxton, and does not seem to be itself a fault. Some fault, however, there must be between the limestone and the outcrop of the Yoredale Grit, for there is nothing like room for all the beds between them to crop out. No evidence, however, could be found as to the place of this break, and it has therefore not been laid down on the map.

The Cumberland fault, up to which the account has now been carried, is most clearly shown in the brook east of the farm-house of that name. North of The Hole it throws down a patch of the Second Grit; in the brook east of this house the outcrop of the little coal on the top of the Third Grit is repeated by this fault.

In the next brook the Quainford fault crosses the present one, and much confusion follows. Evidence for the fault is still given by the way in which different grits are brought against one another; it is well seen in the brook by Dun Cows, and at last seems to die out a little beyond the edge of the map.

Three small patches of the Second Grit lie on the downthrow side of this fault, but the chief feature south of it is the fine range of the Third Grit. The coal above is present, and still keeps for some way the thickness of 4 feet 6 inches. A small patch of the same bed caps a hill east of Wilson Rocks, cut off on its south side by the Lower House Fault.

Between the Cumberland fault and Flash the Fourth and Fifth Grits are easily traced. The Fourth is a soft, coarse, red grit, and at the hill top at Flash the joints and cracks in it are filled with Calc Spar.

The Fifth is quarried near Parsonage, where it is a thick-bedded red sandstone.

Below the outcrop of the lowest grit we have a good section in the Yoredale Beds along the brook from Flash Bank; it is as follows:

1. Thick sandstone. *Yoredale Grit.*
2. Dark shales, with thinly bedded hard sandstones - - - - } *Yoredale Sandstones.*
3. Black shales, with Ironstone. }

Fault.

4. Same as (2), repeated by the fault.
5. Very black shale, with limestone nodules.

Cumberland fault.

The evidence for the Lower House fault, which was mentioned a little way back, lies mainly in the way in which different grit beds abut against one another along its line; the measures too in the brook from Flash Bottom become very much broken on getting near the

fault. This brook gives a good section of the measures below the Feather-edge Coal, at the outcrop of which we have

Black shale. *Goniatites*; *Aviculo-pecten papyraceus*.
Grey shale. *Lepidodendron*, 1 ft.
Coal, very thin at the crop.
Soft underclay, with *Stigmaria* rootlets, 8 ft.
Rough Rock.

To the east the First, Third, Fourth, Fifth, and Yoredale Grits form clear ridges; the last has become finer grained and more quartzose. The Second Grit is wanting, and we shall by and by see that on the other side of the trough it has already thinned out.

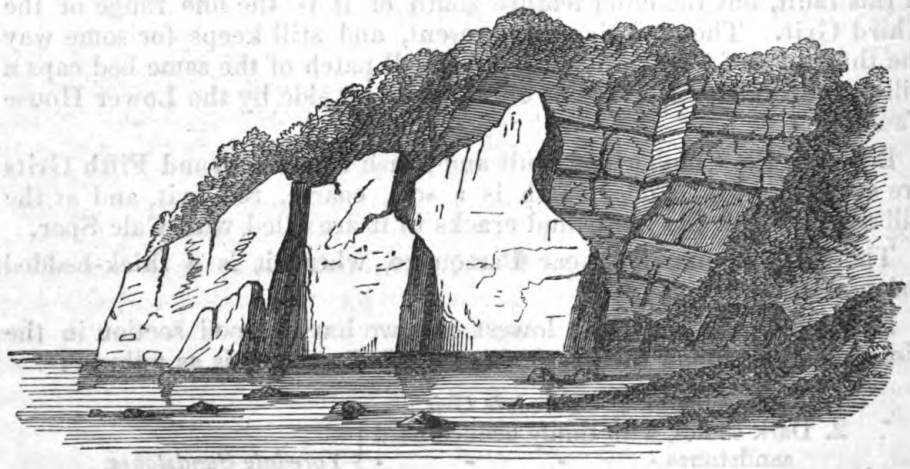
A little tract lying between the Cut Thorn fault and a fault that we will call the Crag and Gradbatch fault, may now be conveniently described.

The last-named fault breaks off the ridges of the different grit beds in a very marked way one quarter of a mile south-east of Little Hill End, and brings the Rough Rock on its south side against the Fourth Grit on the north. It was worked up to in the coal pits on Goldsitch Moss. North of Green Hill's Colliery it brings the Third Grit against the Coal-measures, and from hence it either bends round suddenly to the north so as to run by Crag Hall, or is met by a north and south fault. Whichever is the case, the effect is such as would be produced by a fault bending in the somewhat unusual way drawn on the map.

The tract is crossed by a fault running by the farm-house, Quainford, in a north and south line, which we may call the Quainford fault. From Quainford to Birchen Booth good evidence of fault is found in the River Dane. The sketch below shows probably the exact break.

Fig. 14.

Section in the River Dane, above Love Lane Bridge.



Beds of flagstone, nearly vertical, resting against horizontal beds of flagstone and shale.

Between the two houses just mentioned Lower Coal-measures on the east abut against the ridges of the First, Second, and Third Grits, which run up to the fault from the west, and end off sharply against its line. Traces of the fault are still found along the Dane, and in the brook east of Black Clough, and it seems at last to die out in a brook about one mile north of that house, where a little fault showed in the shales above the Second Grit.

Little more need now be said about this tract. Between the Cut Thorn, Quainford, and Crag and Gradbatch faults lies a little basin showing the beds between the Third Grit and Lower Coal-measures. In the latter the Goldsitch seams have been worked at Robin's Clough, and a section has been given on p. 26. At Leech Hole were traces of old coal workings on the top of the Rough Rock, but no other signs of the Feather-edge Coal were found.

The valley to the east of the Quainford Fault is occupied by Lower Coal-measures. The crops of some of the coals may be seen in the brooks from Flash Bottom and Far Brook: the dip is small and the beds roll considerably. The highest bed shown is a red sandstone which caps the hill west of Green Gutter Hill; it is flaggy at bottom, but coarse and massive at the top. (See section on p. 26, where this bed is marked No. 1.)

Next in order come the neighbourhood of Shutlingslow and the little Goldsitch Coal-field.

In the angle between the anticlinal and the Cut Thorn fault, lies a plateau formed of the thick massive bed of the Third Grit, deeply cut into by the valley of Wild Boar Clough. Upon this plateau rests a long hill ranging north by east, along the flanks of which the Second Grit crops out, and the whole is crowned by the fine conical peak of Shutlingslow, capped by a little outlier of Rough Rock. A small anticlinal seems to run along the ridge, the beds on the east flank dipping towards the east at about 10°, while the Rough Rock on the top dips west at 5°. This hill, though not quite the highest, is by far the most striking in the neighbourhood, and from some points of view its steep sides and sharply peaked top give it very much the look of a volcanic cone. The Fourth and Fifth Grits crop out to the north of the plateau formed by the Third; the Fifth may be seen at Higher Hollin Tongue, and in the brook where it abuts against the Cut Thorn fault. It is a thick-bedded, soft, red sandstone.

We now pass to the *Goldsitch Coal-field*, throughout which the beds lie with the most perfect regularity in the form of a long trough, broken off on the north by the Crag and Gradbatch fault. On each side of the central valley, which is occupied by Lower Coal-measures, the massive gritstones slope up the hill sides in broad sheets of heather-clad rock, ending at top in rugged crags, with the broken ends of the beds sticking boldly out into the air. The synclinal arrangement of the strata is thus shown as clearly as in a model, and perhaps it would be difficult to find a place where the shape of the ground points out so unmistakeably the geological structure of the country. For this reason the little coal basin, though of small commercial value, is of great interest to the geologist.

To pass to details: a general section of the measures has been already given; they are beautifully shown in the brook between Wetstone Hole and Goldsitch Houses (see Fig. 15). We will begin with the lower beds:—*The Fifth Grit* may be easily traced from Dane Bridge round the trough to the Crag and Grandbatch fault; it is quarried near Roach Gate and at Bramcott, and shows as a fine red sandstone. The line of *the Fourth Grit* is also for the most part clear; in quarries above Pheasant Clough it is a massive, close-grained, hard, red grit, and it keeps pretty much this character as far as its outcrop below The Rocks, but hence northward it seems to become thinner, and about Wetstone Hole was scarcely, if at all, traceable.

The Third Grit forms a clear unbroken ridge, often, as at The Roaches* and The Rocks, with a splendid escarpment; fine sections are given by the River Dane, and the brook running through Gradbatch Wood. A little to the south of Castle Cliff Rocks is a very curious chasm in this rock, known as Ludchurch. It is a rent running through the solid grit, in the line of strike, for about 100 yards, from 30 to 40 feet deep, and with a breadth of from 6 to 10 feet: the walls are vertical or overhanging, and it gives the idea that the front of the hill has parted bodily from the main mass, and slipped a little forward, leaving this fissure along the line of fracture.

A line of *the Second Grit* runs through Berry Bank End up to the anticlinal fault. The rock is next seen in the valley of Folly Grove Mill, where it must be close on 100 feet thick; hence its outcrop may be traced by the shape of the ground to the River Dane near Stonyway Head; but in the section there given the rock has fallen off very much, showing as a mixture of shale and flagstone 30 or 40 feet thick; beyond this we soon lose all traces of the bed, though a few feet of flagstone found between the third Grit and the Rough Rock, near Rock Hall, would seem to be its last feeble representative. This is the first instance we have come to of a Grit bed dying out altogether; other cases will occur as we go farther south.

Within the ridge formed by the third Grit, *the Rough Rock* runs in a somewhat lower, but well marked and unbroken, range. The bed has for the most part its usual soft crumbly nature.

The Feather-edge Coal has been worked at Green Hill's Colliery, where it was found to be 6 feet thick, and a line of crop workings may be traced for about one quarter of a mile to the north-west. Between here and Shaw Houses the crop is nowhere seen, but there is a black Goniatite shale in the brook below Goldsitch Houses, just where the crop should be (Fig. 15, 6 *a*). The miners say that in some places where the coal was sought, they found the floor and roof, but the coal was absent. This bed has also been worked from Shaw Houses by Blue Hills to Hazlebarrow, from which house northwards to the Crag and Gradbatch Fault no trace of the crop was seen.

Above the Feather-edge Coal come black shales with beds of flagstone (No. 6 in Fig. 15); they were found in a sinking at Blue Hills, for a section of which I am indebted to Mr. Sykes, of Leek, to be 90 yards thick.

Above these lies a thick sandstone (No. 7 in Fig. 15), which seems to be the *Woodhead Hill Rock* of Mr. Binney; at Blue Hills, 20 yards of it were sunk through without reaching the bottom. The outcrop of the rock makes a clear feature round the greater part of the trough, and a knoll of it at the south end, at the "turn of the beds," forms a point on the watershed between the Mersey and the Trent (see *ante*, p. 13).

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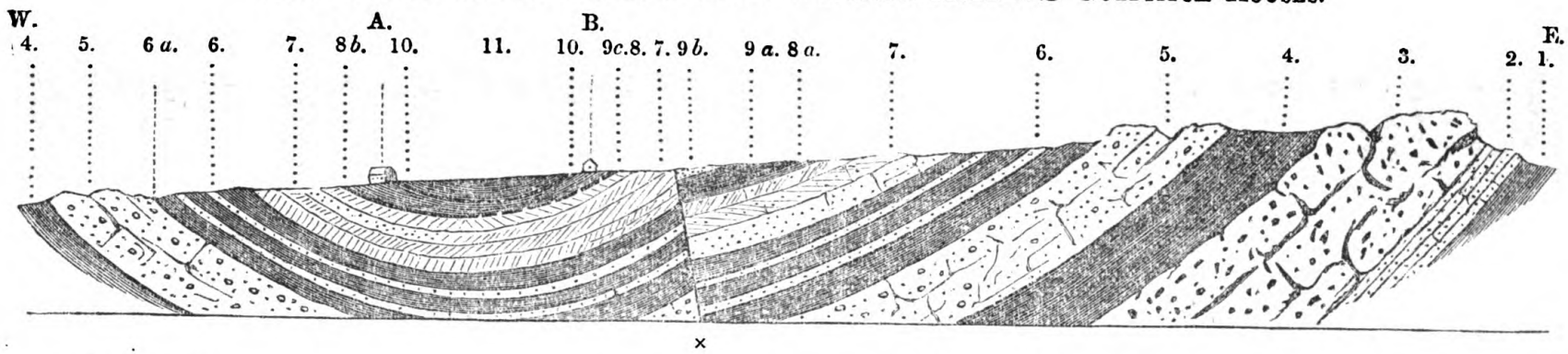
* The following quaint extract from the "Compleat History of Staffordshire," published in 1730, is amusing. I am indebted for it to Mr. Thomas Wardle, of Leek. "Here are also vast Rocks, which surprize with Admiration, called the *Henclouds* and *Leek Roches*. They are of so great a Height, and afford such stupendous Prospects, that one could hardly believe they were anywhere to be found but in Picture. They are so bare, that they have no Turf upon them, nor indeed any Earth to produce it; which, whether they were so from the Creation, or were uncovered by the general Flood, or washed clean by Rain, it is not possible to account for, unless we suppose the Turf being taken off to burn (as is usual in this Country), this latter should carry off the Mould, and leave them bare: but as rocky as they appear, they certainly grow bigger, as have been made evident to Demonstration by Billets, Peeble-stones, yea, a Man's Skull found in them."

Fig. 15.

SECTION GIVEN BY THE BROOK BETWEEN WETSTONE HOLE AND GOLDSITCH HOUSES.



1. Sandy shales.
2. Flaggy sandstones.
3. Coarse, massive, red grit and conglomerate. *Third or Roaches Grit.*
4. Black shales.
5. Coarse, massive, red grit. *First Grit, or Rough Rock.*
6. Shales, flags, and sandstones. (No trace of the Feather-edge Coal on the east side of the basin. At 6*a* a black shale, with *Goniatites.*)
7. Red sandstone ; sometimes soft and massive, at others very much current-bedded. *Woodhead Hill Rock.*
8. *Bassy Coal.*
   8*a*. Coal very thin, roof of very black friable shale, with *Goniatites, Orthoceras* (?), *Aviculopecten papyraceus.*
   8*b*. A mass of black shale, 5 or 6 feet thick, with very thin seams of coal, crowded with fossil plants, *Lepidodendron, Sigillaria, Favularia, Poacites, &c.* Floor hard.
9. Shales, mostly dark.
   9*a*. Ironstone nodules, with *Neuropteris affinis*, and fish.
   9*b*. Chocolate-coloured shale.
   9*c*. Ferns in plenty ; ironstone, with *Anthracosia.*
10. *Cannel Coal.* Hard floor. *Anthracosia acuta* in roof.
11. Black shales.

A. Goldsitch Houses.

B. Barn.

×. Fault.

On this sandstone lies a mixture of coal and black shale, known as the *Bassy Seam* (No. 8 in Fig. 15); its outcrop is well shown below Goldsitch Houses.

Above lies the *Goldsitch series* of shales and sandstones, with thin coals, of which a section has been given on p. 26. The outcrop of the Cannel seam may be seen in the brook by Goldsitch Houses, Fig. 15; but no good natural section of the whole group exists. I suspect that the thicknesses given by the miners are greatly exaggerated. In a pit a quarter of a mile E.N.E. of Little Hill End, the Silver Seam was reached at a depth of 47 yards, which would give about 700 feet of Lower Coal-measures at that spot, and, as the upper part of the division is not there present, the total thickness would, according to the colliers' account, be at least 100 feet more.

Faults.—A fault, with a downthrow to the north of 50 yards, runs through the words "Sniddle Head;" it was proved in the workings at Goldsitch Moss.

A fault running N. and S. by Blue Hills was proved in the old workings; it throws down four yards to the east; it may, perhaps, be the same as is seen in the brook above Goldsitch Houses, Fig. 15.

On the west, south, and east of the belt of Millstone Grit which runs round the Goldsitch Coal-field, is a large tract of Yoredale Rocks, much broken by faults and rolls, in spite of which, however, a general basin-shaped arrangement of the rocks can be traced.

Yoredale Grit.—On the east side of the Goldsitch Trough this bed runs by Morridge Top to Bareleg, where it is hard and quartzose, and hence to Dry Stones, where it is a coarse quartzose conglomerate: hence it may be traced to Swansmoor, but between that house and Blackshaw Moor Farm no signs of it were found: from the latter house it may be clearly traced as far as Thorncliff, where we again lose sight of it for a while; but a sandstone which forms a marked ridge in the map to the south (72 N.W.) from Steel House to Over Bradnop, where it is cut off by a cross fault, may perhaps represent the bed.*

On the west side of the trough the traces of this bed are equally fragmentary; its outcrop from Swithamley Park to Bank Top is clear enough, but from this point southwards for three miles I failed to find the least sign of its presence. At the toll gate one mile from Leek, on the Buxton road, is a sandstone, which may be the Yoredale Grit; it runs by Kniveden, up to the cross fault just mentioned.* To the south of this fault we find no representative of the Yoredale Grit, and its irregularity may be due to the fact that it is here just dying out. On the west of the Anticlinal fault we shall see presently that it disappears a little to the south-west of Macclesfield.

Below the western outcrop of the Yoredale Grit lies the *Meerbrook Valley*, probably occupied by shales dipping at a low angle to the east, but few sections cut down to them through the Drift. The following are worth notice:—In the brook about 10 chains south-west of Old Smithy, *Goniatites*, *Aviculopecten papyraceus*, and *Calamites* were found in black shale. In the brook immediately to the east of New Grange, Plants, *Goniatites*, *Aviculopecten papyraceus*, and *Modiola*

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* The possibility that this bed may represent the Yoredale Grit deserves mentioning. The point is, however, doubtful, and the sandstone has therefore not been coloured as Yoredale Grit on the Maps: it may belong to the Yoredale Sandstones, which it is not unlike in look.

occurred in black shales underlying a bed of concretionary earthy limestone, and the same fossils were found by Mr. R. Gibbs at the foot of the Tittersworth Reservoir. A limestone bed may be seen in black shales in the brook west of The Marsh. These beds would seem to lie between the Yoredale Grit and the Yoredale Sandstones of Gun Hill, and it is partly on the strength of these sections that the shales 1 *c.* in the section on p. 17 are described as perhaps holding a few thin limestones.

