

thanks, proposed by the President, and seconded by the Secretary (Dr. Foulerton), after which the party took the 7.20 p.m. train for London, having spent a very pleasant day.

WORKS OF REFERENCE.

Sheet 46 of Geological Survey Map.

FITTON, W. H.—“Strata below the Chalk,” ‘Trans. Geol. Soc.,’ 2nd series, Vol. iv.

MORRIS, J.—“Excursion to Aylesbury” (1873), ‘Proc. Geol. Assoc.,’ Vol. iii, p. 210.

DE LORIOU, P. E., and PELLAT, E.—‘Étage Portlandien des environs de Boulogne,’ p. 189.

BLAKE, J. F.—“Portland Rocks of England,” ‘Q. J. G. S.,’ Vol. vi, p. 189.

HUDLESTON, W. H.—“Excursion to Aylesbury” (1880), ‘Proc. Geol. Assoc.,’ Vol. vi, No. 7.

EXCURSION TO THE MOUNT, EALING, AND HORSINGTON HILL.

JUNE 18TH, 1887.

(In conjunction with the Ealing Microscopical and Natural History Society.)

Director : J. ALLEN BROWN, F.G.S., F.R.G.S., &c.

(*Report by THE DIRECTOR.*)

The principal object of this excursion, which was attended by about a hundred Members, was the examination of exposures of stratified beds believed to be contorted and furrowed by the action of ice, at the Mount, Ealing, where a second large reservoir is now being constructed for the Grand Junction Water Company.

The party was met at Ealing Station by the Director, and proceeded by way of Castlebar Hill to examine a section of very high-terrace river-drift, exposed on its lower slope at about 125 feet above Ordnance Datum. The sections at this pit present features of some interest, considering the high level of the deposits. The upper terrace river-deposits are here over 20 feet thick, and much thicker than in many parts lower down in the valley.

It is remarkable that the upper surface of the gravel beneath the brick-earth dips towards the higher part of the hill to the north, and that the oldest gravel, which is nearly horizontal, has been eroded in the opposite direction to the general dip of the valley-deposits, thus forming a channel filled with gravel and sand, and showing that after the deposition of the thick, nearly horizontal,

stratified gravel beds beneath, the water receded, and that apparently this spot formed a temporary land surface, traversed by a tributary to the main stream. The same evidence of a stream having cut a channel in the old gravel has been found in pits more than 200 yards to the south.

This section illustrates in a marked manner the erosion of the Thames Valley, and the deposition at successive periods of the gravel and brick-earths; and shows that by the retreat of the waters at intervals from different spots, habitable land surfaces were formed, traversed by minor streams; the subsequent return of the waters of the main stream again submerging such old land surfaces and depositing river-drift matter upon them.

Two very fine flint implements have been found from five to eight feet below the present surface, besides worked flakes. The implements are of the oldest type, *i.e.*, of the St. Acheul form and abraded. One of them, which is nearly six inches long, is deeply ochreous in colour, and contains old cracks produced by frost, the fissures being filled with black carbonaceous matter; the other has a glossy black surface; both of them being in the Director's collection.

The Director pointed out that gravel is found in pockets in places all the way up Castlebar Hill, while near the top at the 155-foot contour there is a bed of subangular river-drift gravel, surmounting a deposit of rounded pebbles of apparently greater age, but at too low a horizon to belong to the Bagshots.

The Members then walked along the ridge to "the Mount." The present excavation is a short distance north of the one made in 1883, and is on the north slope of the hill. The latter is at the top, and was examined by the Members of the Association, and afterwards described in a paper read at the Meeting of the Association in June, 1883.*

In the sections inspected at the Excursion in 1883 the exposures showed finely stratified beds of fine sand and loam, traversed and disturbed by deep furrows and channels filled with red sand, rounded pebbles intermixed with smaller ones of quartz and other rocks, and large fragments of sarsen.

