3. *On the SKULL and GREATER PORTION of the SKELETON of GONIOPHOLIS CRASSIDENS from the WEALDEN SHALES of ATHERFIELD (ISLE OF WIGHT).* By REGINALD WALTER HOOLEY, F.G.S. (Read November 21st, 1906.)

[PLATES II-IV.]

I. HISTORY OF THE DISCOVERY OF THE SPECIMEN.

IN the late autumn of 1904, at a place locally called 'Tie Pits,' near Atherfield Point (Isle of Wight), a large mass of the cliff, comprising many thousand tons of the Wealden Shales, subsided, pushing its foot across the beach, until below low-water line. As the sea washed away the base, the mass continued sinking, and fresh horizons were denuded. In 1905 a series of heavy 'ground-seas' cast up blocks of limestone and ironstone, containing crocodile-bones, which were discovered on the sand, between high- and low-water marks. The skull came ashore in six pieces, and on as many different occasions.

Scutes and fragments of bones were constantly picked up. One block found by a local fisherman was forwarded to the Sedgwick Museum, at Cambridge. After correspondence with Mr. Henry Keeping, the well-known Curator, I was put in communication with Prof. T. McK. Hughes, F.R.S., who, with great liberality and courtesy, wrote that in 'the interest of scientific progress' he thought that their block should be handed over to me, and this was accordingly done. The collection of the skull, etc. would have been impossible, but for the aid of Mr. Walter White, the coxswain of the Atherfield lifeboat, who obtained the separate portions by visiting the beach at every tide. The horizon whence the specimen was derived is 80 to 90 feet below the top of the Wealden Shales.

II. HISTORY OF THE BRITISH GONIOPHOLIDÆ.

The genus *Goniopholis* was first founded in 1841 by Owen.¹ The type-specimen, named by him *Goniopholis crassidens*, was obtained from the Purbeck Beds of Swanage, in 1837, by Robert Trotter, F.G.S., and presented by him to Mantell, whose collection is now in the possession of the British Museum (Natural History). It consists of the left mandibular ramus, teeth, scutes, vertebræ, and sundry bones of the pelvic region, lying on two slabs of Purbeck Limestone, one being the counterpart of the other.

Mantell had previously, in the 3rd edition of his 'Wonders of Geology' 1839,² made known and figured the fossil under the name of the 'Swanage Crocodile.' It was described again by him in the

¹ 'Rep. Brit. Foss. Rept.' pt. ii, Rep. Brit. Assoc. 1841 (Plymouth) p. 69.

² Vol. i, pp. 387-89 & pl. i.

2nd edition of his 'Medals of Creation,'¹ and in 'Petrifactions, & their Teachings,' and in other of his works, while it was finally more fully described by Owen in 1878.²

In the Reptile Gallery of the Natural History Museum (Geological Department), the same frame contains, not only the two type-blocks, but a smaller one, with the impression of the orbital region of the skull and a fragment of the frontal bone, situate between the orbits; and the impression and fragments of a moiety of the right ramus. This particular block was not referred to by Mantell or Owen. It is not mentioned in either of the works cited, nor is it noticed in the 'Catalogue of Fossil Reptilia & Amphibia' pt. i (1888), of the British Museum. When I mentioned this to Dr. A. Smith Woodward, he referred to Mantell's original manuscript-catalogue of his collection, where it is noted; consequently, no doubt as to its belonging to the type-specimen can be entertained.

Separate teeth are figured by Owen.³ He refers to, and figures, the greater portion of the premaxillæ of *Goniopholis*, revealing the almost entire narial aperture, discovered by Mr. G. B. Holmes, of Horsham, in the Wealden of Cuckfield (Sussex). He ascribes this specimen to *Goniopholis crassidens* without stating reasons; but, as no teeth are preserved and the premaxillæ are unknown, it could alone have been suggested as belonging to that particular species, by the horizon from which it was derived. In the same supplement,⁴ Owen simply refers to fig. 5, pl. i, remarking that the specimen there figured was from the Purbeck Stone. It comprises the anterior ends of the rami, *minus* the spleuials, now in the possession of the British Museum. This fossil is also referred to *Goniopholis crassidens*, because of its geological horizon. That this was the reason is made evident by his stating,⁵ in reference to three vertebræ, that

'they were obtained by Mr. Holmes from the same bed of Wealden Clay, at Cuckfield, as the teeth and scutes figured in pl. iii, characteristic of the genus *Goniopholis*, to which, therefore, I refer them.'

