

SKETCH OF THE GEOLOGY OF NORTHUMBERLAND.

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The county of Northumberland is so large that only a very small portion of it can be visited in even the busiest week's excursion. Its geological features are so arranged, however, that, by a judicious selection of routes, most of their more striking characteristics can be fairly inspected within that time. It may be added that such a rapid inspection will enable those Members of the Association whose devotion to stones is not too severely engrossing, to enjoy some remarkable scenery little known to the ordinary tourist, and to glance in passing at a considerable number of objects of archæological interest. Indeed here, more perhaps than elsewhere, the form of the country, and the positions of the Roman and mediæval remains with which it abounds, are so closely connected with the nature and lie of the rocks, that the geologist is to a great extent forced to take an interest in Great Walls and Border fortresses as well as in sections, faults, and fossils.

The high ground of Northumberland lies in its western half, culminating in Cheviot itself (the highest mountain of the Cheviot range), which is well within the English Border, and between the South Tyne and Derwent rivers in the Allenheads district. The Cheviot heights—great round-backed hills with steep, grassy slopes—are formed of igneous rocks (chiefly porphyritic): the rest of the high land is formed of Carboniferous rocks, and more especially of sandstones and grits belonging to the Bernician and Millstone Grit Series, as will be explained presently. These hills are heather-covered, and often bold in outline. The contrast between them and the green bosses of the Cheviot group is very striking, and is nowhere better seen than from Billsmoor, on the road between Elsdon and Rothbury.

The lowest ground of the county is occupied by its highest rocks—a common thing in geology. It coincides with the coast-

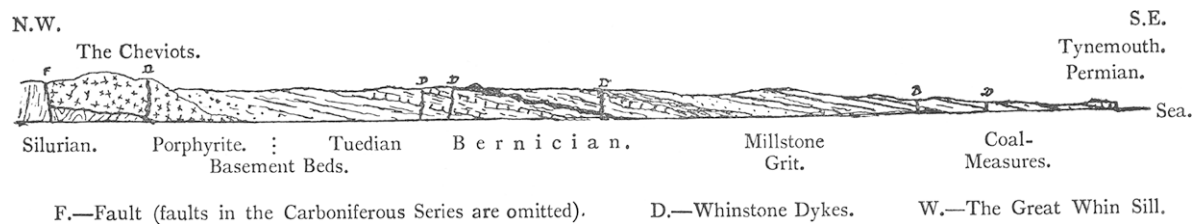


Fig. 1.—Diagrammatic Section through Northumberland.
(Length about 40 Miles ; Vertical Scale greatly exaggerated.)

line and the coal-field from the mouth of the Coquet to that of the Tyne, and extends westward up the river as far as Stocksfield.

In order to understand how the sedimentary rocks lie, it is convenient to take the *massif* of the Cheviots as a centre from which the dips radiate towards the sea to the east, and towards the Tyne and South Tyne to the south. The general strike of all the post-Silurian beds will therefore be fairly represented by a curved line running approximately parallel to the base of the Cheviot porphyrites. The strata near the Cumberland and Durham boundaries must be regarded as practically flat and undulating. In making this general statement it must be understood that no account is taken of the many local changes of dip due to the very numerous faults and other disturbances of the district.

The rivers—again speaking generally—run across the strike and with the dip, but the Tyne and South Tyne between Haltwhistle and Corbridge form a notable exception to this rule, and for that distance run almost exactly along the strike.

Another useful general statement may be made as to the direction of the faults and dykes of the district. The dykes occur (with the exception of some running due east and west) in two well-marked series having S.W. and N.E., and S.E. and N.W. directions respectively. The faults follow this rule also to a great extent, but there are among them—especially among the large ones—more east and west lines of dislocation. North and south faults are, with few exceptions, small and unimportant.

Silurian Rocks.—These, though they probably form the floor upon which all the newer rocky structure of Northumberland is built up, are but seldom visible. In the upper reaches of the Redewater about Whitelee, in the upper Coquet at Makendon, and a little south of Ingram, vertical or contorted clay-slates and grey-wackes are exposed as inliers. Judging from their resemblance to beds in the adjoining counties of Roxburghshire and Berwickshire, they may probably be referred to the Upper Silurian; but, in the absence of fossils, it is impossible to speak with certainty.

Cheviot Traps.—Under this name I have elsewhere grouped all the pre-Carboniferous igneous rocks which make up the Cheviots proper, and which under various forms were poured

over the denuded edges of the Silurian beds during Old Red Sandstone times. The study of these old lavas, ashes, etc., has only recently become possible, but Mr. Clough, Mr. J. J. H. Teall, and Professor Petersen have already made much headway in their microscopic analysis. More especially is this the case as regards Mr. Teall, whose papers on Northumbrian petrography in the 'Quarterly Journal of the Geological Society' and in the 'Geological Magazine' are of the first importance. It is with much pleasure that I hear that Mr. Teall has furnished the Association with a petrological account of the igneous rocks occurring in the region referred to in the present sketch, a fact which relieves me of much responsibility.

