and the melting action of its summer warmth, why should this gravel not be found over the whole of Southern England, instead of being confined to the glacial depression-districts of the south coast?

(To be concluded in our next Number.)

III.—NOTE ON A FORE-PADDLE OF *METRIORHYNCHUS* FROM THE OXFORD CLAY OF PETERBOROUGH.

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IN the description of the skeleton of *Metriorhynchus* given in vol. ii of the Catalogue of the Marine Reptiles of the Oxford Clay, very little could be said about the fore-limb. The only parts then known were a number of humeri and, in one or two cases, some small disc-like bones which were regarded as the radius and ulna: the most complete fore-limb was figured on p. 172 of the volume quoted. In order in some degree to fill this gap a short account was given (tom. cit., Introduction, p. xiii) of an imperfect fore-paddle of a specimen of the closely related *Geosaurus gracilis* from the Solenhofen limestone. This beautiful skeleton, originally described by V. Ammon (*Geognostische Jahreshefte*, vol. xviii, p. 12), has recently been acquired by the British Museum, and a photograph of it is given as a frontispiece to vol. ii of the Catalogue of Oxford Clay Reptiles. The specimen is beautifully preserved, and is remarkable for showing the outline of the tail-fin and other traces of the soft parts. Unfortunately for the present purpose the fore-limb is represented only by impressions of the bones, and no trace of the humerus can be seen, but still a good idea of its short paddle-like structure is given: this is shown in figure 1.

FIG. 1.—Fore-paddle of *Geosaurus gracilis*. a. radius; b. ulna; c. radiale; d. ulnare; mc. 1-4, metacarpals. R 3948. Nat. size. From *Catalogue of the Marine Reptiles of the Oxford Clay*, p. xiii.

It will be seen that proximally there are two pairs of disc-like bones, the homologies of which are not certain. Ammon regards the proximal pair (a and b) as being the radius and ulna, the distal pair (c and d) as the radiale and ulnare. Fraas in his account of the fore-limb of *Geosaurus* adopts the same view (*Palaeontographica*,

vol. xlix, 1902, p. 56, pl. viii, fig. 3), but in his specimens the bones of the proximal pair are much larger than the distal. If this interpretation is correct, then the distal carpals must have disappeared or, as seems unlikely, have fused with the proximals. The first metacarpal is an expanded plate, the other three rod-like; the fifth is wanting in Ammon's specimen, but is figured by Fraas, who also shows the number of phalanges as 2, 3, 4, 3, 2, but this is very uncertain; in *Geosaurus gracilis* Ammon figures a single phalange in each of the first three digits.

Recently Mr. A. N. Leeds has collected from the Oxford Clay of Peterborough a nearly complete left fore-limb of *Metriorhynchus*, together with portions of the right.

Fortunately the clay in which the left carpals and proximal ends of the phalanges lay has been preserved, and from the impressions of the bones their position can be determined. On the right side the second, third, and fourth metacarpals are in situ in the matrix, and there is an impression of the proximal end of the fifth. The humerus, radius, and ulna on both sides are unfortunately completely freed from matrix, and their exact relative position remains doubtful. Figure 2 shows what is regarded as the most probable arrangement of the bones of the left paddle (p. 446).

The *humerus* (*h.*) is much compressed from before backwards, and its preaxial border is produced into a strong deltoid crest, forming a triangular expansion and terminating in a small tuberosity. The head is oval and is strongly convex. Beneath the deltoid crest the shaft is a flattened oval in section, and the distal articulation is a slightly convex facet occupying the whole of the end of the bone and running up a little on to the preaxial border.

The *radius* (*a*) is a flattened plate the edge of which is thickened, and bears an articular facet on its upper inner border and another at its distal end. In front of these facets the body of the bone forms a large flattened expansion, projecting considerably preaxially. This bone is regarded as the radius (1) on account of its larger size, there being a tendency for the preaxial bones of a paddle to become enlarged, a condition here seen also in the radiale and first metacarpal; (2) because its distal articulation agrees very well with the upper articular surface of the radiale.

