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ORIGINAL ARTICLES.

I.—NOTES ON THE GEOLOGY OF THE ISLE OF MAN.

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(PLATE I.)

THE following notes have been made during a few weeks' holiday in the Isle of Man, and my special object is to notice those points which have a bearing upon the geology and physical history of the neighbouring Cumberland mountains. For many years I have, from time to time, looked across to the hills of Mona's Isle, regarding them as a portion of the Cumbrian group standing aloof from their brethren, and often have I wished to carry my hammer amongst them. My wish has at last been fulfilled, but the bad weather of the coldest of summers has prevented the observations made being as full as I had intended. Such as they are I offer them.

At the outset I would wish to add my testimony to the careful and accurate observations of the Rev. J. G. Cumming, as recorded in his work on the Isle of Man, made when geological science was far less advanced than at present.

My remarks shall be grouped under the heads of the various formations represented, and a final glance taken of the physical history of the island as contrasted with that of the Cumberland mountains.

SKIDDAW SLATES.

One of my chief objects in examining the geology of the Isle of Man was to see whether the group of rocks supposed to answer to the Skiddaw Slates of Cumberland threw any light upon the subdivisions of these latter. In previous papers I have pointed out that the so-called Skiddaw Slates may be divided into the following parts, commencing with the highest member:—

4. *Skiddaw Slate proper* (black clay-slate of Skiddaw).

3. *Coarse Grit.*

2. *Black Iron-stained Slates.*

1. *Thick-bedded Sandy and Gritty Series* (of Grasmoor and Whiteside).

The Grit No. 3 I have thought to represent the Arenig Grit of N. Wales, which it resembles in character and, so far as can be ascertained, position. No. 4 would then stand for the Arenig Slates, No. 2 for the Tremadoc Slates, and No. 1 represent the Lingula

Flag Series. Moreover, No. 4 is succeeded *conformably* by the Volcanic Series of Cumberland, but in the south-western corner of the Lake District the slates of this division are absent, and the volcanic ashes immediately succeed the grit, and are conglomeratic in character, rounded pebbles and blocks of the grit being bedded with the ashy material.

Trusting that further light might be thrown on these subdivisions by an examination of the Skiddaw Slates of the Isle of Man, I began by seeking the uppermost beds described by Profs. Harkness and Nicholson as conformably underlying volcanic ash-beds occurring at Douglas and Clay Heads. But I have not been able to satisfy myself that there are any volcanic beds answering in age to those of the Lake District, and on writing to Prof. Nicholson to inquire more particularly as to the ashy members of Douglas Head and Clay Head, he replies, "So far as my own imperfect recollection serves, it is quite possible that we may have mistaken light-coloured gritty bands in the Skiddaw Slates for ashes." I think that this must have been the case, and that for two reasons. In the first place, I could find no beds with decided ashy characters, but the sandy and gritty characters prevail in the localities named. In the second, at both places the dip is to the W.N.W., and any beds occurring at either Head must, if they be conformable, *underlie* that portion of the Skiddaw Series. In the case of the Douglas Head rocks, the dip, though very high—sometimes nearly vertical—is persistently westwards for three-quarters of a mile, from behind the Dock to the Head itself, and therefore any conformable volcanic rocks occurring at Douglas Head would *underlie* a great thickness of the Skiddaw group. After having examined the fine cliff-sections all round the island more or less carefully, and having traversed the mountain groups in several directions, I have failed to find any portion of the Volcanic Series of Cumberland represented. At the same time it might be rash to say that none of the thick flaggy and gritty-looking beds so largely developed have mingled with them fine ashy material; this may still be the case, and yet the whole belong to the series of marine sedimentary deposits known as the Skiddaw Slate group.

Being disappointed in obtaining a defined upper limit to the slaty series, my next object was to light upon some defined band of sandstone or grit which could be traced across the island, and thus give an horizon. I hoped, indeed, to meet with my Skiddaw or Arenig grit. It is necessary to state that all the south-eastern portion of the island from Port St. Mary north-eastwards to the central valley between Crosby and Douglas, is for the most part devoid of good sections, except along the coast-line; also that large portions of the mountain area north of the central valley are very sectionless, great spreads of drift sometimes sweeping up the several valleys, and oftentimes the mountain slopes being uninterruptedly grassy.

Upon the small map (Fig. 1) I have marked the general direction of the dips observed; these are for the most part at a considerable angle, and often nearly vertical.