In many cases the arrangement of the Cheviot porphyrites and their associated rocks in irregular flows can be detected, and sometimes their bedded appearance is quite surprising—as, for example, at the Ridlees and at Cottonshope Burn; but much of this may be due to superinduced structure on a large scale. It may be mentioned as a warning to geologists having but little time to investigate the district, that the line of junction between the Cheviot traps and the sedimentary rocks around them is often a faulted one. At Makendon, where this is the case, the fault makes it appear as if the porphyrites had at that point pierced through and tilted up the Silurian grits which lie at a high angle against them. This, indeed, is the view I formerly took of this section; and I now abandon it with regret, and in obedience to undeniable evidence gathered within the last few months. In this instance the age of the traps is not affected by the view taken of the nature of the junction between them and the grey-wacke, since the latter is, in either case, the older. When, however, the sedimentary beds are newer than the igneous rock, as at Linnshiels, lower down the Coquet, a mistake of this kind would plunge one into complete error. At this spot Lower Carboniferous strata appear as if tilted up at a high angle, by the intrusion from below of the Porphyrites next them. The inference is, naturally, that the latter are newer than the former, until it is found by careful examination that the Carboniferous beds are partly made up of pebbles of the Porphyrites (which must necessarily, therefore, be the older of the two), and, further, that the line of junction is really a fault.

At Ingram there occurs an interesting red quartz-breccia which has not yet received the attention it deserves.

Basement Beds.—The lowest post-Silurian sedimentary rocks of the region (except small patches of sandy beds associated with the porphyrites) are dark reddish-brown conglomerates, which were formerly classed as Old Red Sandstone. They stand in exactly the same relation to the undoubtedly Carboniferous beds above them as do the dark conglomerates which along the Penine Escarpment lie unconformably upon the upturned Silurians of that region, and conformably beneath the Carboniferous Roman-Fell conglomerates. They also stand, it is true, as regards the series above them, just as the Upper Old Red Sandstone of Berwickshire (at Cockburnspath, for instance) does to the Calciferous Sandstone (or Tuedian) Series. In both cases the conformity upwards into the undisputed Carboniferous is perfect, and one cannot err in regarding these conglomerates as the basement beds of the Carboniferous rocks, whilst the fact that the Upper Old Red Sandstone Series of Scotland is separated by a marked unconformity from the Lower Old Red has induced many competent observers to group it altogether with the Carboniferous. Under these circumstances the term Basement Beds cannot, I think, be objected to when applied to those dark conglomerates which at Akeld, Roddam, and in several other burn-sections at the foot of the Cheviots, are well-shown lying upon the Porphyrites. The outcrop of these beds is a very narrow and discontinuous one.

On the Scottish side of the Border there are some contemporaneous traps which conveniently separate the Red Sandstone group or Basement beds from the Tuedian beds; but these only just enter Northumberland, near Carham.

Tuedian Beds.—A perfectly gradual passage takes place from the Basement conglomerates to a thick series of Sandstones, greyish, greenish, and purple shales, with inconstant beds of argillaceous, usually non-fossiliferous calcareous beds, similar to the well-known cement-stones of Scotland. This is the Calciferous Sandstone Series of Maclaren and the Scottish geologists, the Tuedian beds of the late George Tate and most English geologists. As a series, it is not very well defined, and the conditions of deposition to which its beds are due are not yet clearly understood. Whatever those conditions may have

been, they were not favourable to marine life. The series contains singularly few fossils. In nearly twenty years I have never found but two kinds—an undetermined Brachiopod, like an *Athyris* in general form, and a large *Nautilus*, of which many specimens, entire but very obscurely preserved, were found a little above Alwinton thirteen or fourteen years ago. I understand, however, that other marine remains have been discovered in these beds by more recent collectors. In the upper part of the series, limestones having minute oolitic structure, and partly silicified into chert, are sometimes met with, as at Hetchester, between Rothbury and Harbottle, on the Coquet. The outcrop of the Tuedians in Northumberland is very variable in breadth, but is nowhere of great extent except along the Tweed, whence the series derives its appropriate name. The general character of the series is exceedingly well seen in Coquetdale, above Sharperton, and about Holystone, and at many places between Alnwick and the Cheviots.

Fossil plants are not uncommon in the Tuedian sandstones, and from the fact that *Lepidodendron Veltheimianum* occurs in them, these beds have been paralleled with the Kulm of Central Europe, though there is every reason to think that the correlation is only partially good, the Kulm representing much more than the Tuedian.