These beds were nearly horizontally stratified, with a slight dip to the south, except where the furrows occurred, but they were pressed together and twisted under the channels, some of which

* *Vide* 'Proc. Geol. Assoc.' Vol. viii, p. 172-181.

were over 50 feet long. The evidence was very strongly in favour of the flexures and contortion of the beds (clearly caused by pressure from above) being due to the stranding of masses of ice, which, afterwards melting, deposited the drift found in the pockets.

Another theory often applicable to irregular beds of gravel, *i.e.* that such pockets might be due to the disturbance of the beds by underground springs, was then, as in the present exposures, quite untenable; since on such a hypothesis the curvature of the beds should be most marked nearest the place where the underlying substance was removed, and should extend upwards towards the top of the overlying beds—whereas the opposite is the case here, the bedding becoming horizontal again a short distance beneath the contorted or compressed lines of stratification, and strong impermeable loamy clay occurring beneath them.

At and around the site of the present reservoir numerous boulders of small size have been, and still may be found, some of which are striated. In the Director's collection from the fields there may be found boulders of granite (three varieties), quartz, quartzite, veined greenstone, trap, Carboniferous Limestone, red sandstone, Upper Oolite, Forest Marble, Lower Greensand with glauconite, Bargate Stone, Chalk Rock, tabular and nodular flint, Sarsen and others not determined, intermixed with rolled flint pebbles.

The evidence derived from the sections in the first excavation in 1883, of glacial agency, or the action of large masses of ice as far south as Ealing, is confirmed in the present exposures, and the further development to the north of the stratified beds opens up an interesting question as to the age of that deposit. First, it is well to point out some new features in the present sections which seem to place beyond doubt the nature of the agency by which these laminated beds underlying large masses of gravel, sand, large sarsens, and other rocks were deposited on the top and higher slopes of this hill, which seems to have been, even when the stratified beds were formed, an undulating or rising bottom beneath the waters.

The contorted channels or pockets of ice-drift now only extend about 400 or 500 feet down the hill from the road—lower down the laminated beds become parallel and regular—and the furrows filled with detritus are absent. At a still lower level, rather beyond the northern limit of the excavation, there is yellow loamy clay. It is very probable that all this ground and much of the country to the north was once covered by similar ice-drift, which has since been denuded and removed by fluvial and sub-aërial action.

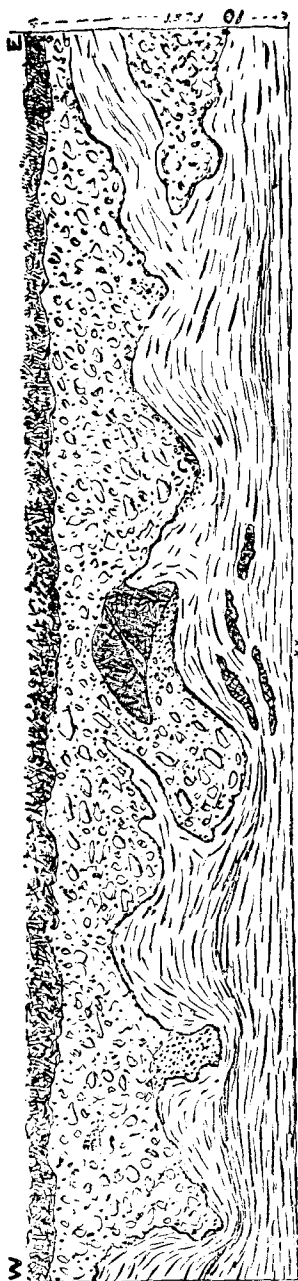


FIG. 1.—Section at the Mount, Ealing. (About 50 feet long.)
 ** Included deposits of purple clay.
 * Included mass of sand.

The contortion and disturbance of the stratified beds beneath and around the irregular deposits of hard concrete-like gravel, &c., has been markedly shown all over the upper part of this excavation. In some of the sections the laminated beds are curved up, wave-like, on one side of the channels filled with compressed gravel, apparently showing the point of greatest resistance encountered by the grounding mass of ice which afterwards deposited it. In others, long tongue-like masses of sand and gravel, with inclosed deposits of purple clay, are seen extending like irregular furrows into the midst of the stratified beds, bending and compressing the lines of stratification, and often apparently churning them up until the bedding is lost.