With these latter there were also preserved a caudal vertebra, coracoid, humerus, ilium, femur, and other bones.

The preceding appear to be the only recorded remains of *Goniopholis crassidens*, and, excepting the isolated fragmentary moieties referred to that reptile by Owen, the skull was unknown.

Another species, under the name of *Goniopholis simus*, was described by Owen⁶ from a skull, *minus* the lower jaw, from the Purbeck of Swanage. This particular specimen had been previously described by Hulse,⁷ together with a skull and mandibles, acquired by Mr. Willett, from the Purbeck of Swanage, and

¹ Vol. ii (1854) pp. 677-79.

² 'Monograph of the Fossil Reptilia of the Wealden & Purbeck Formations' Suppl. viii (Palæont. Soc. 1878) p. 1.

³ *Ibid.* pl. i.

⁴ *Ibid.* p. 4.

⁵ *Ibid.* p. 5.

⁶ *Ibid.* p. 7.

⁷ 'Note on Two Skulls from the Wealden & Purbeck Formations, &c.' Quart. Journ. Geol. Soc. vol. xxxiv (1878) pp. 377-81 & pl. xv.

ascribed by him to *Goniopholis crassidens*, but both skulls undoubtedly belong to the species *G. simus*.

There is a feature on the skull of the type-specimen which is not noted by either of these authors. A bony ridge, from the inner anterior border of the orbits, passes across the frontal bone in a curve, developing in the centre into a prominent eminence 6 mm. high, which in life must have been slightly higher, as the apex is gone. It is well defined, and has not been caused by crushing.

On enquiry of Prof. Louis Dollo, I was informed by him that the skull of *Goniopholis simus* in the Musée Royal d'Histoire Naturelle de Belgique, at Brussels, shows no traces of the crest. However, this keel is found in *Nannosuchus gracilidens* as well, and is also not noted by Owen. It is interesting to observe that it is also present in the recent caimans and the North American alligator, but not in any of the crocodiles that I have examined. Thus it appears in *Caiman latirostris*, *sclerops*, *niger*, *latifrons*, and *Alligator mississippiensis*; while it is absent in *Crocodylus niloticus*, *palustris*, *porosus*, *robustus*, *americanus*, and in the gharials.

In 1879¹ Owen described another species under the name of *Goniopholis tenuidens*, from the anterior portion of a mandible, from the Middle Purbeck of Durlleston Bay. He estimated the jaw of *Goniopholis crassidens* to have measured about 2 feet in length, and *G. tenuidens* about a quarter of the size; and he differentiated the latter from *G. crassidens* and from *G. simus* by this and the greater slenderness of the teeth.

To four vertebræ, Owen gave the name of *Goniopholis carinatus*. He figured them,² but gave no description.

The fossils from which these four species of *Goniopholis* have been formed appear to be the only specimens from Britain that have been hitherto described.

Through the kindness of Dr. A. Smith Woodward, and Mr. E. J. Baily, of Battle (Sussex), who forwarded the specimen to the Natural History Museum, I have been enabled to study the skull of a *Goniopholis*, discovered by the latter gentleman in the Purbeck limestone near Battle. The skull is very much flattened, and portions of the upper jaw alone remain, much apparently having been destroyed at the moment of discovery.

The premaxillæ, as far as 13 mm. from the tip of the snout, are entire; but there a small section is missing. The greater part of the maxillæ and nasals, *minus* their posterior ends, are preserved. The prefrontals, lachrymals, and all other bones are absent, except the hinder portions of the frontal and postfrontal, and the anterior of the parietal. These latter, and the impress left on the matrix by what is lost, determine the supratemporal fossa to be subquadrate, and only slightly larger than the orbits. The articular ends of the quadrates remain.

¹ 'Monograph of the Fossil Reptilia of the Wealden & Purbeck Formations' Suppl. ix (Palæont. Soc. 1879) p. 2 & pl. i.

² 'British Fossil Reptilia' 1849-84, vol. ii, pl. xiv.

The external nares are subterminal. Traces of bony prominences occur on the lateral borders of the nares. There are five alveoli on each premaxilla, twelve on the imperfect right maxilla, and fifteen on the left. Many of the teeth are preserved, and they all show the lateral carinæ and the serrations characteristic of *Goniopholis*. Owen gives the difference in breadth to length of crown, as less in *Goniopholis simus* than in *G. crassidens*; nevertheless, it is questionable whether the teeth are alone sufficient to distinguish one from the other, so similar are they. The sculpturing of the skull is similar to that seen in *G. simus*.