To draw a hard and fast line between the Tuedian and the overlying Carboniferous Limestone Series is impossible. This is my deliberate opinion after many attempts on my own part and many trials of the suggestions of others. There is, as I explained some ten years since, a lateral dovetailing between the two series, so that there is not only perfect passage from the lower to the upper, but also an irregular distribution of the local conditions which determined the continuance of the Tuedian facies in the Northumbrian area of deposition. In some parts of that area Tuedian conditions lasted long after they had been superseded by more purely marine conditions in others not far off. One result of this is that some of the non-fossiliferous Tuedian cement-stones seem occasionally to pass gradually laterally into blue limestone of the Carboniferous Limestone type, full of marine fossils.

In that indefinite zone of beds which may be regarded as partly Tuedian and partly Bernician are some thick beds of

Sandstone, which I have called the Harbottle Grits, and which furnish most of the more salient hill-tops and fells of westernmost Northumberland. In the Harbottle district, and to the south-west of it, these grits would properly come within the Bernician group, since limestones of the full marine type occur associated with them. At any rate these grits form a broad belt of high, craggy ground, which is one of the most striking characteristics of the wilder parts of Northumberland.

It is in a member of this group that the interesting shell *Anodonta Jukesii* has been found near Chillingham, and at the Beacon, near Holystone. The discovery of this fossil proves that in the North of England the shell lived to a much later geological date than in Ireland, or that the Old Red Sandstone state of things in Ireland was synchronous with that of the Lower Carboniferous in Bernicia and that the shell in question thrived in both; or, again, that the Kiltorkan beds are newer than they are usually stated to be, viz., Carboniferous (and not even *earliest* Carboniferous) instead of Upper Devonian or Old Red Sandstone. I incline strongly to the last view, and so, I am pleased to say, do Mr. G. H. Kinahan and Professor Boyd Dawkins.*

Bernician Series.—Under this head are grouped together all the strata from the lowest bed of purely marine Carboniferous limestone to the highest, both inclusive. From what has been said with regard to the Tuedian it will be seen that the position of the lower limit of the Bernician is a variable one. So is that of the upper limit. Nevertheless, the 4,000 to 8,000 feet of deposits which constitute this series form a well-defined whole, and offer to the observer the most noteworthy feature in Northumbrian geology. The conditions under which the Bernician beds were accumulated were conditions of incessant oscillation—deepish sea giving place to beach and beach to land, and land in turn sinking, through shallow water, to deepish sea once more. The rocks resulting from this constant alternation of deposits are :

Limestones, thin (rarely exceeding 20 feet, and, in the case of the "Great Limestone" only, attaining 40 feet in the neighbourhood of Ryall and Great Whittington), and usually full

* See Dawkins "On the Range of *Anodonta Jukesii*," 'Trans. Manchester Geol. Soc.,' Vol. xvi, p. 247, 1882.

of fossils, such as *Productus giganteus*, *P. semi-reticulatus*, *Lithostrotion junceum*, *L. Portlockii*, various Cyathophylloid corals, crinoid stems, *Saccamina Carteri*, and a number of smaller foraminifera, &c.

Calcareous shales, usually associated with the Limestones (immediately above or below them) and sometimes representing them. These beds are very fossiliferous, and yield a large number of species, such as *Productus longispinus*, *P. pustulosus*, *Lingula* (3 or 4 species), *Discina nitida*, Trilobites (chiefly tails of *Phillipsia*), *Fenestella*, and many other Polyzoa, occasional crinoid heads, many bivalves, including in some localities (especially at Budle) *Posidonomya Becheri*, etc.

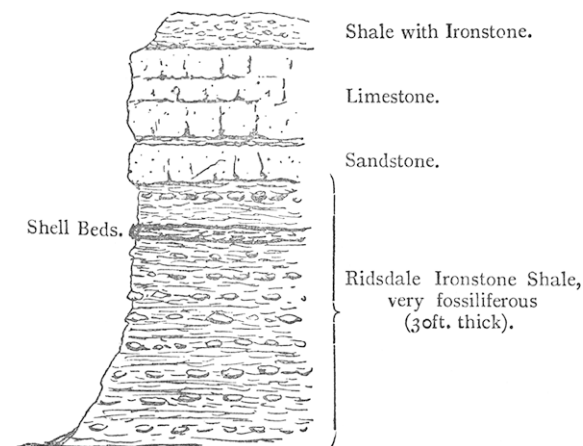


Fig. 2.—Section of the Beds Exposed in the Ridsdale Ironstone Pits (Lower Bernician).

Shales, generally without fossils, often of considerable thickness. These, as well as the calcareous shales, often contain clay-ironstone in nodules and in bands, and these are sometimes fossiliferous. The Ridsdale Ironstone shale is important, and is interesting for the large number of fossils which it yields.

