apparent antiquity of the deposit, inclined me to the opinion that they were not refuse heaps. This conclusion I now think to have been erroneous. I detected lately in one of the lowest seams in the second set of deposits N. of Tremlyd Point, many bits of carbonized wood, with fragments of bone, pebbles, and stones, some of which appeared to have been burnt, together with the right metacarpus of a sheep, perfect but carious. Above this deposit was between eight and nine feet of sand, with some thin seams of mussel shells, about $3\frac{1}{2}$ ft. up, capped by a seam nearly a foot thick, just under the sandy surface soil. A little to the north, and still lower down in the cliff, was a thin dark carbonaceous band, in which I found two teeth, very decayed, of a sheep. This, and the first seam also, contained rotten fragments of *Littorina*, *Purpura*, *Buccinum* (?), *Cardium*, *Tapes* (?). Still further to the north we have the following section. (1). Sandy soil, with mussel shells, 9 inches. (2). Sand, with fragments of mussel shells, $4\frac{1}{2}$ -ft. (3). Mussels, with carbonized wood, $\frac{1}{2}$ -ft. (4). Sand, 1-ft. (5). Mussel shells, 2-ft. (6). Sand, and sandy talus, about 3 feet. (7). Shore a little above high-water mark. Nevertheless, though I have to thank Mr. Darbishire for correcting my error, I yet doubt whether all these deposits "must be set down as appertaining to the most recent human period." That, however, is a point of minor importance.

P.S.—The above paper was written immediately after making the observations recorded therein. At that time I concluded, from the silence of those who had written or spoken on the subject, whether before the Literary Society at Manchester or the Geological Society of London,¹ that no literature existed on the subject. Since my return to Cambridge, in conversation with various friends, I have been directed to sources from which I find myself not alone in the opinion expressed above. See especially the abstract of a paper "On the Agency of Land Snails in corroding and making deep Excavations in compact Limestone Rocks," by Dr. Buckland, in the Proceedings of the Geological Society of London, Vol. iii., p. 430; and a valuable memoir, "Observations sur les Hélices Saxicaves du Boulonnais," by M. Bouchard-Chantreaux.² The author of the latter discusses at considerable length the mode of excavation, and attributes it to the action of an acid secreted by the snail's foot. His observations on the form and arrangement of the burrows correspond very closely with my own, and his excellent lithographs of two groups might almost have been copied from some of those near Llandudno.

III.—ON THE SURFACE-GEOLGY OF THE LAKE-DISTRICT.

By C. E. DE RANCE, of the Geological Survey of England and Wales.

THE following notes were made during a few days' leave of absence, spent chiefly on the Green-slate area of the Lake-district, the beds of which have an east-north-east and west-south-west direction

¹ Quarterly Journal, Vol. xxv. Proceedings, p. 280.

² Annales des Sciences Naturelles. 4me Ser., Zoologie. Tome xvi., p. 197.

of strike, extending across the country in a belt about fourteen miles in width, resting on the Skiddaw Slates, and passing under the various divisions of the Coniston series. The characteristic feature of this tract of country is the uniformity in direction of all the gorges, or depressions, in which the lakes occur. The initiative of their direction (as pointed out by Dr. Nicholson)¹ appears to have been given by a system of north and south faults: thus Windermere, Rydal Water, Grasmere, and Thirlmere may be said to lie in one line of depression. Between the two last-mentioned lakes the pass of Dunmail Raise forms a col between two valleys. In the bottom of the valley, between the pass and Grasmere, there are immense mounds of moraine matter, the pebbles are all angular and strictly local. Steel Fell and Seat Sandal form two cliffs on either side, that on the western being much the steeper; the summit of Helm Crag, being much weathered, forming the well-known "couchant lion with a lamb under its nose," of the guide books. Following up the ice marks of Easdale Valley into that of Raise Beck, there seems little doubt that the two glaciers occupying these valleys united between Silver How and Nab Scar, and thence bore down upon Loughrigg Fell, which stopped its forward progress in a direct line, deflecting it into what is now Rydal Water. The lake Grasmere is excavated in a rock-basin, and one can easily understand its excavation being due to the immense pressure of the ice infringing on Loughrigg Fell. A similar state of things took place at the foot of Rydal Water; the rocks here are moutonnéed and glaciated upwards.