The rock occurs in four forms. 1. As a coarse thick-bedded sandstone or grit, slightly conglomeratic in parts. 2. As more or less thickly-bedded flags of a grey colour within but often ironed on the outside. 3. As black slate frequently flaggy in character, and occasionally cleaved. 4. As soft black shale, not unlike coal-measure shales. All these forms also recur in the Lake District Skiddaw Slate group. No. 1 is perhaps best seen at St. Ann's Head, four miles south of Douglas. No. 2 is well represented at Douglas, and furnishes most of the building material of the town. No. 3 may be well seen about South Barrule slate quarries, where cleavage is developed, and on Spanish Head, where the black flags, lying almost flat, are quarried for gate posts. No. 4 occurs in the upper parts of Glen Meay (west of South Barrule), and other places.

It would be unsafe to offer any decided opinion upon the divisions of the Skiddaw Slate in the island without having made a detailed survey of the whole, and still more so to point to certain parts as the equivalents of Lake District divisions. That gritty beds occurring at St. Ann's Head and on Carn Gerjoil (marked in round dot pattern on the map) resemble on the whole the Skiddaw or Arenig Grit previously alluded to, is but imperfect evidence at the best. This much is however to be said in favour of their identity, that the slates of the Snae Fell range, extending from N. Barrule, through Snae Fell, to Greeba and S. Barrule, have a general north-westerly dip, and much resemble the black slates of the Cumberland Skiddaw. The sandy and gritty beds of St. Ann's Head dip eastwards, while those on Carn Gerjoil dip westwards. It may be that they respectively represent the two sides of an anticlinal which runs from a little south of Ramsey to a little west of Douglas. On the other hand, it is possible that some large fault runs through the nearly east and west central valley, between Douglas and Peel. Gritty bands again occur south of Peel. Prof. Nicholson also describes a quartz rock with pebbles three miles west of Ramsey dipping to the north-west, and containing black shale bands, and a little south of Crosby station I observed a thick bed of quartzite dipping west under black shale. Very likely, indeed, there are gritty beds on several different horizons, and, indeed, on the east of the island especially, the beds appear much more sandy than is the general character of the series in the Lake District.

A *broken* line from south of Ramsey to near Douglas indicates the general direction of a marked anticlinal; and a *dotted* line from the south of Laxey to Douglas, a marked synclinal. An anticlinal again appears running through the harbour of Port Erin, and on the north side of this, especially at Bradda Head, the rocks are beautifully contorted, though showing a general north-west dip; on the south side, however, about Spanish Head, the beds are almost horizontal or dip slightly seawards, giving rise to large slips and broken ground known by the name of the chasms. With the chance of a large fault between Douglas and Peel it is hard to parallel the rocks north and south of Port Erin with any particular portions of those in the north of the island. The strike of the black flaggy

slates of Greeba and St. John's seems however to be continued across the valley. On the whole it appeared to me that the Skiddaw Slates of the Isle of Man throw no light on the divisions of the same series in the Lake District; and probably, when the island is minutely surveyed, all defined bands being traced, more help will be derived from the Lake District than given by the Isle itself.

CARBONIFEROUS.

The various beds of the Carboniferous Limestone Series are very minutely described by Mr. Cumming, and I would here only offer some remarks, (1) on the conglomerate at the base, and (2) on the volcanic rocks interbedded with the limestone.

1. *Basement Conglomerate*.—Although Mr. Cumming gives to this conglomerate and its associated sandy beds the name of Old Red, it should be specially noted that at the early date at which he wrote he recognized the complete conformity between these beds and the overlying limestone.

It is scarcely necessary for me to notice the paper by Mr. Howorth published in the GEOLOGICAL MAGAZINE, 1877, pp. 411 and 456, as his endeavour to lay bare the supposed errors made by Mr. Cumming has been met by a paper in the May number of the same MAGAZINE for 1879, by Mr. G. H. Morton. It is, however, preposterous that one who confesses himself to be "not an experienced geologist" should so confidently assert that the conclusions drawn, after long and careful study, by one who *was* an experienced geologist, were erroneous. Nothing could be clearer than that the conglomerate beds underlie the Carboniferous Limestone, that they are almost wholly made up of sandstone or quartzite pebbles, and that the beds do not represent boulder deposits of the Glacial Period.

