

32. EVIDENCE of the ACTION of LAND-ICE at GREAT CROSBY, LANCA-SHIRE. By T. MELLARD READE, Esq., C.E., F.G.S. (Read May 13, 1885.)

(Abridged.)

In previous papers\* I have described a deposit of rubble-débris and red sand lying on the Triassic rocks and underlying the Low-level Boulder-clay and sands in the neighbourhood of Liverpool, which I suggested was due to the grinding and crushing action of land-ice. I also pointed out that where this deposit did not occur, the rocks, as is well known, are usually polished, grooved, and striated. Until lately no opportunity has occurred of testing the validity of this view by reference to any other than sandstone rock that such land-ice may have moved over †.

In October 1884 I described, in the 'Geological Magazine,' a section of Keuper marls at Great Crosby previously unknown, and since then I have made frequent observations of the upper part of the marls in relation to the Low-level Boulder-clay that overlies them.

From time to time as the excavations have proceeded, it became clearly apparent that the upper part of the marls had been from some cause or other much disturbed. There were imbedded in it large angular and sometimes nearly square blocks of sandstone. These were not merely pressed into the surface, but actually imbedded in the marl at all angles. In the undisturbed marls are well-defined bands of a harder nature, and one of these bands was at one place broken up and contorted, the fragments displaced, and irregularly forced into and amongst the worked-up softer marls or shales (see fig. p. 455). This was very striking, as the band continued in an undisturbed condition towards the south-west ‡.

As fresh faces were disclosed by the progress of the excavations, it could be distinctly seen that in some cases the upper soft fissile marls had been forced up into contortions. The thickness of the disturbed bed was from 3 to 4 feet.

The imbedded sandstone blocks were of two kinds: one a very fine-grained grey rock slightly micaceous; the other composed of coarsely rounded grains, mostly quartzose. They are evidently sandstones belonging to the Keuper series, though not found in this pit *in situ*. Neither are they exactly like any of the Lower Keuper sandstone beds found in the quarry at Little Crosby, about one mile and a half to the north-west. I am of opinion that they belong to beds underlying those at the bottom of the pit, which at the north-east side approach in structure the coarser of the two sandstones.

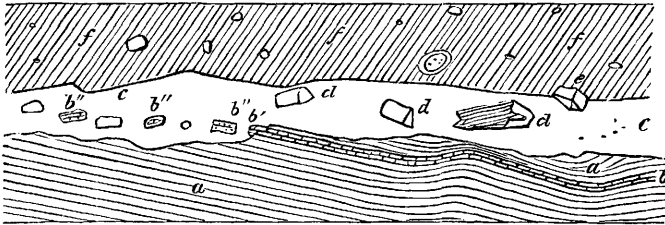
\* "Drift deposits of the N.W. of England," Quart. Journ. Geol. Soc. vol. xxx. p. 27; and vol. xxxix. p. 122.

† Mr. Strahan, in his Survey memoir of the 'Geology of the Country around Chester,' 1882, says "There is evidence of the passage of a heavy body over the ground in the crushing and drawing out of soft beds as if by pressure" (p. 29).

‡ The contortion of the beds below the eroded line in the section I consider to be due to earth movements.

It was not until several examinations were made that I was able to discover any striations on the imbedded sandstone. At last I detected them on a block measuring 4 ft.  $\times$  2 ft. 10 in.  $\times$  1 ft. 9 in. in extreme dimensions. On washing the marly clay off the face, very good parallel groovings were disclosed, running along the plane of bedding and the longer axis. With this clue I soon saw that the undersides of most of the stones were polished smooth, and others irregularly scratched.