On the west of the Meerbrook Valley there rises to a height of about 1,000 feet above the sea the long anticlinal dome of *Gun Hill.* It is made up of Yoredale Sandstones, in places hardened, perhaps by pressure, into a close-grained semi-crystalline quartz rock, which is largely quarried for road metal. On the east side of the hill the dip averages 20° to the east, at its south end the beds are seen dipping at about the same angle to the east, south, and west; while along the west flank they roll over, and where near the Anticlinal Fault plunge down at 45° or 50° to the west.

Thin-bedded, hard, red sandstones crop in the lane north of The Fould, where they are broken by a fault; the beds and fault shown in the brook S.W. of Haddon are most likely the same. In the centre of the hill is a thin-bedded, rather coarse grit. The hard quartz rocks may be well seen in the beautiful section at Gun Stonepits, a sketch of which is given below, taken in one of the quarries on the crest of the saddle. It shows the actual turn of the beds, the gentle slope to the east, and the steeper dip to the west.

Fig. 16.

Sketch of Gun Stonepits.

Between the sandstone beds, many of which are well ripple-marked, lie thin shale partings. *Calamites* and other plants are common. The rock shows marks of having undergone great violence; it is shattered throughout by countless little cracks. The beds have slipped upon one another, and along vertical joints parallel to the dip, marking both these and the planes of bedding with slickenside.

Mr. Hodgkinson, of Newcastle-under-Lyme, who made a boring at a point where the beds are flat, has kindly furnished me with the following section of it.

Section of a Boring at the Top of Gun Hill.

	ft.	in.
Stone	0	9
Coal	0	1
Sandstone	11	8
Grey metal	1	5
Sandstone, light	1	7
Grey metal	0	1
Sandstone, fine-grained	1	0
Grey metal	14	3
Sandstone, fine	1	9
Dark grey metal	1	1
Hard sandstone	3	3
Dark grey metal	1	4
Hard sandstone	4	5
Coarse grit, with pebbles	0	7
Grey metal	0	2
Very hard sandstone	3	4
Coarse grit, with pebbles	1	1
Hard sandstone	0	7
Soft sandstone	9	6
Sandstone, light	1	11
Do. very hard	2	8
Do. dark	2	6
Do. light	0	9
Coarse Grit, with pebbles	1	0
Sandstone, hard and light	1	4
Grey metal	1	5
Sandstone, light	5	2
Do. do.	4	8
Light fine rock	2	10
Grey metal	1	1
Fine sand rock	1	5
	84	7

A hill on the east of North Hill's Wood, near Leek, is probably made up of Yoredale Sandstones: from the few dips that could be seen it seemed that the arrangement of the beds was dome-shaped.

We now pass to the eastern side of the Goldsitch Trough. A fault leaves the Cumberland Fault at Dun Cow, running southwards to Sunny Dale, where it seems to branch into two, one bearing to the west and the other to the east of south: these we will call the East and West Mixon faults respectively.

Between the outcrop of the Yoredale Grit and the West Mixon Faults, the Yoredale Sandstones come out, and some of the deeper brooks cut down to the black shales and thin limestones of the bottom Yoredale group. The streams and quarries give plenty of good sections.

The West Mixon Fault ends off against a fault ranging along the west flank of Morridge towards Blackshaw Farm, which may be called the Morridge Fault. In the space between the eastern outcrop of the Yoredale Grit, the Morridge Fault, and the east and west fault already mentioned through Over Bradnop, the Yoredale Sandstones occupy the whole ground, and in them we find a bed of very coarse massive conglomerate. An east and west section across Morridge, taken a little beyond the southern edge of 81 S.W. shows us:

Sandstone, perhaps Yoredale Grit (runs through Steel House in Map 72 N.W., see note to p. 54)	Upper Group.
Shales	
Coarse quartzose conglomerate	Middle Group.
Shales	
Hard, fine, thin-bedded sandstones	
Black shales, broken by Morridge Fault	
Fine, thin-bedded sandstones: a band of good building stone, here and there a fine conglomerate, at the bottom	
Black shales, with ironstone and thin limestones at the bottom	Lowest Group.

The East Mixon Fault is well shown in the brooks which it crosses till near Upper Elkstone (in 81 S.E.), where it seems to die out.

The ground between the two Mixon Faults is occupied by beds of Middle and Lower Yoredale Groups, often enormously contorted.

They are well shown in the brook by Pye Clough, and the sketch below, taken by Badger's Clough, near the line of the eastern fault, will give some idea of the broken state of the strata.

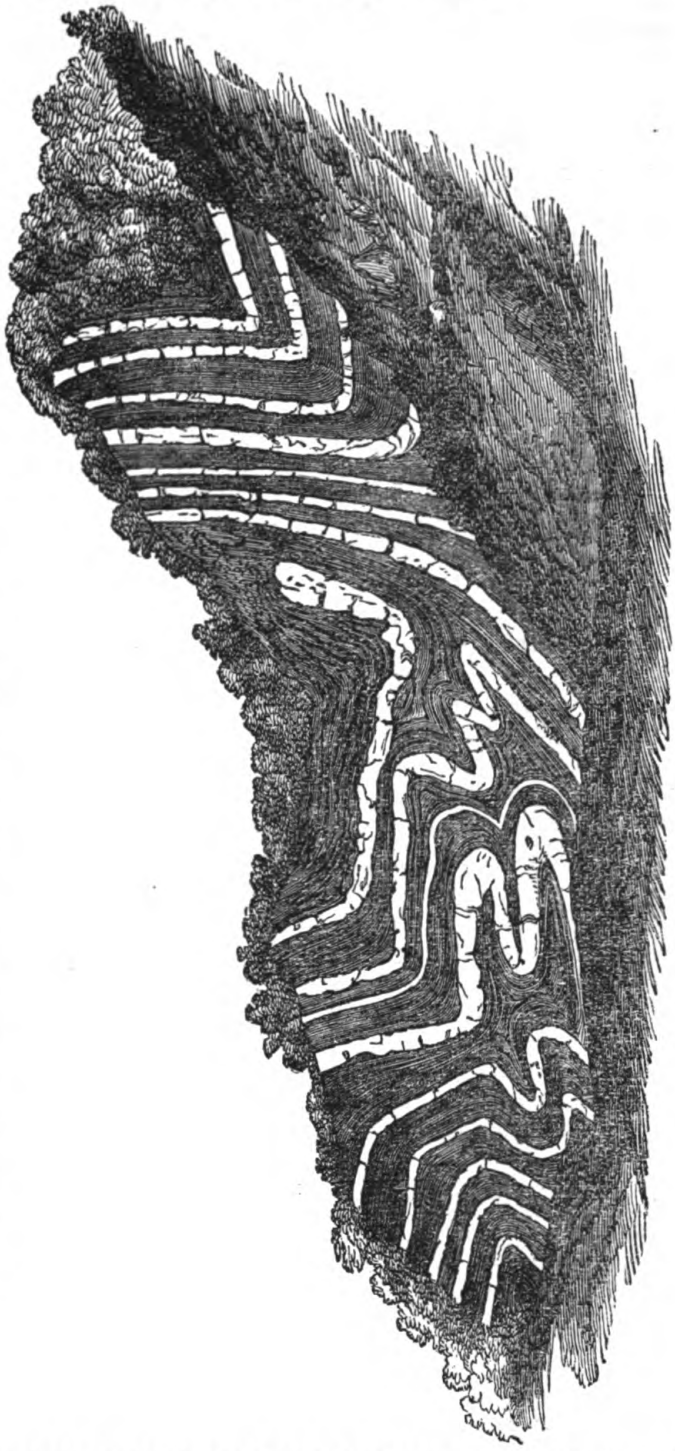

Fig. 17.

CONTORTIONS IN HARD YOREDALE SANDSTONES AND SHALES. BADGER'S CLOUGH.

In the black shales, with interbedded limestones, near the farm-house, Folly, were large Goniatites, one foot across, filled with soft, putty-like clay. They were too imperfect to allow of the species being determined.

To the south, as the faults get farther apart, the beds between become less and less disturbed, and at last seem to fall into a regular saddle, in the middle of which a little patch of the *Mountain Limestone*

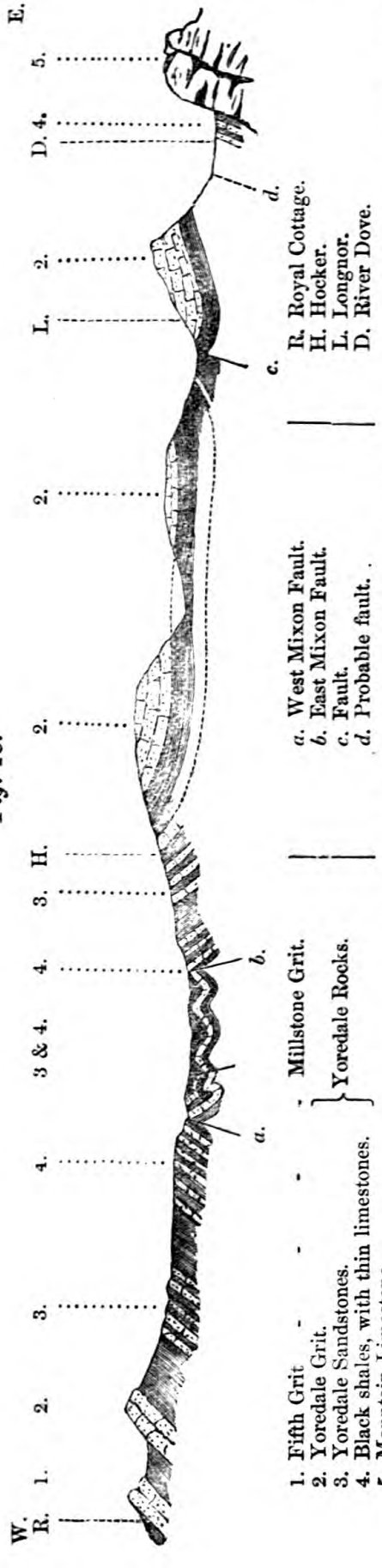

Fig. 18.

comes up at Mixon. This seems to be a long oval-shaped dome, reaching from about New York to the reservoir below Lower Acre, broken into a large number of anticlinals and synclinals, or "trough and hackle," to use the local term, with their axes ranging N.N.W. nearly.

Mineral lodes, which were formerly worked for copper, run along the crests of the ridges, and are crossed by a set of east and west veins, which break through and slightly "heave" the north and south lodes. Among the rubbish heaps of the old mine I found *calc spar, fluor spar, copper pyrites, green carbonate of copper, galena,* and a little *blende.* It would be impossible on so small a map to give any idea of the many folds in the rock, or to lay down with any accuracy the irregularities they must cause in the boundary line of the limestone.*

Around the main mass of the limestone we cross, as we ascend the hill, the outcrop of the lowest Yoredale group; some of the thin limestones are pure and crystalline, with fossils, and others have what look like impressions of fucoids on their surface. Higher up these beds are covered by the Yoredale Sandstones: the following order may be noticed:

Black shales and thin sandstones, some beds of the latter towards the bottom lime-cemented, and full of broken shells and encrinites.
Black shales and thin limestones.
Mountain Limestone.

The gradual introduction of carbonate of lime, first as a cement to the sandstones, then in thin beds, mostly earthy, with shales between, and lastly in the pure solid mass of the Mountain Limestone, is worth attending to.

* I could hear of no working plans of the old mines, and what little information I managed to get was picked up from an old miner on the ground. The chief lodes were drawn in by Mr. Warrington Smyth.

Beyond the East Mixon Fault we find mostly the black shales and thin limestones of the lowest Yoredale group: these, however, soon dip below the Yoredale Sandstones, and these are again in turn covered up by the Yoredale Grit, which, as before mentioned, spreads over a great part of the country as far as Longnor. The succession is well shown in the brook running from High Ash to Longnor, and will be understood from the woodcut on preceding page, Fig. 18.

Farther south the shales and limestones are seen between Fleet Green* and Upper Elkstone*; the Yoredale Sandstones form the ridges of Lady Edge* and Lum Edge;* and a band of the Yoredale Grit runs through Newtown;* while a patch of sandstone west of Booseley Grange* perhaps belongs to the Fifth Millstone Grit.

The beds last described are cut off by a fault on the east, which seems to pass into the anticlinal that brings up the Mountain Limestone at Butterton.* The fault bounding the Mountain Limestone of Ecton* on the east can be traced as far as Brund,* and most likely runs on to Longnor.* Over the ground between these faults we have few sections; but on the high grounds, as Ravage Top,* Yoredale Sandstones are found, and beds belonging, perhaps, to the lowest Yoredale group crop in the valley.

Between the fault last mentioned and the main body of the Mountain Limestone, lies the *Millstone Grit outlier of Sheen Hill*, which falls next to be described. From the north of Longnor* towards Hartington* the River Dove runs nearly along the junction of the Mountain Limestone with the overlying shales; on the west side of the valley the ground rises very steeply, and the top of the ridge is capped by the Yoredale Grit, upon which rests the outlier just mentioned, showing the following beds:

Coarse red Grit; a little patch at the top of Sheen Hill. - - - -	*Third, or Roaches Grit.*
Shales, ironstained at the bottom.	
Fine, hard, whitish grit, weathering red; forms the flanks of Sheen Hill. - -	*Fourth Grit.*
Shales.	
Fine yellow sandstone, lying in a broad shallow basin. - - - -	*Fifth Grit.*
Shales.	
Yoredale Grit.	

It is on the strength of this section that the Longnor Sandstone is taken to be the Yoredale Grit, and the necessity for some fault between its outcrop and the Mountain Limestones inferred, see p. 49.

We now have carried our account as far as the southern edge of map 81, and next come to another large tract of Yoredale Rocks lying in maps 72 N.W. and 72 N.E., north of the Cheadle Coal-field.

Little more can be said of this country than that it is so excessively broken by faults that next to nothing can be made of it. The synclinal arrangement which we have hitherto been able to trace along the whole of the Goyt Trough is very faint and irregular, and were it not that it reappears so clearly in the Cheadle Coal-field, we should be disposed to end off the Goyt Trough on the south hereabouts. The greater part of the country is occupied by the Yoredale Sandstones; a coarse conglomerate, like that already mentioned on the flanks of Morridge, is seen at Sharpcliff and at other points on the same ridge to

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* These places are in Map 81 S.E.

the south-east.* The black shales and thin limestones of the lowest Yoredale Group are beautifully shown in the river Hamps, along whose valley a fault or very sharp anticlinal seems to run. Beds of black calcareous shales, with large limestone bullions, crop in the Coombes Valley, three miles S.S.E. of Leek, by the "S." of Spirit Holes Wood: they were pointed out to me by Mr. Wardle, who has obtained many fossils from them.† An attempt has been made to lay down some of the main faults, but the lines only claim to be very rough approximations.

Between the anticlinal fault at Wetley Rocks and the River Churnet is a small triangular patch of Yoredale Sandstones. This I only notice here, as it has been largely explored by boring and sinking for the Froghall Ironstone! Large sums of money have thus been fruitlessly spent under the direction of "practical men," where the smallest tittle of geological knowledge would have at once shown the attempt to be hopeless.

Millstone Grit of the Cheadle Coal-field.—We have now nearly reached the line along which the Carboniferous Rocks are covered up by the New Red Sandstone of central England, and find the synclinal form of the Goyt Trough, which had been for a time hidden and confused by the faulted nature of the beds, reappearing very clearly in the shallow basin of the Cheadle Coal-field. In the belt of Millstone Grit that runs round this hollow we have only two beds left of the thick group we started with on the north. They are the representatives of the *Rough Rock* and *Third Grit*, and with the shales between do not reach a thickness of more than 300 or 400 feet. They have for the most part become finer and softer, though the Third Grit keeps here and there a certain massiveness of structure to the last. We will now mark out their line of outcrop, starting from the west. The *Rough Rock* is clearly traceable from Stansmore Hall round the edge of the Coal-measures to Moss Lee. The line of the *Third Grit* till we get to Smithy Sprink is very doubtful; a thin bed of coarse red grit was seen behind Wetley Moor Farm-house, but this was the only section I could light upon, and I am by no means sure that the bed does not thin away altogether a little to the south of this. From Smithy Sprink to Moss Lee the *Third Grit* runs with a very clear escarpment.

Hence the two beds can be followed with more or less certainty to the eastern boundary fault of the Coal-field. Along the east side of the fault running by Belmont Chapel the *Third Grit* makes a very fine cliff, most likely marking the face of the fault: the rock is very thick-bedded, and stands up in striking columnar masses.

A little patch of Rough Rock is brought up by faults in the bed of the Churnet at Hazles Wood.

On the east of the boundary fault of the Coal-field are three outliers of the *Third Grit*, viz., at Hope Stone, a little patch capping the hill to the south, and a larger one at Foxt.

On the south side of Shirley Hollow the third bed again crops out with a splendid escarpment in Harston Wood, while above we have the Rough Rock. A little coal has been worked in the shales between. These lines of grit are cut off by a fault through Oldridge and Whiston. Then follows a belt which is very obscure, with the exception of the patch of the *Third Grit* thrown down by a little

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* Like conglomerates are noticed by Farey, History of Derbyshire, p. 228.

† See Appendix I., p. 93.

fault at Garston Rocks. About Monystone, however, the *Rough Rock* begins again to make a clear escarpment, and may be easily followed till it is covered up by the Pebble Beds of the New Red Sandstone at Oakamoor; the line of the Third is equally good, especially its fine escarpment in Star Wood. The dip being small, a long spur of this bed runs out between Oakamoor and Cotton, upon which stands Beelow Hill, capped at the top by a little outlier of Rough Rock.

For an account of the Iron Ore of Froghall and the Coal-measures of the Cheadle Coal-field, see "The Iron Ores of Great Britain" (Mems. of Geol. Survey), Part IV., p. 277; and a paper by Mr. E. W. Binney, Mems. of Lit. and Phil. Soc. of Manchester, vol. xii. p. 34.

Millstone Grit of Combs Moss.—To avoid breaking in upon the account of the Goyt Trough, we have passed over this outlier, but will now retrace our steps, and take it in hand. Everyone who has been at Buxton, or has cast a glance at the Ordnance map of the neighbourhood, will have noticed a large flat-topped hill to the north of the town, which goes by the name of Combs Moss. It stands in the middle of a shallow basin, bounded on all sides by faults. On the east is the fault forming the boundary of the Mountain Limestone; on the north a fault ranging north-east runs near Chapel-en-le-Frith; on the west a large fault runs west of south through Cock Yard; while on the south the area is bounded by the fault which has been already mentioned as most likely running north of the limestone boundary between The Plecks and Buxton. In the centre of this area is the elevated plateau of Combs Moss, formed of the Third Grit. At the top lies a hummock of shales, and the little coal at the junction has formerly been worked.* The outcrop is seen in one of the brooks on the east flank, which gives the section below:

	ft.	in.
Black shale.		
Coal. - - - - - - -	0	10
Light grey underclay, with lumps of raddle. - -	2	0
Third Grit.		