Moutonnéed rocks occur wherever the gorges are narrow and contracted, or wherever a mass of rock, opposite the entrance to a valley, formed a bar to the further progress of a glacier. The glaciated rocks above Skelwith Force being an example of the first; those at the entrance to Grisdale, above Patterdale Hall, of the second.

The feature which strikes the eye of a geologist, on viewing the country from the top of Helvellyn, is not the "sea of mountains" of the guide books, but the flatness of the tops of the hills; the valleys and gorges appearing mere gashes in the upland plain. This plain (which may possibly be part of that old plain of marine denudation which has been described by Professor Ramsay, in his "Geology of North Wales"), varies but little in elevation; the watershed of the lake country, as pointed out by Mr. Bolton, being a complete circle. Within this circle all the streams flow north, and fall into the rivers Derwent and Cocker, which unite at Cockermouth, and thus drain nearly the whole of the Lake-district. Some of the most remarkable passes of the district are situated on the southern edge of this circle, as Kirkstone Pass and the Pass of Dunmail Raise. It would thus appear, before rain began to fall, and rivers to flow, over this tract, in pre-glacial times, that there was a circular tract of high flat land in the centre of the district, surrounded by sloping ground dipping outwards in every direction. This circular plain (the top of a truncated cone) being no doubt the result of a pause in the subsidence during

¹ Geology of Cumberland, p. 18.

which the sea denuded the rest of the country into a gently inclined plane.

Mr. Mackintosh, in an article on the Lake-district in the GEOLOGICAL MAGAZINE for 1865, comments on the fact, that "we continually meet with a precipitous *escarpment* running along one side of a mountain-range, the other side of which is a gradual slope;" and, further, that "the steep escarpments generally face the east, south-east, or north-east, apparently showing that the indenting and undermining current must have assailed the ancient Cumbrian Archipelago from the east." His facts are undoubted, but I regret I cannot agree with the inference. For if the sea formed the indented voes of the eastern slope of Helvellyn, acting from the east, it could not have also formed the precipitous slope of the *western* side of the narrow Thirlmere valley, also acting from the east; for as the valley runs in a north and south direction at the foot of Helvellyn, it follows that the sea must have entirely denuded away the Helvellyn range, before it could have been exposed to the eastern breakers. It seems to me rather that the western sides of the gorges, or eastern sides of the hills, are steeper because they are most exposed to frosts and consequently to landslips than the opposite sides. My friend, Mr. Bolton, of Ulverstone, thus describes the effects of a winter's frost on the disintegration of the rocks of the lake district:—"At Dow Crags sometimes may be seen a spectacle of no common interest; the immense cliffs for a considerable distance are perpendicular, and in some places overhang the base, containing fissures and joints which admit moisture. . . . A hard frost in winter converts all this into ice, which, by its natural expansion, forces off from the parent rock large masses of stone, to bound and crash along the steep descent at the foot of the cliffs, . . . some large blocks even entering Goat's Water before their progress is arrested, the border of that small lake being covered with their debris . . . several single stones . . . weighing about three or four tons each."

The western sides of the valleys are more subject to landslips than the eastern, not only because they are more subject to the frost influence of easterly winds, but because the normal dip of the Green-slate being south-easterly, the rocks of the western slopes have an upward dip, causing the beds to have a tendency to slide along the dip planes into the valley beneath, while the inward dip of the eastern slopes defy the effect of frost to disintegrate their mass. They do not, however, entirely escape; for though less ruthlessly, and less suddenly destroyed, the gradual wear of western storms of wind and rain, round the step-like form, first impressed by the running brook, and finished by the glacier, into a gradual slope, or rather a parabolic curve.

At page 304 of his article, "on the Lake-district,"² Mr. Mackintosh mentions the *eastern* side of Helvellyn, as a "sea cliff," which

¹ "Geological Fragments," p. 45, 'Dow,' or 'Doe,' crags are a little west of Conistone Old Man.—C. E. R.