On the western side of Langness the conglomerate may be well studied in its relations to both underlying and overlying rocks. At low tide the complete conformity of the conglomeratic beds dipping westwards, with the overlying limestone, may be well seen, and near high-water mark the complete unconformity of the conglomerate with the underlying Skiddaw Slate is also admirably shown. This is especially the case where an arch has been worn through the slate, the upper part consisting of conglomerate; close by is a little fault, throwing the conglomerate against the slate (see Fig. 3). For the most part the pebbles lie with their long axes in the planes of bedding; and so far as I remember it was but exceptionally that the formation assumed anything of the appearance of a true glacial or boulder deposit.

The red sandstone cliffs north of Peel contain conglomeratic portions, and dip to the north-west. These beds have been described by my friend Mr. Horne,¹ who parallels them with the Calcareous Sandstone series of Scotland.

2. *Volcanic Rocks of Carboniferous Age*.—The coast-line between Castletown and Poolvash is perhaps the most interesting part of the

¹ Trans. Edin. Geol. Soc. vol. ii. pt. 3, 1874.

island to the geologist, for here he sees a small ancient volcano dissected and laid bare. I was at once reminded of some of the ash-necks of Carboniferous age occurring just north of the Scottish border. The rough plan (Fig. 2) will help to illustrate the following remarks. The Volcanic rocks extend from Scarlet Point to Poolvash, a distance of about a mile and a quarter, and consist almost wholly of ash and breccia, intersected by dykes of basalt. The Stack of Scarlet shows the finest development of basalt, and from this point there runs a dyke of the same in a W.N.W. direction, which, when best seen, is about fifty feet wide, but westwards it is much hidden under cover of cultivated ground. With regard to this line of intrusive basalt, there cannot be a doubt, I think, but that it represents an original line of eruption, the part nearest to the Stack being the spot where the volcanic fires first reached the surface, and where the vent became finally choked with large ejected blocks and scoriae, the basaltic lava welling up through a central fissure, and flowing over the volcanic breccia as it is seen to do upon the east side of the dyke. A little farther west along the shore the greenish ashy material is less coarse, and becomes distinctly stratified, this representing the matter falling outside the vent and becoming rudely bedded beneath the shallow sea. Just before reaching the bedded ash, other portions of the lava-flow may be seen overlying the ash, and exhibiting a very vesicular structure in bands. Nearer to Poolvash the ash is interstratified with limestone, both the grey and the black Posidonian band, so that there can be no doubt but that the eruption partook of a submarine character.

A second mass of vesicular basalt, with brecciated portions, occurs just W. of Scarlet Point; it does not, however, seem to extend as a dyke, and its southern margin is hidden by the shore-line.

The order of events would seem to have been this: During the deposition of the grey limestone and the bands of black calcareous mud, a vent was opened out through the bed of the sea—probably but shallow—from which many large blocks were ejected, the most of them falling back into the rent, while the smaller material fell at a little distance from the centre of eruption, and became roughly stratified and partly mixed up with the calcareous deposits. Then lava welled up from the vent (about Scarlet Point), forced its way through a fissure extending some distance westwards, cutting through the previously-deposited ash, and finally flowing over the ash in the form of a vesicular lava-stream, only small patches of which are now visible.

The limestone immediately north-east of Scarlet Point is much altered, and near the junction with the basalt, as Mr. Cumming has observed, it is not always easy to distinguish between the two rocks. Some small dykes or threads of basalt among the limestone bands are very interesting in their course and behaviour. Between the Stack and the lime-kilns the limestone is also finely arched in places, and I was interested to observe the minute cracks extending *along* the summit of one arch, for the most part filled with carbonate of lime. The same fine curving in the thick limestone beds may be

seen along the shore north of Derby Haven; Mr. Cumming connects these curves with the intrusion of igneous rocks beneath, and not with general movements of the whole series of deposits, as I should be more inclined to do. The two—igneous intrusion and general contortion—may well, however, be intimately connected.

With regard to the former greater extension of the Carboniferous rocks, it is difficult to say much. That they once extended well over the lower south-eastern portion of the island there can be but little doubt, and there is every reason to believe that the red sandstones of the shore-line north of Peel dip beneath limestone occurring a short way out to sea, but it would be rash to assert that all the older rocks were once covered by beds of Carboniferous age, and, as seems very probable in the Lake District area, a ridge of Silurian rocks may have stood well up above the sea during the whole of the Carboniferous period, and around this early form of the Isle of Man the conglomerates were piled up and the limestone beds formed.