The skull, from the articular end of the quadrate to the tip of the snout, measures 578 mm. (23 inches), which is a greater length than that of the type-skull of *G. simus*. The other measurements are in corresponding ratio. It was, therefore, an older or a more robust individual than the type, to which, considering the shape of the supratemporal fossæ, the anterior nares and their subterminal character, the teeth, and the sculpture of the cranium, I have no hesitation in referring it.

As is well known, the osteology of this species was made familiar by Prof. Louis Dollo in 1883,¹ by means of the magnificent specimens obtained from the Wealden of Bernissart.

III. DESCRIPTION OF THE ATHERFIELD SPECIMEN.

The skull and bones discovered at Atherfield are remarkable for their well-preserved condition and lack of distortion. The skull is much as it was in life, and, if found *in situ*, would have been entire. The cranial roof is nearly square to the orbits, the snout moderately elongate, and the skull very depressed. Another prominent feature is its wedge-shape, there being a gentle rise from the nares to the posterior margin of the parietal. Laterally it gradually widens; while the under margins of the mandibles sustain a nearly-horizontal line to the angle of the angular bone. Viewed from above, the general form is that of the broad-faced Proœlians, although, owing to the wide expansion of the cranial roof, the tapering appears more acute than it really is. The width between the upper temporal arches is much less than that of the lower. The upper and lower temporal arches and the parieto-squamosal bars are strong, but narrow.

The interorbital space is wide. The posterior border of the skull, as it leaves the outer point of the squamosals, forms a deep crescent, the inner horn of which is on the parietal, a third of the distance from the parieto-squamosal suture. This is followed by a shorter and shallower crescent, with a corresponding larger crescent, to the opposite squamosal.

The whole surface of the skull is magnificently sculptured with deep, more or less circular pits, without a free space or any bony

¹ 'Première Note sur les Crocodiliens de Bernissart' Bull. Mus. Roy. Hist. Nat. Belg. vol. ii 1883) p. 309.

keels or prominences. There is a deep and large depression immediately in front of each orbit, and situated on the maxillæ.

The nasals (Pl. II, *a*) apparently just reach the anterior nares. Rapidly expanding to a width of 57 millimetres, they quickly contract to 50 mm. from these openings. From here they gradually widen, till they meet the prefrontals and frontal, when they taper into attenuated points.

The maxillæ (Pl. II, *b*), broad and deeply festooned, resemble those of the recent crocodiles.

The lachrymals (Pl. II, *c*) are large. On their hinder extremities are two strong ridges, converging forward and divided by a deep groove, forming the anterior boundary of the sockets.

The prefrontals (Pl. II, *d*) are small. Their outer posterior edges take a share in the orbital rim.

The frontal (Pl. II, *e*) is quadradiate, a long posterior ray uniting with the parietal, and shorter rays with the postfrontals; these also bend forward, and form a small section of the orbits. A broad anterior ray meets the prefrontals and nasals.

The postfrontals (Pl. II, *f*) are stirrup-shaped, the spur meeting the squamosal, and the branches comprising the posterior boundary of the orbits, the outer being the longer, reaching the jugals and completely bounding the sockets from the infratemporal fossa.

The squamosals (Pl. II, *g*) and the parietal (Pl. II, *h*) are near in shape to the similar bones in the Proœlians, but the greater extent of the supratemporal fossæ causes them to throw out longer branches.

The jugals (Pl. II, *i*) complete the orbits. From here to their union with the quadrato-jugal they are long, slender, rod-like bones, with a slight median bend similar to that seen in the Teleosaurs.

The quadrato-jugals (Pl. II, *j*) are also narrow, and carry on the bar, made by the jugals, to their union with the quadrate.

The quadrates are not well displayed. The articular end of the right has been destroyed by the sea, and the left is buried in matrix and hidden by other bones.

The supraoccipitals are covered by the atlas and axis, and by the matrix.

Portions of the exoccipitals are to be seen, on each side of the foramen magnum. The outer branch of the left is also visible. It resembles the same moiety as in the recent crocodiles, with perhaps a broader ledge for muscle-attachment.

The occipital condyle (Pl. III, *d*), compared with the size of the skull, is small, and has no median groove.

The basioccipital has a very broad longitudinal ridge, from the condyle to the median eustachian tube.