Round the flanks of the hill run the outcrops of two grit beds, the Fourth and Fifth Grits, representing the Kinder Scout Grit. The upper is mostly a coarse red grit, the lower not so coarse and flaggy. They make a fair feature, but they are much thinner, and vastly less striking, than the rock to the north, of which they are the equivalents. Below these is found the Yoredale Grit, a fine-grained brown sandstone.

A fine view of this hill may be seen from near Chinley Head. A broad valley stretches to the south, occupied by the shales lying between the Kinder Scout and Third Grits, the former of which rises into a range of hills on the east, while on the west runs the ridge of Cracken Edge, crowned by bold cliffs of the latter. At its far end the valley is closed in by Combs Moss, the Third Grit at the top of which stands out most beautifully, and ends off sharply in a line of crags, broken here and there by large landslips, while below we may

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* This has been noticed by Farey (History of Derbyshire, p. 170), but he has very naturally fallen into the mistake of identifying the grit of Combs Moss with the bed that caps the High Peak. They have this in common, that each is the lowest *coarse* grit in its neighbourhood; for the Kinder Scout Grit, even in this short distance, has fallen off so much that, without tracing carefully step by step its thinning out, no one would believe that the two sandstone beds on the flanks of Combs Moss could be the representatives of the striking mass of rock on Kinder Scout.

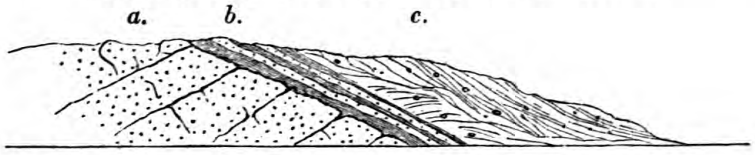
trace three fainter lines of cliff, marking the outcrops of the Fourth, Fifth, and Yoredale Grits.

New Red Sandstone Outlier of Leek.

Before passing to the measures on the west of the Anticlinal Fault, a word may be said on the outlier of Pebble Beds in the middle of which Leek stands.* It is a long narrow strip running along the valley of the Churnet from Pack Saddle Hollow on the north to Hill's Wood† on the south. I only know of one section where the junction with the underlying Carboniferous rocks is shown, but that clearly proves that the New Red Sandstone conglomerates have filled in a hollow in the older rocks. This section, a sketch of which is given below, is made by a road-cutting south of Moss Lee Mill,† three miles and a half S. by E. of Leek ; it was pointed out to me by Mr. Wardle.

Fig. 19.

SECTION SHOWING THE JUNCTION OF THE PEBBLE BEDS WITH CARBONIFEROUS ROCKS. SOUTH OF LEEK.



a. Hard, white sandstone. - - - Yoredale Sandstones.
b. Red marl, with two veins of coarse sand.
c. Soft, mottled, false-bedded sandstone, with quartz pebbles. } Pebble Beds of New Red Sandstone.

There is another little outlier of these beds on the hill east of Ashcombe Wood ;† the rock may be seen in an old lane between Basford Bridge Farm† and Felt House.†

II. *The Country between the Anticlinal and the Red Rock Faults.*

We have here to take in hand, first, *the Coal tract between Hyde, Poynton, and Macclesfield.* Its general structure has been already described (p. 12), and the nature of its measures given on pp. 28–30.

At its northern end the space between the two faults just mentioned is mainly occupied by Coal-measures, though patches of Millstone Grit are thrown up by cross faults. Further to the south the Anticlinal Fault makes a bend to the east, and allows room for a belt of Millstone Grit to come in between it and the Coal-measures. From Disley westward the dip is steadily west, and we cross the full series of the Lower Coal-measures, which form the hilly tract of Lyme Park, and then reach the Poynton Coal-field, an account of the measures of which will be found on p. 30.

So far the strike of the beds has been upon the whole north and south, but about three miles to the south of Rainow the outcrops begin to bend round to the west, and we reach the southern end of the long, narrow, half basin of Carboniferous Rocks we have been describing. The *Fourth* and *Fifth Grits* have passed into fine sandstones, but are still clearly traceable ; they are both quarried about Pygreave, east of Macclesfield, and in the lower bed are some curious concretions, of which a sketch is given on the following page.

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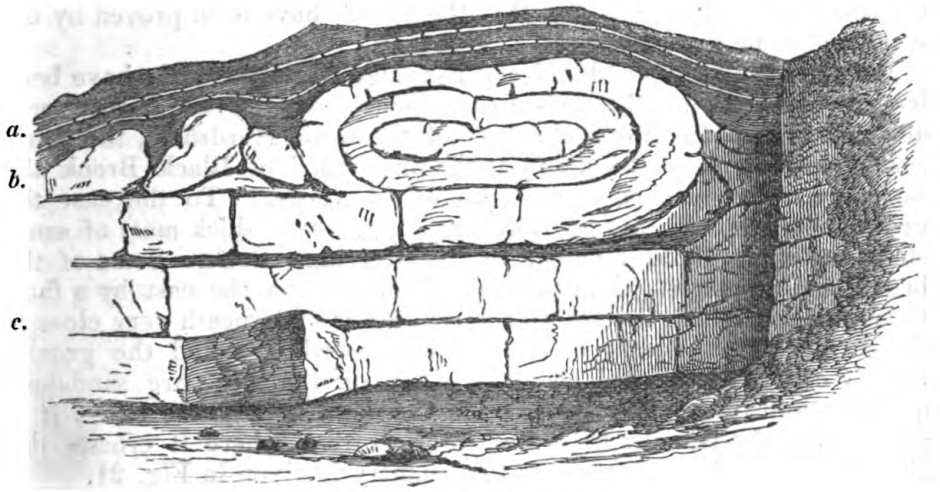
* Horizontal Section of Geological Survey, Sheet 42, crosses this outlier, the southern part of which was mapped by Mr. Hull.

† In Map 72 N.W.

Fig. 20.

CONCRETIONS IN THE FIFTH GRIT, in a quarry a quarter of a mile N. by E. of Langley Hall.



a. Sandy shale, with thin bands of stone.
b. Concretionary sandstone.
c. Hard, fine-grained sandstone, very evenly bedded.
Large nodule about 25 feet long.

The fourth bed is also very largely quarried at Windaway Head.

An outlier of sandstone, which most likely belongs to the Fifth Grit, lies on the hill top between Dirty Gate and Forest Chapel.

The *Third Grit* is best seen in the large quarries on Tegg's Nose; it is there a close-grained, hard, red grit, making an excellent building stone. The little coal on the top of this bed has been worked near Rainow,* where it is 10 inches thick, and on the south of Blakelow Stoop.

The *Second Grit* and *Rough Rock* could for the most part be traced with accuracy; the former has a fine escarpment at The Oaks, and may be seen in quarries near One House and Bull Hill; the Rough Rock will be best seen in a quarry at Rulow Knob. The brook running from Lamin Load to the mill at Rainow gives a good section of the Millstone series.

We now come to the Coal-measures, of which a general section has been already given on p. 23. There are two main faults; the one, which we will call the Kerridge fault, ranges from Bollington along the west side of Kerridge, past One House, where it is seen in the brook, and through Tegg's Nose Farm, where it brings about a sudden change in the strike of the beds; it will be seen by and by that this fault can be traced south to Badderley Edge, on the borders of the Pottery Coal-field. The other, which may be called the Hurdsfield fault, branches from the Red Rock fault at the "s" of the word Hurdsfield, and runs south. Other small faults have been drawn from information given by Mr. George Needham and Mr. J. Vare of Rainow.

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* The crop was seen in the brook west of Billinge Head, where we have

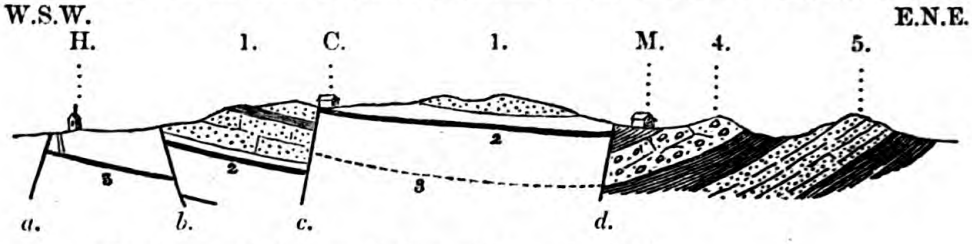
	ft.	in.
Grey shale.		
Coal - - -	1	0
Clay - - -	1	6
Grey shale - -	3	6
Third Grit.		

Between the Red Rock and the Hurdsfield faults the ground is much hidden by Boulder Clay. It will be seen that the outcrops of the grit beds on the south do not run up to the Red Rock fault, but are cut off by a branch fracture : its exact line is not very certain, but the beds in the angle between it and the Red Rock fault have been proved by old workings to be Coal-measures.

Between the Hurdsfield and the Kerridge faults the coals have been largely worked ; in the coal-pits at Segley the "Great Smut" was 40 yards deep. In a pit at the "s" of the word Hurdsfield, the "first seam" was 40 yards deep, and at the first "k" of Black Brook the same seam was reached at a depth of 54 yards.* To the east the ground rises rapidly, and the hills are capped by a thick mass of sandstone and shale, the equivalent of the Kerridge Rock. Some of the beds are very coarse. The sandstone is cut off on the east by a fault through Cliff, which throws up the coal seams underneath very close to the surface ; on the east of the line we accordingly find the ground thickly covered with old coal-pits, while on the west are sandstone quarries, and this enables us to trace the fault with great ease ; it is also seen in the lane by Cliff, and in a cutting where it crosses the Buxton road. A section across this country is given in Fig. 21.

Fig. 21.

SECTION ACROSS THE LOWER COAL MEASURES EAST OF HURDSFIELD.



1. Sandstone and shale, equivalent of the Kerridge Rock.
2. Great Smut Coal.
3. Middle Sweet seam.
4. Rough Rock.
5. Second Grit.
a. Hurdsfield Fault.
b. Fault.
c. Cliff Fault.
d. Kerridge Fault.
H. Hurdsfield Colliery.
C. Cliff.
M. Marsh.

The Big Mine (Feather-edge Coal) is worked on Eddisbury Hill, it is from four to six feet thick, but only fit for brick-kilns or lime burning : in a pit just above the "r" of Eddisbury, it lies 69 yards deep.

To the east of the Kerridge Fault is the ridge of the same name, capped by a thick outlier of sandstone with shale partings.† The sandstones are largely quarried, yielding excellent flags and building stone ; some beds are very coarse ; and at the top of the hill is a conglomerate with quartz pebbles. A small fault runs along the west side of the hill, throwing down 12 yards on the west.

The little coals have been sunk to on the west of the hill : at a pit one-eighth of a mile north of Wood End the "first seam" was reached at 90 yards, and the "second" at 104. On the east of the hill a tunnel has been driven from near the outcrop to work the coals. A section across Kerridge is given in the next page.

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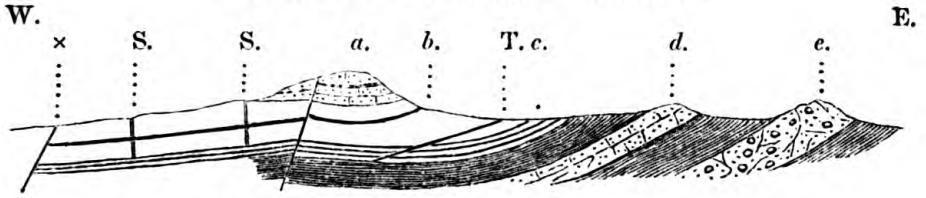
* From these data the probable crops of the seams have been laid down on the Map from calculation.

† See the second note on p. 23.

Fig. 22.

SKETCH SECTION ACROSS KERRIDGE.



a. Kerridge Rock.
b. Great Smut Coal.
c. 1st, 2nd, 3rd, and 4th Coals.
d. Sandstone. *Woodhead Hill Rock.*
e. Rough Rock.
T. Tunnel.
S. Shafts.
× Kerridge Fault.

Yoredale Rocks.—In the northern half of the country now under consideration the Millstone Grit abuts against the Anticlinal Fault on its west side, leaving no room for the underlying beds to come out. South of Whitesides, however, the Yoredale Rocks show between the outcrop of the Fifth Grit and the Anticlinal Fault. The chief feature is made by the Yoredale Grit, which rises at first with a steep dip, but soon rolls over, and lying nearly flat, covers the hill top in one place for the breadth of nearly a mile. It may be seen in many quarries by the Macclesfield and Buxton road. The same bed crops about Ridge Gate, and in the banks of the highest of the reservoirs of the Macclesfield Waterworks, but it is not easily traceable. This is the last that we see of the Yoredale Grit on the west side of the Anticlinal Fault.

The long shallow trough, to which we have given the name of the *Rudyerd Basin*, may be next described.

It begins on the north to the west of Shutlingslow, and reaches on the south as far as the little coal-field of Wetley and Shafferlong. In the northern half the Anticlinal Fault runs along the centre of the trough, and only allows its western half to show at the surface; but from Rushton southwards, as the axis of the hollow bends away to the west, the true basin form is found, the rocks rising and cropping on each side to the west and east respectively.

North of the River Dane we have the three lowest grits, lying nearly flat in the middle of the trough, but rising sharply towards the western edge. A fault, which is well shown in the brook, north of the "h" of Oaken Clough, prevents these beds from running up to the Anticlinal Fault, and throws up between a wedge of Yoredale Rocks.

The Fourth and Fifth Grits have pretty much the same fine flaggy character as about Macclesfield, but the former becomes coarse here and there. The Third Grit is still coarse and massive, though in the outlier at Hammerton, if it really belong to this bed, the rock is much finer and more crumbly.

South of the River Dane the four arms of the Fifth Grit, which have been laid down on the map meeting in a patch of the rock at Toft House, are somewhat doubtful; but after a good deal of labour, this seemed to me the most likely arrangement of the rock.

We have now reached the tract of Gritstone in the middle of which lies the pretty reservoir of Rudyerd. These beds seem to be bounded on the west by a fault, which is seen in the brook near Barns Lee, and which seems to cut off the ridges formed by the outcrops of the Fourth Grit south of that farm and at Birch Trees: its further course is

doubtful, but it seems to bend to the south-west, and again to cut off the Fourth Grit at Dunwood.* One reason for drawing it thus is that while the beds on one side of the line have a gentle easterly dip, we find on the other side steep dips to the west.

Between this and the Anticlinal Fault the beds lie in a double trough, the axis of one hollow running nearly along the Congleton and Macclesfield road, and the line of the other hollow ranging in a direction nearly parallel through Birch Trees.

The Fourth Grit has here somewhat recovered its character; in the railway cutting north of Horton station, where the beds are much tossed about, it is a hard, close-grained, red grit, very much like that quarried below the Roaches (see p. 51): in Raecliff Wood the rock is very coarse, but about Horton soft and crumbly.

As already mentioned, the Fourth Grit is cut off by a fault on the west of the basin, on the east side it may be followed to Hollin Hay Wood,* where it is of small thickness; here it is covered up by Alluvium and New Red Sandstone; but it never reappears to the south of this point, the Third Grit being everywhere succeeded below by the Yoredale Sandstones. Here then we have reached a point where the thick massive grit of Kinder Scout and Hayfield, which reaches in the north a thickness of 800 or 1,000 feet, dies out altogether.

The Third Grit, of which there are two outliers, still keeps very coarse, and is here and there a conglomerate.

There now only remain to be described the outcrops of the Rough Rock and Third Grit around the Wetley Coal-field.* The latter, though clear and well marked at the northern end, becomes very faint and uncertain southwards, and I suspect that about Heath House* it is on the point of dying out. Both beds are mostly fine and soft, and altogether unlike the coarse massive rocks that lie on the same horizon in the north. The Rough Rock is best seen in the fine crags of Wetley Rocks,* where the beds are nearly on end, on account, most likely, of the close neighbourhood of the Anticlinal Fault.

At Rangemoor* we have the following section:

	ft.	in.
Rough Rock; here a very coarse grit.		
Chocolate coloured and red sandy shales - -	20	0
Dark shales, with thin bands of poor ironstone, and a thin coal.		

The colour of the shales below the Rough Rock has led to many fruitless sinkings for ironstone in these measures, and even still the miners stick to the notion that the Froghall Stone will yet be found in them.

For an account of the Coal Measures of Wetley, see "The Iron Ores of Great Britain" (Mems. of Geol. Survey), Part IV. p. 276.

We may next take in hand a large tract of Yoredale rocks, bounded on the north by the Macclesfield Grits and Coal-measures, on the east by the Rudyerd Basin, and on the west by the Red Rock Fault and the Biddulph Trough. No traces of the Yoredale Grit are found within this area, and we shall mostly have to deal with beds of the Middle Group.

The Kerridge Fault (see p. 22), may be traced all across this district. There is good reason to believe that a fault runs along the

* In Map 72 N.W.

east side of Bosley Minn, and where the line crosses the River Dane, a little east of Hug Bridge, the beds are very much broken ; about Lee House, south of Rushton, there is also much disturbance ; and further south, three-tenths of a mile E.S.E. of Park House, the beds are seen in the road cutting to be enormously contorted.

One mile north of Endon* the fault shows well in a brook, bringing black shales and thin limestones of the lowest Yoredale Group against the Yoredale Sandstones, and from here southwards, as it cuts off the outcrops of the latter beds, its line makes a clear feature across the country ; it then runs by Badderley Edge,* throwing the Millstone Grit against the Coal-measures.

There are only two important sections to the east of this fault. One is given by the deep brook course between Bosley Minn and Winkle, and shows mostly black shales with a few thin limestones, and in one place limestone "bullions" with *Goniatites :* the beds dip to the east very irregularly at high angles. The other section is given by the River Dane, from Hug Bridge eastward, and is as follows :

1. Black shales, rolling, and very much faulted ; perhaps belonging to the Third division of the Yoredale Beds.
2. Yoredale Sandstones and shales, at first much broken, but gradually falling into a steady dip of 20° to the east. A small coal of 4 in. was once worked in these beds.
3. Fine massive sandstone. Fifth Millstone Grit.

