## NOTICES OF MEMOIRS, ETC.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, YORK, 1906. — ABSTRACTS OF PAPERS READ BEFORE SECTION C (GEOLOGY).

### I.—THE GLACIAL DEPOSITS OF THE EAST OF ENGLAND. By F. W. HARMER, F.G.S.

THE eastern part of Norfolk forms a low-lying area which, could the glacial beds be removed, would seldom rise above the 100 foot contour. This region, therefore, with the Fenland, was the first part of East Anglia to be overrun by the North Sea ice. None of the resulting moraine (similar, for example, to the Contorted Drift of Cromer) is now found in the Fenland, as it has been destroyed by the subsequent advance of the inland ice-stream to which the Chalky Boulder-clay was due; its former presence is evidenced by the occasional occurrence there of igneous erratics like those found on the Norfolk coast.

At this period, moreover, the North Sea ice must also have advanced over Holderness and the East Lincolnshire plain. A portion of the glacial deposits of those regions may therefore be of equivalent age to the Contorted Drift of Cromer. As, however, the movement of the Scandinavian glacier from north to south must have been gradual, the Contorted Drift may be somewhat newer than the earliest of the glacial beds of North Britain.

Before the deposition of the Chalky Boulder-clay in East Anglia, the North Sea ice had withdrawn from a great part of that region, and it did not reappear. During its retreat, however, it heaped up a well-marked terminal moraine in the form of a hummocky ridge of drift, in places reaching 300 feet above O.D., extending 20 miles in a S.S.W. direction from Mundesley and Cromer.

The Chalky Boulder-clay of Suffolk is blue and intensely Kimeridgian; that of Norfolk is whitish, with a chalky matrix, the boundary between the two being clearly defined. Jurassic Boulder-clay, moreover, may be traced across the Fenland from Suffolk into the Lincolnshire plain, while the chalky drift of Norfolk is represented by the chalky clay which is piled against the western slopes of the southern part of the Lincolnshire Wolds to a height of 300 and 400 feet. The behaviour of the last-named drift is instructive. Due to ice crossing the chalk range through a depression running from north to south in the direction of the present valley of the Bain, it turns suddenly to the south-east as it approaches the lower ground, instead of overflowing the latter, as it must have done had that course been open to it. The separation between the Jurassic and the Chalky Drift is as clearly marked in Lincolnshire as it is in East Anglia. Produced from the former district to the latter, the line dividing them *runs diagonally across the mouth of the Wash.* The author has, moreover, traced a trail of Neocomian erratics for 100 miles in the same direction from the plain of the Witham to the neighbourhood of Ipswich.

These facts suggest the existence of two confluent but distinct ice-streams travelling, *pari passu*, from N.W. to S.E., that which occupied the Jurassic plain being sufficiently the stronger to thrust on one side the ice descending from the Wolds, diverting it towards Norfolk, mounds of Chalky Boulder-clay more or less parallel with the escarpment being accumulated between the two as a medial moraine near Horncastle. This view explains why, at the period in question, the North Sea ice was unable to enter East Anglia through the Wash Gap.

The absence of the intensely Chalky Boulder-clay of South Lincolnshire from the Lincolnshire plain to the west of Market Rasen, where the escarpment is unbroken and more than 500 feet high, indicates that no ice overflowed the Wolds near that place, nor did any cross from the North Sea to the north of the Humber.

It must therefore have been the region south of that river, and north of Caistor, where the Wolds have been broken up and eroded, which supplied the grey flint and hard chalk (other than that of the Norfolk Drift), which is found everywhere in the Chalky Boulder-clay over such an enormous area. So prodigious is the total amount of this débris that, were it brought together, it would almost bridge over the depression now dividing the Lincolnshire from the Yorkshire Wolds.

From the Fenland the Great Eastern glacier fanned out in all directions: to the east over Suffolk, overflowing also the chalk escarpment from Newmarket to Hitchin, from which it travelled down the dip-slope south-eastward into Essex, and southward towards Finchley and St. Albans. To the south-west it occupied the basins of the Welland, the Nene, and the Ouse with a confluent ice-sheet overspreading the higher ground which separates them. Moving along the strike of the Oxford Clay up the valley of the Ouse, it filled that region with Boulder-clay of which the matrix is prevalently Oxfordian; further to the north-west the glacial drift contains a larger proportion of Liassic detritus. The Boulder-clay which covers the chalk region immediately below the crest of the escarpment is, as a rule, very chalky, as is the drift to the west of the Lincolnshire Wolds, and for the same reason, viz., that it was principally the upper and cleaner portion of the ice-sheet which mounted the slopes of the chalk hills. Some Jurassic débris from the Fenland was, however, carried over into Essex, but not enough to give the drift of that region a typically Jurassic character.

