34 SCOTLAND.MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN AND THE MUSEUM OF PRACTICAL GEOLOGY. THE GEOLOGY OF EASTERN BERWICKSHIRE. (MAP 34)

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GEOLOGICAL SURVEY

OF

GREAT BRITAIN,

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MUSEUM OF PRACTICAL GEOLOGY.

THE GEOLOGY OF

EASTERN BERWICKSHIRE.

(Map 34.)

BY

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GEOLOGY OF EASTERN BERWICKSHIRE.

(Sheet 34, Scotland.)

CHAPTER I.

Physical Features of the District and General Distribution of the Rocks.

The present Map represents a triangular portion of Berwickshire occupying about 120 square miles. This area extends along the margin of the German Ocean from the village of Cockburnspath nearly to Berwick-upon-Tweed, and advances inland along the southern base of the triangle to the outskirts of the town of Dunse. It thus includes the eastern extremity of the Lammermuir Hills, the undulating ground between St. Abb's Head and the mouth of the Tweed, and a small part of the northern edge of the great valley or "merse" of Berwickshire.

This proximity of high uplands to a rich agricultural plain gives rise to considerable diversity in the physical features of the district. A line drawn in a north-easterly direction from Dunse Law to the sea at St. Abb's Head divides the Map into two nearly equal portions. That to the north-west is the region of the Lammermuir Hills, which plunge into the sea along the range of precipitous cliffs between the Siccar Point and Coldingham. Hence it is only the north-eastern extremity of this range of hills which comes within the limits of the present Map. The general scenery of this portion however corresponds to that of the more westerly parts of the chain. It consists of highly inclined Silurian grits and shales, but nowhere rises to a height of more than between 800 and 900 feet above the sea. Its outlines are rounded and undulating, save where fissured here and there by steep ravines. Wide heathy uplands stretch away inland, sinking gently down into tortuous intervening valleys, but with no determinate system, so that the chain is thus composed of numberless smooth-backed coalescing ridges and hills. The surface of this hilly ground is for the most part covered with heath and bent, and is used as a pasturage for sheep. The narrow sequestered valleys are dotted with solitary farmsteads where the adjacent slopes have been laid under the plough, and the fields are now creeping further up the hill sides every year; but the whole district still retains its quiet pastoral character. The portion of the Lammermuir chain embraced in this sheet is traversed by two main valleys; that of the Whiteadder Water, and that followed by the line of the North British Railway. Of the vale of the Whiteadder in its course across the hills only a small part is here represented, where the stream, bending round and piercing the granitic mass of Cockburn Law, issues from the high grounds at Preston, about two miles to the north of Dunse. The valley in which the railway runs crosses the chain completely from side to side. Its summit level, forming the watershed of the hills, in place of being a ridge dividing the sources of the streams, is a flat peaty meadow from the margin of which the ground rises rapidly on both sides. From this point the valley stretches to the south-east for about a mile, where, at nearly right angles, it receives the Eye Water,

and then pursues its course until at the village of Ayton, this stream is turned sharply to the north-east, and cutting a deep ravine across some hilly ground reaches the sea at Eyemouth. The north-western continuation of this great transverse valley is the deep glen occupied by the Pease Burn. This stream for the first half of its course flows in a south-easterly direction until it reaches the flat peaty meadow just referred to, when, instead of continuing in the same direction and joining the Eye Water, it wheels round at an acute angle to the north, and enters the ravine which reaches the sea to the east of Cockburnspath. This marked defile ranges from 100 to 150 feet in depth, and is well known from the arch which crosses its seaward end, called the Pease Bridge. As it lay across the ancient highway along the east coast between England and Scotland, it was always a pass of importance. Cromwell wrote of it as "the strait pass at Copperspeth,* where ten men to hinder "are better than forty to make their way." Patten, a Londoner who accompanied the Duke of Somerset's expedition into Scotland in 1548, describes it as "a valley running straight eastward and toward the "sea, a xx skore broad from bank to bank above, and a v skore in the "bottom, wherein runs a little river; so steep be those banks on either "side, and deep of the bottom, that who goeth straight down shall be in "danger of tumbling; and the comer up so sure of puffing and pain; for "remedy whereof the travellers that way have used to pass it, not by "going directly, but by paths and footways leading slopewise, from the "number of which paths, they call it (somewhat nicely indeed) the "Peaths."