It is noticeable that above these irregular conglomerated masses of shingle, sand, and purple clay, the stratification is also destroyed, and the loam and sand which alternately compose the laminated beds are mixed up, as if on the melting of the mass of ice the sides of the upper part of the furrow had fallen in.

The Director said he had measured and sketched a large mass of combined stratified beds, with the gravel, &c., above it, which was temporarily left

standing in the excavation. The gravel was continuous as an irregular deposit, and may have been on an average four feet deep and nearly 50 feet long, with a width of 18 feet. This patch was much larger, but it had been cut off and isolated by the workmen. Such a quantity of matter, without the underlying beds, must have weighed nearly 150 tons, and if, as appears to have been the case, it was all thrown down together, including a boulder of sarsen, the mass of ice which deposited it must have been of the proportions of a small berg.

The pressure exercised by masses of stranded ice, pushing before them, contorting and churning up the laminated beds into the remarkable flexures now exposed, seems to be the only means which could have brought about such results. The ice itself, perhaps interstratified with gravel, sand, and clay, came probably from the westward or north-westward. It may very well have been derived, in greater part at any rate, from the ice-mantle and glaciers, which are believed to have extended in the middle part of the Post-Pliocene period into the Midland Counties, and even into Essex.

Some such a condition of the country must have occurred about this time in this part of Middlesex; and we have not far to seek even for the direct action of a glacier or an ice-foot, as at Finchley, about six or seven miles away, there is the well-known large deposit of boulder clay, with its contained striated boulders of Northern rocks, of which we have probably the representatives on the Mount, above the ice-borne gravel to which reference has been made.

The Finchley deposits, as well as the scattered detritus just mentioned, appear to indicate either the occurrence in the heart of Middlesex of the moraine of a glacier, or they are the ice-borne detritus and mud deposited under subaqueous conditions.* Coming now to the laminated beds of loam and fine sand overlying the brown sandy clay, which is found from the trial borings to occur beneath them, the stratification or dip of these deposits has been clearly shown to follow the slope of the hill, and it has been proved by the borings, as well as shown by the sections, that the beds lie unconformably upon the London Clay. They are, however, thicker at the top of the hill, where they are probably 35 to 40 feet in thickness, and thin out as the lower part of the excavation is

* *Vide supra*, p. 144-147.

reached, a short distance below which they disappear, and denuded London Clay comes to the surface.

The result of the trial-borings is as follows:—At the upper part of the excavation, which is within 18 or 20 feet of the top of the hill, the Lower Eocene is not reached at 29 feet 6 inches. About the centre of the works, or at 156 feet elevation, the London Clay is reached at the depth of 34 feet from the surface, while at the extreme northern end, the London Clay was met with at 22 feet 6 inches from the surface, which is there at the 136 foot contour.

These beds extend as an irregular terrace, overlooking the Thames Valley to the south, as well as the wider basin on the north, over the top and higher slopes of Hanger Hill, and they have been traced by the Director beyond, to the higher ground overlooking Twyford Abbey down to the 120 foot contour. In fact they occur all along the upper slopes of the higher part of the ridge dividing the Thames Valley from the wider extension of the basin on the north, from Castlebar Hill to the eastern extremity of the ridge, where it descends to the lower ground of East Acton.

The dip in the stratified beds and their unconformability to the London Clay was not so evident in the sections exposed in 1883, when the first excavation was made, and the occurrence of thin plates of mica and light clay bands and sand in the deposit gave rise to the hypothesis in the minds of some of the geologists then present, that this formation might belong to the Bagshot series, a remnant of which is found on Harrow Hill. The sections now seen will, no doubt, entirely set aside this suggestion, in view of the unconformability of the beds to the London Clay, let alone the occurrence of large boulders of sarsen which have been found in them, one of which was examined, and measured nearly 12 feet in circumference. Such a determination is also precluded by the much higher horizon of the outlier of the Bagshots at Harrow Hill, which is only about $2\frac{1}{2}$ miles distant in a direct line.