The contour of the external nares (Pl. II, *k*) cannot be determined, for the premaxillæ have been broken off, excepting a small portion which comprises the termination of the nasal floor, and a fragment of the posterior extremity of both the right and the left. These suggest that they were not subterminal as in *Goniopholis simus*, and that the nasals just entered their posterior

border; also that the premaxillæ described by Owen¹ do really belong to *Goniopholis crassidens*.

The orbits (Pl. II, *l*) are ovoid. Their posterior borders are high. Laterally they gradually decline on to the lachrymals. Here a deep and wide groove divides them. From the bottom of this groove to the summit of the supraorbital rim there is a vertical elevation of 49 millimetres (2 inches).

Any other than a forward vision was precluded. The type-skull of *Goniopholis sinus* is so flattened by pressure, and the boundaries of the orbits so much destroyed, that it is impossible to say how near in this respect they approached to those of the skull under consideration; and Prof. Dollo does not refer to this in his previously-mentioned description of the Bernissart specimens.

The supratemporal fossæ (Pl. II, *m*) are very large, almost twice the size of the orbits. Their inner and posterior margins form curves, while their outer and anterior margins are nearly straight, forming a right angle at their junction.

The lateral temporal fossæ (Pl. IV, fig. 1, *a*) are large, as is also the tympanic cavity (Pl. IV, fig. 2, *a*). These fossæ are divided by a postfrontal and jugal bar. The orbits apparently do not communicate with them.

The palatines (Pl. III, *a*) continue with nearly the same width as when they leave the pterygoids, to half their length. Here they expand, meeting the maxillæ 31 mm. from the front extremity of the palatal fossæ. Their posterior extremities form only the extreme anterior boundary of the posterior nares, for they immediately connect with, and become exterior to, a process thrown out by the pterygoids.

The pterygoids (Pl. III, *b*) have their posterior borders much damaged. They appear to widen gently from their median suture, to their contact with the mandibles. Here they have a short expansion, then curve inwards to the palato-ptyergoid vacuity. Anteriorly, they throw out a process which forms the lateral borders of the nares, and outwardly a portion of the margins of the palatal fossæ.

The transpalatines (Pl. III, *c*) sweep round from the pterygoids to the maxillæ, narrowing the hinder breadth of the palatal vacuities. Their surface on their inner and outer moieties is concave, and convex on the median.

The posterior nares (Pl. III, *f*) are divided by a pterygoid septum, and are twice as long as wide. The palatines border only their extreme anterior point, the pterygoids forming the remainder of their margins.

The median eustachian canal (Pl. III, *g*) is large. It is situated wholly on the pterygoid plane, very near to the posterior nares.

The palato-ptyergoid vacuities (Pl. III, *e*) are long and oval, with their posterior end contracted by the inward curve of the transpalatine bone.

¹ 'Monograph of the Fossil Reptilia of the Wealden & Purbeck Formations' Suppl. viii (Palæont. Soc. 1878) p. 4 & pl. i.

The maxillo-palatine suture leaves the palatine suture at right angles, and at a distance of 30 millimetres from it turns sharply, keeping a straight line parallel with the latter, until near the palatal vacuity, where it doubles back at an acute angle, and immediately enters the vacuity.

The premaxillo-maxillary suture is hidden by the symphyseal extremity of the mandibles.

The mandibles (Pl. IV, fig. 1, *c*) are long and slender. They have no vacuity. The incisary region is well raised, and sinks rapidly to the laniary. There is no, or only a slight, elevation in the median region of the alveolar tract; they rise without further undulation to their articular end. The alveolar tract extends probably some 288 millimetres (11.33 inches).

The symphysis is short. The mandibles at this end are heavy and broad, their outer margins being very square. At almost regular intervals up either side of the symphysis are a series of pits in line, and deeper than any in the immediate area.

The splenials (Pl. III, *i*) enter well into the symphysis.

There are only two teeth preserved, both in the hinder region of the maxillæ, one in the right, the other in the left. They are both small. They have the characteristic ridges and well-developed carinæ, laterally, midway between the concave and convex sides. As the mandibles are firmly fixed against the upper jaw, and the line of junction is filled in by matrix and pyrites, the dental formulæ cannot be ascertained.

The alveoli that are visible prove the teeth to have been very unequal in size, and the upper overbit those of the lower jaw.

The atlas and axis vertebræ (Pl. II, *o* & *p*) are cemented by the matrix and pyrites to the occipital region of the skull, above the condyle. The neural arch of the atlas and the distal ends of the floating ribs are preserved, but they cannot be fully exposed without damage.

