thanks to Mr. Claughton for his goodness to them throughout the entire day, the members of the Association made their way to the railway station. On the way Dr. Fraser distributed a series of duplicate fossils from his own fine collection, and the party closed its week's work with a vote of thanks to Mr. Meeson, whose work as Excursion Secretary had done so much to make the whole excursion a success.

EXCURSION TO HILLMORTON AND RUGBY.

SATURDAY, MAY 7TH, 1898.

Director: BEEBY THOMPSON, F.G.S., F.C.S.

Excursion Secretary: W. P. D. STEBBING, F.G.S.

(*Report by THE DIRECTOR.*)

OF the members who availed themselves of this excursion, those coming from London reached Northampton about 10.55 a.m., and others joined later on at Kilsby Station, Hillmorton, and Rugby respectively. From Kilsby and Crick Station a walk of about $1\frac{3}{4}$ miles brought the party to the first section to be visited, that near Hillmorton.

RED-BANK BRICK-WORKS.—These brick-works, visited by permission of the proprietor, Mr. Young, of Rugby, are situated to the east of Hillmorton village. It is a comparatively new section of Lower Lias that is worked, and no fossils have, so far, been found to indicate the zone. Attention was particularly called to the capping of coarse gravel, and to the inclination of the clay surface to the north at the northern boundary of the excavation.

HILLMORTON SAND-PITS.—A few yards only separates the last-named section from the very extensive sand-pits owned and worked by the London and North-Western Railway Company. These pits were visited by permission of Mr. W. H. Williams, of Watford. The following interesting characteristics were pointed out:

The excavation now exposed is about 50 feet vertical at the eastern end, and consists of sand and gravel, but the sand has been proved within the limits of the workings for another 130 feet; thus the sand and gravel are together about 180 feet thick. Water is found within 2 feet of the present working level, and some few years back the L. and N.-W. Ry. Co. bored 145 feet with the object of procuring a supply, but the quantity available was too small to be of service. Mr. R. Lowe, district superintendent, to whom we are indebted for some of these particulars, informed us that 15 feet below the present working level the sand becomes darker in colour.

The upper part of the exposed section consists of some 8 to
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10 feet of coarse gravel, which rests unconformably on the sand (or on an older gravel) as it does on the clay in the brick-yard. This very distinct separation of the two sets of deposits was best seen in a small sand pit nearer to the village of Hillmorton.

The sand rests against the northern face of a highly-inclined cliff of clay, for the boring proving such a great depth of sand is quite near to the Red-Bank brick-works; and Mr. Low said that once, when a slip of the sand from the face of the clay occurred, the clay was like a wall; moreover, the slope of the clay in the brick-yard, towards the sand-pits, was once measured, and found to be 25 degrees.*

Towards the eastern end of the excavation it is very noticeable how the material becomes coarser, until at the dead end the whole 50 feet would be better described as gravel than sand. Westward, along the face of the excavation, were seen long stretches of finely-bedded and of false-bedded sand, with here and there long thin bands of clay or of carbonaceous matter; less frequently lenticular patches of gravel occurred. The general dip is to the north-west, the angle, however, being small.

In explanation of the phenomena observed, the following propositions by the Director seemed to receive the assent of the members present: (*a*) that the sand (or gravel) occupies a former depression in the Lower Lias of the district; (*b*) that it is a true glacial deposit, in the sense that only the rapid melting of snow or ice could account for the long-continued and violent, though restricted, floods to which the deposit is due, as well as the varied character of the material; (*c*) that the torrents which brought the gravel, sand, and clay came from the north or north-east, and spent a large portion of their energy upon a barrier formed by the high ground north of Kilsby and extending through Hillmorton towards Dunchurch; (*d*) that the chief point of impact lay to the eastward of Hillmorton, in the direction in which the sand so rapidly passes into gravel; (*e*) that this line of impact was ultimately breached (or overtopped) by the torrents, in places, one being just about where there is now a depression bridged by the railway and cut through by the Oxford Canal,† and some of the gravel poured through this vent into the valley now occupied by the Rains Brook. This rounding of the Hillmorton ridge by the gravel is well seen to the east of Red-Bank brick-works, lower down the hill towards the canal wharf; (*f*) that one main flow of water, diminishing in velocity, was approximately that of the present Clifton Brook, the diminished

* This banking of drifts against the northern sides of hills has been noted before, see *Geology of the London Extension of the Manchester, Sheffield, and Lincolnshire Railway*, Pt. I, by C. Fox-Strangways, F.G.S., *Geol. Mag.*, Dec. IV, vol. iv, March, 1897, pp. 54 and 56.

† Another breach was probably between Crick and Kilsby, cutting through the south-eastern end of Kilsby tunnel, the material extending and expanding towards Welton and Daventry.

velocity being made apparent by the deposit of sandy, contorted Boulder Clay near to Rugby, visited later in the day.

THE CENTRAL BRICK-YARD, HILLMORTON.—This section was next visited, by permission of the proprietor, Mr. Rathbone, and a number of fossils obtained indicative of the "Armatus"-zone, the chief being *Ammonites planicosta*, *A. densinodus*, and *A. trivialis*.

After a rest of half-an-hour for luncheon at Hillmorton, the party proceeded to Mr. Satchell's brick-yard, about half-a-mile towards Rugby. The pit was too wet, owing to recent rains, to permit of an examination of the clay itself, but some fossils indicative of three zones of the Lower Lias, were obtained: *Ammonites densinodus* and *A. planicosta* from the "Armatus"-zone; *A. raricostatus* and *A. tardecrescens* from the "Raricostatus"-zone; and *A. bifer* and *A. oxynotus* from the "Oxynotus"-zone.