The bone here regarded as the *ulna* (*b*) is smaller than the radius. At its upper end it is much compressed and bears an oblique facet for the humerus; its posterior border is produced into a thin, sharp process, marked with striæ directed towards its apex—possibly this served for the attachment of a strong tendon. Distally the bone narrows and thickens, terminating in a rounded facet for the ulnare.

As already remarked, the exact relations of the radius and ulna to one another and to the neighbouring bones are uncertain, they being freed from the matrix, but in the case of the carpals and metacarpals the case is different, the bed of matrix in which they lay being preserved. The *radiale* (*c*) is the larger of the two carpals; its proximal border is thickened and bears a straight articular surface for the radius; its anterior border is convex, while the posterior is concave, and bears at its lower end a facet for the ulnare. Distally it

articulated with the plate-like first metacarpal and perhaps partly supported the second.

The *ulnare*(*d*) is an oblong bone articulating with the ulna proximally and having a facet at the lower end of its anterior border for union with the radiale: distally it supported the third, fourth, and fifth metacarpals and to some extent the second.

The first metacarpal (*mc.I.*) is a thin, much expanded bone, probably triangular in outline when complete: it articulates with the convex border of the radius only. The second metacarpal, which is rather longer, is a narrow, compressed bone, expanding a little at its upper

FIG. 2.—Left fore-paddle of *Metriorhynchus*. *a.* radius; *b.* ulna; *c.* radiale; *d.* ulnare; *h.* humerus; *mc.* I–V, metacarpals. Two-thirds nat. size.

end, which articulated between the radiale and ulnare. Distally it terminates in a sharp edge and probably had no phalange articulating with it. The third metacarpal is larger but otherwise similar: it articulates with the ulnare only. The fourth is about the same length as the second, but is considerably more slender. The fifth is about as long as the fourth, but has a more slender shaft. It has a marked expansion at each end, and distally bears a facet presumably for a phalange, the only one which appears to have been present.

The paddle of *Metriorhynchus*, as compared with that of *Geosaurus*, does not seem to have undergone such extreme modification especially

in its proximal region: thus the humerus is still quite recognizably Crocodilian, while that of *Geosaurus*, figured by Fraas, is not. In the case of the radius, and more particularly the ulna, there are still traces of their condition as long bones, while in *Geosaurus* this is not the case. The carpals and metacarpal are similar in both genera, but the phalanges seem to have undergone most reduction in *Metriorhynchus*.

In most reptiles in which the fore-limb has become paddle-like it tends also to become larger, this enlargement being frequently accompanied by additions to the number of bones composing it. Thus, not only is it usual for the number of phalanges to be increased, sometimes very greatly, but additional elements may appear in the carpal region, e.g. in *Tricleidus*. In *Metriorhynchus*, on the other hand, the paddle-like modification was acquired while the limb was undergoing reduction, and in this case the number of elements has been much reduced, the phalanges having nearly, and the distal carpals entirely disappeared. The limb had already become so small that it can have been of little use in swimming or even in balancing.

Some dimensions (in millimetres) of this paddle are given below:—

Humerus: length	67
width of upper end	21
width at deltoid crest	(approx.) 27
width at distal end	15
Radius: greatest length	22
greatest width	26
Ulna: greatest length	26
greatest width	15
Radiale: greatest length	19
greatest width	15
Ulnare: greatest length	14
greatest width	12
Length of metacarpal I	(approx.) 19
II	23
III	26
IV	22
V	21

The two coracoids and the left scapula are also preserved, but they do not seem to differ in any marked respect from specimens described in the Catalogue.

IV.—MOINE PEBBLES IN TORRIDONIAN CONGLOMERATES.

By J. W. GREGORY, D.Sc., F.R.S.

THE relation of the Torridon Sandstone to the Moine Gneiss or 'Eastern Schists' is one of the primary questions in the geology of the Scottish Highlands. These two widespread series of rocks occur on opposite sides of the great overthrusts in North-Western Scotland; and another remarkable feature of their distribution is that though the Torridon Sandstone often rests directly upon the Lewisian Gneiss, it never occurs on the Moine Gneiss. The view has therefore been suggested that the Moine rocks are the eastern metamorphosed continuation of the Torridonian. Some altered Torridon Sandstones certainly resemble the rocks of the Moine Series.