Post-Carboniferous.—The island contains no records, not even of the most fragmentary description, of any of the geological periods from the Carboniferous to the Glacial epoch. As in the Lake Country area, so here, during this long period of time, denudation was probably at work, in all its various forms, carving out the island from the Old Silurian nucleus and Carboniferous framework. At some period after the close of the Carboniferous, elevation and faulting must have occurred, by which the present relative positions of Carboniferous and Silurian rocks were attained, but it is impossible to say certainly when this happened or whether it may not have occurred more than once. Analogy with the neighbouring Lake District area would suggest that these movements mainly took place soon after the close of the Carboniferous Period or in early Mesozoic times.

There is every reason to believe that the island had much of its present form at the commencement of the Glacial Period, as was the case with the land in Cumbria, nor was that form much modified during glacial times.

The glacial deposits also do not differ from those of Cumbria. There is the usual stiff clay with stones, of probable ice-sheet origin, and stratified sands and gravels of generally more modern date than the clay. These sandy deposits, especially developed at the north end of the island, have yielded many remains of shells, and are, undoubtedly, for the most part marine in origin. A few miles south of Point of Ayre these sandy beds are contorted and even inverted, possibly by the grounding of icebergs. Moreover, the glacial drift runs up into the interior of the island in the form of gently sloping plateaux, such plateau-form being, as I believe, the indication of marine action upon the first formed Glacial Till.

I noticed no definite moraines, nor are glaciated rock-surfaces at all abundant, the Skiddaw Slate generally not being a good preserver of glacial markings. The best example of such that I met with was just above Port Groudale, on the north side of Banks How, where the direction of the scratches was nearly north and south. Other

good cases of more or less east and west striation occur in the limestone, where exposed upon the shore, just south of both Castletown and Port St. Mary. I cannot, however, think that these last could have been produced by land-ice, but more probably they are due to current-floated ice, when the land was submerged slightly beneath its present level.

There is also a great absence of boulders on the mountain-sides; and no cases, as far as I could see, of large *foreign* boulders upon the mountain-slopes, and away from the boulder-deposits of low levels. Boulders of local greenstone and granite do, however, occur in this way, and sometimes in very anomalous positions, such as the granite blocks on the west side of South Barrule, the granite itself being on the east side, at a much lower level. Upon the east coast, especially at Port Groudale, well-rounded specimens may be gathered from the little beach of nearly all the igneous and granitic rocks common in the western and north-western portion of the Cumbrian mountain area, mixed doubtless with specimens from Scotland.

Altogether, I should be inclined to say—from a limited acquaintance with the island and its Drift phenomena—that the marks of an old land-glaciation were few as compared with those left by marine conditions acting during this period. Of local glaciers I could find little or no evidence, though on a more thorough survey some may perhaps be found. It is more than probable that the ice-sheets from Scotland and Cumbria, or from the former alone, swept over this island, glaciating it from north to south, and leaving behind much unstratified till. Then came a period of submergence, when old glacial deposits were modified, and floating-ice, during at least part of the period, transported boulders from Cumbria, and locally to and fro between different parts of the island, the shore-line being oftentimes well glaciated in the process.

At one time the island, as it now stands, must have been represented by a chain of islands separated from one another, much as the Calf is now parted from the mainland, with strong tidal currents setting through the straits. Thus the Spanish Head promontory must have been parted from the Bradda Head island, and this again from the larger tract of hilly country between Fleshwick Bay and Slieau Whallian, forming the South Barrule island; while the strait running between Douglas and Peel must have separated the southern islands from the large northern one comprehending all the northern part except the low and exclusively drift-covered extremity.

The question next arises, To what extent was the island submerged? In my Papers and Memoirs upon the Geology of the Lake District I have given reasons for thinking that that area was submerged to the extent of some 2,000 feet or more; the evidence being mainly derived from the position of various groups of boulders. Similar evidence in the Isle of Man is for the most part wanting, so far as my limited researches enable me to judge, though the presence of granite boulders upon the western slopes of S. Barrule, up to a height of nearly 1,500 feet, points rather in the same direction; for it is not easy to understand how an ice-sheet coming from the north

could carry boulders in a W.S.W. direction to the other side of a mountain some 700 feet higher than the ground from which the granite blocks could be derived. On the other hand, if the island were gradually submerged to the depth of 1,500 feet or more, shore-ice might by degrees raise the blocks of granite, and they would be carried in the end to positions into which they could not possibly have been brought by an ice-sheet moving from the north.