Another and an important branch of the Great Eastern glacier passed up the Trent basin. One portion of this climbed the marlstone escarpment near Grantham, and spread Chalky Boulder-clay over the high land to the south of that place; another part followed the Trent valley towards the south-west until it met the ice streams of the Dove and the Derwent, the combined ice-flow being thence southwards up the valley of the Soar. Glacial drift containing, on the one hand, Pennine and Mount Sorrel erratics, and, on the other, Jurassic and Cretaceous débris, may be traced for many miles to the south and south-west of Leicester towards Rugby and beyond.

At one time it was believed that the crescentic moraines of York and Escrick represented the greatest extension of the Teesdale ice. Now, the driftless area to the south of York notwithstanding, it is admitted that the ice reached as far as Barnsley and Doncaster; the comparative absence of drift immediately to the south of those places cannot, therefore, have any value as evidence, in the face of the fact that Chalky Boulder-clay sets in again in great force still further to the south. The enormous area covered by the moraine of the Great Eastern Glacier, 10,000 square miles in extent, is inconsistent with the view that it can have been wholly due to ice crossing the Wolds at the two places named. We seem, therefore, driven to admit the existence of a great ice-stream continuous from the mouth of the Tees to the Fenland, and from the Pennines to the Yorkshire moorlands and the Wolds.

The study of the glacial deposits of the East of England does not appear to support the view that mild interglacial conditions obtained at any time in that region between the deposition of the Cromer Till and the 'cannon-shot' gravels which overlie the Chalky Boulder-clay.

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II.—Lake Oxford and the Goring Gap. By F. W. Harmer, F.G.S.

DEEP borings at Sandy, Newport, and Hitchin, and further west at Stony Stratford, reveal the existence of drift-filled valleys, extending in one case to a depth of 140 feet below sea-level, which were probably connected with that of a pre-glacial river running in a north-easterly direction towards the North Sea. Similar deep borings at Boston, Fossdyke, and Long Sutton may represent the mouth or the seaward extension of such a valley.

As far as the Midland Counties are concerned, the gorge at Goring is unique. At no point between Newmarket, in Suffolk, and Blandford, in Dorset, in the one case, or between Lincoln and Bradford-on-Avon on the other, have the Cretaceous or Oolitic ranges been cut down to the base-level of the plains, nor does water run through them from one side to the other. Cases similar to that of Goring occur, however, at three of the places named, as well as at Ancaster, and at Ironbridge, in Shropshire. All these are of a distinct type from the dip-slope valleys of the Oolitic and Cretaceous ridges, and they must have originated in a different manner. They have certain striking features in common. Not only do they cut continuously through the ridges, at right angles to the natural drainage of the plains, but they form narrow, sharply cut, U-shaped gorges, having an extremely modern appearance, as distinguished from the older-looking, wider, and more gradually shelving basins of the dip-slope rivers. They are invariably accompanied by lake-like depressions, lower than the general level of the plains, opening into trumpet-mouthed gorges, through which the former are drained.

Dealing first with the gorges at Lincoln and Ancaster, the effect of the advance of the Vale of York glacier to Barnsley and Doncaster, and the obstruction of the gap separating the Yorkshire from the

Lincolnshire Wolds by the North Sea ice, as explained in a former paper, must have impounded the drainage of the Trent basin and caused the formation of a lake, the overflow of which could only have escaped over some part of the Lincoln ridge. Unless the Lincoln and Ancaster gaps were already in existence, which seems to the author improbable, some such overflow must have been initiated at that time. The continuous advance of the Trent glacier southwards would eventually have blocked the Lincoln gorge, probably with drift, and the Ancaster gap would have been originated, being afterwards similarly blocked, in its turn, as the ice moved on. These channels, however, would have been reopened successively, and probably deepened, when the ice retreated.