The odontoid bone is united to the centrum of the axis. Compared with the latter, it is large. Its anterior articular surface is slightly convex. At this end it has a strong broad ridge, laterally and ventrally. The centrum of the axis is small. The neural spine of the axis is missing. Both the atlas and the axis vary little from those of recent crocodiles.

Four more or less perfect cervical ribs are also embedded here.

The third cervical vertebra (Pl. IV, fig. 2, *b*) is lying in the matrix in the pelvic region. The fourth, fifth, sixth, and portion of the seventh cervicals (Pl. IV, fig. 1, *d-g*), and the proximal ends of their ribs, are contained in a small block of rock, showing a recent fracture posteriorly.

The next block has a similar face anteriorly. The portion that filled the gap has not been recovered. On this block, and on three others all exactly fitting on to each other, are a part of the sixth, the seventh, eighth, ninth, tenth, and eleventh dorsal¹ (Pl. IV,

¹ The number of cervical and dorsal vertebræ is here taken to be equal to the number of the corresponding vertebræ in *Goniopholis sinus*.

fig. 2, *c*), four lumbar (Pl. IV, fig. 2, *d*), and the first sacral (Pl. IV, fig. 2, *e*) vertebræ, in consecutive series, many sternal and abdominal splint ribs, the left coracoid, the left humerus, the right and a moiety of the left ilium, right ischium, and the two femurs.

All the vertebræ are amphicœlous, otherwise they approach in form closely to those of the recent crocodiles. The neurocentral suture rises from behind forward in the cervical. It is convex in the dorsal and lumbar, while in the first sacral it is sigmoid.

There are eight right coracic vertebral ribs (Pl. IV, fig. 1, *h*) and four left, more or less perfect. Many of the cartilaginous sternal ribs lie scattered in the matrix between the vertebral ribs, some being well exposed. Four of the abdominal splint ribs (Pl. IV, fig. 1, *j*) are preserved.

The coracoid (Pl. IV, fig. 2, *g*) is very elongate. It has a slight expansion at its ventral end.

The humerus (Pl. IV, fig. 2, *h*) is a very powerful bone. The deltoid ridge is not displayed. It is 25 millimetres shorter than the femur. Owen¹ gives further particulars of this bone.

Embedded in the matrix on the right of the skull, under the squamosal, lie the distal ends of the radius and ulna, and (?) the radiale and ulnare. There is a portion of the shaft of a limb-bone visible in the left supratemporal fossa, as it passes from the base of the skull towards the left orbit.

The ilium (Pl. IV, fig. 1, *k*) has the pre-acetabular portion short, and the post-acetabular very long and strongly curved. Owen describes it (*op. cit.* p. 3) as being 'broader than in the existing Crocodilians.' The acetabular region is a shallow concavity, with plenty of space for the play of the femur. On the summit of the crest the bone is considerably thickened, and the spinous process very highly developed.

The ischium (Pl. IV, fig. 2, *i*) is short. Proximally it is much bifurcated. Its distal end is moderately broad.

The distal end of one of the pubic bones has alone been recovered.

The femur (Pl. IV, figs. 1 & 2, *m* & *j*) has the usual Crocodilian characters, with the inner portion of the proximal condyle and the median trochanter more strongly developed.

Twenty consecutive right dorsal scutes (Pl. IV, fig. 1, *p*) and several of the median ends of the left lie in the natural position. Two of the scutes on the right show well the characteristic pegs. There are also nine scutes of the ventral buckler, joined by their sutures. Numerous dorsal, ventral, and other scutes are scattered throughout the matrix. They call for no detailed description, as their characters are well known.

The portion of the axial skeleton obtained, that is, from the tip of the mandibles to the posterior end of the first sacral, measures 1.505 metres (4 feet 11½ inches); and, if we allow for the missing cervical and dorsal vertebræ 1.930 metres (6 feet 4 inches), the total length of the reptile must have been about 3½ metres (11½ feet).

¹ 'Monograph of the Fossil Reptilia of the Wealden & Purbeck Formations' Suppl. viii (Palæont. Soc. 1878) p. 5.

