

ring the single vertebra (Figs. 1–3, Plate III.) to the same species as those represented by Fig. 5.

If no other indications of an enaliosaurian reptile had been obtained from the Triassic (?) beds of Nelson Province, or from the Waipara beds or boulders, the part of a limb-bone—I believe femur—sketched by Dr. Hector, and of which a reduced view is given at Fig. 4 and 4a—would have sufficed.

It shows the hemispheroid articular head, coarsely pitted by the characteristic circular depressions, with slightly raised margins. The degree of contraction of the shaft to the broken and the indicated retention, so far, of a subcylindrical shape of shaft, are incompatible with any known modification of an Ichthyosaurian humerus or femur. These are more angular, and transversely oblong at the proximal end, and more rapidly compressed and expanded towards the distant one in the fish-like sea-lizard. The fragment of limb-bone, in the Museum at Wellington, is plainly plesio- or plio-saurian, and most probably part of the same species, if not individual, as the trunk sketched in Fig. 5. The long diameter of the head of the bone is 3 inches, 6 lines; the short diameter is 3 inches. The peripheral contour is flatter or less convex on one side than the other, as it is in the same part of the femur of *Pliosaurus portlandicus* (Monograph, in the volume for 1869, of the Palæontographical Society, tab. iv., fig. 3), in which the small crateriform pits of the articular surface are shown; but this character is common to *Plio-* and *Plesio-saurus*.

Other genera of Mesozoic saurians are suggested by the "List" drawn up by my friend, the explorer of this dangerous but richly-stored locality: but the difficulty of precise determination from outline-sketches, even as to whether an obviously cup-and-ball vertebra be "pro-" or "opistho-coelian," decides one to wait, for the present.

PLATE III.

Plesiosaurus Hoodii, Owen.

- | | |
|--------------------------------------|-------------------|
| Fig. 1. Cervical vertebra, end view. | } Half nat. size. |
| " 2. " " side view. | |
| " 3. " " under view. | |

Plesiosaurus crassicaudatus, Owen.

- | | |
|---|------------------------|
| " 4. Proximal part of femur. | } One-third nat. size. |
| " 4a. Articular end of femur. | |
| " 5. Trunk-ribs and vertebrae from base of neck, one-sixth nat. size. | |

II.—ON THE AGE OF THE STRATIFIED DEPOSITS, WITH MAMMALIAN REMAINS AT CROFTHEAD, NEAR GLASGOW.

By JAMES GEIKIE, District Surveyor of the Geological Survey of Scotland.

(With Two Woodcuts.)

IN the GEOLOGICAL MAGAZINE for September, 1868, I described a section of Drift deposits which had been exposed in the cutting of the "Kilmarnock and Crofthead Extension Railway." If the reader refers to that paper he will find it stated that the Lower

Boulder-clay of the locality in question contains certain intercalated beds of clay, sand, and gravel which have yielded *Bos primigenius*. Quite recently the remains of the horse and the great Irish deer have been met with in the same deposits. In the present paper I do not mean to say more about the character of the stony clay which overlies the beds with mammalian remains. There can be no doubt whatever that it is truly Boulder-clay. But as I understand that several members of the Glasgow Geological Society have since visited the section, and, while agreeing with me as to the glacial origin of the overlying Till, have yet expressed an opinion that this bed is not in its natural position, but has slipped down upon the stratified deposits from the adjacent hill-slope, it may be well to point out how all the facts are against such a supposition.

1. The bedded deposits of clay, sand, and gravel do not differ in the slightest degree from similar intercalated beds of very common occurrence in the Lower Boulder-clay of the south-west of Scotland. Along the numerous stream-courses of West Lanarkshire, Ayrshire, and the neighbouring counties, abundant evidence on this head will convince the most sceptical. I may add that near to the bottom of the *Bos*-beds I obtained from finely laminated clay a few scattered stones, all well striated—the smallest not bigger than a walnut, the largest about the size of one's fist. Here again we have a repetition of phenomena common to the Boulder-clay of the west and east of Scotland. In the valley of the Tweed, for instance, we have alternations of tough yellow Boulder-clay with beds of gravel (often full of scratched stones), and considerable thicknesses of sand and laminated clay, which occasionally exhibit a few scattered erratic blocks and striated stones. The same appearances are repeated in the valleys of the Stinchar, the Ayr, the Doon, the Irvine, the Avon, the Clyde, and their numerous tributaries. There can be no doubt that these bedded deposits are truly intercalated with the Boulder-clay, for excellent sections, which the merest tyro will understand at a glance, frequently present themselves in flat undulating country where there cannot be any possibility of intermittent landslips having occurred.

2. Throughout the trappean district in the neighbourhood of Crofthead, and for many miles to the west, south, and east, the hill-tops and steeper hill-slopes are singularly bare of Boulder-clay, that deposit being only met with in the bottoms of valleys and sheltered hollows, and here and there sparsely scattered over the gentler hill-slopes.