Here we have a very clear section without any trace of the Yoredale Grit, and there can be no doubt therefore that that bed has thinned out before this. The contortions in No. 1 are well shown in the river bank, specially about three-eighths of a mile east of Hug Bridge.

On the west of the Kerridge Fault the most noticeable features are Bosley Minn and the group of hills to the north-west of it. They are both made up of Yoredale Sandstones thrown into many sharp folds, and, as was the case on Gun Hill, the rock is often a semi-crystalline quartzite. The north-westerly of these two masses abuts against the Red Rock fault ; and in a brook, one quarter of a mile south-west of Rough Hay, some of the lowest Yoredale limestones are brought up close to the fault. In the wood to the north-east of Rough Hay the beds dip towards the fault, and then quickly roll over to the east ; at the turn they are shattered with countless little cracks, the whole rock being broken up into fragments small enough for road making. Large quarries in the "crowstone," as the rock is locally called, may also be seen in Ratcliff Wood. Following the edge of the hill, we find the dip to be north-west about Lee, north at Sprout House, and gradually changing to north-east along Hollin Lane, where the crowstone is again largely quarried. The beds are vertical at Rossen Clough, perhaps owing to a continuation of the Hurdsfield fault to this point, to the south of which the fault passes into a sharp anticlinal, which is well shown in the brook near Milking Stead. Still farther to the south, about Dawson and Swallow, is a very contorted bit of ground, in which anticlinal and synclinal follow one another so rapidly as to baffle all attempts to trace accurately the run and order of the beds. East of Dawson, and in the brook south of Higher Pettels, shales, with a few thin limestones, overlie the crowstone ; they are perhaps the beds marked 1 *c.* in the general Yoredale Section on p. 17.

The smaller hill of Bosley Minn also seems to have its bedding dome-shaped, and to be made up of a crowstone like that just described.

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* In Map 72 N.W.

Between Bosley Minn and Cloud Hill sections are not plentiful, but the following order of beds below the Fourth Grit, the lowest Millstone Grit hereabouts, may be made out:

1. Black and grey shales, with a little flagstone (brook W. and N. of Woodhouse Green).
2. Thin-bedded hard flagstones, with partings of shale (River Dane, from Bosley Station to Bosley Mill) - - - } Yoredale Sandstones, Second Division of Yoredale Rocks.
3. Black shales, with a few thin limestones (brook beside Big Fenton) - - } Third Division of Yoredale Rocks.

Once more the Yoredale Sandstones are brought up by a very sharp anticlinal along the high ridge to the east of Biddulph Moor. From the Congleton and Leek road southwards, to the edge of Map 81 S.W., the beds plunge steeply down on either side, and the pressure which seems to have squeezed them into their present shape has been so great as often to reverse the dip, which in some cases is as steep as 50°, *into the hill:* cases of reversal on a smaller scale may be seen in most of the brooks that run down the sides of the ridge. Here also the rock is a close-grained half crystalline quartzite, like that on Gun Hill, but not quite so much altered; the lowest bed seen is here and there a fine conglomerate. Southwards, in Map 72 N.W., the Badderley Edge fault cuts off the eastern half of the saddle, and we have the Yoredale Sandstones rising from beneath the Millstone Grit on the east of the Pottery Coal-field at an angle of about 40° (which gradually falls off to 20° as we go east), till they abut against this fault.

A brook on the south side of the Congleton and Leek road, running from near New House to The Brook, cuts right across this anticlinal, and shows very beautifully the steep dips on either side; on the west the beds are all but on end for some distance; on the east the dip is not quite so steep. The best section on the east side of the ridge is made by the brook at Shirkley Wood. Climbing this ravine we cross two beds of crowstone, with black shales above and between them: these beds dip at very high angles, and are in places vertical and even tilted over so as to dip into the hill; then follows a flat of shale, from beneath which another bed of crowstone rises steeply, but soon rolls over and dips to the west: this last bed is in parts a conglomerate with small quartz pebbles.

On the western side the steep dip of the measures is well shown by a brook crossing the north part of Biddulph Moor and running by Spring Coppice, the lower part of which also cuts through the Millstone Grit and Lower Coal-measures of the Biddulph Trough.

Besides these sections there are many quarries where the stone is worked for road metal.

The Anticlinal space between the Wetley and Pottery Coal-fields, is wholly occupied by Yoredale Sandstones.

In the middle of the Yoredale tract just described lies an outlier of *New Red Sandstone Pebble Beds* and *Permian rocks at Rushton Spencer.* A section of the Permians has been already given on p. 36. This outlier is bounded on the north by a fault, seen in the River Dane (Fig. 18, p. 36), which tilts the Permian sandstones in the railway cutting at Morris Grange. The brook running down from Peck's House cuts through the Permian sandstones, and in the River Dane below we have the mottled marls above them and the overlying Pebble Beds. The lane leading from High Ash to Rushton James shows

some thickness of Permian marls and sandstones, but at the latter farm-house they fail, for a section shows Pebble Beds resting on Yoredale shales; this unconformity to the New Red Sandstone, and their mineral character, makes it very likely that these beds are really of Permian age.

On the east side of the outlier traces of like Permian beds were found, but the sections were not very good.

An outlier also seems to cap the hill top at Woodhouse Green, but from the absence of sections and the drift covering its boundary is wholly conjectural.

The Pebble Beds call for no particular notice.

Lastly, we come to the Coal-field of The Potteries, the northern end of which, lying in map 81 S.W., is known as *The Biddulph Trough.*

Millstone Grit.—South-west of the farm-house, Cloud Wood, faint traces of a sandstone which may represent the *Fifth Grit* were found; it could not be mapped. On the north flank of Cloud Hill the *Fourth Grit* is seen in quarries; it is a thick-bedded, close-grained, red grit, not unlike the same bed on the west of The Roaches (see p. 51). From here the rock may be traced along the east side of the basin as far as the brook which runs through Spring Coppice, where it shows as a reddish sandstone tending to become flaggy. Hence southwards the bed is never seen again, and it therefore most likely soon thins out. Here again then we have reached a point on the line along which the Kinder Scout Grit dies away.

The Third Grit and the Rough Rock are still found in force, and their outcrops form the bold ridges which bound the trough on either side; the two beds with the shale between reach a thickness of about 400 feet.

Starting from the south-east we find the two beds about Bagnall* showing as soft red sandstones, for the most part not very coarse. A little coal has been worked on the top of the Third Grit near Bagnall.* Northwards the beds get gradually coarser; a fine section of them is given by the brook which runs from near Cowall* into the Knipersely Reservoir.*

About Wickenstone the Rough Rock makes a very marked feature in the landscape; huge tables of it slope up from the valley at an angle of 45°, and rise bare of any covering boldly into the air, while the edges of the beds are broken off sharply and show a steep cliff on the east. A little farther to the north the escarpment of the Third Grit becomes the more marked of the two; it is not here, as is often the case, bounded at top by a nearly straight line, but is crowned at intervals by sharp conical peaks, which rise like towers along a rampart.

Thus the beds run on, till, at Cloud Hill, the northern end of the trough, the outcrops bend round and run south by west till they abut against the Red Rock Fault at Fair House.

Cloud Hill, 1,190 feet above the sea, is capped by the Third Grit. Viewed from the New Red Sandstone plain on the west this hill forms a very striking object in the landscape. The cliff formed by the Third Grit is seen at the top, the flanks being formed of the Fourth bed, which makes no feature, and the shales below. At the foot of the slope runs the Red Rock Fault, throwing down the Upper Keuper Marls. The River Dane winds through the flatter country occupied by these beds, its course being marked by a series of little cliffs, above which are river terraces covered by old alluvium.

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* In Map 72 N.W.

On the west of the Biddulph Trough, along Congleton Edge to St. Thomas' Church, the two grits crop out at high angles. They have here exchanged characters, the Rough Rock being a close-grained, firm stone, while the Third Bed is soft and crumbly, and is largely ground into sand for use in the Potteries. In the latter bed, where the road from Brook Houses crosses the ridge, is a bed of very pure white clay, 6 feet thick, with two or three inches of bright red hæmatite at the bottom. About the same spot a bed of coal, from 2 to 4 feet thick, has been worked on the top of the Third Grit.

It is somewhat difficult to get a sight of the shale band lying between the First and Third Grits; for owing to the steep dip it occupies a very narrow strip of ground, and sections are scarce. At my last visit, however, I was lucky enough to find a deep road-cutting just laid open, which gave the following order of the beds.

	ft.	in.
Rough Rock, coarse massive grit and conglomerate.		
White sandy clay, with a bed of sandstone at the bottom	3	0
Pink and white sandy clay, with beds of sandstone	13	0
Hard fine grit, in parts a conglomerate	10	0
Pink and white sandy shale, with beds of sandstone	14	0
Hard fine sandstone	5	0
Shale, sandy and pink in the upper part, dark and clayey lower down	57	0
Interval, with no section, most likely shale	102	0
Black shale		
Coal, 2 ft. to 4 ft.		
Underclay and shale (?), 4 ft. to 6 ft.		
Third Grit, massive, not very coarse.		

At St. Thomas' Church is a very sudden change in the arrangement of the measures; hitherto we have had a ridge of Millstone Grit dipping steeply to the east, overlaid by Coal-measures on the one side, and with Yoredale Rocks coming out from below on the other: but to the south of the church we find the ridge formed by a *saddle* of Gritstone, plunging down on either side below Coal-measures. This, of course, requires a fault along the line where the change takes place. There are no sections to show its exact place on the hill, but a fault said to have been proved in the Coal-measures at Mole House runs exactly to the point required.

The anticlinal ridge to the south of this fault is formed of the Rough Rock; it runs as far as Mow Cop, where the beds dip down to the east and south below Coal-measures. The boundary on the west is a fault. The whole is very much broken and disturbed. At Mow Cop the rock is fissured in every direction, the cracks being often lined with Heavy Spar.

Coal-measures of the Biddulph Trough.—A general section of these beds has been already given (pp. 31–33). The lower measures are best shown in the brook between Biddulph Mill and Lea Mill Forges, and in another stream a little to the south. The thick sandstone beneath the "Two Foot" or "Little Row" coal is on this side of the basin massive and fine grained. At its crop on the west side it is in parts a coarse conglomerate, which may be seen in a quarry ¼ mile N. by W. of the Hay Hill. The crops of the "Little Row" and "Crabtree" coals have been laid down from old workings, and from information furnished by Mr. Goslin, of Congleton, and Mr. Bradbury, of Braldey Green.

The crops of the thick coals north of a fault through the Hay Hill and Red Cross T.G. have been laid down as well as the small scale of the map would allow, with the assistance of Mr. W. Chadwick, bailiff

to Mr. Bradbury of Bradley Green Colliery, from whose plans the faults on this ground were also drawn.

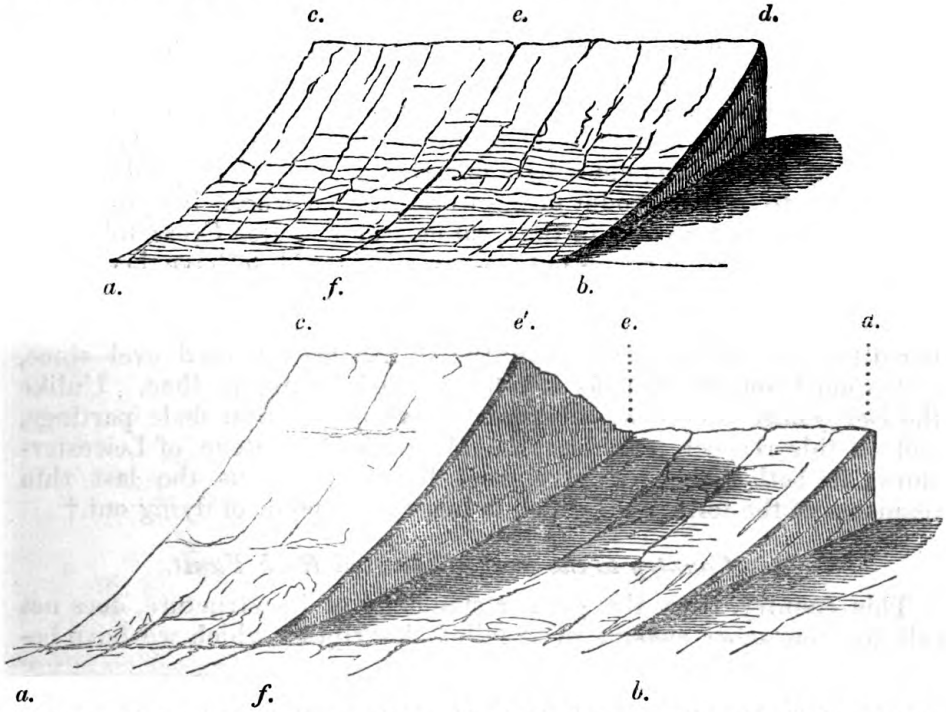
The coal crops on the south of the fault just mentioned were mostly laid down from calculation, the data being their depth and the dip at Tower Hill Colliery, kindly furnished by Messrs. Williamson.

The coal crops on the west of Mow Cop, in 81 S.W., were traced for me by David Oakes, an old collier.

On the west side of the basin the beds rise very steeply, sometimes even at an angle of 70°, the average dip being about 40°. On the east the rise is much more gentle, about 15° on the average. The one set of beds are known among the colliers as the "Rearing Mines," and the other as the "Flats." The working of the "rearing" coals is attended with some difficulty and danger. The yield per acre is, of course, very large, and by "crutting," or driving horizontal galleries across the strike from one bed to another, several seams can be worked at the same time from the same shaft. I am told by Mr. Bradbury that faults which run across the basin are found to have their greatest throw in the "rearers," and to die out in the "flats." This and the steep dip on the west side of the basin seems to show that the beds have been bent into their present shape by a strong lateral pressure acting from west to east. Such a force would tilt up the beds along the western edge of the trough, and when a crack had been produced, it might well be that the measures on one side would be tilted more than those on the other, the result of which would be a fault whose throw would change in the manner above described. A model would best explain my meaning, but I hope the woodcut below may be some help to the reader.

Fig. 23.

Diagram to show the way in which the change of throw of the faults in the Biddulph Trough may have been brought about.



Let *a b d c* (1) be the surface of a bed of coal stripped of the overlying measures; *a f b* the axis of the trough; and let the bed rise

steeply towards *c* and *d;* also let *e f* be a crack running across the strike. Now let a pressure from behind act upon the part of the bed *a f e c* more violently than on *e f b d*, so as turn the former round *a f* as an axis, and throw it into the position *a f e' c* (2) ; *e f e'* will then be the face of a fault having no throw on the one side of the line *a f b*, but with its throw increasing step by step from *f* to *e*, exactly as is found to be the case with the faults of the Biddulph Trough.

For an account of the southern part of the Pottery Coal-field, see "The Iron Ores of Great Britain" (Mems. of Geol. Survey), Part IV.

There now remains to be described only a small tract of Yoredale Rocks on the west side of the Biddulph Trough, with the little patch of *Mountain Limestone at Astbury.*

We may first mention that there is here no trace of the Yoredale Grit, which fact gives a further proof that the bed has thinned out before this.

In the upper part of the measures the following sections are worth notice. In a quarry by the road side, south-west of Holly Wood, we have

	ft.	in.
Dark shale, with fossil-bearing nodules of limestone* -	15	0
Hard dark-grey quartz rock (Gannister), with thin partings of dark shale, containing layers of coal from one-eighth to one-fourth of an inch thick. Large *stigmariæ*, with rootlets	20	0

Thirty-two chains north-east of Puddle Bank is a quarry in like beds ; in the upper shales was a band of earthy limestone with *Goniatites.* A little coal that has been worked in the wood hard by is most likely in some way connected with the Gannister.

It would seem that this bed is one of the hard fine-grained Yoredale Sandstones, which, under circumstances locally suitable for the production of coal, has taken the form of a Gannister.

The greater part of the remainder of this district is covered with drift, but the road over the hill from Astbury lime works gives us the beautiful section in the next page.

From this section it will be seen that the limestone lies in a saddle between two faults : to the south-west it is soon carried below the surface by a steep dip, aided by a downthrow fault of 16 yards, which was drawn from the account of the workmen and whose line produced falls into the fault proved in the Coal-measures at Roe Cross toll gate. The limestone barely comes out to-day ; it is said to have been accidentally discovered by a Derbyshire servant girl about 200 years ago, who noticed that the rock in the brook was the same as she had seen burnt for lime in her native county : it has been worked ever since, and is much sought after, as it yields a good hydraulic lime. Unlike the Derbyshire limestone, this rock contains some thin shale partings, and in this respect resembles the Mountain Limestone of Leicestershire : in both cases we have most likely before us the last thin remnants of the formation, which is just on the point of dying out.†

(B.) *Country to the west of the Red Rock Fault.*

This country, from the greater simplicity of its structure, does not call for the same amount of detailed description which we have be-

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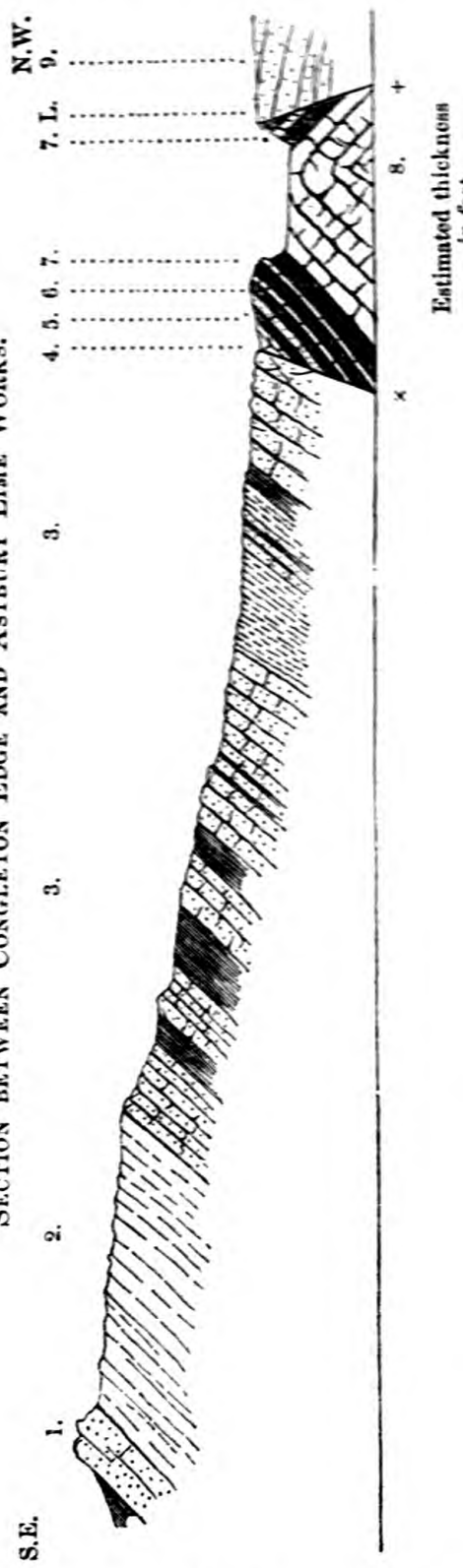
* For a list of the fossils, see Appendix, p. 92.