² GEOL. MAG., Vol. II.

he accurately describes as being, "not only the most precipitous, but indented with voes separated by *edges*, one of the voes terminating in Red Tarn Cwm." I have not the 6-inch ordnance maps of this district, but from a rough observation I made, when descending the precipitous slope described by Mr. Mackintosh, believe the base is about 860 feet below the apex of Helvellyn, dipping at an angle of from 40° to 60° ; on the Catchedecam side the angle is rather less, on Striding Edge rather more. From the bottom of the precipice to Red Tarn is a gradual slope of perhaps 50 feet. Through the centre of this slope, flows Red Tarn Beck, the first commencement of which is found in a small pond of running water immediately below the precipice, fed by a number of springs, issuing from the base of the cliff. The water, notwithstanding the great heat of the weather at the time of my visit (August), was intensely cold. From the dryness of the season, the lake Red Tarn was empty, and I therefore had an opportunity of examining its bottom. The banks consist of angular fragments, derived from the mountain above, none seemed to have experienced ice or glacier action, and most certainly there was no sign of the sea, neither a rounded pebble, or a single foreign fragment. The bottom of the Tarn was composed of fine sand brought by the springs out of the mountain; the banks of fragments, torn off its slopes by frosts and landslips. The sub-aërial deposit in which this lake occurs, appears to have choked up the bottom of the gorge under the mountain to a considerable depth, but following Red Tarn Beck, down the valley towards Ulleswater, the beck cuts down to rock, which is here and there glaciated. If the sea formed the two voes on either side of Striding edge, it is difficult to understand why it did not destroy the edge itself, especially as we know that the sea destroys headlands at the same and even "quicker rates than it works back lowlands." Though I agree with Mr. Mackintosh, "that, in those river gulleys which graduate upwards into larger valleys we may often discover a sufficient distinction between their respective contours to justify our referring the one to fluvial, and the other to marine denudation" (p. 303), as applied to some districts, yet I think such hollows of undulation in the original surface of marine denudation, in the lake district, are of extreme shallowness, and play altogether a secondary and unimportant part in the physical features of the country. Nor does it appear that the higher portion of this mountainous district was ever beneath the Glacial sea. From the shortness of the time I spent in the Lake-district, I was not able to make out the height to which it reached, but the rocks did not appear to be glaciated above a level of about 1,700 feet above the sea, the glaciation down to about 400 feet above sea level appearing to have been caused rather by land ice than by the grounding of ice-bergs. In the low country of Furness, the same sequence of upper and lower Boulder-clays, divided by a middle sand and gravel, occurs as was described by Mr. Hull, F.R.S., in 1863, as occurring in the Manchester district;¹ which classification has been adopted by Mr.

¹ Additional Observations on the Drift Deposits, etc. Mem. Lit. Phil. Society, vol. ii., 3rd series. Geol. Sur. Mem., on Qr. Sh., 88, S.W.

Mackintosh in his paper on the "North-west Lancashire Drifts," read before the Geological Society on June 23rd of this year.

In the Manchester district, described by Mr. Hull, the upper and lower clays are identical in character; they are both of a reddish colour, contain rounded and sub-angular pebbles and boulders, which appear to have been thrown down from icebergs in a Glacial sea, rather than by an ice sheet. The lower Boulder-clay is stated by Mr. Hull never to make its appearance in the hill country, and the Middle Drift, which rests on the denuded surface of the lower Till, in the low country, is found resting on the bare rock in the upland valleys of south-east Lancashire, and the bordering parts of Cheshire.¹ In one locality near Macclesfield, in an escarpment half-a-mile east of the Little Dog Inn, on the Buxton-road, Mr. Prestwich, F.R.S., discovered marine shells in Middle Drift, at an elevation of between 1,100 and 1,200 feet above the level of the sea,² which nearly corresponds in elevation with the bed with marine shells on Moel Tryfaen, described by the late Mr. Trimmer. As these are the highest elevations in which marine shells have been found, and as Mr. Hull, in his paper on the Manchester Drift, states, as Sir H. De la Beche had done long before, that no erratic ascend the hills of that district above an elevation of 1,800 feet, and that, "not a trace of a foreign rock occurs on the table-land of the Peak, which is about 2,000 feet high," it would appear that the fact of the absence of all traces of marine action, during the Glacial and Post-glacial periods, above an elevation of 1,700 feet in the Lake-district, is in accordance with what has already been observed in East Lancashire, in Derbyshire, Cheshire, and North Wales, and that there is little or no proof that the north-west of England was ever submerged to a greater depth during those periods.³