IV. AGREEMENT OF THE ATHERFIELD FOSSIL WITH THE TYPE-SPECIMEN OF *GONIOPHOLIS CRASSIDENS*.

As previously noted, the impression of the skull on the slab containing the type-remains had never been described. Further, it has been seen that the known portions of the skull of *Goniopholis crassidens* consist of teeth and part of the left mandibular ramus; for the fragments of the mandibles described and figured by Owen were, as before stated, apparently referred to this species because they were discovered on the same geological horizon. With the ramus, teeth, and odd bones of the type, the Atherfield fossil agrees. The impression of the cranial surface on Mantell's slab begins near the position of the parieto-frontal suture, and embraces the outline of the anterior moiety of the left supratemporal fossa and portions of the pre-frontals, lachrymals, nasals, and maxillæ. No trace of the sutures of these bones is to be found, and so their form cannot be determined. The anterior outline of the orbits can be fairly judged.

So far as can be ascertained, the orbits longitudinally and transversely, and the measurements of the impression of the left inner anterior corner of the left supratemporal fossa, agree with the Atherfield skull. The sculpturing, the contours of the orbits, the slightly-concave interorbital space, and its elevation as it nears the orbital rim, likewise are close to that of the Atherfield cranium.

With the impression was a fragment of bone, across the interorbital tract, near the position where the keel noted in *Goniopholis simus* occurs. It seemed possible that its presence might be due to a similar ridge having given an extra grip on the matrix.

On my calling Dr. A. Smith Woodward's attention to this possibility, he deemed it important enough to have the fragment removed, with the result that no keel was discovered, but a concave pitted surface as in the Atherfield skull.

From these considerations I have no hesitation in assigning the Atherfield remains to *Goniopholis crassidens*. That being so, I shall endeavour to demonstrate that the skull of *G. crassidens* differs in many important particulars from that of *G. simus* and other *Goniopholidæ*, and hereafter shall refer to it as *Goniopholis crassidens*.

V. COMPARISONS BETWEEN THE SKULLS OF *GONIOPHOLIS CRASSIDENS* AND *G. SIMUS*.

(1) In its dimensions the skull of *G. crassidens* is a third greater than that of *G. simus*. The general outline is similar.

(2) In *G. crassidens* the supratemporal fossæ are twice the size of the orbits, in *G. simus* only slightly larger.

(3) In *G. crassidens* they are subcircular, but subquadrate in *G. simus*.

(4) Deep pre-orbital depressions exist on the maxillæ of *G. crassidens*; mere traces in *G. simus*.

(5) The lateral temporal fossæ and tympanic cavity are greater in *G. crassidens* than in *G. simus*.

(6) Absence of an inter-orbital ridge in *G. crassidens*; its presence in *G. simus*.

(7) The nasals, anteriorly, in *G. crassidens* widen till near the constriction, whence they quickly converge to the anterior nares, the posterior border of which is apparently reached. In *G. simus* they do not broaden, and on reaching the premaxillæ rapidly contract to an acute point 27 millimetres from the anterior nares.

(8) In *G. crassidens*, the hinder extremities of the premaxillæ are very blunt, and probably do not extend 29 mm. beyond the anterior nares. In *G. simus* they are very sharp, terminating where the nasals begin to narrow, 70 mm. from the anterior nasal opening.

(9) In *G. crassidens* the surface of the skull is deeply and uniformly pitted, without any other sculpturing. In *G. simus* it is neither so uniformly nor so deeply pitted. Moreover, the nasals have a crinkled surface anteriorly and posteriorly, and are almost free from pits, and those that occur are very shallow. The frontal is also crinkled at its juncture with the nasals, while behind this to the orbits it is quite smooth and free from ornamentation.

(10) In *G. crassidens* the posterior nares are twice as long as they are wide, and, except their extreme anterior margins, are entirely formed by the pterygoids. In *G. simus* they are narrower, and a third of their border is formed by the palatines.

(11) The form of the palatines reveals a remarkable dissimilarity.

In *G. crassidens* the pterygo-palatine suture rises acutely from the posterior end of the suture connecting the palatines to the palatal fossa. In *G. simus* it is nearly horizontal, with a crenated contour.

In *G. crassidens* the lateral margins are almost parallel, only slightly expanding as they approach the maxillæ. In *G. simus* they soon commence to dilate, and continue to widen to the maxillo-alveolar border.

In *G. crassidens*, the palato-maxillary suture leaves the palatal median suture at right angles, and, keeping horizontal for 31 mm., turns at a right angle, parallel with the median suture until near the pterygo-palatine vacuity, where it doubles back at an acute angle into that fossa.