Of what age, then, are these and the underlying beds? It is to be observed that similar deposits are found on Horsington Hill, and on high ground at Harlesden and Willesden sandy loam is traceable, which suggests the same kind of deposits. On Dollis Hill, Neasden, lately visited by the Association,* there was a

* *Vide supra*, p. 148-152.

shallow excavation (not deep enough, however, to fully determine the age of the bed) in which gravel and loamy deposits were found which appear to indicate a similar bed. Something of the same kind is also found on the high ground at Hendon.

Taking the foregoing facts into consideration, and also that the stratified deposits on the Mount are only divided on the south side by a belt of probably denuded London Clay, about $\frac{1}{3}$ of a mile wide, from undoubted high-terrace river-drift gravel, &c., containing flint implements, they may well be regarded as of Post-Pliocene age—older than the highest bench of river-drift in this neighbourhood.

No mollusca or organic remains of any kind have been found in them, but the constituents of the gravel seem to be largely derived from the Bagshots intermixed with moraine matter or glacial drift, transported and redeposited.

It is highly probable that such glacial drifts were widely spread over the northern part of the Thames Basin in Post-Pliocene times before the present valleys were eroded, and that in the great denudation and removal of matter which has since taken place the larger proportion of such accumulations has disappeared, and much of that which is left may be of the nature of a washed-out or *remanié* deposit.

The large number of rolled pebbles contained in the furrows, many of which are black and derived either from the Lower Eocene or Bagshots, suggests their having been torn up by ice and subsequently transported and redeposited under considerable pressure as the ice masses melted, leaving them jumbled up together with the sandy loam in as little order as any boulder-clay deposit. Such a hypothesis does not involve the occurrence of large icebergs—it is more probable that large masses of coast- and shore-ice were detached from the ice mantle in milder seasons, as well as that originating in the north, and they may have been the agents by which the material has been transported.

However we may speculate on this part of the subject, we are met with the fact that stratified beds are here found at and above the 210 foot contour, and this leads to the demonstration that at the period when these beds were formed almost all the country between the Chalk hills of Hertfordshire and Surrey, and extending, perhaps, beyond the least elevated ground in those counties, was either wholly submerged and so formed a great tidal estuary, or else

a lake or chain of lakes. Professor Phillips* has shown us that an estuary or sea loch, into which most of the present tributaries of the Upper Thames flowed, once extended as high up the basin of the Thames as Reading, and even beyond. A submergence of even 250 feet in this area would produce that result ; and there is good ground for believing that a subsidence in the land exceeding that amount must have taken place in the Pleistocene period.

It appears probable that these stratified beds were deposited when the land was gradually rising, and after the period of greatest submergence of the Thames Basin ; in fact, as the waters became shallower, though still subject to tidal action. The laminated warp now seen in the wide tidal estuary of the Humber may afford us a parallel for this conjecture.

The observations of Professor Phillips indicate that a system of lakes subsequently existed in the higher reaches of the Thames, both above and below Oxford. Such lacustrine formations may very well have followed the retiring sea, as the uprise in the land continued in this part of the Thames Basin also.

If, then, the stratified deposits before us were not formed in an estuary, they may be due to a lake extending over a large part of Middlesex at a subsequent period. The latter hypothesis is strengthened by the occurrence of the finely laminated matter of which they are composed, pointing to its deposition in tranquil water.

If it is admitted that the boulder clay and moraine matter which is now found at Finchley, Watford, &c., of which there are also traces in isolated patches on the higher ground from Finchley in a S.W. direction to the Mount and Hanger Hill, and which is known to overlie pebbly gravel, &c., was once spread over much of the intervening land ; such an accumulation of detrital matter may have formed barriers and dammed up the waters of the wider river of the past when the present valleys had not been formed. This damming up may very well have been aided by the large masses of ice which, as we have seen from the evidence arising from the furrows and their contained detritus, were then floating about obedient to the winds, currents, and tides. The loamy clay and stratified beds may, in fact, be the equivalent of the Finchley moraine matter, redeposited and altered by running water.