This remarkable ravine, however, is not the only one of the kind along the flanks of the Lammermuir Hills. Several of smaller dimensions occur in the same neighbourhood, where small rivulets have worked their way through the red sandstones and conglomerates that flank the Silurian rocks of the chain. Some deep rents are also to be seen along the coast, as at Dulaw, where the streamlet has formed a ravine fully 100 feet in depth. On the south-eastern edge of the chain the water-courses are less precipitous; instead of jagged defiles, they usually occupy the bottom of valleys that are bounded on either side by sloping hills.†

Of the ground to the north-west of the Lammermuir chain it is unnecessary to speak here, as only a corner enters the area embraced in the present sheet. It is there, however, that the ravines of the Cockburnspath district occur. The south-western edge of the chain corresponds with the line already indicated, which extending from Dunse to the sea at Coldingham, forms a well defined boundary. From the Whiteadder at Prestonhaugh to the valley of the Eye at Reston, the hills rise rapidly from the plain to a height of between 800 and 900 feet, forming a long smooth-backed ridge, known as Bunkle Edge. Between the Eye Valley, again, and the Coldingham Shore the distinction between hill and plain becomes in a manner lost, and the surface is broken up into an endless series of ridges and of interlacing depressions that rarely deserve the name of valleys.

The district which lies to the south-east of the Lammermuir Hills, and occupies the other half of the present Map, may be regarded as a part of the great merse or plain of the Tweed Valley, bounded, however, on the north-east by a band of hilly ground—a sort of spur from the Lammermuirs—which extends along the coast from Coldingham by Lamberton

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* A corruption still used for Cockburnspath.

† Mr. Milne Home has described some of these ravines in his paper on the Geology of Berwickshire, Trans. Highland Soc. xi. 180.

to within a mile of Berwick, when it sinks down into the plain. This part of the county is in truth a bay from the level plain of the merse, sweeping northward past Dunse till it reaches the foot of the hills of Bunkle Edge, whence it deflects towards the east, and, skirting the high ground of Lamberton Moor, joins the main valley again at Berwick. It is traversed by several streams descending chiefly from the hills that lie towards the north-west. Of these the most important is the Whitadder, which, as just mentioned, issues from the Lammermuir chain at Prestonhaugh, and thence runs in an easterly direction until it falls into the Tweed, nearly two miles above Berwick. Its banks exhibit in many places precipitous sections of the strata which occupy the greater part of the Berwickshire plain, and which are also laid open in a series of deep ravines opening upon the Whiteadder in the neighbourhood of the village of Foulden.

The coast-line along nearly the whole of the district pourtrayed on the present Map is rocky and precipitous. Here and there, as at Cockburnspath, Coldingham, and Eyemouth, there are sandy bays bounded by gently sloping shores or by bluffs of lesser elevation. But by much the larger portion of the sea-margin is a precipitous cliff-line, hardly accessible save by boat. At Tun Law, to the west of St. Abb's Head, it rises to a nearly vertical height of 500 feet, and forms thus the highest range of headlands on the east side of Scotland. This wild coast is worn by the incessant surge into caves and arches and solitary stacks; the haunt of multitudes of sea-fowl. The tides run swiftly round the headlands; hence, even on the calmest summer day, when the surface of the water is scarce roughened by a ripple, the white foam may yet be seen breaking over many a half-sunk skerry, and mantling along the base of the cliffs. The forms of these precipices vary with the changes of geological structure, the most lofty and rugged being those of the convoluted Silurian strata, with their associated masses of igneous rock, while the most fantastic in outline and the richest in colouring are those of the red and mottled carboniferous sandstones.

The oldest formation shown on this Map is the Lower Silurian. Its area coincides with that of the Lammermuir chain, and with that of the high ground which forms Lamberton Moor extending from near Berwick to Eyemouth. A third, and considerably smaller portion is seen on the shore for about a mile and a half between Coldingham and Eyemouth, whence it extends for rather more than two miles inland in a south-westerly direction. Next in order of age comes a remarkable series of volcanic conglomerates, ashes, red felspathic sandstones and marls, which from the scanty fossils detected in them are assigned, though with some hesitation, to the horizon of the Lower Old Red Sandstone. They rest unconformably on the Lower Silurian strata, and are seen at two localities on the coast, at Eyemouth and at Coldingham, in both of which they separate the smallest Silurian patch from the two larger ones. They then unite towards the south-west in a broad belt, which, extending across from Bunkle Edge to the foot of the Lamberton Hills, proceeds in a south-westerly direction until it is abruptly and unconformably overlaid by an irregular band of red sandstones and marls belonging to the Upper division of the Old Red Sandstone. At Prestonhaugh on the Whitadder this latter band rests directly on the Silurian grits and shales, whence as it wheels round by Dunse Law, it expands into the great range of conglomerate hills of Harden, and then into the basin of red sandstones that flank the Lammermuir chain throughout the rest of this county. To the east of Dunse this strip of Upper Old Red Sandstone after widening out between Bunkle Edge and Lamberton Moor to a breadth of two miles, rapidly dies away, and is succeeded by the Lower Carboniferous series.

