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1851

On the Superficial Accumulations *and* Surface-markings *of* North Wales. By Prof. A. C. Ramsay, F.R.S., G.S.

Read March 26, 1851.

[For the other Communications read at this Evening Meeting, see vol. vii. p. 200.]

During several summers, while investigating the more solid geology of North Wales in connexion with the Geological Survey of Great Britain, my attention has been occasionally directed to the subject of the action of ancient glaciers in that country, which were first described by Dr. Buckland in 1841*; and I have especially endeavoured to discover traces of a sequence of events characterizing the glacial epoch.

On both sides of the Menai Straits, the low ground of Anglesea and Caernarvonshire is often covered by a coating of "drift†," composed of beds of sand, gravel, and occasionally of clay, mingled with boulders, and sometimes bearing marine shells characteristic of the period.

On Moel Tryfan Mr. Trimmer discovered such shells in beds of gravel, at the height of 1392 feet above the level of the sea‡. From Moel Tryfan, these superficial deposits are continuous, at similar elevations, on the high grounds towards the valley of the Seiont, on the seaward side of the mountain ranges of Caernarvonshire. The valley of the Seiont is comparatively clear of "drift." Between Cwm Seiont

* Proc. Geol. Soc. vol. iii. p. 579 *et seq.* See also Quart. Journ. Geol. Soc. vol. i. p. 153 *et seq.*, p. 300, and p. 460 *et seq.*

† In this paper the term "drift" is used to denote the marine deposits of the Pleistocene sea, without special reference to the transport of materials from a distance.

‡ Proc. Geol. Soc. vol. i. p. 331.

and Llyn Padarn there is a wild moorland tract, covered by the same deposits, in which I found fragments of shells at an elevation of about 1000 feet. On the rough slopes on either side of the lakes of Lanberis, the "drift" has again in a great measure been removed, small patches alone remaining nestled amid the smaller hollows of the hills. Surrounding these more fertile spots, the ruined surfaces of masses of rock rounded and polished by glacier-action often rise almost destitute of vegetation. Between Llanberis and Nant Francon there is another broad high moor formed by "drift" of great thickness, and which, from an average height of about 1100 to 1300 feet, stretches eastward into the valley of Marchlyn-mawr, where it attains an elevation of about 2000 feet. Standing on this moor, above the left bank of the Ogwen, the eye easily detects on the opposite banks a corresponding accumulation, stretching smoothly up the higher valleys towards Aber, and bending on the east and south-east towards the sources of Afon Berthan, the Llafar, and Afon Gaseg; streams rising in the higher recesses of Carnedd Dafyd and Carnedd Llewelyn, on their seaward flanks. I am informed by Mr. Trimmer that he has good reason to believe that this part of these deposits contains shells at a height of about 1000 or 1200 feet. In the valleys, through which flow the streams last named, the "drift" attains an elevation of about 2300 feet, stretching into their wide recesses with a smooth outline, broken only by long lines of faintly-marked terraces, indicative of sea-margins during pauses in the later upheavals of the country. From this highest point it may be followed without a break to the present sea-level. Having ascertained by this unbroken continuity that the drift actually attains an elevation of 2300 feet on the flanks of Carnedd Llewelyn and Carnedd Dafyd, there is no difficulty in understanding the reason of the existence of similar masses in neighbouring isolated valleys high amid the mountains. This occurs in the elevated valley between Y Glyder fawr and Y Garn, in which a deposit of "drift" (see fig. 1, p. 375) stretches from the summit of the cliffs that overhang Cwm Idwal (2300 feet high), to the top of the hills overlooking the Pass of Llanberis.

In Anglesea, although by no means scarce, the larger boulders are much less numerous than in the "drift," where it approaches the mountains of Caernarvonshire. As far as I could discover, they are principally composed of fragments of the rocks of the island. On the opposite shores, approaching the mountains, they gradually increase in quantity, being scattered in and on the "drift," until at its margin, where it surrounds the higher points of land, the boulders often form a large proportion of its material, packed closely together along the sides of the hills, and in the nooks of the higher valleys. Even these coarse accumulations, however, when viewed at a little distance, present a generally smooth and regular outline. Sometimes on isolated hills, or on the summits and sides of high ridges, where the smaller "drift" has been removed by denudation, boulders and subangular masses lie singly scattered on the surface. A good example occurs on the east side of Nant Francon, on the long ridge of Pen-yr-olen-wen. One of these masses lies on the summit of this ridge, about 2000 feet above

the sea. Its dimensions are 9 yards by 5, by 2 yards in height. Its weight cannot be less than from 90 to 100 tons. The parent rock, of felspar-porphyry, is at least a mile distant.