But there is yet another fact pointing to a great submergence. There are no Alpine plants upon the mountains of the Isle of Man, no trace—according to the late Edward Forbes (quoted by Cumming in an appendix to his volume)—of that Alpine Flora which has representatives upon the English and Welsh mountain-summits, and which remains as a testimony to the geologically recent Arctic climate of our latitudes. Now this receives a full explanation if we can find reason to believe that the highest land upon the island was completely submerged after the period of maximum glaciation. If there was a submergence in the adjacent Cumbria to the extent of 2,000 feet, it is certainly not impossible that the area of the Isle of Man experienced a submergence to the same amount; and since Snae Fell is only 2,034 feet in height, this would mean the destruction of the glacial flora altogether.

It may be difficult to believe in this great oscillation of level, but if the evidence is strong in support of it, mere difficulty of belief must not stand in the way of our accepting it. It is certainly not more difficult to believe than the fact that Alpine summits 12,000 feet high, formed of marine beds of Eocene age, must have been elevated to this amount, accompanied by contortion and metamorphism of the rocks, since the close of that period. It has always seemed to me that the unwillingness to admit this great depression and re-elevation in such recent times, on the part of some geologists, arose in this case from there being so little to show for it, or, in other words, from the movement having necessarily taken place quickly or continuously, and for the most part unaccompanied by great disturbance. But surely if widespread movements of the crust are possible at all—as we know they are—we need not expect them always to take place at the same rate, or to be accompanied by similar results. It is well also to remember the strong evidence brought forward of late to show that great submergence took place at this same time over the northern part of N. America (see especially the papers by Mr. G. M. Dawson).

PHYSICAL HISTORY OF THE ISLE OF MAN AND CUMBRIA CONTRASTED.

Contrasting now the physical history of the Isle of Man during past periods with that of the Lake District, we find that the earliest records in both areas are of the same age—that of the Skiddaw Slate; and that in both cases the deposits indicate a generally shallow sea in which muddy and sandy strata were laid down, while the still coarser material of an occasional pebble-bank points to not far distant continental land.

While this state of things was interrupted in Cumbria by an outburst of volcanic violence, sub-marine eruptions passing into sub-aerial, we have no direct evidence to show that such was the case over the present area of the Isle of Man, though it is probable that some of the finer volcanic ash was, at any rate, occasionally wafted for many miles westwards. That this area, in common with that of Cumbria, underwent elevation, accompanied by denudation, in post-Silurian and pre-Carboniferous times, is at any rate probable, and, as in Cumbria also, the early formed Carboniferous strata were deposited around a Silurian nucleus, the embryo Isle of Man. At this time, off the shores of that early Mona, submarine volcanic eruptions recurred, synchronous or approximately so with other like eruptions occurring farther northward over the present area of Scotland. There is no evidence of any such action taking place around the shores of the Cumbrian nucleus, although there are, south of Ullswater, masses of basalt which have broken into the Basement Conglomerate, and which may represent—as may also the Shap granite—abortive attempts of the Volcanic fires towards eating their way to the surface. Then in both areas we find the long unrepresented periods from Carboniferous to Glacial times, during which, after elevation at the close of or soon after the Carboniferous period, the mountain district of Cumbria and Mona's Isle were respectively fretted by the denuding forces into their present form of hill and dale, under climates varying from semi-tropic warmth to glacial cold. As the cold of our last Glacial period, so called, reached its maximum, both districts were shrouded in ice-sheets, that of Cumbria self-born, that of Mona bearing down upon it most likely from a distance. Then followed a milder time and a submergence to such an extent that in all probability Cumbria was represented by but a group of islands and Mona disappeared entirely beneath the waves. As the land in both areas once more appeared, glacial conditions returned to a considerable extent, and floating-ice laden with stones and boulders played its part in the cold drama, small bergs and flocs being wafted first in one direction, then in another, as the currents changed with the varying amounts of elevated land. At length both the hilly areas of Cumbria and Mona stood up once more as of old, surrounded by a framework of low-lying land connecting the two districts, and allowing of the migration of fauna and flora from what by slight depression soon became the mainland, to the future independent Island of Man. Thus Mona is like a cast-off bud from Cumbria's group of rocky mountains.

EXPLANATION OF PLATE I.

FIG. 1. Sketch-Map of the Isle of Man.

„ 2. Sketch-plan of Volcanic Rocks at, and west of Scarlet Point.

„ 3. Conglomerate resting unconformably upon Skiddaw Slate, and the two faulted against one another. West side of Langness. The slate has been worn away leaving a natural arch of conglomerate.