By referring to the Map it will be seen that the boundary line between the upper members of the Old Red Sandstone and the base of the Carboniferous group runs from Prestonhaugh on the Whiteadder in an E.S.E. direction, keeping parallel to the course of that stream until near Mordington the Old Red Sandstone disappears, being overlapped by the Carboniferous strata which rest directly on the Silurian. The strike of the Carboniferous beds, however, continues the same until about a mile from Berwick, when it takes an abrupt turn to N.N.W., owing to the occurrence here of a large fault. The effect of this dislocation is to throw down the Carboniferous beds against the older formations, and to extend them as a narrow belt between the high grounds at Lamberton and the shore until at Burnmouth the fault reaches the coast-line and the Carboniferous strata, tilted up on end, then run out to sea. On the north-west side of the Lammermuir Hills, another portion of the Old Red Sandstone is seen resting on the edges of the Silurian grits and slates, and graduating upward, as on the south-east side, into the white sandstones of Dunglass, which there appear to form the base of the Carboniferous series. Several minor patches of Old Red Conglomerate occur as outliers in various parts of the district. One of these forms the rounded eminence called the Bell Hill immediately to the south of St. Abb's Head, another occupies the crest of the headland at Eyemouth, known as Cromwell's Fort, a third hangs as a prominent crag on the seaward face of the Chesters Hill at Burnmouth, a fourth of only a few yards in circumference lies near the bottom of the Burnmouth ravine, a fifth is cut open by the railway at Lamberton Shields, and the sixth, and largest of all, occurs on the west side of the great fault between Marshall Meadows and the Steps of Grace. The relative proportions of these outliers are best shown on the Map. No such detached parts of Carboniferous rocks occur in the district.

The igneous rocks shown on this Map are for the most part associated with the Silurian strata, and with the ashes and sandstones of Lower Old Red Sandstone age. One large mass of greenstone, however, occurs in the Upper Old Red Sandstone, and forms a considerable hill to the west of Dunse, a capping of basalt crowns Dunse Law, while several dykes occur in the same neighbourhood. Five dykes of greenstone were observed on the coast running out to sea in an E.N.E. direction and cutting through both Carboniferous and Silurian beds. One of them even crosses the large fault, as may be seen along the face of the precipitous cliff as well as in the railway cutting to the north of Lamberton Shields.

CHAPTER II.

Lower Silurian Formation.

The district embraced in the present Map has a peculiar interest in relation to the history of geological science. It was here, among the contorted Silurian strata which form the wild headlands to the east of Cockburnspath, that Hutton demonstrated the revolutions which the earth's crust had undergone by showing that grits and shales, originally deposited horizontally on the sea bottom, had come to be convoluted and piled up on end, and that their exposed edges had been thereafter exposed anew to the action of the waves which had heaped upon them a set of gently inclined conglomerates and sandstones. Here too, amid the same contorted Silurian strata, Sir James Hall made his well-known observations on the

effects of lateral pressure in convoluting large masses of stratified rock.* Nor could the early observers have lighted on a district that more clearly illustrates some of the fundamental principles of geology. The rocks are laid bare in long lines of natural section, both upon the coast-line and among the numerous water-courses of the interior, while later years have added the deep cuttings of the North British Railway across the Lammermuir chain.

The Silurian strata of this region, as pointed out so long ago by Hutton and his followers, are in the highest degree convoluted and broken. Yet this disturbance has not in any way destroyed the stratified appearance of the rocks, although it has rendered the task of elucidating their order of succession a difficult and perhaps even an impossible one. The strata are thrown into rapid flexures, the axes of which run in parallel lines from N.E. to S.W., or N.N.E. to S.S.W. This feature is characteristic not of this district only, but of the whole Silurian tract of the South of Scotland. So persistent is this line of strike of these vertical and highly inclined beds, that the observer may steer his way over the moors and mountains in a straight north-easterly direction by merely keeping his eye on the exposed edges of the rocks as they crop out in the water-courses and along the hill-sides. If, however, he crosses the strike at right angles, he is perplexed with the rapid and apparently inexplicable changes in the dip of the strata. For some way, perhaps, he has traced a set of grits dipping, it may be, at an angle of 70° or 80° to N.W., and he believes that the clue of the order of sequence has at length been obtained. Before long, however, he finds the beds become vertical, and suddenly take a contrary dip towards the south-east, and while he casts about for some character, lithological or otherwise, whereby the stratigraphical succession may be followed out, he is met by an abrupt return of the dip to its former north-westerly direction. Hoping now to regain the lost thread, he follows on, trying at every step to identify bands of grit or shale with those that had previously presented themselves, when again another contortion takes place, the inclination changes once more, and perchance he abandons in despair any attempt to follow out the succession of the Silurian rocks of the Lammermuirs.