† See Hull on "The Distribution of the Carboniferous Strata, &c." (Quarterly Journal of Geol. Soc., vol. xviii., p. 127).

Fig. 24.

SECTION BETWEEN CONGLETON EDGE AND ASTBURY LIME WORKS.



			Estimated thickness in feet.
Millstone Grit	-	1. Third Grit - - - - - -	100
Yoredale Rocks. Middle Group		2. Shales, probably, but no section - - - - -	500
		3. Thin-bedded, fine, hard sandstones and shales - - - -	1,400
		4. Hard, reddish-yellow sandstone.	
		5. Dark sandy shale - - - - - -	20
		6. Impure Cannel Coal - - - - - -	1
	Lowest Group	7. Shales, with thin earthy limestones - - - -	120
Mountain Limestone	-	8. Limestone with thin shale partings.	
		×. Fault.	
		+. Red Rock fault.	
		L. Limekiln Farm.	
		9. Lower Keuper Sandstone.	

stowed on the ground east of the great fault. The chief sections have been already described in Chapter II. I would wish to state, however, that the boundary lines of the sub-divisions of the New Red Sandstone in the north-west part of Map 81 S.W. must be looked upon as

nothing more than the roughest approximations. The lines on the north, where better evidence was to be had, have been some little help, but beyond this we have only the three following sections to guide us.

A soft red sandstone, belonging most likely to the Pebble Beds, was found in the shaft of Roewood Colliery, and a like rock was reached below 24 yards of Drift at Mr. Stancliff's brewery, half a mile south of St. Paul's Church, Macclesfield. Upper Keuper marls and sandstones were reached below the Drift in a well at the copper works, where the Macclesfield and Leek road crosses the canal.* From this we see that there must be a fault between the copper works and the brewery ; a fault in Map 81 N.W., of which Mr. Hull found good evidence, runs when produced between the two. I have been obliged to suppose its throw to be reversed, but it seemed better to do this than to lay down a new fault for whose line there was nothing whatever to serve as a guide.

A. H. G.

CHAPTER IV.

Post Pliocene and Recent Deposits.

Drift or *Boulder Beds.*—The whole of the plain lying west of the Red Rock fault, and composed of Triassic and Permian formations, is covered to a greater or less extent by Drift deposits. East of this line the hills of the Lower Carboniferous beds rise for the most part above the level of the Drift, which we only find occupying the lower part of the valleys, clinging in small patches to the hill sides, or nestling in the hollows.

We have been able to subdivide the Drift deposits into three stages, which occur with remarkable persistency over the whole district : they are as follows :

1. Upper Boulder Clay, or Till.
2. Sand and gravel.
3. Lower Boulder Clay, or Till.

While the above arrangement answers well as a general classification, it ought to be stated that bands of clay frequently occur in the sand, and, less frequently, bands of sand in the clay. These three members are traced upon the Drift Maps of the Geological Survey now in course of preparation.

The Upper and Lower Boulder Clays are in every respect similar. They consist of dark reddish brown stiff clay with subangular pebbles, which frequently have polished, scratched, and striated faces. These pebbles consist of granites, porphyry, Silurian slates and grits, quartz, and Carboniferous grits. At Gorton, in the Upper Till, the following pebbles were found in the order of numerical predominance.

Silurian Grit.	Porphyritic conglomerate.
Felspar porphyry.	Carboniferous Limestone.
Carboniferous Grit.	Ironstone.
Granite.	

The Till in some places presents but rude traces of stratification, while in others it is distinctly laminated, as may be seen by the sections in the railway cuttings under Cobden Edge.

* All three sections were pointed out to me by Mr. Sainter ; he also introduced me in each case to the proprietors, who kindly gave me all particulars required.

The sand and gravel which lies between the two beds of Till varies from 20 feet near Gorton, to probably 100 feet at Prestbury.

It occurs generally in the form of fine colourless sand, full of current-planes, and containing beds of gravel. The pebbles from this subdivison are all more or less rounded and waterworn, and in this respect may be contrasted with those from the Till, which are glaciated.* We do, however, at times find ice-scratches on the pebbles in the sand, but they are always faint; in these cases the pebbles may have come from the Lower Till, and have had the markings partly worn away by the action of running water.† The sand in company with the Upper Till covers the surface of the Cheshire plain, while the Lower Till is generally restricted to the bottom of the valleys.

The whole of these subdivisions rise from the west towards the east, in other words, from the plain towards the hills. This slope is very nearly that of the fall of the brooks, so that, along the Mersey, the Dean, the Bollin, and other rivers, the banks are formed of the same materials for many miles. This slope, which at first sight seems so like a true dip, is, in the opinion of Professor Ramsay, with more probability to be attributed to the deposition of the beds over an originally sloping sea-bottom of the older rocks.

All three subdivisions of the Drift are well shown at Reddish Mills, north of Stockport. The Lower Boulder Clay forms the bed of the river, and above it there are about 40 feet of Sand and Gravel, and still higher up this is covered by the Upper Boulder Clay.

The Lower Till is very well shown in the brick-yards east of Didsbury, where there occurs a few feet of dark laminated mud, on the top of which there is a bed of decomposed vegetable matter, and stems and roots of a small tree, probably the birch. This laminated mud, although but slightly distinguishable by the entire absence of pebbles or stones from the Lower Till on which it rests, Professor Ramsay in a recent visit considered as distinct from the glacial drift, and as being in reality a "warp" or river mud similar to that of the Humber. As a description of this section has been fully given in a former memoir‡ we shall not dwell longer upon it here.

Large boulders of transported rock are not plentiful in the Till, but lie scattered on the surface, sometimes high up amongst the hills. Two of these lie by the road side at Black Hill Gate, on the east side of Saltersford valley, at an elevation of 950 feet: one is composed of granite, the other of dark blue felspar trap.

E. H.

Again on How Moor, three miles south of Whaley Bridge, at a height of about 1,200 feet above the sea, is a large group of erratic blocks, of green indurated slate, blue felspar trap, and coarse syenite. A line of boulders, many of large size, runs along a valley on the east of Macclesfield, between Vale Royal and Brook House: higher up there is an outlier of sand and gravel, and doubtless the whole hollow was once filled in with this deposit, the greater part of which was afterwards cleared out by denudation, the heavier blocks alone being left behind. I also learn from Mr. Sainter, that on the south-east side

* A word to express surfaces which are worn or polished by ice, either in the form of glaciers or icebergs.

† Mr. Prestwich has described (Quar. Jour. Geol. Soc., vol. xvii., p. 446) beds of sand and gravel overlying Boulder Clay at Hull, with traces of a clay like Boulder Clay above them. These beds seem to agree very closely in character with the sand and gravel of the present country; and he mentions that "a few of the limestone blocks retain faint traces of glacial scratching."

‡ Geology of the Country around Oldham (Mem. Geol. Survey), p. 54.

of the farm-house Milking Steads, three miles north-east of Macclesfield, a patch of ground some acres in extent is thickly covered with erratic blocks of igneous and other rocks : the ground is about 1,000 feet above the sea.* But by far the finest of these erratics is a monster boulder that was dug out of the sand and gravel at Macclesfield, and now stands in the public park of that town ; it is of felspar porphyry, seven feet high and 25 feet in girth, and is estimated to weigh between 20 and 30 tons ; some of the edges are still sharp and angular, but one face is most beautifully polished, and traversed by broad shallow grooves. I also noticed a fine boulder lying in a deep wooded brook course on the east side of Cloud Hill ; it measured 8 ft. 6 in. × 6 ft. × 5 ft.

All three divisions of the Drift may be seen round Macclesfield. The Lower Boulder Clay forms the bed of the River Bollin, and its junction with the Sand above is laid open in a little brook course by the "k" of West Bank House. The Sand and Gravel has been of late very largely opened up at the works for the new cemetery. It is there made up of gravels of different degrees of coarseness, and pure clean sand, the whole showing the most irregular current-bedding. Pebbles and boulders of the following rocks were noticed by Mr. Hull and myself in these cuttings :

Hard Silurian Grit (most plentiful).
Granite, several varieties (came next in plenty).
Carboniferous Grits and Mountain Limestone.
Earthy limestone from the Yoredale beds.
Bits of coal.
New Red Sandstone.
Lower Keuper Sandstone, with carbonate of copper, from Alderley Edge.
White vein quartz.
Black Hornstone.

Some of the sand beds were crowded with broken bits of shells, and yielded good filtering material, and many perfect shells were found, a list of which is given in the Appendix. Besides shells, the workmen turned up a number of ruminant bones ; and though it was the opinion of those on the spot that these were truly embedded in the sand, Professor Huxley, to whom I showed the specimens, thought that their unaltered state was very much against such a notion. An account of these bones will be found in a letter to "The Geologist" by Mr. Sainter, vol. vi., p. 185.

It may also here be noticed that in 1862 good specimens of a lightning-tube or fulgurite were found in the sand at Macclesfield : they were described in a letter to "The Macclesfield Courier" by the late Rev. J. C. Meeke, from which the following extracts are taken.

"Some days ago, in the sand-pit, on the west of Bond-street, nigh the new brewery, two vitrified tubes were found, descending nearly in a vertical direction many feet into the sand beds. They seem not to have been discovered by the workmen till after 9 or 10 feet of the higher beds had been removed. They have been traced to the depth of about 22 feet from the top of the bank. The whole of one of them, the workmen believe, has been extracted. It narrowed at its lowest extremity almost to a point, the diameter inside not being more than a line. The internal diameter of the tubes varies from one line to seven or eight. The inner surface is smooth, glossy, and in parts beaded. Their exteriors are more or less rugged, and of a greyish colour. The sand lying immediately round the tubes is much discoloured, probably by the action of the lightning on the oxide of iron contained in the sand beds. One of the tubes, at about 18 feet down, took a bend westward, at an angle of

* See the Geologist, vol. vii., p. 56.

about 50 degrees from the horizontal line. The portion of this tube, yet undisturbed, runs under the face of the sand-bank, and cannot, at present, be traced to its termination."

The thickness of the sand and gravel at Macclesfield is not less than 100 feet.

The Upper Till is largely worked for bricks and tiles; on the Buxton Road it is sandy, with many pebbles and small angular blocks, and is used for bricks; in a pit five-eighths of a mile south of St. Paul's Church it is very stiff, reddish-brown in colour, and, with the exception of a few bits of coal, quite free from boulders or stones; here it is made into drain-tiles.

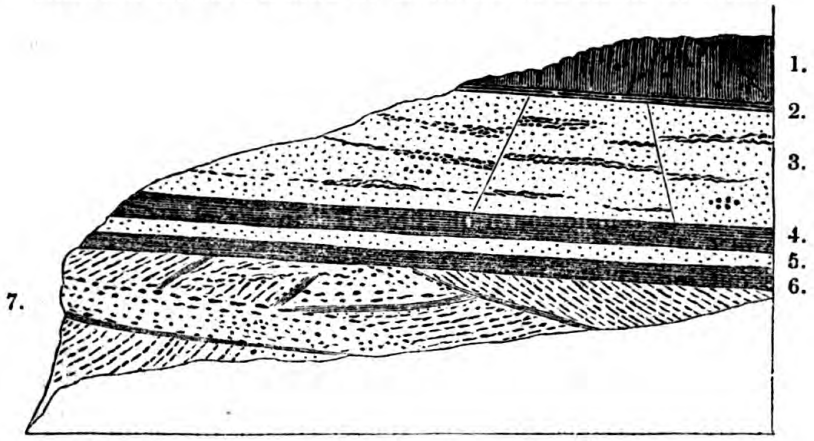
Over the broad spread of sand and gravel which lies between Macclesfield and Congleton, many little outliers of clay have been mapped as Upper Boulder Clay. If they really belong to this division, the Upper Till must rest upon a very uneven surface of sand; this we know is often the case,* but some of the clay patches may belong to the beds of clay lying in the sand; such beds I have noticed, mostly near the top of the division, at the following places:—In a pit near Prestbury, in the valley that leads up to Hareshill, where there is a bed of finely laminated loam in the sand; a quarter of a mile north-west of Mill End, Gawsworth; at the south-east corner of Cocks Moss, just above Little Hill Moor; three-quarters a mile south of Bearhurst; and at Lower Pexhill.

Near Bosley station we have an instance of the irregularity of these Drift deposits, a band of sand and gravel crops on one side of the valley capped by Upper Boulder Clay, while on the opposite side we have only the latter.

The section given in Fig. 25 shows the junction of the sand and gravel with the Upper Boulder Clay at Congleton, and here again we have clays interbedded with the sand at the top of the division.

Fig. 25.

SECTION ON SOUTH SIDE OF CONGLETON PARISH CHURCH.



	ft.	in.	
1. Stiff red clay	4	0	Upper Boulder Clay.
2. Red clay and sand interbedded	0	6	Sand and gravel.
3. Light brown soft sand, with beds of fine gravel and patches of broken coal (small faults)	7	0	
4. Dark red stratified clay	1	6	
5. Soft red sand	0	9	
6. Dark red stratified clay	1	0	
7. Fine gravel and sand, very false-bedded. Bits of shells.			

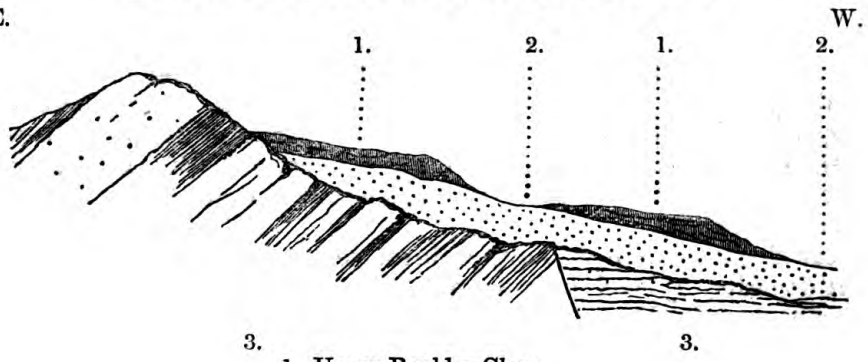
* I cannot point to any spot in the present country where the Upper Boulder Clay is *seen* resting on an eroded surface of sand; but further north Mr. Hull found many

A long strip of sand and gravel runs up the Biddulph Valley, it here rests directly on the stratified rocks, the Lower Till being absent. The sand may be seen lying on black shales near Lea Mill Forges; north of Dane-en-shaw Silk Mill the bed is about 20 feet thick, there and on the west bank of the Dane at Havannah it rests on red marl.

A patch of sand and gravel peeps out, in a rather unlooked-for way, on the west flank of Congleton Edge, near Puddle Bank. I can only account for its presence in the manner shown in Fig. 26.

Fig. 26.

SECTION SHOWING THE PROBABLE ARRANGEMENT OF THE DRIFT BETWEEN PUDDLE BANK AND BROOK HOUSE.



1. Upper Boulder Clay.
2. Sand and gravel.
3. Stratified rocks.

I add a note of the places where shells have been found in the Drift within the present district.

In an outlying patch of sand and gravel, about 3 miles from Macclesfield on the Buxton road, at a height of about 1,200 feet above the sea, Mr. Prestwich found shells, and Mr. Sainter tells me that he has collected there *Turritella, Cardium edule*, and others. A list of nine species found in this gravel by Mr. Darbishire is given in the Appendix.

In the canal cutting near Congleton railway station I found many broken bits of cockle in the Upper Boulder Clay; and further to the east, a quarter of a mile south of the "H" in Wood House, mussels in plenty, and well preserved.

In the cutting of the Biddulph Valley Railway, opposite the Dane-en-shaw Silk Mill, Professor Ramsay found broken bits of cockle; the beds are about the junction of the Upper Boulder Clay and Sand. On the same railway at Whitmore Wood I found many bits of shell, cockle (?), and a fragment of *Turritella communis*, in Upper Boulder Clay. In a lane, 16 chains north-east of Bacon House, the sand was full of broken bits of shell.

But the richest harvest of Drift shell has been yielded by the cemetery cuttings already mentioned at Macclesfield: for a list of the species, see Appendix, p. 95.

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such cases,—at Moston Hall, between Manchester and Oldham; Heyside and Chadderton Workhouse, near Oldham; near Whitefield Vicarage; and other places. See "Geology of the Country around Oldham" (Mem. Geol. Survey), p. 50, and Hull on "The Drift Deposits of the neighbourhood of Manchester;" Mems. of the Lit. and Phil. Soc. of Manchester, 3rd series, vol. ii. p. 453.

Mr. Trimmer mentions that shells have been found 3 miles north of Macclesfield on the Stockport road; 2 miles south of Macclesfield in gravelly clay; in the cutting at North Rode station; and in a pit by the Dane Viaduct, 6 miles south of Macclesfield.*

A. H. G.

River Terraces.—Old terraces of gravel, sometimes rising several in succession above the present alluvial plain of the river, occur on both banks of the Mersey below Stockport. From a position on the edge of a bluff of drift sand at the village of Heaton Mersey, an excellent view of these terraces is obtained. Three of them may be distinctly traced on the south side of the river, rising by steps of 15 or 20 feet above each other and the alluvial plain now liable to floods. That these are of fluviatile origin, and not of the age of the Drift or Post Pliocene, is proved by the fact that they frequently end off against banks of the older drift, and that their upper surfaces slope downward with the fall of the rivers.