Sandstones and Grits of all kinds, thinly-bedded and micaceous to massive and coarse-grained. These often contain impressions of plants, all very similar to those of the Coal-Measures.

Conglomerates.—These are generally in this region merely local coarsening of grit, where quartz pebbles accompany the

ordinary sandy grains of the rock over a certain area. Such beds are well seen at Inghoe and Rothley Crag high up in the Bernician Series. They are coarser than anything in the true Millstone Grit.

Coals occur very frequently throughout the series, and represent the old land-surfaces formed during the periods of emergence of the Bernician area. They are thickest, and more often worked in the Upper Bernician (corresponding to the Yoredale Rocks) and in the lower part of the Lower Bernician, the seams of the intervening part, though numerous, being generally very thin and of poor quality. The collieries of Acomb, Haltwhistle, Plashetts, Lewis Burn, Shilburnhaugh, Shilbottle, Licker, Biteabout, Eglington, North-Sunderland, Lowick, Scremerston, etc., all work these Carboniferous Limestone Coals.

Underclays very generally—but not always—occur immediately beneath the coal-seams of this series. They are sometimes, like those of the Coal-Measures proper, full of stigmarian roots and rootlets, and are occasionally so siliceous as to form true Gannister. In some cases, however, no stigmarian remains occur, and in others the coal-seams lie directly upon ordinary shale or sandstone, or (though only in one or two cases known to me) upon limestone.

Of all these kinds of deposits the sandstones and grits are the thickest, but they are very inconstant. The shales are fairly constant both in continuity and thickness. The coals are by no means so regular as those of the Coal-Measures; they more often split up into two or three seams, and every now and then are “nipped out” or disappear for a space, but some of them are known over a very large extent of country. The Little Limestone seam, for instance, is worked, or, at any rate, can be traced from West Yorkshire through West Durham, across the whole of Northumberland to close to Berwick, on the coast. The limestones are the most regular and continuous, and form, therefore, the best guiding beds for the geologist to follow. In the Alston district, where the Bernician series is comparatively thin, each limestone has for years been well known to the lead-miners, and distinctive names have been given to them, such as the Fell-top, the Little, the Great, the Cockle-shell, the Jew, the Tynebottom, etc. In the same way

other names have been given to the same beds in North Northumberland, where the series is again comparatively thin. In the central district, however, the whole series attains its greatest thickness, and several limestones put in which are not known (in other words, which thin out altogether) to the north and south. Naturally, the Alston names and those of Alnwick and Lowick have had a tendency to extend—the former to the north and the latter to the south. There is thus much confusion in the correlation of the various beds of limestone, and this confusion is only now beginning to give place to order as a result of the careful work of the officers of the Geological Survey in a very puzzling and difficult country.

For many years I have tried to discover some natural divisions in this great *Bernician Series* of Northumberland, but both lithologically and palæontologically I can find in it but one group, the characters of which (allowing for small local variations of no value in stratigraphical classification) are practically the same from top to bottom, and this constitutes one of the most remarkable points of interest as regards the Northumbrian facies of the Carboniferous Limestone Series.

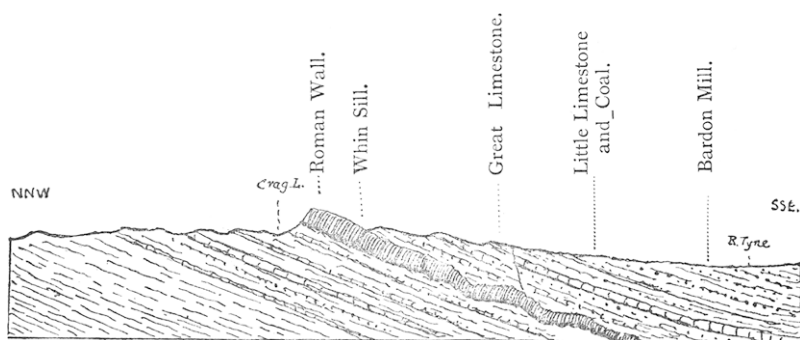


Fig. 4.—Sketch-Section from Bardon Mill to Crag Lough.

The Great Whin Sill.—For the sake of convenience this intrusive sheet of dolerite (the plagioclase-augite rock of Mr. Teall) is mentioned here (though its age would probably place it later on in this enumeration) because it is

found lying between and cutting through the beds of the Bernician Series only. Mr. Teall, in his notes on the igneous rocks, will describe the petrological characters of this great sheet. All that need, therefore, be said here respecting it is that though between Greenhead, where it enters the county, and a little south of Berwick, where it leaves it, it is very bed-like in appearance, yet the evidences of its intrusive character are abundant. The beds lying upon it are very generally baked and altered, as will be well seen at Hotbank, along the Roman wall. It frequently encloses masses of the rocks through which it has thrust itself, as the sections on the coast near Bamburgh and near Dunstanburgh, and at the Farne Islands, will show. It often splits up into two or more sheets, as at Great Bavington, Throckington, and Ratcheugh, and it shifts its horizon from bed to bed, sometimes to the extent of a thousand feet or more.