* 'Geology of Oxford and the Valley of the Thames.'

The true river-drift formed even higher than the 125-foot contour, on the south of the ridge, belongs probably to the next stage, or the formation and erosion of the Thames Valley itself within the basin. That the wider river of the past was rapid in its course, and generally more torrential in its flow, is shown by the larger stones which constitute the lowest deposits of the high terrace. With such strong currents depositing matter at about the same level as the lowest extension of the assumed lacustrine beds, it is quite conceivable that the barriers forming such lakes could be finally swept away, causing much denudation and the rapid transport of glacial gravel. Lyell points out that the bursting through of such accumulations of moraine matter in floods is not an unusual circumstance. The entire absence of shells may be accounted for by the violent disturbance of the beds by ice, combined with the intensity of the cold which then prevailed. Lyell also cites the rarity of shells in glacial lakes, and says that in some Norwegian and Icelandic fiords the waters of the sea are so freshened and chilled by the melting of the icebergs that the fish are driven away and the mollusca killed. It is noticeable that there is the same absence of shells in the highest river-terrace, while at the lower level of the mid-terrace deposits at Brentford, during the formation of which it is believed a milder climate was beginning to prevail, a large number of testacean and other fossils have been found.

A vote of thanks was here accorded to Mr. A. Fraser, engineer to the Grand Junction Water Company, for the facilities he had afforded to the Director and the Members of the Association for viewing the sections, and also to Mr. Phillips, engineer in charge for Messrs. Lucas and Aird, the contractors for the work, for his kindness in furnishing the Director with the results of the trial-borings and a plan of the ground, etc.

After visiting Perivale churchyard and inspecting the tomb, the iron rails of which are embedded in the trunk of a tree, and otherwise twisted out of shape by the growth of others, the party continued the walk to the summit of Horsington Hill. Here the Director addressed the Members upon the changes which have taken place in the face of the country, in the Miocene, Pliocene, and Pleistocene periods, which could only be realized by mentally endeavouring to reconstruct it as it appeared in the Middle Tertiary epoch. A collection of fossils from the London Clay, found in making exca-

vations on Castlebar Hill and the Mount, had recently been added to his collection. They were obtained from the level of about 155 feet, and are believed to belong to the third or middle zone, as defined by Professor Prestwich. Among them are the following :—

<i>Modiola elegans.</i>	<i>Teredo.</i>
<i>Corbula globosa.</i>	<i>Rostellaria (ampla?)</i>
<i>Cardium, sp.</i>	<i>Fusus, sp.</i>
<i>Pecten, sp.</i>	<i>Pleurotoma, several spp.</i>
<i>Cytherea, sp.</i>	<i>Natica, 2 spp.</i>
<i>Nucula.</i>	<i>Nautilus imperialis, &c.</i>

Mr. A. Ramsay, F.G.S., described some years since some fossils from a sandy bed of a few inches in thickness in the Montpelier Road, Ealing, which is at about the same horizon as the above. Among them were numerous specimens of *Natica* and *Pyrula*, associated with a bed of *Modiola elegans*; an assemblage of forms which indicated, he thought, a depth in the Eocene Sea, at the period when the mollusca were living, of from 20 to 80 fathoms. The fossils occur, in his opinion, about 290 feet above the basement bed of the London Clay. Traces of the Roman occupation have lately been discovered on the Mount—portions of seven cinerary urns and a patera of Samian, besides fragments of ruder pre-Roman pottery having been obtained from there. The Director's large collection of Palæolithic and Neolithic implements, savage weapons, &c., as well as his general geological collection, were afterwards examined by the Members. In the first series were the Palæolithic implements—flakes and worked blocks of flint, in all about 600 objects, found on the Workshop Floor, Acton—as well as many flint implements from N.W. Middlesex, &c.