At Underbank, on the right side of the Mersey below Stockport, three of these terraces occur. The lowest is 30 feet above the river, and is opened out in the sand pits east of Heaton Mersey Bleaching Mills; the next is 25 feet higher, and rather narrow; the third is 25 feet above the second, and is opened out in a large gravel pit by the side of Heaton Lane near Travis Brow. This terrace is about 330 yards in width at this point, and in the pit the following pebbles were found, all waterworn:

Red and grey granite.
Silurian slates.
Greenish Silurian grits.
Felspar porphyry, and porphyritic breccia.
Limestone chert.
Carboniferous grits, some like Gannister.
Concretionary ironstone.
One large yellow-coated flint.

A terrace of wider sweep and very much greater length than any of those noticed above, extends on both sides of the river from Didsbury and Cheadle, and for several miles downwards. This terrace is the most ancient in the district, and lies at an elevation of about 50 or 60 feet above the average surface of the river.† It consists of fine gravel or ochreous sand, evenly bedded, forming at its upper surface a level tract of country, which at Stretford is about 5 miles in breadth. Its margin on the north side of the river may be traced from Parr's turnpike, Didsbury, northward to Fallowfield; then westward and northward to Hulme in Manchester; and on the south side of the river from Cheadle Heath westwards, by Cheadle, Gatley, and onward to Altrincham. The sand is not often exposed to view except in the foundations of new houses; its thickness varies from 5 to 10 feet; and it generally rests on the Lower Boulder Clay.

The following section drawn from Cheadle to Didsbury is intended to show the relative position of the terraces to each other and to the River Mersey.

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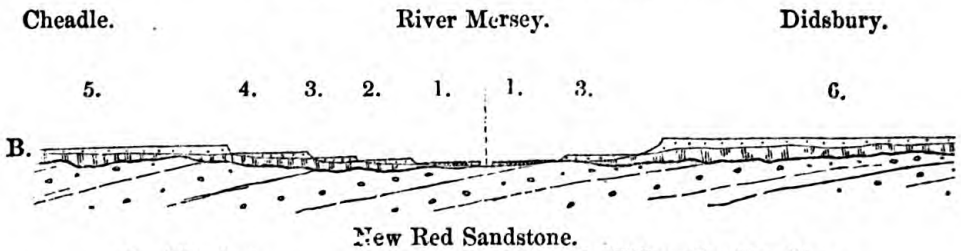
* Quar. Jour. Geol. Soc., vol. vii., p. 201.

† This terrace has been described at some length in the Memoir "On the Geology of Oldham and the Suburbs of Manchester."

FIG. 27.

SECTION ACROSS THE VALLEY OF THE MERSEY AT CHEADLE, SHOWING POSITION OF RIVER TERRACES.



1. Alluvium. B. Till or Boulder Clay.
2, 3, 4, 5, 6. Old River Terraces.

In the section (Fig. 27) the alluvial flat, which is now liable to be flooded during freshets, is marked 1. The next terrace, No. 2, on the Cheadle side, rises 12 feet above the alluvium. On this terrace Wood Farm is built, and the edge is very clearly marked by a sudden descent of a few feet. Terrace No. 3 is that on which Sir J. Watt's house is built; terrace 4 is about 10 feet above last; and the uppermost, and consequently the oldest terrace, is marked by a rise of 20 feet above No. 4. On this terrace Cheadle is built, and the gravel of which it is formed may be seen in a pit near the centre of the village: it rests in some places on Lower Boulder Clay (B) or on New Red Sandstone.

On the north side of the river at this point one terrace, which seems to occupy the level of No. 3 on the south side, is apparent. The highest terrace (6) is on the same level as that at Cheadle, and rests on a floor of Boulder Clay.

E. H.

We again meet with terraces of river-gravel, like those just described, but on a smaller scale, in the valley of the River Dane. Westwards from the North Rode viaduct the river winds from side to side of a flat of an average breadth of a quarter of a mile, on each side of which rise hills of red marl capped by Drift Sand and Gravel. This flat, which is now never flooded by the river, is covered by a few feet of sandy gravel, and shows here and there traces of two or three terraces. The river runs in a deep channel cut through this old alluvium well down into the red marl below. The pebbles in the gravel are of all sizes up to that of a man's fist, and there are sometimes beds of sand: the gravel is at times stratified, but is oftener just such a rude tumbled mass of pebbles and boulders as now lies in the bed of the river; it has doubtless been formed mainly from the waste of the Drift Sand and Gravel. As this gravel rests on red marl, without any trace of Boulder beds between, it is likely that the valley of the Dane has been greatly deepened since the Drift period.

We will now point out the spots where the terraces are most distinctly shown.

At North Rode viaduct there is a terrace on the south bank about 15 feet above the present alluvial flat, with faint traces of a corresponding ledge on the opposite side. At the edge of this terrace, which is not very broad, we pass by a well marked step of about 8 feet on to another which reaches up to the canal. This latter is covered by coarse gravel rudely stratified, the pebbles all lying on their flat sides and

embedded in sand. There is no corresponding higher terrace on the north bank.

Between the Congleton and Macclesfield road and Hags Wood, the south bank of the river is formed by a cliff of red marl about 50 feet high, on the top of which is a broad flat covered by about 8 feet of river gravel. On the opposite bank is a terrace very slightly raised above the river, which runs on to Havannah, where there are traces of one or two higher ledges.

Between Havannah and Congleton, and onwards as far as Forge Wood, a double terrace may be clearly traced along the south side of the valley: the steps are best marked between Buglawton and Congleton,* for below the town a great part of the upper terrace has been carried away, and only patches of the gravel of which it was made up are left to show that it was once there.

Below Congleton, on the north-east side of the valley, a pair of terraces, corresponding to the two just described, may be made out, but they have been much cut up by river-denudation. We soon, however, come on a broad well-marked flat about 15 or 20 feet above the river, with here and there a ledge some 10 feet lower: these run on to the edge of the map.

On the west and south-west of Macclesfield the ground is often covered with peat, which may be traced up to the large bog of Dane's Moss; and clayey deposits which seem to have been formed by the Bollin and its tributary brooks.

The ground is a good deal covered by buildings, and sections are scarce, but the following was laid open near St. George's Church after I had left the town, and a copy of it sent to me by Mr. Sainter.

	feet.
Gravel - - - - - - -	3
Peat - - - - - - - -	2
Dark brown laminated sand (Warp?) - - -	3
Boulder Clay.	

Little terraces of gravel, sand, and clay, are often to be found in the brook courses, and though too small to allow of their being marked on the map, are worth notice, as showing that the stream flowed formerly at a higher level than now, and may be with a larger body of water, and that it has gradually eaten its way lower and lower, cutting through its old alluvium, and even down into the solid rock below. A good case of such a terrace may be seen in the brook that runs beside Hollin Lane, Macclesfield, just above Spout House. It shows some six or eight feet of bedded gravel, sand, and red marly clay, resting on the Crowstone and shales which now form the bed of the brook.

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* See Mr. Trimmer's paper (already quoted at p. 79), Quar. Jour. Geol. Soc., vol. vii., p. 204., where these beds are described as "reconstructed gravels." In Mr. Trimmer's section the "Upper Boulder Clay" and "Sand and Gravel" are also distinguished.

CHAPTER V.

Miscellaneous.

A few general statements, and one or two matters that do not fall under any of the former headings, have been kept for this last chapter.

Yoredale Rocks—Of the three gronps into which these beds were divided, the uppermost is marked by a sandstone bed, which has been called the Yoredale Grit. This bed is most striking in the north of our district, and around the Peak, a little to the east of the present country, reaches a thickness of at least 500 feet: it falls off, however, very rapidly, and at last dies out a little to the south-west of a line joining Leek and Macclesfield.

It was mentioned that each of the two lowest groups of the Yoredale rocks seems to reach a thickness of 2,000 feet. But this estimate must be taken with great caution; it rests on the measured section, Sheet 42, of the Geological Survey, and as the country this section crosses does not give anything like an unbroken view of the rocks along the whole of its line, there may well be faults or rolls unknown, repeating the beds and exaggerating their thickness. Still, no such disturbances have been detected, and the estimate may, therefore, be sound. Also, we have nowhere the entire series in one section, and it may be that one group may swell out locally at the expense of the other; there is, however, no reason to think that this is the case.* Till we can form some trustworthy estimate of the thickness of the Yoredale Beds, any attempt to calculate the probable depth of the Mountain Limestone in the deep valleys, such as those round the Peak and the Saltersford valley, can be only the vaguest guesswork.

Of course we cannot at present fully correlate the Yoredale Beds of Staffordshire and Derbyshire with the Yorkshire type of that formation, as described by Prof. Phillips; but I give the following hints in hopes that they may aid the solution of the problem.

We may first compare our section with that given on Ingleborough; the latter is as follows:

Section on Ingleborough.	ft.	Probable equivalents in Derbyshire and Staffordshire.
1. Coarse grit and conglomerate.		Kinder Scout Grit.
2. Dark sandy shale - -	150	Shales, 1*a*. in section on p. 17.
3. Grey encrinital limestone (The Main Limestone) -	40	Wanting.
4. Sandstone, massive and flaggy, with shale beds	150 to 200	Yoredale Grit.
5. Gap, with no section -	225	Perhaps shales, 1*c*. in section on p. 17.
6. Dark shales and sandstones, with two or more beds of limestone -	500	Yoredale Sandstones.
Mountain Limestone -	600	

* Since the above was written I have measured very carefully the section at Pendle Hill, near Clitheroe, and find there 3,700 feet of measures between the base of the Yoredale Grit, which caps the hill, and the top of the Mountain Limestone; so that, after all, my figures may not be far from the truth.

Passing on northwards to Wensleydale, we find the Yoredale series, as described by Professor Phillips, to be there as follows :*

Section in Wensleydale (Phillips).			Probable Derbyshire equivalents.
		feet.	
Cam or Upper Scar Limestone	Main Limestone	70	Wanting.
	Laminated Grit, Plate with ironstone and coal	80	Yoredale Grit.
	Underset Limestone	30	Wanting.
Hawes Flagstone Group	Laminated Grit, Flagstone, Plate and Grit, Strong Gritstone, Plate and Grit, Impure productal Limestone, Plate and coal	350	Yoredale Sandstones.
	Middle Limestone	30	
	Strong Gritstone, Flagstone, Gritstone, Laminated Grits and plates	150	
	Simonside Limestone	20	
Black Limestone Group.	Flagstone, Plate, Grit, Plate	100	Black shales, with thin earthy limestones?
	Hardrow Limestone	40	
	Gritstone, Plate and Ironstone	100	

Assuming that the sandstone bed, No. 4 on the Ingleborough section, represents the Yoredale Grit, it follows that the Laminated Grit below the Main Limestone in Wensleydale is the equivalent of the same bed, for they both lie immediately below the Main Limestone.

The sandstones in the beds marked No. 6 on the Ingleborough section, and in the Hawes Flagstone Group of Wensleydale, are hard, fine-grained, and very siliceous, and have sometimes a calcareous cement : they agree so closely in all these particulars with the Yoredale sandstones of our present country, that I venture to think they will turn out to be the true equivalents of these latter beds. Of the interbedded limestones there is no trace in Derbyshire and Staffordshire, but we do find calcareous sandstones among the middle Yoredale beds of those counties ; whence it would seem likely that in one case there was a plentiful and in the other a spare supply of carbonate of lime, but that in other respects the two agree fairly well.

The black shales and limestones at the bottom of the Derbyshire and Staffordshire Yoredale Group seem to be wanting or feebly represented under Ingleborough : they may be the equivalents of the Black Limestone Group of Wensleydale, or of the lower part of it ; but I have seen too little of the latter beds to hazard an opinion.

Millstone Grit.—The gradual thinning away of this formation to the south-west has been already mentioned in the course of this memoir.

* Geology of Yorkshire, vol. ii., p. 37.

We will now give shortly the history of each bed from its full developement in the north till it either dies away or is covered up by the New Red Sandstone on the south. The set of comparative sections in Fig. 28. is intended to show the changes in the Gritstone series ; we there see that the *Rough Rock* or topmost bed keeps pretty much the same thickness of from 80 to 100 feet throughout, though at New Mills it swells out locally to fully 200 feet : it is also for the most part coarse and massive as far south as the latitude of Leek, but beyond that line becomes finer, and round the edges of the Cheadle Coal-field and about Bagnall is a soft red sandstone : at Wetley Rocks, though not very coarse, it somewhat recovers itself, and forms bold massive cliffs.

The *Haslingden Flags*, or *second Grit*, run on with very much the same character, and with a thickness of 100 to 140 feet, till about five miles south-west of Buxton, where they die out somewhat suddenly. (See p. 52.)

The little coal lying at the base of the shales between the second and third Grits is one of the most persistent beds of the series, and is found here and there over the whole district. Its average thickness is about one foot, but it swells out to four feet six inches near Buxton, and is found four feet thick on Congleton Edge.

The *Third Grit* is present over the whole of the district. In the extreme north it is about 400 feet in thickness, coarse and massive. It shows some signs of weakness near Whaley Bridge, where for a time it seems to pass into a flaggy sandstone, but it soon returns to its old form, and though it comes down to about 140 feet in thickness near Buxton, it is a very striking mass of gritstone and conglomerate, with bold escarpments on each side of the Goyt Trough, as far south as The Roaches.

It lessens in thickness in the same way on the west side of the Anticlinal Fault, and is about 100 feet thick round Macclesfield, and for the most part not very coarse.

On either side of the Biddulph Trough, in Rudyerd Basin and round the edges of the Cheadle Coal-field this bed is very changeable ; sometimes a coarse and massive grit making good escarpments, as at Cloud Hill, north of Cheddleton, and about Foxt; at others a soft fine red sandstone, making no feature. Its thickness is about 100 feet, but at Wetley Farm, as already mentioned, it seems to have dwindled down to about 20, and to be on the point of dying out altogether. In spite of all these changes this bed keeps more than any other a certain massiveness of structure to the last.

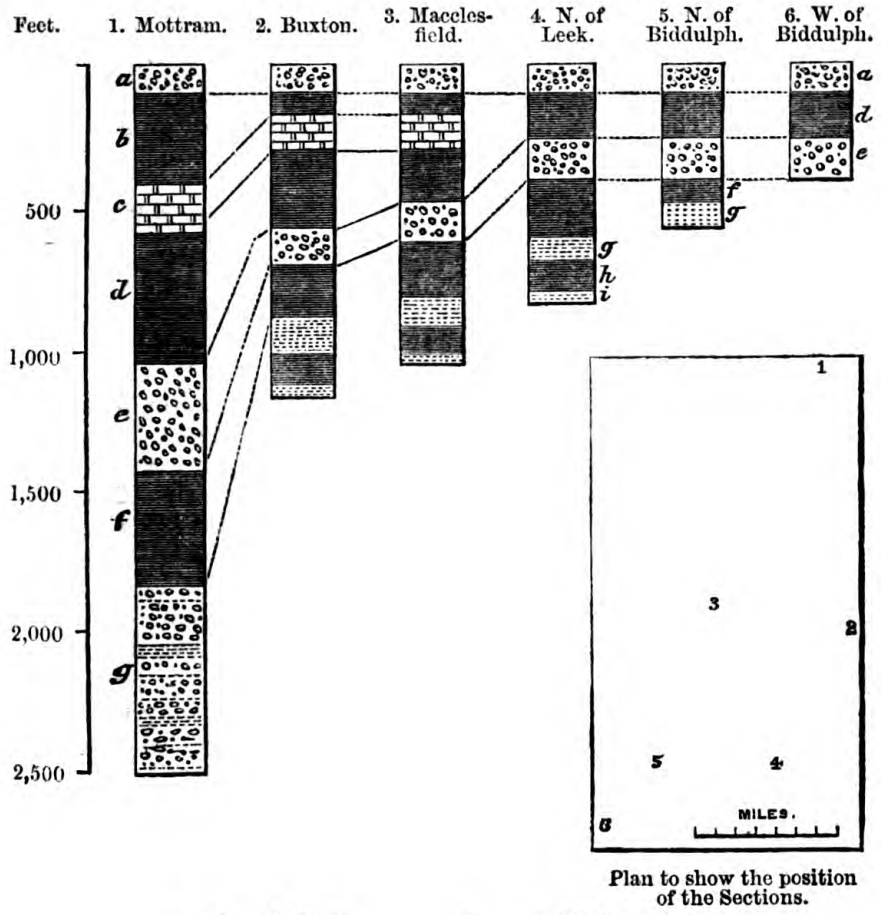
The *Fourth* or *Kinder Scout Grit* shows much more striking changes than any yet noticed. It is in the north a very coarse, massive gritstone and conglomerate, in two beds parted by shale, and reaches a thickness of 800, and here and there, perhaps, 1,000 feet. Thus we see it about Hayfield, but before reaching Chapel-en-le-Frith it has already fallen off greatly both in thickness and character. It next comes out to-day round the flanks of Combs Moss, and on either side of the Saltersford valley, and here is represented by two grit beds, which we have called the fourth and fifth grits, parted by shale. The grits are neither of them very coarse, and the thichness of the whole group is not more than 300 feet, This is the form which it keeps over the whole of the rest of the district.

The fourth is a very changeable bed, sometimes a crumbly red grit, as on Axe Edge ; sometimes a very close-grained, fine gritstone, as beneath The Roaches and at Rudyerd ; and sometimes a flaggy sandstone : it is not seen in the Goyt Trough south of Bramcott, and we

have already mentioned that it thins away step by step till at last it dies out altogether in the Biddulph and Rudyerd Basins. The fifth bed seems to die out somewhat earlier than the fourth. The thick mass of the Kinder Scout Grit therefore disappears entirely before the southern boundary of the country we have been describing.

Fig. 28.

COMPARATIVE SECTIONS OF THE MILLSTONE GRIT.



Plan to show the position of the Sections.

a. Rough Rock.
b. Shales.
c. Second Grit.
d. Shales.
e. Third Grit.
f. Shales.

In Fig. 1.

g. Kinder Scout Grit.

In Figs. 2–6.

g. Fourth Grit.
h. Shales.
i. Fifth Grit.
} Equivalents of the Kinder Scout Grit.

One point more calls for notice. On the top of each of the Grit beds there are traces, more or less distinct, of coal. The Feather-edge Coal lies on the Rough Rock ; there is a little coal on the top of the Second Grit near Buxton ; a coal lies very frequently on the top of the Third Grit ; we have no coal on the top of the Fourth Grit in the present country, but thin seams, accompanied by Gannister or Gannister-like rock, are found on that horizon in Lancashire. The rough,

thick-bedded grits, and the finely laminated shales that lie between them, must of course have been deposited under very different circumstances; and these coal-beds seem to point out that in the intervals during which these changes were being brought about, each grit-bed became for a time a land surface.