The fine, craggy, often columnar, escarpment of the Whin Sill along the line of the Roman wall at Gunnerton and Bavington near Kirkwhelpington, between Alnwick and Dunstanburgh, and from Belford to Spindleston Heugh (the home of the "Laidley Worm") and at Bamburgh, makes it one of the most picturesque features of the country through which it runs, and the fact that many rare plants are restricted to its outcrop makes it a favourite hunting-ground of local botanists.

On an average the Whin Sill is about 100 feet thick, but at Greenhead it is not much more than 20 feet, whereas at Bamburgh and the Farne Islands it is probably more than 200 feet in thickness.

Millstone Grit and Gannister Series.—Overlying the Bernician Series, in the manner already described, are the 300 feet or so of sandstones and shales, of which the Millstone Grit consists in this part of England. There are a few thin and seldom-worked seams of coal in the series, and there are no limestones; otherwise there is little or nothing to distinguish this series from the beds above and below them, and it is probable that had not the Millstone Grit been traced to this point from its typical localities in Yorkshire, this division of the Carboniferous series would not have been recognized in this region. Neither is there any means of separating in a natural manner the Millstone Grit from the Lower Coal-Measures or Gannister series above them. Nevertheless, the Gannister series is now

known to contain, in places (as near Whittunstall to the south of Stocksfield), a few bands of marine fossils, much as it does in the Wortley district in Yorkshire; but these bands are very seldom met with, and cannot serve as a ready means of determining the horizon of the beds among which they occur. Some beds of the extremely siliceous underclays known as Gannister, and used for refractory purposes, are found in this series, but they are not so numerous in it as in the underlying Bernician. *Aviculopecten papyraceus*, some encrinite stems, and some undetermined Brachiopods are the only marine fossils found up to the present time in these Lower Coal-Measures. The coals in this division are few, thin, and seldom worked in Northumberland, though in Durham one or two seams near the top are locally valuable. Near Eltringham one of the very rare Cannel coals of the Newcastle coal-field has recently been won at the same horizon.

Middle and Upper Coal-Measures.—All the beds among which the regularly-worked coal-seams of the great Northern coal-field are found come under this head, but the division of the Coal-Measures is, in this part of England, altogether an artificial one. The boundaries between them are merely well-known coal-seams, the beds above and below which have a common character. The fossil plants cannot, by any amount of ingenuity, be made to yield any clear palæontological stages such as those recognized by Geinitz and Grand'Eury on the Continent. The vertebrate animal remains, though remarkable for their variety, as shown in the magnificent collection of them made by the late Thomas Atthey, of Gosforth, and now preserved in the Newcastle Museum, have hitherto been collected from too few horizons to be of value for stratigraphical classification. The invertebrates, on the other hand, seem to promise better results when better known and carefully worked out. At present all we know concerning them is that there are many horizons at which bivalves of the genera *Anthracosia*, *Anthracomya*, and *Anthracoptera* occur in the Coal-Measures, and in the higher beds a few at which *Lingula squamiformis* has been found, whilst on the banks of the Wear, opposite Claxheugh, above Sunderland, the remains of insects were, years ago, discovered by Mr. Kirkby, together with a curious organism referred by him (very doubtfully indeed, I think) to the genus

Ancylus. There is nothing in any of these remains to prove purely marine conditions, but much to prove the close neighbourhood of the sea, and the presence of estuarine waters during the time of the coal-forest flat-lands of the North of England. The chief coal-seams of the Northumberland (not Durham) Coal-Measures are as follows, in descending order:—

(N.B.—The thicknesses vary from place to place, and are, therefore, approximately correct only.)

UPPER COAL-MEASURES (so-called).

18. *The Closing Hill Seam*.
450 feet of sandstones, shales, and underclays.
17. *Hebburn Fell Seam*, 2ft. 8in. thick.
250 feet of sandstones, shales, and underclays.
16. *Five-quarter Seam*, 4ft. thick.
260 feet of sandstones, shales, and underclays.
15. *70-Fathom Coal*, 2ft. at most.
50 to 180 feet of sandstones, shales, and underclays.

MIDDLE COAL-MEASURES (so-called).