3. The overlying Boulder-clay in the Crofthead section is only a continuation of the same deposit which, increasing in breadth as the valley widens to the south-west, creeps further up the gentler valley-slopes in that direction than it does where the valley contracts and the hill-slopes become steeper. Hence the position of the Boulder-clay in this valley is quite natural, and just what one would expect to find.

4. The underlying laminated clays, etc., are in places highly crumpled and contorted, and the foldings are so arranged as to show

that the force which squeezed and puckered them must have acted in a direction *down* and not *across* the valley. Moreover it is a fact that the similar intercalated beds of clay, sand, and silt, so commonly met with in the Lower Boulder-clay of Scotland, almost invariably show contortions in the same manner as here.

5. An examination of the slope of the ground above the spot where the mammalian remains were found, certainly does not favour the idea of a landslip having taken place. The accompanying section (Fig. 1), drawn on a true scale, will better show this than mere verbal description. I have represented here the original surface of the ground before the railway operations were begun, and the line of section crosses the valley a few yards below the spot where the skull of the great ox was got. From B to A the general slope of the hill-side is not more than 11° ; and from A the hill continues to slope up at the same angle for a distance of 470 yards, to where the hill-top is reached at a height of about 725 feet above the level of the sea. At B the rock-surface suddenly dips down at a much steeper angle, and against this slope the stratified beds abut. The Boulder-clay which rests upon these deposits originally extended as far as c, but was subsequently removed during the progress of the railway cutting. Now if the overlying position of the Boulder-clay is supposed to be due to a landslip it will also be necessary to suppose that the Till in question has glided bodily down a long gentle slope of 11° , that it has performed this wonderful feat of agility without leaving behind it any portion of its substance, and that after toppling down the slope at B it has crept boldly on over the level surface of the *Bos*-beds for a distance of at least 150 feet!¹

6. As the Boulder-clay which overlies the *Bos*-beds at the place from which the section (Fig. 1) is taken is the same deposit as that beneath which the stratified clays, etc., re-appear some little distance further up the valley, it follows that, if at the former place the overlying position of the Till be due to a land-slip, then the same must be the case here too. Upon such a supposition we have to believe that the Boulder-clay has slid along a slope of 12° for a distance of 230 feet at the very least, or if we suppose it to have come from the flat hill-top then it must have glided along the same gentle slope (12°) for some 660 yards or thereabouts. After this it must have had sufficient impetus to carry it for a distance of about 230 feet over the nearly level surface of the underlying lacustrine deposits!

But the accompanying section (Fig. 2) will show more clearly the nature of the ground. The general slope of the hill-side, above the Boulder-clay terrace, b2, is, as I have just stated, only 12° for a distance of 660 yards to the highest point [725 feet above the sea], overlooking the valley at the place from which the section is taken. The slope is quite bare of Boulder-clay. At b2* a small patch of Boulder-clay is represented, which by this time may have been

¹ I have not represented much of the south-east slope of the valley, as I do not suppose any one will dream that the Boulder-clay has slid from that quarter.

cleared away. It is only the tailing-off of the Boulder-clay which, as we follow it towards Shillford, creeps a little further up the southern slopes of the valley, but is there very thin.¹ No overlying Boulder-clay, however, occurs on this side of the valley as we approach the spot from which section Fig. 1 is taken. The slopes of the rock surface below the drift deposits, as shown in the two sections, are protracted from the angle formed by the sides of the valley, and the depth from the level of the railway to the rock thus obtained agrees closely with that ascertained from borings. If the reader refers to my former communication (Vol. V., p. 393) he will there find stated the evidence for the existence of the Boulder-clay underlying the lacustrine deposits, which is represented in the accompanying woodcuts (Figs. 1 and 2) at *b1*.

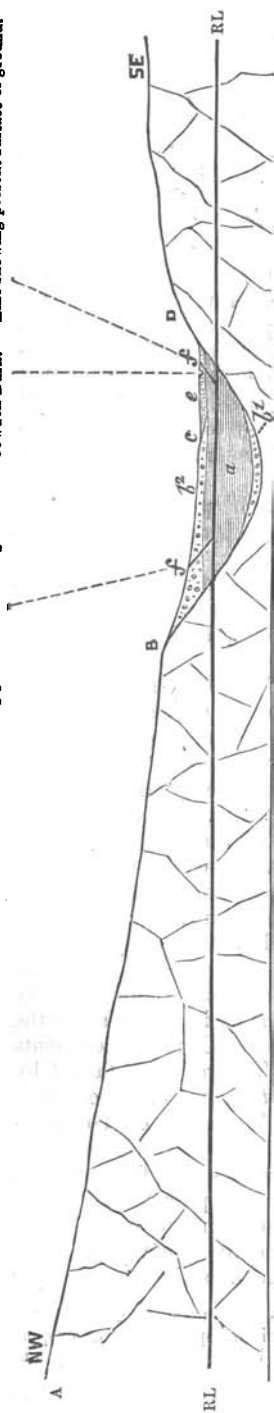
Quite recently the railway operations were interrupted by a landslip. The lacustrine deposits had been so deeply cut into that the downward pressure of the superincumbent Boulder-clay forced the soft wet beds below to bulge forward, and I was told that the rail-road was squeezed up some six or seven feet. The navvies had only repeated what the stream had done before. It appears clear to me that Boulder-clay, resting on lacustrine deposits, once filled up the entire hollow from B to D. By and by the stream cut its way down through the Till and cleared it away from *c* to D. The underlying soft, wet silt, sand, and clay, now pressed down unequally by the Till (*b2*), yielded, and bulged up at C, where, of course, the stream gradually washed it away. Thus the Boulder-clay, I believe, is now at a slightly lower level than formerly. Similar landslips may often be witnessed along the river-courses in the west of Scotland. In the valley of the Calder Water (River Avon) for instance, at Calderbraehead, the river has cut its way down through a broad and gently sloping terrace of Boulder-clay into deposits of soft clay, silt, and sand, which, from borings, have been ascertained to be of great thickness. Now, just as in the Cowden valley, so here, the weight of the overlying Boulder-clay has forced the subjacent denuded and exposed deposits outward into the stream, which is rapidly carrying them away, and the result is that the surface of the ground adjoining the river is permanently lowered. Thus, neither in the case of the Cowden Valley, nor in that just mentioned, have the landslips been caused by the sliding forward of the Boulder-clay upon the stratified deposits, but by the undermining, displacement, and actual abstraction of the soft foundations on which the Boulder-clay rests.