I am well aware that heretofore it has not been customary to consider accumulations at so great an elevation as belonging to glacial marine deposits. They have either been altogether disregarded, or confounded with glacier-moraines. But when we consider their continuity with the shell-bearing strata, their regular smoothly sloping outline, and their gradual change from gravelly drift with a few scattered boulders on the coast, to the coarser and more massive accumulations among the mountains; and further, if we add to this the travelled boulders and masses of rock on the *summits of hills and ridges* 2300 *feet high*, it seems to me impossible to resist the conclusion, that the whole material from the present sea-margin upwards is of marine origin, and due to the operation of one general set of causes extending over a definite period.

In this communication I will not enter on the general proofs of the ancient extension of glaciers among these mountains, formerly so beautifully inferred by Dr. Buckland*. From numerous observations I have convinced myself, on what I consider perfect evidence, that this inference is correct, and with the materials I have collected I may at some future period produce a map of the extent and course of the glaciers of Caernarvonshire, or of North Wales generally. Believing then in their former existence, it is sufficient for my present argument to state that belief.

The "drift" deposits, above mentioned, often rest on and sometimes conceal the rounded, polished, grooved, and scratched surfaces (*roches moutonées*), due to the operation of glaciers, the effects of which are so clearly traceable in the Pass of Llanberis, Nant Francon, and other valleys of Caernarvonshire. *Roches moutonées*, surrounded by, and partly denuded of drift, may be seen near Llyn-y-Gader, in the neighbourhood of the Caernarvon and Beddgelert road, and in the valley leading from the base of Snowdon to Capel Curig. These great glaciers, therefore, *preceded* the deposition of the "drift,"—a circumstance mentioned by Dr. Buckland, in 1841†, who however attributes its distribution "to a great diluvial wave or marine current, advancing from the north, and propelling before it the materials of which the drift is composed‡." It may be objected that denudations during the submergence of the country must have removed the glacier-markings. On the other hand it may be replied, 1st, that the exposed polished rocks are for the most part of extreme hardness; 2nd, that rocks rounded and polished by glaciers, in offering surfaces of small resistance to the sea-waves, run a high chance of escaping their wasting influence during submergence; and 3rd, that they principally occur in the recesses of valleys that anciently, at various levels, formed narrow sinuous arms of the sea, where on the whole still water would prevail. The superincumbent drift has in a great measure preserved them from the wasting effects of atmospheric influences in more recent times.

* *Loc. cit.* † Geol. Proc. vol. iii. p. 579. ‡ *Loc. cit.* p. 584.

It is evident that before this glacier period the land had already received its present grand contour, and this conclusion may be generally applied to European and American surfaces on a large scale underlying the "drift." If the data previously stated be correct, it appears that, after the great glacier period, much of the country was depressed beneath its present level, at least 2300 feet, by which means the glacier-markings were covered by accumulations of superficial detritus. The higher parts of Wales, at the utmost from 800 to 1000 feet above water, must have formed a group of islands, perhaps too insignificant and low to admit of the formation of glaciers on their flanks.

The scratches and polished surfaces in Anglesea (like those in the vale of the Firth of Forth and in the lowlands of Ireland) seem to me to be due to the action of floating ice, the direction of the grooves being quite unconnected with those of the glaciers in the neighbouring mountains of Caernarvonshire. In Anglesea the grooves (at Harlech, in Tywyn-trewan, near the Holyhead Railway, on the "Yellow Sandstone," near Penrhos Llugwy, on the coast near Carmels Point, and at various localities near Llanfairynghornwy) generally run about E. 30° N. It is worthy of remark that near Penrhos-Llugwy, on the polished and grooved surfaces, potholes occur (where no stream could have run) of the kind frequently made on sea-coasts by the gyration of stones in hollows, showing that, since the rocks were smoothed and scratched, they have formed a sea-margin, from which the drift has been removed by denudation.

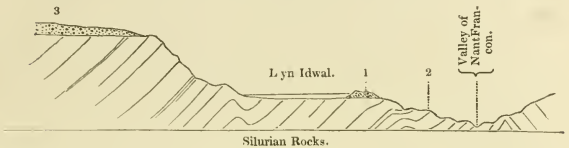
Whatever the conditions were under which boulders were dispersed from the height of 2300 feet downwards, they were brought to a close by the gradual re-elevation of the country. One of the characteristic features of the scenery of North Wales is, as I have elsewhere observed*, due to this elevation, the outlets of certain valleys being dammed up by greater accumulations of sediment towards their openings, the free egress of the drainage being prevented, and lakes having been formed, after the manner indicated by Mr. Darwin in his "Geological Observations on South America†." Examples of this may be seen at low levels in Caernarvonshire in Llyn Cwellyn and Llyniau, and on high ground in some of the lakes on the north side of Cader Idris in Merionethshire, and in Marchlyn-bach and Marchlyn-mawr in Caernarvonshire, where, in the latter case, the barrier of "drift" reaches an elevation of about 2000 feet.

But there are other lakes, such as Llyn Llydaw, on the Capel Curig side of Snowdon, and the celebrated Llyn Idwal, which are clearly dammed up, not by marine deposits, but by the moraines of glaciers (see fig. 1). As an example of the moraine-dammed lakes I select Llyn Idwal, in Cwm Idwal, the moraines of which have been described by Mr. Darwin‡. A terminal moraine spreads across the valley, and dams up the lake. Lateral moraines extend up the sides of the valley on either side.