*Section at Mowbrey Brick and Tile Works, Great Crosby.*



*a, a.* Grey shaly Keuper marl. *b.* Hard band in Keuper marl broken off at *b'*, *b''*, *b''*. Fragments of hard band, *b*, scattered through and imbedded in the "kneaded-up" marl. *c, c.* "Kneaded-up" marl, that is the Keuper marl or shale, worked-up into a grey clay. *d, d.* Blocks of sandstone, some fine-grained and strong, others coarser in grain and often smoothed and striated, in one instance strongly fluted. *e.* Half-imbedded block *f.* Low-level Boulder-clay (marine), containing far-travelled erratics and broken marine shells (brown in colour).

Specimens of the undisturbed marl and the kneaded-up marl were sent to Mr. David Robertson, F.G.S., who kindly examined them microscopically. No organisms were found in either, and they were practically of the same constitution. No far-travelled erratics, nor any stones or material that could not be referred to the Keuper formation could be found in the kneaded-up marl. Even the half-imbedded stones were, in all cases that I have seen, Keuper sandstones. The true erratics are confined to the overlying Low-level Boulder-clay. This clay is so distinctive a deposit that it is only necessary to say that here as elsewhere it contains fragments of marine shells, and is undoubtedly of aqueous and marine origin.

*Importance of the Discovery.*—The evidence of these disturbed shales is of importance taken in connexion with the prevalence in South-west Lancashire and Cheshire of glacial markings and smoothed rocks.

At the present moment (March 1885) is to be seen a very fine example of polished and striated rock at Flaybrick Hill, Birkenhead, Cheshire, a veritable *roche moutonnée* which has only just been bared of its covering of Low-level Boulder-clay.

It has, however, been a moot point with local geologists whether these markings are due to land- or floating ice. I have myself always considered that the weight of evidence preponderated in favour of land-ice, though there are some facts apparently irrecon-

cilable with that view. The phenomena described in this paper seem to me stronger evidence in favour of the land-ice hypothesis than any I had previously seen. It seems to me next to impossible that the disturbance of these shales could have been effected by floating ice in any form, and the entire absence of extraneous material in the "kneaded-up marls" lends further force to this view.

It is not easy to get the exact direction of the dip of the shales; but it is from north to south or between that and north-east to south-west. It follows from this that the lower beds must crop up towards the north, though the country is so buried in a mantle of Low-level Boulder-clay that the outcrop is not seen. If the disturbance of the shales were due to land-ice coming from the north or north-west (the nearest striæ so far recorded are at Little Crosby quarry, 22° W. of N., and opposite the Police Station at Great Crosby, 40° W. of N.), the outcrop of the lower beds consisting of sandstones would be torn up and pushed over and into the kneaded-up shales at all angles, and this so far corresponds with the facts described. Some of these rocks may have been glaciated *in situ*, and then broken off and pushed along and into the shales.

The tendency of the foregoing facts and phenomena is towards proving that the period of greatest cold preceded the deposition of the Low-level Boulder-clay. This I have already pointed out, first in 1874 and in various papers since.

#### DISCUSSION.

The PRESIDENT, while admitting that Mr. Reade's evidence seemed to point to land-ice, said that it was difficult to imagine a glacier on so slight a slope as that between the Lake-country hills and Liverpool.

Mr. WHITAKER insisted that the lower bed, having no erratics from a distant source in it, must have been of different origin from that with so many far-travelled blocks.

Dr. HINDE said that the absence of far-travelled erratics in the till of the area described by Mr. Reade was a local and not a general characteristic of this kind of rock, since in the lake-region of Canada and the United States the till, which is believed to have been similarly formed by land-ice, contains an abundance of erratics from distant localities, though it is mainly composed of the débris of local rocks.

The AUTHOR admitted the difficulty suggested by the President as to the motion of ice from so distant a source as the Lake-district over so slight a slope. He believed, however, that the mechanics of land-ice remained to be explained; but the facts he had recorded in the paper seemed to him quite irreconcilable with the theory that the deposit was formed by floating ice either as icebergs or shore-ice. In reply to Dr. Hinde, he stated that he did not think that the view that the Canadian Boulder-clay was due to land-ice was by any means proved to be the true one.