Referring next to the case at Goring, we find scattered over the low country round Oxford a number of isolated hills, generally capped by gravel, the origin of which it is not easy to explain on the hypothesis of the fluviatile erosion of the Oxford plain; they present no such difficulty, however, if we regard the latter as the site of an ancient lake, the bottom of which has been gradually lowered.

It has been long known that the gravels in question contain Triassic pebbles, but it is still more important to notice the presence in them, often in great abundance, especially as they are traced towards the gap, of grey Lincolnshire flint.

This flint drift connects itself with a great trail of such detritus extending continuously from Buckinghamshire to the Wolds, being exceedingly common both in the Chalky Boulder-clay of the Ouse basin and in the gravels into which the latter passes towards the south-west.

The grey flints occur in the highest part of the Oxford gravels, at elevations exceeding 400 feet, as, for example, on a hill immediately to the south-west of that place, and at Basildon, near Goring, above the narrowest part of the gorge. The erosion of the Oxford plain, and of its outlet below that level, cannot, therefore, have commenced until after the arrival of the glacial drift in that region.

Other gravels, also containing Triassic pebbles and Lincolnshire flint, occur at a somewhat lower level, representing a later stage in the deepening of the bed of Lake Oxford and of the Gap.

The south-westerly advance of the Chalky Boulder-clay glacier up the Ouse basin, preventing any possible drainage to the east through the Stony Stratford Valley, must have caused the formation of a lake over the comparatively low ground which probably then existed between the Chilterns, the White Horse, and the Cotswold Hills. That the drainage of this lake was from the first in the direction of the present gorge is shown by the presence of flint gravel immediately above it, near the 400 foot contour; it occurs also within it at a lower level. Once started, the drainage has continued to run in the same direction to the present day. The swirl of the water, swollen, especially in summer, by the melting of the ice-sheet which lay close at hand, converging constantly to one point, eventually produced the trumpet-shaped opening which formed such a marked feature of the Gap.

The bottom of the lake, composed of soft Jurassic clay, was gradually deepened, *pari passu* with the excavation of the gorge, the deepest part being always, as shown on the contour maps, near the mouth of the latter, where the erosive power of the escaping water was the greatest.

## REVIEWS.

I.—Geology: Earth History. By T. C. Chamberlin and R. D. Salisbury. Vol. II: Genesis–Paleozoic; pp. xxvi, 692, with 306 illustrations. Vol. III: Mesozoic–Cenozoic; pp. xi, 624, with 576 illustrations. (London: John Murray, 1906. Price 21*s.* each net.)

IN continuation of the account of "Processes and their Results," reviewed in our August number, we now call attention to the second and third volumes. They complete this great geological work, and aim at giving an interpretation of the record of the rocks, based on acquired knowledge. In the second volume the story opens with matter that is necessarily more or less imaginative or speculative, matter requiring astronomical, physical, and chemical knowledge, not of great practical moment to the geologist, but full of interest to those who wish to start "In the beginning," with Nebular and Meteoritic hypotheses of the earth's origin; with Cosmology in fact, about one-fifth part of the volume is occupied; and many points briefly mentioned in the first volume are here amplified.

The authors adopt a modified Nebular, or Planetesimal, hypothesis, and mark out the stages of the earth's evolution as (1) astral, (2) molten, and (3) lithic eons, with a practically solid globe; leading on to (4) a primitive volcanic eon, accompanied at first by prodigious volcanic activity, and later attended by sedimentation and the introduction of life. In this last eon we pass from the unknown into the partially known; into the oldest accessible formations, classed in the Archeozoic era. This is the era of schists and granitoid rocks, a complex series including outflows of lava, volcanic tuffs, igneous intrusions of various types, together with sedimentary rocks; all more or less highly metamorphosed, crumpled, and deformed. The presence of life is suggested by carbonaceous shales, certain iron-ores, limestones and cherts, similar to those which owe their origin in part to organic action. This era, it is thought, may have exceeded that of all subsequent time.

Between the Archeozoic and the next era represented in the rocks, there is everywhere great unconformity. This next phase is termed the Proterozoic (a synonym for Algonkian as used by the U.S. Geological Survey). The term is apt to be confused with that of Protozoic suggested by Murchison in 1839, and adopted by Lapworth for the Lower Palæozoic (Cambrian, Ordovician, and Silurian).

In this Proterozoic era it may be said that geological history