I saw the section at Crofthead, in November last, in company with my friend and colleague Mr. Croll, and I shall only add that he was as much surprised as myself that any one could fail to see the truly intercalated character of the lacustrine deposits which have yielded the mammalian remains.

¹ If, therefore, I had taken the section (Fig. 2) across the valley, a little nearer Shillford, it would have shown a larger portion of Boulder-clay in the position represented in the annexed woodcut at *b2**.

(PLATE 100. 2.) LONGITUDINAL SECTION, SHOWING ORIGINAL SURFACE OF GROUND (NEAR WHERE *Bos primigenius* WAS FOUND) BEFORE RAILWAY OPERATIONS WERE BEGUN.

Line showing present surface of ground. Cowden Burn. Line showing present surface of ground.



RL, Level of Railway, about 450 feet above the sea.

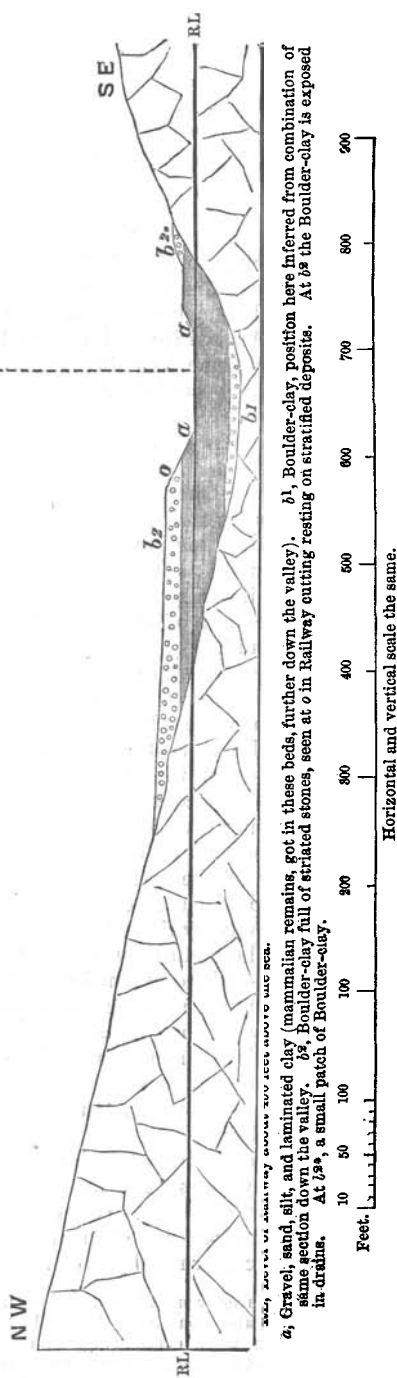
a, Lacustrine deposits with mammalian remains.

b1, Boulder-clay.

b2, Overlying Boulder-clay.

e, Alluvium, &c. f to f', removed by railway operations.

(FIG. 2.) HORIZONTAL SECTION (true scale) across the valley of the Cowden Burn, about 250 or 300 yards above the place where *Bos primigenius* was found. Railway cutting.



SEAL, SURFACE OF ORIGINAL GROUND NOW ACES HUNTO AND DEB.

a, Gravel, sand, silt, and laminated clay (mammalian remains, got in these beds, further down the valley). b1, Boulder-clay, position here inferred from combination of same section down the valley. b2, Boulder-clay full of striated stones, seen at o in Railway cutting resting on stratified deposits. At b2 the Boulder-clay is exposed in drains. At b2, a small patch of Boulder-clay.

Feet. 10 50 100 200 300 400 500 600 700 800 900

Horizontal and vertical scale the same.