In *G. simus* the course of this suture is quite different. Owen¹ thus describes it:—

‘The palato-maxillary suture is strongly sigmoid, describing as it leaves the mid-line a convexity forward, then a concavity.’

In addition to these differences in the skulls, the dimensions of *Goniopholis crassidens* are one-third greater than those of *G. simus*.

¹ ‘Monograph of the Fossil Reptilia of the Wealden & Purbeck Formations’ Suppl. viii (Palæont. Soc. 1878) p. 8.

VI. COMPARISONS WITH *GONIOPHOLIS TENUIDENS*, *NANNOSUCHUS*,
AND *OWENIASUCHUS*.

Goniopholis tenuidens (Owen).

The anterior end of the mandibles is the only portion of the skull that is known ; this reveals no agreement with the same moiety in *G. crassidens*. It differs by its :

- (1) Much smaller size and by the contour of the alveolar tract.
- (2) The high elevation of the incisary and median regions of the alveolar tract, and its deep laniary concavity.
- (3) The sharp and more slender teeth.

The Genus *Nannosuchus* (Owen).

Agrees in :

- (1) The general form of the skull.
- (2) The articulation of the dorsal scutes.

Differs in :

- (1) The small size of the skull.
- (2) The shape of the supratemporal fossæ.
- (3) The relative magnitude of the orbits to the supratemporal fossæ.
- (4) The outline of the posterior border of the skull formed by the parieto-squamosal bar.
- (5) The presence of an interorbital ridge.
- (6) The presence of a supraorbital bone.
- (7) The form and length of the nasals and their non-entrance into the nares.
- (8) The recurved slender teeth.
- (9) The form of the dorsal scutes.

The Genus *Oweniasuchus* (A. Smith Woodward).

Agrees in :

- (1) Mandibles similar in form, and their deeply-reticulated posterior external surface.
- (2) The absence of a mandibular vacuity.
- (3) The very slight laniary concavity.

Differs in :

The short extent of the alveolar tract.

VII. MEASUREMENTS OF THE TYPE-SKULLS OF
GONIOPHOLIS CRASSIDENS AND *G. SIMUS*, IN MILLIMETRES.

	<i>G. crassidens.</i>	<i>G. simus.</i>
Length, articular end of quadrate to tip of snout	...	415
Length, occipital condyle to tip of symphysis	544	...
Breadth between extreme outer points of squamosals ...	205	149
Breadth of roof across posterior border of supra-temporal fossæ.....	258	...
Do., anterior border	230	...
Breadth between inferior-temporal arcades, across posterior border of supratemporal fossæ	339	...
Breadth across anterior points of orbits	196	...
Breadth between festoons	159	...
Breadth between constrictions	...	64
Longitudinal diameter of supratemporal fossæ	90	44
Transverse do.....	90	40
Longitudinal diameter of orbits	67	46
Transverse do.	49	33
Longitudinal diameter of posterior nares	50	44
Transverse do.....	25	8
Longitudinal diameter of palatal fossæ	197	...
Transverse do.....	70	...
Length from angle of angular bone to tip of symphysis...	597	...
Breadth of mandibles across posterior end of posterior nares.....	330	...
Do., posterior end of symphysis	108	...
Greatest breadth of symphysial end of mandibles	142	...
Length of symphysis.....	85	...
Length along which splenials merge into symphysis	35	...

Where the measurements are not stated, this omission is because the corresponding portions of the skulls are either too badly preserved for accuracy, or are missing.

VIII. MEASUREMENTS OF THE MORE IMPORTANT BONES OF THE
SKELETON OF *G. CRASSIDENS*, IN MILLIMETRES.

Antero-posterior diameter of odontoid bone	25
Dorso-ventral do.	49
Antero-posterior diameter of centrum of axis	48
Dorso-ventral do.	30
Length of coracoid	180
Length of humerus	280
Length of ilium.....	207
Length of ischium.....	135
Breadth of proximal end of ischium	70
Breadth of distal end of ischium	105
Length of femur	305

IX. CONCLUDING REMARKS.

In conclusion, I would observe that we have here a crocodile in which the vertical elevation of the orbits is greatly more accentuated than in the Teleosaurs or other Amphicœlians, and very far removed from the everted orbits of the Procelians. Their direct

frontal aspect curtailed the arc of vision, and it would seem that the creature's prey, or foes, were in an unobserved position when once behind the orbits.