Coal-measures.—It may be worth while to see how far the Coal-measures of North Staffordshire agree with the Lancashire type. The general section of the Lower Coal-measures of Lancashire is as follows:

1. Flags of Rochdale and Upholland.
2. Shales and micaceous sandstones, with a group of four or five thin coals. The roofs of the coals contain a well-marked group of marine fossils. The coals have Gannister floors, notably in one case, and here and there in others.
3. Shales with a thick sandstone bed, known as the Woodhead Hill Rock.
4. The Feather-edge Coal, resting directly on the Rough Rock.

This type prevails throughout the belt of Coal-measures running down from Hyde to Macclesfield, as indeed it ought, for this is nothing but a limb of the Lancashire Coal-field.

It can also be very clearly traced in the little coal-basins of the Goyt Trough as far south as Goldsitch. In the Cheadle Basin the hæmatite of Froghall takes the place of the Feather-edge Coal, but the Woodhead Hill Rock* and the thin coals with their marine fossils (No. 2.) are found. We may say then that upon the whole the Lower Coal-measures of the Goyt Trough agree well with those of Lancashire.

Between the measures of the Pottery Coal-field and those of Lancashire there is a general family likeness, but when we come to details the two do not agree very well. In both we have in the upper part red and purple clays with limestone yielding *Spirorbis carbonarius*.† In the middle measures I do not know that any one has been able to identify the coal seams of the two fields, but marine fossils have been discovered, upon about the same horizon as those of Ashton-under-Lyne,‡ by Mr. J. Ward, in the bass above the Bay Coal and in the Priorsfield bass of the Pottery district; the species, however, in the two cases are for the most part different.§ We have in the Pottery Coal-field no trace of the Upholland Flags of Lancashire, and it is therefore not easy to say where the line between the Middle and Lower Measures is to be drawn. The lower coals of Wetley Moor and Biddulph have the same fossils in their roofs as those of Lancashire, but they do not agree in number and place with the latter. Lastly, low down in the measures is a thick sandstone bed which holds about the same place as the Woodhead Hill Rock of Lancashire, and may represent it.

Before laying down my pen, I would wish to point out how well the country we have been describing is suited for observing the important part which atmospheric and river action must have played in bringing

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* See a paper by Mr. E. W. Binney, Lit. and Philos. Soc. of Manchester, vol. xii., p. 34.

† Iron Ores of Great Britain (Mem. Geol. Survey), Part IV., p. 259. The bed was also pointed out to me by Mr. J. Ward, of Longton.

‡ Geology of the Country around Oldham (Mem. Geol. Survey), p. 64.

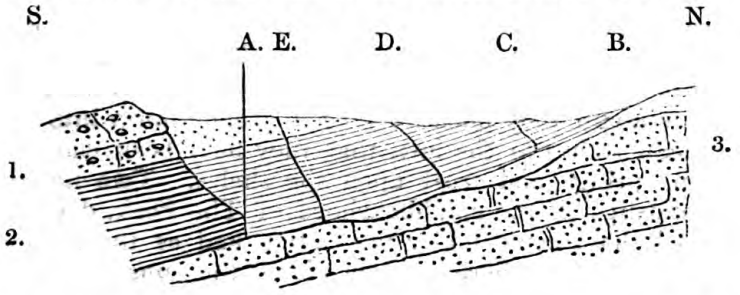
§ For a list of these fossils, see Appendix, p. 94.

about the present shape of the ground. No one who marks well the work done by the brooks every winter, will hesitate to allow that they alone are quite able, if time enough be given, to have scooped out the greater part, if not the whole, of the present valleys.

The plan of these memoirs does not allow of a full discussion of this very interesting subject, and I shall therefore only point out one way in which the action of a small brook may have hollowed out a very wide as well as deep valley. The woodcut, fig 29., is a section across Ashop Clough on the north side of the High Peak ;* and this case is chosen because it shows in a more marked way than any valley in our own immediate district that I can think of, the mode of action which I fancy has been the cause of very many other valleys throughout the country.

Fig. 29.

SECTION ACROSS THE VALLEY OF ASHOP CLOUGH.



The darker part represents the surface and position of the rocks at the present day. No. 1 is a bed of gritstone resting on the shales No. 2, below which there lies a thick sandstone bed, No. 3. The brook now flows for some distance over the top of the sandstone bed, as at A, with a steep cliff of shale on the south side, which it is daily undermining and wearing further back. Now suppose that the faint line at the top of the figure is the nearly level surface which would result from long-lasting marine denudation, and that a brook ran parallel to the course of the present one through B. ; this brook would cut down through the shales till it reached the top of the sandstone, No. 3, the hardness of which would prevent its cutting any deeper ; it would then attack the little cliff of shale on its south bank, undermining and eating it back, and so step by step wearing its way and shifting its channel further to the south till it came into its present position, having in the mean time flowed in turn at the foot of a succession of such cliffs as C, D, and E. At the same time rain, frost, and the action of the air will vastly aid the stream in its work of destruction, by loosening masses of rock from the face of the cliff, which falling into the brook will be ground down and carried away by the running water.

Moreover, when this process had gone on for some time, and the valley had been so far enlarged as greatly to increase the volume of water in the brook, the latter might gain strength enough to cut down into the sandstone bed ; and once there it would eat out a deep narrow ravine, for the sandstone, unlike the shale, would form solid cliffs able to hold out against the action of the weather ; and not easily undermined. In this way, I think, we may account for the curious

* In Map 81 N.E.

behaviour of several streams, which seem to have chosen to cut a deep narrow channel through solid grit beds, rather than through a band of more easily worked shales lying hard by.

A kindred subject is that of landslips, which call for a passing notice.

It often happens, when a steep cliff or hill side of shale is capped by solid rock, that the former has been undermined, and has given way beneath the weight of the overlying rock, huge masses of which have slid down into the valley beneath, sometimes with so much regularity that each bed in the cliff above can be clearly traced in the mound below, and it sometimes looks as if these tumbled lumps could be lifted up and fitted back again into the hollow they have left, so little broken are they by their fall. With respect to the cause which brought about these slips, my colleague Mr. Hull writes to me : "My own impression "with respect to some of them at least is, that they occurred when the "latest waters of the glacial sea were retiring, and when, by their "power in undermining the rock-capped banks, such slips, at that "time coast slips, were more likely to take place on a large scale "than at a later period." I think the unbroken state of many of the slipped masses is against this notion, for if they had lain for long at the foot of a sea cliff they must have been ground down into mud and shingle. I lean rather to the idea that they have been caused by the action of rain, springs, and frost upon the shales. Two instances of very large landslips in the neighbourhood of The Peak, dating only a few years back, have come under my notice, and as these have been brought about by atmospheric agency alone, the same may have been the case with all.

The finest landslip in our district is at Coombs Edge, near Glossop. The following account of it is from the note-book of Mr. Hull :— "This hill, which rises to a height of 1,356 feet, is of a horse-shoe "form, and being capped by Millstone Grit presents a mural escarp- "ment on both sides. On the inner side the flanks are covered with "landslips, which near the centre of the curve assume an outline of wonderful regularity, like a series of small escarpments repeated by faults, all nearly of the same form."

A. H. G.

APPENDIX ON THE FOSSILS.

Mountain Limestone.

The following list of fossils from the Mountain Limestone of Staffordshire is reprinted, with the author's permission, from a chapter on the Geology of the neighbourhood of Leek contributed by Mr. T. Wardle to "The Ancient History of Leek by Mr. J. Sleigh" (Leek, R. Nall, 1863).

The whole has been revised by Mr. Etheridge, and some extra-British species, which are given on the authority of Mr. Wardle's list alone, are marked thus ×.

Sub-Kingdom, **ANNULOSA.**
Province - ARTICULATA.
Class - - Crustacea.

Brachymetopus Ouralicus (?), De Vern.
Griffithides globiceps, Portlock.
Phillipsia Brogniartii, Fischer.
P. Derbiensis, Martin.
P. pustulata, Schloth.
P. seminifera, Phil.
Cyclus radialis, De Kon.

Province - ANNULATA.
Class - - Annelida.

Serpula parallela, McCoy.

Province - ANNULOIDA.
Class - - Echinodermata.

Platycrinus lævis, Miller.
P. ellipticus, Phillips.
Pentremites Derbiensis, Phillips.

Sub-Kingdom, **MOLLUSCA.**
Province 1. - ODONTOPHORA.
Class - - Cephalopoda.

Nautilus biangulatus, Sow.
N. bistrialis, Phil.
N. cariniferus, Sow.
N. costalis, Phil.
N. dorsalis, Phil.
× *N. Edwardsianus*, De Kon.
N. globatus, Sow.
N. ingens, Martin.
N. Luidii, Martin.
N. multicarinatus, Sow.
N. triangulatus, Sow.
N. tuberculatus, Sow.
Discites hexagonus, De Kon.
D. subsulcatus, Phil.
D. sulcatus, Phil.
D. tetragonus, Phil.
Orthoceras arcuatum, Phil.
O. Breynii, Martin.
O. cinctum, Sow.
O. dactyliophorum, De Kon.
O. filiferum, Phil.
O. fusiforme, Phil.
O. Goldfussianum, De Kon.
O. inæquiseptum, Phil.
O. lineolatum, Phil.
O. reticulatum, Phil.
O. subcaniculatum, De Kon.
O. undulatum, Sow.
O. unguis, Phil.
Gomphoceras.
Cyrtoceras annulatum, Phil.
C. Gesneri, Martin.
× *Gyroceras serratum*, De Kon.
Goniatites calix, Phil.
G. crenistria, Phil.
G. excavatus, Phil.
G. Gilbertsoni, Phil.
G. Henslowi, Phil.
G. implicatus, Phil.
G. intercostalis, Phil.
G. Looneyi, Phil.
G. nitidus, Phil.
G. obtusus, Phil.
G. reticulatus, Phil.
G. rotiformis, Phil.
G. spirorbis, Phil.
G. sphæricus, Phil.
G. striatus, Phil.
G. truncatus, Phil.

Class, PTEROPODA.

Conularia quadrisulcata, Sow.

Class, GASTEROPODA.

Natica ampliata, Phil.
N. elliptica, Phil.
N. lirata, Phil.
N. plicistria, Phil.
N. spirata, Sow.
N. tabulata, Phil.
N. variata, Phil.
Eulima Phillipsiana, De Kon.
Loxonema constricta, Sow.
L. rugifera, Phil.
L. scalaroidea, Phil.
L. sulculosa, Phil.
L. tumida, Phil.
Macrocheilus acutus, Sow.
M. curvilineus, Phil.
M. globularis, Phil.
M. imbricatus, Phil.
M. rectilineus, Phil.
M. sigmalineus, Phil.
Turritella spiralis, Phil.
T. suturalis, Phil.
T. tenuistriata, Phil.
Turbo biserialis, Phil.
T. semisulcatus, Phil.
× *Trochus Hisingerianus*, De Kon.
T. Yvanii, Lev.
Euomphalus acutus, Sow.
E. æqualis, Sow.
E. calyx, Phil.
E. catillus, Sow.
E. depressus, Sow.
E. Dionysii, Goldf.
E. pentangulatus, Phil.
E. pileopsideus, Phil.
E. pugilis, Phil.
E. tabulatus, Phil.
Phanerotinus cristatus, Sow.
P. nudus, Sow.
Platyschisma glabrata, Phil.
P. helicoides, Sow.
P. ovoidea, Phil.
P. tiara, Sow.
Pleurotomaria abdita, Phil.
P. atomaria, Phil.
P. biserrata, Phil.
P. conica, Phil.
× *P. Eliana*, De Kon.
P. excavata, Phil.
P. limbata, Phil.
P. monolifera, Phil.
× *P. Murchisonia*, D'Arch.
P. rotundata, Sow.
P. spiralis, Phil.
P. strialis, Phil.
P. striata, Sow.
× *P. tæniata*, De Dern.
P. tornatilis, Phil.
P. tumida, Phil.
P. vittata, Phil.
Capulus angustus, Phil.
C. neritoides, Phil.
C. trilobatus, Phil.
C. tubifer, Phil.
C. vetustus, Phil.
Metoptoma elliptica, Phil.
M. oblonga, Phil.
M. pileus, Phil.
Patella curvata, Phil.
P. mucronata, Phil.
P. retrorsa, Phil.
P. scutiformis, Phil.
P. sinuosa, Phil.
Dentalium priscum, Goldf.
Porcelia Woodwardii, Sow.
Bellerophon apertus, Sow.
B. cornu-arietis, Sow.
B. costatus, Sow.
B. Ferussaci, D'Orb.
B. hiulcus, Sow.
B. tenuifascia, Sow.
B. Urii, Flem.

Province 2. LAMELLIBRANCHIATA.

Ostrea.
Avicula cycloptera, Phil.
A. laminosa, Phil,
A. lunubata, Phil.
A. radialis, Phil.
A. squamosa, Phil.
Posidonomya vetusta, Sow.
× *P. Becheri*, Goldf.
Aviculopecten arenosus, Phil.
× *A. Bosquetianus*, De Kon.
A. deornatvs, Phil.
A. dissimilis, Flem.
A. Dumontianus, (*var.*) De Kon.
A. ellipticus, Phil.
A. fimbriatus, (*var.*) Phil.
A. interstitialis, Phil.
A. plicatus, Phil.
A. simplex, De Kon.
A. stellaris, Phil.
A. sublobatus, Phil.
A. tesselatus, Phil.
× *A. villanus*, De Kon.
Gervillia inconspicua, Phil.
Pinna flabelliformis, Martin.
P. spatula, McCoy.
Mytilus.
Myalina gryphus, Portl.
M. lamellosa, De Kon.
Modiola elongata, Phil.
M. granulosa, Phil.
M. lingualis, Phil.
M. squamifera, Phil.
Arca cancellata, Martin.
Cucullæa arguta, Phil.
× *C. McCoyana*, De Kon.
× *C. Kaimæana*, De Kon.
Ctenodonta cuneata, Phil.
C. gibbosa, Flem.

C. undulata, Phil.
× *Solemya abbreviata*, Ryk.
× *S. parallela*, Ryk.
S. primæva, Phil.
Axinus axiniformis, Phil.
Dolabra (?) securiformis, McCoy.
Conocardium aliforme, Sow.
C. armatum, Phil.
C. minax, Phil.
C. rostratum, Mart.
C. trigonale, Phil.
Cypricardia ylabrata, Phil.
C. parallela, Phil.
C. rhombea, Phil.
C. trapezoidialis, De Kon.
Sanguinolites angustatus, Phil.
S. arcuatus, Phil.
S. oblongus, McCoy.
S. tricostatus, De Kon.
Myacites gibbosa, Sow.
M. tumida, Phil.
Cardiomorpha oblonga, Sow.
Cardiomorpha lamellosa, De Kon.
C. laminata, Phil.
× *C. striata*, De Kon.
× *C. sulcata*, De Kon.
Edmondia uniformis, Phil.
Edmondia sulcata, Phil.

Province 3. MOLLUSCOIDA.

Class - BRACHIOPODA.

Terebratula hastata, Sow.
T. sacculus, Martin.
T. vesicularis, De Kon.
Athyris ambigua, Sow.
A. Carringtoniana, Davidson.
A. expansa, Phil.
A. globularis, Phil.
A. lamellosa, Lév.
A. planosulcata, Phil.
A. Royssii, McCoy.
A. subtilita, Hall.
Retzia radialis, Phil.
R. ulotrix, De Kon.
Spirifera Carlukiensis, Davidson.
S. convoluta, Phil.
S. cristata, Sow.
S. cuspidata, Martin.
S. distans, Sow.
S. duplicostata, Phil.
S. elliptica, Phil.
S. glabra, Martin.
Do., var. *linguifera*, Phil.
Do., var. *decora*, Phil.
S. insculpta, Phil.
S. integricosta, Phil.
S. lineata, Martin.
Do., var. *reticula*, Phil.
S. ovalis, Phil.
S. pinguis, var. *rotundata*, Sow.
S. planata, Phil.
S. rhomboidea, Phil.
S. striata, Martin.
S. subconica, Martin.
S. triangularis, Martin.
S. trigonalis, Martin.
S. triradialis, Phil.
S. Urii, Flem.
Spiriferina laminosa, McCoy.
Cyrtina septosa, Phil.
Rhynchonella acuminata, Martin.
R. angulata, Linnæus.
R. Carringtoniana, Davidson.
R. cordiformis, Sow.
R. flexistria, Phil.
R. gregaria, McCoy.
R. pleurodon, Phil.
R. pugnus, Martin.
R. reniformis, Sow.
R. trilatera, De Kon.
R. Wettoniensis, Davidson.
Camarophoria crumena, Martin.
C. globulina, Phil.
Orthis Keyserlingiana, De Kon.
O. Michelini, Lév.
O. resupinata, Dalman.
Strophomena analoga, Phil.
Streptorhyncus crenistria, Phil.
Do., var. *Kellii*, McCoy.
S. radialis, Phil.
Productus aculeatus, Martin.
P. Carringtonianus, Davidson.
P. cora, D'Orb.
P. costatus, Sow.
P. ermineus, De Kon.
P. fimbriatus, Sow.
P. giganteus, Martin.
P. humerosus, Sow.
P. Keyserlingianus, De Kon.
P. Koninckianus, De Derneuil.
P. latissimus, Sow.
P. longispinus, Sow.
P. margaritaceus, Phil.
P. mesolobus, Phil.
P. plicatilis, Sow.
P. proboscideus, De Verneuil.
P. punctatus, Martin.
P. pustulosus, Phil.
P. scabriculus, Sow.
P. semireticulatus, Martin.
P. sinuatus, De Kon.
P. spinulosus, Sow.
P. striatus, Fischer.
P. sublævis, De Kon.
P. tesselatus, De Kon.
P. undatus, Defrance.
P. Wrightii, Davidson.
P. Youngianus, Davidson.
Chonetes Buchiana, De Kon.
× *C. Dalmaniana*, De Kon.
C. Hardrensis, Phil.
C. papilionacea, Phil.
Discina nitida, Phil.
Lingula mytiloides, Sow.
L. squamiformis, Phil.
Crania quadrata, McCoy.

Class, POLYZOA.

Glauconome anceps, Schloth.
G. bipinnata, Phil.
G. pluma, Phil.
Fenestella flabellata, Phil.
F. irregularis, Phil.
F. membranacea, Phil.
F. nodulosa, Phil.
F. tenuifila, Phil.
F. undulata, Phil.
Sulcoretepora parallela, Phil.
Ptylopora flustriformis, Phil.
Polypora laxa, Phil.
P. polyporata, Phil.
Ceriopora rhombifera, Phil.
Pustulopora oculata, Phil.
P. spicularis, Phil.