GREAT CENTRAL RAILWAY.—From Satchell's pit, a walk of a quarter-of-an-hour, brought the party to the Great Central Railway, where it intersects the Hillmorton and Dunchurch road. Only a very small portion of the slopes had not been grassed over, but this small portion permitted of an hour's collecting from the "Oxynotus"-zone, *Ammonites oxynotus*, *A. bifer*, *A. polymorphus*, *Gryphaea cymbium*, *Hippopodium ponderosum*, *Spiriferina walcotti*, and a few gasteropods, being the more noticeable fossils found.

Walking towards Rugby, Mr. A. W. Casson, the Resident Engineer for this portion of the line, pointed out a small temporary excavation, from which was obtained *Ammonites turneri*, *A. semicostatus*, etc., indicative of the "Turneri"- or "Semicostatus"-zone.

Contorted Boulder Clay.—A little nearer to Rugby there was an exposure of a considerable thickness of Boulder Clay. This is a brownish material which looks like and cuts like a clay when wet, but is far more like a soft grey sandstone when dry, easily crumbling in the fingers. It is a compound of sand and clay, the two materials being mixed up in the most erratic manner, giving a peculiar and pretty contorted appearance when half dry. As a rule this clay is free from any derived material—either rock or fossil—that can be identified, but here and there patches of gravel have been found in it containing a varied collection of pebbles and rolled fossils; at other places only masses of small fragments of chalk occur.

This Boulder Clay, like the sands of Hillmorton, rests on the northern side of an inclined face of Lower Lias Clay, except that a few feet of blue Boulder Clay with local Lower Lias fossils in abundance is interposed, this latter material being little more than the disturbed upper layers of the Lias beds on which it rests.

The contorted Boulder Clay is of considerable thickness, and everything seems to point to its being a contemporaneous and

continuous deposit with the Hillmorton Sands, being laid down in water the velocity of which had been considerably checked by a land barrier which it was unable to surmount. The small icebergs which would certainly accompany flood water derived from the rapid melting of ice was probably the cause of the contortions, by acting on the soft freshly-deposited mixture of mud and sand; and the stranding of such icebergs would account for the occurrence of isolated patches of gravel.

RUGBY PORTLAND CEMENT CO.'S WORKS.—A walk of about $1\frac{1}{2}$ miles through Rugby and New Bilton brought the members to the large quarry in the Lower Lias Limestones. Here they were met by Mr. Brooks, the manager, and Mr. Edyvean-Walker, the proprietor, who kindly invited them to partake of refreshments before going into the quarry.

The excavation is through the "Bucklandi" and "Angulatus" zones, and is considered to be the finest inland section of Lower Lias Limestones in the country. Attention was called to the beautiful banded appearance, which is supposed to have given to the whole formation the name of Lias, a corruption of the word layers. The entire absence of Boulder Clay or sand on the clay was pointed out, though the never-failing gravel capping was present. Passing through a connecting tunnel under the railway, a second excavation was examined, where what appeared to be a triangular pocket of sand, though only one side could be seen, extended to the base of the workings. The depression here is no doubt of pre-Glacial origin, and the sand of the same age as that at Hillmorton.

There was no time for a detailed examination of this extensive section, and very little for the collection of fossils; but those who carried away large specimens of *Lima gigantea* no doubt quite realised the fact that fossils were to be found by the time they reached Rugby Station.

Lieut.-General McMahon, on behalf of the Association, thanked Mr. Edyvean-Walker for his courtesy and hospitality.

RUGBY AND NEWBOLD CEMENT WORKS.—From the last section a walk of about a mile brought the company to the Rugby and Newbold Cement Works. This excavation shows a face very much resembling the one at New Bilton, viz., frequent alternations of clay or shale and limestone, giving a strikingly banded appearance to the section, which, judging by this and the fossils seen, evidently belongs to the *Bucklandi*-zone. The chief point of interest here, however, was the sharp anticline shown on the north-eastern side of the pit. Mr. A. M. Hurst, by whose courtesy the section was examined, said that this anticline had been traced for about a mile, that the stone in it was not only more difficult to get, but when got was very inferior in quality for cement-making purposes—"the virtue had been taken out of it." This, of course, rather points to its being due to some sudden

LOWER LIAS LIMESTONE, SHOWING ANTICLINE TRENDING EAST AND WEST.
(*Reprinted, by permission, from the Memoirs of the Geological Survey.*)

violent movement, but bearing in mind the sharpness of the curves, and their small lateral extension, it was considered it could not be due to upheaval from below, but rather indirectly to relief of pressure from above. Some photographs were taken of the anticline. The plate which is here reproduced is from Mr. H. B. Woodward's "Jurassic Rocks of Britain" (vol. iii, p. 164, *Mem. Geol. Survey*), kindly lent by the Director-General of the Geological Survey. It is from a photograph by Mr. J. D. Paul, and shows the anticline rather better than it can be seen now. A considerable quantity of water percolates through the limestones in the lower part of the excavation; Mr. Hurst said about 12,000 gallons per hour.

From the Newbold Quarry a walk of about a mile brought the party to Rugby Station, where a well-earned meal was partaken of. Lieut.-General McMahon proposed a vote of thanks to the Director, which was carried unanimously. The return journey to London was made by the 6.47 train from Rugby.

NOTE.—Since the Excursion on May 7th I have been reading two papers, the titles of which stand first in the list of references below, and these lead me to believe that a good portion of the plateaux to the west of Hillmorton, embraced by a curve extending round to near Rugby station, is made up of the Brown Boulder Clay, and that this clay may have been deposited in a kind of bay out of the main track of the water.

B. THOMPSON.

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