14. *High Main Coal*, 6ft. thick.
150 feet (?) of sandstones, shales, and underclays.
13. *Grey Seam* (formed by the uniting of two seams known as the *Metal Coal* and the *Stone Coal*, which, in some places, are 33 feet apart).
60 to 110 feet of sandstones, shales, and underclays.
12. *Yard Coal*, 2ft. 10in. to 4ft. thick.
60 to 100 feet of sandstones, shales, and underclays.
11. *Bensham Seam*, 2ft. 5in. to 5ft. thick.
75ft. of sandstones, shales, and underclays.
10. *Five-quarter Seam* (formed by the uniting of the *Tyne Six-quarter* and *Tyne Five-quarter* seams, at times 25 feet apart).
50 feet of sandstones, shales, and underclays.
9. *Low Main Coal*, 2ft. to 6ft. thick.
30 to 100 feet of sandstones, shales, and underclays.
8. *Plessey Seam*, 2ft. to 3ft. thick.
80 to 150 feet of sandstones, shales, and underclays.
7. *Beaumont Seam*, 3ft. thick.
20 feet of strata.

6. *Hodge Seam*, 2ft. 4in. thick.
20 feet of strata.
5. *Tilley Seam*, 2ft. to 3ft. thick.
15 feet of sandstones, shales, and underclays.
4. *Hand Seam*, 4in. thick only, but useful as a guiding bed.
20 feet of strata.
3. *Busty Bank Seam* (formed by the uniting of the *Stone Coal* and *Five-quarter Coal*, at times 25 feet apart).
40 feet of sandstones, shales, and underclays.
2. *Three-quarter Coal*, 3ft. thick.
50 feet of sandstones, shales, and underclays.
1. *Brockwell Seam*, 1 to 4ft. thick.—This seam is the artificial boundary line taken between the Middle Coal-Measures and the Lower Coal-Measures and Gannister Series.

It will be noticed that the same name (e.g., *Five-quarter Coal*) is frequently repeated in the above list. If to this fact it be added that the seams have different names in most of the principal districts of the coal-field—the nomenclature on the Tyne differing from that on the Wear for example—it will be seen that the correlation of the coal-seams of one locality with those of another is by no means an easy task. The best attempt at this is that made by Mr. J. B. Simpson in his chart of sections published in 1877.

What the really uppermost beds of the Northumbrian Coal-Measures may have been like we have no means of knowing, for they were denuded off, and those left behind slightly tilted up before the deposition of the Permian rocks. The upturned edges of the Coal-Measures beneath the Permian are almost always of a reddish colour, stained, in fact, by the overlying deposits—a fact which favoured, and indeed led to, the belief, held for many years, that these red beds represented the Roth-totliegende, and were, in truth, Permian. Mr. R. Howse was the first to point out the truth in this matter.

The Coal-Measures are traversed by numerous faults called “dykes” by the miners; these rarely make any feature at the surface. A famous one—the “ninety fathom dyke” is exposed in the cliffs at Cullercoats; this throws down the Permian Beds. Further west, north of Newcastle, the throw of this fault exceeds 1000 feet.

Permian Rocks.—Allowing ourselves (as we shall do on.

the occasion of the Association Excursion) to go out of Northumberland as far as Marsden and Whitburn, on the Durham coast, the development of the Permian rocks on the east side of Northern England can be excellently studied; the lower rocks of the same system can be examined in the fine coast sections from Hartley and Cullercoats southwards.

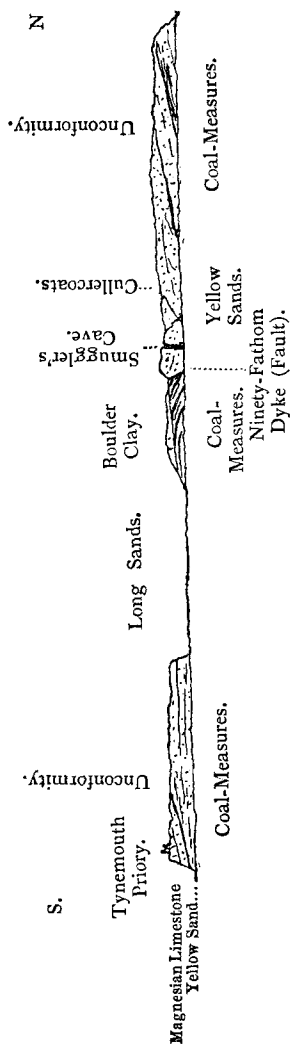


Fig. 5.—Sketch-Section from Tynemouth to Cullercoats, Across the Ninety-Fathom Dyke.

Yellow Sands.—At Hartley, Cullercoats, and Tynemouth cliff, the lowest division of the Permian—the *Yellow Sands*—is well shown. It consists, as the name implies, of incoherent sands rather than of sandstone, yellow in colour, made up of coarse, rounded grains of quartz, and in places cemented by carbonate of lime, and showing some tendency to concretionary structure. This is especially well shown at Cullercoats. The thickness of these sands is very variable. Lying as they do unconformably upon the Coal-Measures, they fill up the inequalities in the surface of denudation, are thick when the hollows of the old floor are deep, thin when these are shallow, and absent altogether when there are prominences instead of hollows. No fossils have ever been found in these sands. They are extremely false-bedded, and, being very open in texture and underlain chiefly by shales, form a water-bearing horizon which is of the greatest danger to the many pit-sinkings carried down to the Coal-Measures, which, in the East of Durham, are concealed by the Permian beds.