I cannot, therefore, agree with my friend Mr. Mackintosh, further than admitting that the sea, in Pre-glacial times, acting along lines of weakness, caused by faults and anticlinal axes, produced hollows of undulation, which determined the way water should flow, and in which rivers and brooks should cut down the step-like gorges of our existing Lake-district.

To those who state, with Prof. Sedgwick, that the proof of the limited excavating power of rivers in the lake district is being furnished by the small quantity of detritus they have yet been able to deposit in the lakes which receive their waters; it may be replied, first, that the lakes not only receive their waters, but also deliver them; that the lakes, almost without exception, are nothing but expanded rivers carrying detritus, not into lakes, but into the sea. To take an instance: Codale and Easedale Tarns flow into Grasmere, the latter into Rydal Water, whose waters, flowing down the Rothay, enter Windermere. Blea Tarn, Langdale Tarn, Stickle Tarn, Elter Water, all flow into Brathay, which, after falling over

¹ Hull, Mem. Lit. Phil. Soc., vol. ii., etc., p. 455.

² Darbshire, Geol. Mag., Vol. II., p. 303.

³ These three Drifts do not occur in the Lake-district, and true *Moraine Drift* descends as low as 100 feet above sea level.

Skelwith Force, and receiving the drainage of Loughrigg Tarn, joins the Rothay and falls into Windermere, which also receives Blelham Tarn, Esthwaite Water, Out-Dubs Tarn, and other small lakes; the Lake Windermere itself flows down the Leven, a considerable river, of which the River Crake, which drains Coniston Water, is a tributary. The two rivers unite at Greenodd and flow into Morecambe Bay, between Ulverstone and Cartmell. The Leven, at its mouth, therefore, contains the drainage of at least twenty lakes, of which five are of considerable size, and I think few can doubt that this river has been partly instrumental in the formation of "Morecambe Sands." And, secondly, again considering the immense depth of some of the lakes, the deep chasms in which they lie, it is impossible to say that there are not immense quantities of detritus concealed beneath their placid waters. At the time of my visit last month, from the dryness of the season, the heads of many of the lakes were dry, and I was, therefore, able to examine several of them, and I found the bottom invariably to consist of fine alluvial sand, capped by a thin coating of peat or vegetable growth; a section through one of these deposits would probably exhibit a succession of thick bands of alluvium, and thin seams of peat, the former thrown down in winter, the latter formed in summer; in this way several tracts have been reclaimed at the heads of several of the lakes.

I have been induced to publish the above hasty notes, because, with the exception of Mr. Mackintosh's paper, to which I have so often referred, little has been printed on the Surface-geology of the district. I have abstained from giving any sections of details, leaving them to the more able hands of those officers of the Geological Survey, who are now engaged in the survey of that region.

On my way south, I called on Mr. Bolton, of Ulverstone, the author of a most interesting work on the geology of Furness (the result of more than seventy years' labour), who showed me blocks of limestone bored with holes from the neighbouring mountains, and other blocks from the sea-beach of Walney Island, also composed of Carboniferous limestone, with similar holes, in each of which may be seen the two perfect shell-valves of a *Pholas*. But none of the holes were quite so large as those described to me by Mr. Mackintosh, as occurring in the block he sent up to the Geological Society.

IV.—ON THE OCCURRENCE OF PLANTS IN THE SKIDDAW SLATES.

By HENRY ALLEYNE NICHOLSON, M.D., D.Sc., M.A., F.G.S., Lecturer on Natural History in the Extra-Academical School of Edinburgh.

(PLATE XVIII.)

THE occurrence of plant-remains in the Silurian and Cambrian rocks is a subject of great interest, but one which has not hitherto been sufficiently investigated. Many supposed plants have been described by Emmons, Hall, Billings, and Dawson, from the older Palæozoic rocks of North America, and little doubt can be