* Athenæum (No. 1171), 1850, p. 377. † P. 24.

‡ Lond., Edinb. and Dubl. Phil. Mag. 1842, vol. xxi. p. 180; and Edinb. N. Phil. Journ. 1842, vol. xxxiii. p. 352.

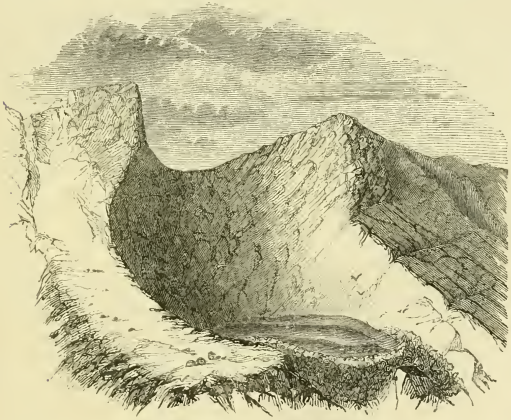
Fig. 1.—*Diagram illustrative of the damming up of lakes by means of moraines, as in the case of Llyn Idwal, and of the relation of the Drift to the subsequent Glacier-conditions.*



1. Moraine forming the dam of the lake.
2. Grooved and polished surfaces formed by more ancient glaciers.
3. Pleistocene "drift" at an elevation of 2300 feet.

There are other cases, as in Cwm Graianog, Nant Francon (see fig. 2), where, the drainage immediately percolating the loose piles of stones, no pent-up water is found within the barrier.

Fig. 2.—*Cwm Graianog, Nant Francon, having a terminal moraine of loose stones which admits of the drainage of the valley.*



But these moraines are often at a lower level than much of the Pleistocene "drift," as in the case of Llyn Idwal, where the level of the lake is about 1000 feet beneath the level of the ordinary "drift" on the summit of the cliffs, which I have already stated is in a high isolated valley, open at both ends (see p. 372). It is without tributary valleys, and the small rivulet which gradually gathers in its hollow, and flows into the Pass of Llanberis, has rarely succeeded in cutting through the drift of the higher ground to the solid rock beneath. It is im-

portant here to recall the circumstance that the "drift" of this valley attains an elevation about equal to that of similar deposits, which may be traced without a break from the seaward flanks of Carnedd Llewelyn to the shores of the Menai.

If, therefore, the loose moraine-heaps of Cwm Idwal had been formed during the great glacier period already mentioned, it would either in all probability have been destroyed during the depression and re-elevation of the land that followed that period, or it would have been covered over and smothered in the succeeding drift.

I am therefore forced to the conclusion, that there were two glacier periods in this land; first, one preceding our Pleistocene deposits, and a second on a much smaller scale, either when the land was rising from the Pleistocene sea, or possibly when during a portion of this process of rising it attained a higher elevation than at present. The moraines of these latter glaciers are to be seen in the mouths and recesses of the higher valleys, such as Cwm Idwal and Cwm Graianog, and in the valley of Llyn Llydaw and Cwm-y-Clogwyn, on the flanks of Snowdon, and also in the upper part of Cwm-llafar, where a small lake has been drained by the stream cutting its way to the base of the moraine*. These moraines are often of a massive character, being composed of piles of heavy angular stones heaped rudely together. In Cwm Graianog, on the summit of the pile of smaller blocks, half way between the bounding hills, there is a stone, now split by the weather, measuring $33 \times 27 \times 4\frac{1}{2}$ feet, and weighing about 250 tons. The shortness of the courses of these glaciers at first seemed to me a great difficulty, varying as some of them do from $\frac{3}{4}$ of a mile to $1\frac{1}{2}$ mile in length. An examination of the maps of MM. Schlagintweit† removed this objection, for on ground of similar form glaciers equally short are not uncommon. In Wales true moraines never occur in the main valleys opening into low tracts approaching the sea. In many of these valleys even most of the drift has been removed, by means which at a future period I hope to explain.

* The glacier has originally extended beyond this point, having in its course scooped out *a long straight hollow in the drift*. That this was not hollowed out by the stream is evident from the circumstance that the surface of *alluvial* detritus is not thickly strewed with boulders accumulated by the gradual removal of intermingled smaller sediment by means of river-action. The broad terrace of drift on the right bank of the stream is thoroughly charged with such boulders, often of large size. The removal of the lighter material by river-action would have concentrated these on the surface of the straight alluvial hollow through which the stream flows. This *concentration* of boulders may be seen in many of the Caernarvonshire valleys. A well-marked instance occurs on the banks of the river Gorfai, two miles S. and S.E. of Caernarvon.

† Untersuchungen über die phys. Geogr. der Alpen, 8vo. 1850.