Marl Slate.—At Tynemouth, where this celebrated bed is well seen, though unfortunately not to be hammered or collected in, a few feet of Magnesian Limestone intervene between it and the Yellow Sands; but this is not usually the case. The Marl Slate is (at most) a three-foot band of greyish sandy, shaly limestone, easily split into thin slabs, on which remains of fishes, and sometimes (as at Midderidge) other vertebrates, abound. It is the great Permian fish-bed from which every Museum has some spoils, and that at Newcastle a unique collection. At Ferry Hill, as the Members of the Association rush northwards from London in their express, they can catch a rapid view of what is even a finer section—showing the stratigraphical relations of this bed—than at Tynemouth or at Cullercoats. At the last-named place the fish-bed can be collected in, but can only conveniently be reached at the lowest tides.

Magnesian Limestone.—Tynemouth Priory stands on this; and the splendid line of cliffs from South Shields to Whitburn and Sunderland exhibits all its strange and unique forms. Fossils there are some in it certainly, but distributed fitfully, and scarcely likely to reward any but the local collector. Nevertheless, at Tunstall Hill and Humbleton Hill, both places near Sunderland, and at the present moment open for collect-

ing, good specimens may be obtained. But it is not the fossils that make the Permian Limestone of this East Coast so interesting. It is its singularities of bedding and texture, its extraordinary variety of concretionary forms (most of them unexplained), its breccias, and its caves. To the north of Frenchman's Bay the stone is compact and regularly bedded, with here and there large potato-stones or geodes, lined with beautiful crystals of dolomite, ankerite, or chalybite. Overlying this rock, and separated from it by a very undulating line of division, is the thick, so-called cellular limestone, a rough, cavernous rock of the most irregular and variable appearance, in which are great cavities filled with a powdery calcareous

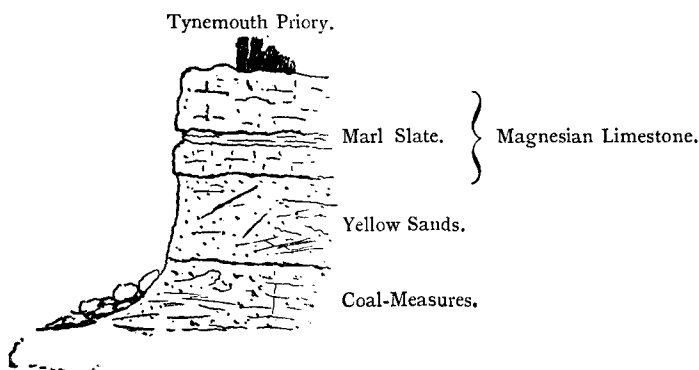


Fig. 6.—Section of the Lower Permian Rocks in the Cliff at Tynemouth Priory.

substance, locally known as Marl. Caves and arches of all kinds are found where this stone forms the coast-line, which, if seen in the proper state of the tide, is extremely attractive. Between Frenchman's Bay and Marsden Rock some fifteen "breccia-gashes" are exposed in the cliffs. I have given this name to some puzzling funnel-shaped fissures in the rock, which are filled up by a breccia of the same stone, cemented by more dolomitic limestone. These "gashes" are of all sizes, and sometimes are covered over by undisturbed beds of the limestone. I have referred them to the collapse of the roofs and walls of the caverns which are so numerous in this member of the Permian, and which, being usually full of water, present to the miner the same dangers which have been adverted to in

reference to the Yellow Sands. Some recent earthquakes at Sunderland seem to be due to the formation of such "breccia-gashes."

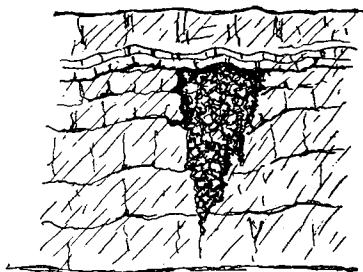


Fig. 7.—Breccia-Gash in the Magnesian Limestone at Marsden Bay.

Proceeding from Marsden to Whitburn, the various concretionary forms assumed by the limestone, and so well described by the late Professor Sedgwick in his classical Memoir,* are admirably seen, until the well-known cannon-ball form, recently likened, by Mr. Rutley, to the spherulitic structures in igneous rocks, comes into view near the last-named village.

The Permian above the Magnesian Limestone does not come within the scope of this sketch.