Sub-Kingdom, **CŒLENTERATA.**

Class - - ACTINOZOA.

Columnaria (*Beaumontia*) *laxa*, McCoy.
Favosites incrustans, Phil.
F. parasitica, McCoy.
Alveolites depressa, M. Edw. & J. Haime.
A. septosa, Hem.
Chætetes tumidus, M. Edw. & J. Haime.
Michelina tenuisepta, De Kon.
Syringopora geniculata, Phil.
S. laxa, Phil.
S. ramulosa, Goldf.
Cyathaxonia cornu, Michelin.
Cyathophyllum regium, Phil.
C. Stuckburyii, M. Edw.
C. Wrightii, M. Edw. & J. Haime.
Amplexus caralloides, Sow.
A. cornu-bovis, Michelin.
A. spinosus, De Kon.
Lithostrotion affine, M. Edw. & J. Haime.
L. basaltiforme, M. Edw. & J. Haime.
L. irregulare, M. Edw. & J. Haime.
L. junceum, M. Edw. & J. Haime.
L. Martini, M. Edw. & J. Haime.
L. Portlockii, M. Edw. & J. Haime.
Zaphrentis cornucopiæ, M. Edw. & J. Haime.

A list of fossils from the Mountain Limestone in the valley of the river Dove, near Longnor, will be found on page 6 of the explanation of the Horizontal Section, No. 57, of the Geological Survey. Park Hill and Chrome Hill, about two miles N.N.W. of Longnor, are very rich localities.

YOREDALE ROCKS.

The species in the following list were determined by Mr. Etheridge, with the exception of those marked S., which were named by Mr. Salter.

Yoredale Grit. 1 *b*. in the section on p. 17.	*Calamites Sigillaria*, and other Plants.	Quarries on Leek Waste.
	Plants (S.) - - - -	Tittersworth Reservoir, near Leek.*
	Goniatites - - - -	Bearda Mill, near Leek.†
	G. excavatus (S.), Phil. - -	Tittersworth Reservoir, near Leek.* Brook west of Barley Ford, Bosley.‡
	G. obtusus, Phil. - - -	Congleton Edge.§
	G. reticulatus, Phil. - - -	Brook west of Barley Ford, Bosley.‡
	G. striatus, Sow. - - -	Congleton Edge.§
	G. truncatus (S.), Phil. - -	Brook west of Barley Ford, Bosley.‡ Tittersworth Reservoir, near Leek.*
Beds below the Yoredale Grit, 1 *c*. in the section on p. 17.	*Macrocheilus ?* sp. - - -	Congleton Edge.§
	Aviculo pecten papyraceus, Goldf.	Bearda Mill, near Leek.†
	———— *alternatus*, McCoy	S.W. of Wood Hay, near Congleton.§
	———— *fibrillosus*, Salter -	
	Ctenodonta gibbosa, Flem. -	Congleton Edge.§
	Inoceramus - - - -	S.W. of Wood Hay, near Congleton.§
	Modiola (S.) - - - -	Tittersworth Reservoir, Leek.*
	Myalina - - - - -	Brook W. of Barley Ford, Bosley.‡ S.W. of Wood Hay, Congleton.§
	Chonetes tuberculata, McCoy -	Congleton Edge.§
	Discina nitida, Phil. - -	
	Productus longispinus, Sow. -	
	———— *semireticulatus*, Mart.	
	Streptorhynchus crenistria, Phil.	

* See p. 55. † See p. 54. ‡ See p. 67. § See p. 72.

Yoredale Sandstones.	*Calamites*, and other Plants.	Gun Hill, near Leek.
Black shales and thin limestones.	Branched fucoids (S.) -	Quarry half a mile W. of Over Acre. Mixon.*
	Aviculopecten papyraceus ? -	Near Mixon.

* The lowest group of the Yoredale Rocks is for the most part very barren of fossils. This quarry, I think, deserves further search.

The exact place in the series of the following fossils is doubtful, so I place them by themselves. The localities were pointed out to me by Mr. Wardle, and the species determined by Mr. Salter.

Goniatites bilinguis, Salter - - -	Felt House Wood, 4 miles S. by W. from Leek; in sinkings for ironstone.
G. excavatus, (?) Phil. - - - -	Do.
G. micronatus (?) - - - -	The Combes, 3 miles S.S.E. of Leek.
G. reticulatus, Phil. - - - -	Do., and Felt House Wood.
G., large sp. - - - - -	Felt House Wood.
G., sp. - - - - - -	The Combes.*
Orthoceras cinctum, Sow. - - -	Do.
Nautilus subsulcatus - - - -	Do.
Anthracoptera - - - - -	Do.
Aviculopecten papyraceus, Goldf.† - -	Do.
Cardiomorpha † - - - - -	Do.
Ctenodonta gibbosa, Flem. - -	Do.
Posidonia † - - - - - -	Do.
Discina nitida, Phil. - - - -	Do.
Annelid tracks - - - - -	Do.
Spirorbis carbonarius,† McCoy - -	Do.

* See p. 60. † On the authority of Mr. Wardle.

Millstone Grit.

The only fossils noticed in this formation have been *Lepidodendron*, *Sigillaria*, and *Calamites* here and there iu the grit beds, and *Aviculopecten papyraceus* with *Goniatites* in the roofs of the little coals.

Lower Coal Measures.

Measures of the Goldsitch Basin (pp. 26 and 53).*

Bassy Seam.	*Lepidodendron*, sp. - - -	Western outcrop below Goldsitch Houses.
	Ulodendron - - - - -	
	Favularia nodosa, Lindl. - -	
	Calamites Suckowii, Brong. - -	
	Stigmaria ficoides, Brong. - -	
	Goniatites - - - - -	Eastern outcrop in the Goldsitch Brook.
	Orthoceras (?) - - - -	
	Aviculopecten papyraceus, Goldf. -	
Shales above the Bassy Seam.	*Neuropteris affinis*, and fish in ironstone nodules.	Goldsitch Brook.

* The species marked M. are given on the authority of Mr. Molyneux, from a list drawn up by him and lent to me by Mr. T. Ward of Longton; the remainder of the species were determined by Mr. Salter.

Cannel Seam.	*Anthracosia acuta*, Sow. - -	Goldsitch Houses.
	Palæoniscus - - - } M.	
	Megalicthys Hibberti, Ag. - } M.	
	Rhizodus - - - - }	
Measures above the Cannel Seam.	*Pecopteris Serlii*, Brong. - -	Goldsitch Brook.
	Sphenopteris Höninghausi, Brong. -	Do.
	Spirorbis carbonarius, McCoy }	
	Cytheropsis - - - }	
	Anthracosia ovalis, Mart. - } M.	
	——— *robusta*, Sow. - }	
	Acanthodes - - - }	
Thick Seam.	*Megalicthys Hibberti*, Ag. - }	
	Palæoniscus - - - } M.	
	Rhizodus - - - - }	
Thin Seam.	*Goniatites Listeri*, Mart. - }	
	Aviculopecten papyraceus, Goldf. }	
	Anthracosia - - - - }	
	Posidonia Gibsoni - - } M.	
	Megalicthys Hibberti, Ag. - }	
	Palæoniscus - - - }	
	Rhizodus - - - - }	
Silver Seam.	*Palæoniscus* - - - } M.	
	Rhizodus - - - - }	

Lower Coal Measures of the Biddulph Trough (p. 27).

Two Foot or Little Row.	*Modiola* (?) - - - - -	A quarter of a mile W. of Outwood Gate, Biddulph.
Four Foot or Crabtree.	*Goniatites Listeri*, Mart. - - }	Old Colliery at Lea Mill Forges, near Congleton.
	Orthoceras - - - - - }	
	Aviculopecten papyraceus, Goldf. - }	

Middle Coal Measures.

A list of fossils from the Middle Measures of the Pottery Coal Field will be found in Part IV. of the Iron Ores of Great Britain (Memoirs of the Geological Survey). Some new marine forms have lately been discovered by Mr. T. Ward, of Longton, in the Bay Coal Bass and the Priorsfield Bass, beds well up in the Middle Coal Measures,* and, perhaps, on about the same horizon as the strata near Ashton-under-Lyne, which yielded marine fossils.† At my asking, Mr. Ward kindly placed these fossils in the hands of Mr. Salter, who has determined the following species.

———	Bay Coal Bass.	Priorsfield Bass.
Goniatites Looneyi, Phil. - - -	×	
„ *Listeri*, Mart. - - -	×	
„ sp. like Listeri - - -	×	
Nautilus (*Discites*) *falcatus*, Sow. - -	×	
Macrocheilus, sp. - - -	×	
Aviculopecten papyraceus, Goldf. - -	×	
Ctenodonta, sp. ? - - - -	×	

* Iron Ores of Great Britain, Part IV. p. 261.

† Geology of the Country round Oldham (Mems. of Geol. Survey), p. 64.

	Bay Coal Bass.	Priorsfield Bass.
Anthracosia ovalis, Mart.		×
„ *acuta*, Sow.		×
„ *lateralis*, Brown		×
Anthracoptera quadrata, Sow.		×
Anthracomya, new sp.		×
Lingula mytiloides, Sow.		×
„ *squamiformis*, Phil.	×	
Discina nitida, Phil.	×	
Beyrichia arcuata, Bean		×

Drift.

List of Shells found in the "Middle Sand and Gravel" at the New Cemetery, Macclesfield.

These shells were first noticed by Mr. Sainter, and for several months the cuttings were daily watched by Mr. Lowe. In the large collection gathered by the latter, there are several shells undoubtedly spurious, which had been palmed off by the workmen on the collector; these, however, can be picked out at a glance by their look and unaltered state, and are besides tropical species. From Mr. Etheridge I have a list of the names of a number of the more perfect specimens which were submitted to him. The whole batch has since been very carefully looked over by Mr. Darbishire, who has kindly allowed me to print the following list and accompanying remarks from his manuscript notes.

Mr. Darbishire says, "All the specimens are either much broken, even into "small fragments, or much rolled and worn. A certain number may be put on "one side as bearing the appearance of greater apparent freshness, having "parted with less animal matter. These uniformly show signs of great attri-"tion. They are noted in the column headed B.

"The species noted in the column headed A. present, as a whole, a facies of "more complete fossilization, being often friable, and all, except only in the "case of minute convolute shells, particularly broken up into little pieces. A few "species, particular specimens of which appear to be of doubtful authority, are "marked D.; the obviously spurious shells have not been noticed." I have added two species, marked with the letter E., not in Mr. Darbishire's list, on the authority of Mr. Etheridge.

References.—c., common. f., frequent. r., rare. v. r., very rare.

Species.	A.	B.	Remarks.
Pholas crispata, Linn.	r.		
P. candida, Linn.	- -	v. r.	D.
Mya truncata, Linn.	f.		
M. arenaria, Linn.	v. r.		
Psammobia ferroensis, Chemnitz	f.	- -	Many fragments: remarkably thick.
Donax anatinus, Lamark	- -	v. r.	
Tellina solidula, Pultney	c.	f.	Whole valves and fragments: many D.
T. tenuis (E.), Da. Costa.			
Mactra solida, Linn.	r.	- -	Valves and fragments.
Lutraria elliptica, Lam.	v. r.		
Cytherea chione, Linn.	f.		
Venus verrucosa (E.), Linn.			
V. striatula, Donovan	r.	- -	Fragments.
	- -	v. r.	Valves. D.
Artemis lincta, Pult.	r.		

Species.	A.	B.	Remarks.
Cyprina Islandica, Linn -	c.	- -	Small, much worn fragments.
Astarte elliptica, Brown -	r.		
A. arctica, Gray - -	f.		
Cardium echinatum, Linn.	f.	- -	Fragments.
	- -	r.	Whole valves. D.
C. aculeatum (?), Linn. -	v. r.	- -	Two fragments so named may be of the last species, but query.
Cardium rusticum, Linn. -	r.		
C. Norvegicum, Spengler -	v. r.		
C. edule, Linn. -	f.	- -	Fragments.
	- -	2.	Whole valves. D.
Mytilus edulis, Linn. - -	f.		
Modiola modiolus, Linn. -	r.		
Nucula - - -	v. r.		A fragment.
Arca lactea, Linn. - -	v. r.		
Pectunculus - - -	v. r.		
Pecten opercularis, Linn. -	v. r.	- -	Fine valves in Mr. Sainter's collection, very fresh : spurious.
Ostrea edulis, Linn. -	v. r.	- -	Several fragments are very doubtful.
	- -	r.	
Patella vulgata, Linn.	v. r.	- -	D.
	- -	r.	
Dentalium entale, Linn. -	r.		
Dentalium abyssorum, Sars. -	- -	v. r.	
Trochus cinerarius, Linn. -	- -	v. r.	One in Mr. Sainter's collection seems genuine : others D. : *no fragments.*
Littorina littorea, Linn. -	- -	r.	Fragments broken, rolled, and much worn : some D.
L. littoralis, Linn. - -	- -	r.	No fragments observed : ? D.
L. rudis, Don. - -	- -	r.	
Turitella communis, Risso	c.		
	- -	c.	Some of these are very fresh. D.
Aporrhais pes-pelicani, Linn	2		
	- -	1.	D.
Natica nitida, Don. - -	- -	r.	
N. monolifera. Lam. - -	v. r.		
Murex erinaceus, Linn.	r.	- -	Fragments.
	- -	r.	Entire : much rolled.
Purpura lapillus, Linn.	f.	- -	Fragments.
	- -	f.	Entire : much rolled.
Nassa reticulata, Linn.	r.	- -	Fragmemts.
	- -	f.	Entire : much rolled.
N. incassata, Müller -	v. r.		
Buccinum undatum, Linn. -	f.	- -	Fragments : certain specimens D.
Fusus gracilis, Loven -	v. r.	- -	One, young, genuine; another, adult, may be genuine; another, with epidermis, spurious.
F. antiquus, Linn. - -	r.	- -	Fragments: much rolled.
Trophon clathratum, Linn. -	f.	- -	Large and small.
Mangelia turricula, Montagu -	f.		
M. rufa, Montagu - -	r.		
Cypræa Europea, Montagu -	v. r.		
Cliona - - -	r.	- -	In *Turritella*.

Among these shells Mr. Darbishire finds the following six species not mentioned in Professor E. Forbes' list of the Pleistocene Fossils of the British Isles (Memoirs of Geological Survey, vol. I.): viz.:

Pholas candida. (D.)
S. *Cytherea chione.*
S. *Cardium rasticum.*
S. *C. aculeatum* (?)
S. *Arca lactea.*
Littorina littoralis.

These, with the exception of *Littorina littoralis*, are all "shells of species "which at present reach their *northern* limit within the British seas, extending "on our western shores from the Spanish province; the species marked S. being "characteristically shells of the Spanish or Southern province."

Of the species common to the Macclesfield drift and Prof. Forbes' list, the following reach their *southern* limit within the British seas:

Cyprina Islandica.	*Astarte elliptica.*
Astarte arctica.	*Trophon clathratum.*

While the following extend southwards as far as the English Channel:

Mya truncata.	*Buccinum undatum.*
„ *arenaria.*	*Fusus antiquus.*
Modiola modiolus.	„ *gracilis.*

"These ten species are in fact *northern species extending southwards.* Of the "remainder, the whole range considerably southwards of the British Isles, but "as a set present a characteristically British aspect." *

In an outlying patch of sand and gravel near Walker Barn, about three miles from Macclesfield on the Buxton road, Mr. Darbishire found the following shells:*

Tellina solidula, Pultney.	*Cardium edule*, Linn.
Mactra.	*Mytilus.*
Cytherea chione, Linn.	*Turritella communis*, Risso.
Artemis exolita, Linn.	*Trophon.*
„ *lincta*, Pultney.	

Since the above was written a paper on these shells has been published by Mr. Darbishire in the "Geological Magazine" for July 1865, to which the reader is referred for a further description.

APPENDIX II.

Additional Observations on the Red Rock Fault at Poynton.

While these pages were passing through the press some interesting experiments were being carried out at Poynton Collieries, under the direction of Mr. Greenwell, with the object of ascertaining the position and character of the Coal-measures on the western side of the "Red Rock" fault. It will be observed on referring to the map that the formation which forms the boundary of the Poynton Coal-field along the line of the fault is the Lower Permian Sandstone. As a large portion of Lord Vernon's property is situated upon this and the overlying New Red Sandstone, and the Poynton Coal-field is of limited extent, it is naturally a matter of interest and importance to ascertain whether the Coal-measures with workable seams extend at moderate depths under this tract. With this object a horizontal tunnel was driven westward from the Park Pit, at a depth of 200 yards from the surface. After crossing the four-foot seam, and at a distance of 437 yards, a large down-throw fault was struck, and a series of reddish shales and grits, dipping westward at angles varying from 50° to 70°, were entered on the opposite side. On continuing the tunnel several smaller faults were crossed, and a seam of coal three feet in thickness, unknown in the Poynton district, were passed through. Beyond this, Coal-measure shales and clays with *stigmaria* were proved, and the tunnel was left off in a reddish grit, similar to those found in the Coal-measures of Denton and Hyde.

Whether the large fault just described is the great "Red Rock" fault or another at a small distance to the east of it, is a question which is evidently not solved by this experiment, as the Coal-measures may or may not be those which naturally underlie the Permian Sandstone. Leaving this question to be solved by further trials, which I hope will be undertaken, I wish to notice

* From MSS. notes of Mr. R. D. Darbishire.

the alteration which the strata appear to have undergone on approaching the fault, and in illustration of which Mr. Greenwell had taken care to preserve specimens.

The whole of the beds on either side had evidently been subjected to violent compression and friction, by which considerable amount of heat was evolved, producing in the strata the following changes :—

The four-feet coal on approaching the fault was found changed into compact cinder, the bituminous matter being driven off, while the strata above and below were highly indurated. On the west side of the fault, besides the the change of colour similar to that which Coal-measure strata undergo when heated, the beds had become unusually hardened, and the ironstones so changed as to resemble reddish jasper.

The combined action of heat and pressure is in this case admirably illustrated, and the appearance of the strata is in striking contrast to that of the Coal-measures along the line of the Irwell Valley fault, where the beds run up, and end off against the fault without any change either in their position or structure.

E. H.

INDEX OF PLACES.

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