Some of these perplexing and seemingly anomalous features receive their explanation in the range of sea-cliff towards the east. In the interior we walk along the denuded edges of the strata; and many intervening parts are there obscured by the drift of the valleys, or by the thick moory vegetation of the hills. But along the coast line, where the waves have cut a vertical section some two or three hundred feet high, and several miles long, the origin of the difficulties that so beset us among the uplands is at once explained. We there see that in ascending the river-courses we had been in reality crossing a series of rocks thrown into rapid arches and troughs, and that the abrupt and puzzling changes of dip really represented the alternating sides of these great folds and curvings of the strata. As the general trend of the coast line is from N.W. to S.E. it crosses the strike of the beds, and hence the section thus laid bare represents pretty nearly the true relative proportions of the curves, not much distorted, as they would be by any marked deflection from a line transverse at a right angle to the axis of plication. With a sinuous outline, there are of course numerous parts of the coast where the

* See Hutton's "Theory of the Earth," vol. i. p. 454 *et seq.*; Playfair's "Illustrations of the Huttonian Theory," p. 213; "Life of Hutton," Playfair's works, vol. iv. p. 78; Sir James Hall, "On Vertical and Convoluted Strata," Trans. Roy. Soc Edinb. vii. 79; "On the Revolutions of the Earth's Surface," Ib. p. 162.

cliff exhibits a more or less oblique section, but the same indented character enables us to correct such distortion, by constantly presenting coves and creeks where the true direction of the beds is shown.

Yet although the coast rocks explain the causes of those rapid changes of inclination which are often so difficult to follow in the inland parts of the country, they present new obstacles to the determination of the order of succession among the Silurian strata of this part of Scotland. The curvings are not all mere simple folds, but are sometimes so reduplicated upon each other that it becomes next to impossible to decide whether, after we pass beyond such a disturbed belt, we are upon higher or lower beds. And as if to crown the difficulties, the curves are not unfrequently broken through by faults. These cut off abruptly the thread whereby the observer may have been attempting to follow out the order of superposition, and they leave the task well nigh as hopeless as ever.

The great Silurian tract of the South of Scotland appears to be traversed along its centre by an anticlinal axis which, passing south of the town of Moffat, stretches away towards the German Ocean on the one side of the island and to the Irish Sea on the other.* On the north-west side of this line the strata, notwithstanding their endless crumplings and plications, dip on the whole away towards the north-west, so that in passing over the hills on that direction, we gradually ascend from a low part of the Lower Silurian series to the upper parts of that group (as developed, for instance, in the valley of the Girvan, in Ayrshire) until we reach even the true Ludlow rocks of the Upper Silurian series, as shown among the hills of Lesmahagow and in the Pentlands. Again, in traversing the chain towards the opposite quarter we meet with the same evidence of a gradual ascending series from the dark slates at the bottom of the system up into the Upper Silurian strata of the south of Kirkcudbright and the hills of Cumberland.† This structure is rendered visible by a gradual change in the lithological character, and still more in the fossil contents of the strata, rather than by any clearly traceable upward succession of bed upon bed. We see that, viewed as a whole, the outer edges of this long Silurian zone are formed of strata higher in geological position than those of its centre. But it is very difficult to decide in any particular district whether one set of beds is actually higher or lower than another. At the best the decision in most cases rests only upon a combination of probabilities.

The anticlinal axis observable in the central and south-western portions of the Silurian belt is in all likelihood prolonged to the north-east; but I have not yet been able to recognize it with certainty in the Lammermuir district. From Dirrington Law across the Lammermuir chain to Gifford the prevailing inclination of the Silurian strata (as shown on Sheet 33 of the Geological Survey) is towards the north-west. These hills therefore probably lie on the north-western side of the axial line. If we draw a line from Dirrington Law in a N.N.E. direction to the sea, at a point between East Castle and Dulaw Dean, and then examine the Silurian strata to the south-east, we shall find their general dip to be south-easterly as far as the great trough of Lower Old Red sandstones and ashes to be afterwards described. We might therefore infer that the anticlinal axis runs out to sea somewhere to the east of East Castle. But when we pass to the eastward of the belt of Lower Old Red Sandstone, and examine the coast section from Eyemouth to Burnmouth, we find the

* See Sedgwick, Edinb. New Phil. Journ., xlix. 362, li. 250; Nicol. Quart. Journ. Geol. Soc., vi. 53; Harkness, *op. cit.*, vii. 46, xii. 288; Murchison, Ib. vii. 162; Siluria, 3d Edit., 167.

† See Sedgwick, *loc. cit.*; Murchison, Quart. Journ. Geol. Soc., vii. 139.