Of the formations between the Permian and the Glacial deposits in the geological column, none are now found in Northumberland. This great hiatus in the succession of things is represented by the rubbing down and sculpturing which all the rocks hitherto described in this paper have undergone at the hands of the various agents of denudation, marine and sub-aërial.

Dykes of Igneous Rocks.—What has been said in the earlier portion of this sketch with respect to the general direction of the dykes will be enough in view of Mr. Teall's accompanying "Notes," with the addition of a statement that the age of the dykes varies, and that whilst some are probably not later than Triassic, it is likely that others may have been intruded in Tertiary times.

Boulder Clay.—More than a third of the county is covered

* 'Trans. Geol. Soc.,' Ser. 2, Vol. iii, p. 38, 1829.

with Boulder Clay of very variable thickness; near Morpeth it has quite recently been proved to be at least 186 feet thick, and in the east and south-east it has always been the greatest obstacle to the investigation of the geology of the rocks buried beneath it. Personally, chiefly for the reason last stated, I dislike Boulder Clay; but some Members having less familiarity with its evil points may care to see it. In that case, I can recommend the sections at the Trow Rocks, and near the Black Middens at Tynemouth, and those along the coast near Howick. There the typical Boulder Clay of the district, with large scratched and polished boulders of limestone and basalt, and less-marked blocks of porphyrites, granite, sandstone, greywacke, and many other rocks, can be studied to every advantage.

Except some fragments of Arctic shells, found, by Mr. Howse, in an upper member of this group once exposed near the mouth of the Tyne, no fossils have hitherto been discovered in the Boulder Clay.

Glacial Gravels and Sands.—Some glacial gravels and sands made up of far-travelled pebbles occur in the Boulder Clay in irregular patches. Most of them, however, occur above it, and in some parts of Northumberland occupy very considerable areas; but, since these gravels have very commonly been remodelled by streams running along the lines of the pre-Glacial valleys, it follows that there is considerable difficulty in distinguishing the true Glacial deposits of this kind from the more recent but still ancient high-level river-gravels formed by actual rivers in their early days. The Glacial gravels still fill up many old valleys, such, for instance, as that of the Team, which in ancient days was a channel carrying the Wear into the Tyne; such, again, is a valley which once carried the Irthing into the South Tyne, or another which led the Blyth into the Wansbeck. They can be well studied in the valleys of the Derwent, the Tyne (especially the South Tyne), and the Wansbeck.

Later Gravels.—These have been mentioned in the preceding paragraph, and can be seen terraced to a height of several hundred feet above the present river-level along the flanks of the South Tyne valley, from the point at which that river unites with the North Tyne to form the Tyne proper, to Haltwhistle.

Kaims.—The old British word *Caim* (a heap) is locally applied to several of the strange ridges of gravel and sand to which the names Eskers, Åsar, and Kames have been applied by geologists. Beautiful examples of such ridges are to be seen at Chat Hill, and between the Hoppen and Spindleston, near Belford. I have read a considerable number of theories accounting for these Kaims in text-books and elsewhere, but am still quite unable to explain them.

Recent Deposits.—Under this head must be grouped the great deposits of the Moorland districts in which remains of extinct animals, such as the Red Deer, *Bos longifrons*, etc., are found, but the accumulation of which is still going on; the gravels and loams of our rivers; the sands of our beaches; but these need little notice here.

For lists of fossils and minerals, and for fuller details on the geological structure of the district, I beg to refer to my 'Handbook to the Geology of Northumberland and Durham,' about to be published by Messrs Lambert and Co., of Newcastle-upon-Tyne.

PETROGRAPHICAL NOTES ON SOME OF THE IGNEOUS ROCKS OF NORTHUMBERLAND.

By J. J. H. TEALL, M.A., F.G.S.

(Read July 2nd, 1886.)

In various papers published in the 'Quarterly Journal of the Geological Society'* and the 'Geological Magazine'† I have given details as to the mineralogical and chemical characters of some of the igneous rocks of Northumberland. To the facts published in those papers I have little to add, but as the President has requested me to offer some general remarks on the subject with a view to the Long Excursion, I gladly comply with his request. Since the papers were written I have gained a more extensive experience of the igneous rocks of similar

* "Petrological Notes on some North-of-England Dykes," 'Quart. Journ. Geol. Soc.,' Vol. xl, 1884, p. 209. "On the Chemical and Microscopical Characters of the Whin Sill," 'Quart. Journ. Geol. Soc.,' Vol. xl, 1884, p. 640.

† "Notes on the Cheviot Andesites and Porphyrites," 'Geol. Mag.,' Decade II, Vol. x, 1883, pp. 100, 145 and 252. "On some Quartz-Felsites and Augite-Granites from the Cheviot District," *Ibid.*, Dec. III, Vol. ii, 1885, p. 106.