In the greater length of the femur than of the humerus, and the deep depression on the hinder extremities of the maxillæ, which are evidently the vestiges of preorbital vacuities, *Goniopholis crassidens* is nearer the Teleosaurs than *G. simus*, but is farther removed than the latter from them in the position of the posterior nares.

Considering the massiveness of the head, and the weight which its heavy armour must have given to the body, the length and slenderness of the mandibles is remarkable. It is surprising how they withstood the strain occasioned in a combat with, or the capture of, the creature's more powerful congeners.

The reptile was capable of a gape of over a metre.

The presence of the interorbital keel, found in all the American alligators, is probably the developed trait peculiar to a line descended from the *Goniopholidæ*.

My thanks are due to Dr. A. Smith Woodward, F.R.S., for much kindness and help in the preparation of this paper.

EXPLANATION OF PLATES II-IV.

PLATE II.

Dorsal aspect of the skull of *Goniopholis crassidens*. $\frac{1}{4}$ nat. size.

a = nasals; *b* = maxilla; *c* = lachrymal; *d* = prefrontal; *e* = frontal; *f* = postfrontal; *g* = squamosal; *h* = parietal; *i* = jugal; *j* = quadrato-jugal; *k* = nasal passage; *l* = orbit; *m* = supratemporal fossa; *n* = right mandibular ramus; *o* = atlas; *p* = axis; *q* = 1st & 2nd right cervical ribs; *r* = distal end of ulna; *s* = distal end of radius.

PLATE III.

Ventral aspect of the same. $\frac{1}{4}$ nat. size.

a = palatine; *b* = pterygoid; *c* = transpalatine; *d* = occipital condyle; *e* = palato-ptyergoid vacuity; *f* = posterior nares; *g* = median eustachian canal; *h* = dentary; *i* = splenial; *j* = angular.

PLATE IV.

Fig. 1.—Right lateral aspect of the skeleton of *Goniopholis crassidens*.

$\frac{1}{10}$ nat. size.

a = lateral temporal fossa; *b* = jugal and quadrato-jugal bar; *c* = mandible; *d* = 4th cervical vertebra; *e* = 5th cervical vertebra; *f* = 6th cervical vertebra; *g* = portion of 7th cervical vertebra; *h* = vertebral ribs; *i* = sternal ribs; *j* = abdominal splint ribs; *k* = ilium; *l* = ischium; *m* = femur; *n* = proximal end of tibia; *o* = distal end of tibia; *p* = dorsal scutes; *q* = ventral scutes.

Fig. 2.—Left lateral aspect of the same. $\frac{1}{10}$ nat. size.

a = external auditory meatus; *b* = 3rd cervical vertebra; *c* = dorsal vertebra; *d* = lumbar vertebra; *e* = 1st sacral vertebra; *f* = sternal ribs; *g* = coracoid; *h* = humerus; *i* = ischium; *j* = femur; *k* = cervical scutes.

R.W.H., Photo.

Bemrose, Collo.

DORSAL ASPECT OF CRANIUM OF GONIOPHOLIS
CRASSIDENS.

R.W.H., Photo.

Bemrose, Collo.

VENTRAL ASPECT OF CRANIUM OF GONIOPHOLIS
CRASSIDENS.

Fig. 1.
 $\frac{1}{10}$ nat. size.

Fig. 2.
 $\frac{1}{10}$ nat. size.

R.W.H., Photo.

Bemrose, Collo.

RIGHT AND LEFT LATERAL ASPECTS OF SKELETON OF GONIOPHOLIS CRASSIDENS.

DISCUSSION.

Dr. SMITH WOODWARD congratulated the Author on his first contribution to the Society's Proceedings. It was an illustration of the importance of local collectors for the progress of Palæontology. Although the remains of *Goniopholis crassidens* were among the commonest of Wealden fossils, the precise characters of the species had remained unknown, until the discovery which the Author had now described. The new observations were of all the greater value, because the Goniopholidæ represented an entirely-new departure in the evolution of the Crocodilia at the end of the Jurassic Period; and biologists needed an exact knowledge of the skeleton of these reptiles, before they could discuss the meaning of the development in question. The late Sir Richard Owen thought that the first appearance of alligator-shaped crocodiles, such as *Goniopholis*, was correlated with the incoming of warm-blooded quadrupeds and birds, which would form a new kind of prey.

Mr. E. T. NEWTON remarked on the interest of this specimen, in that it supplied for the first time the skull of *Goniopholis crassidens*, which species had been established chiefly on the peculiar form of the scutes. The skulls that Hulke had described in 1878, one of which he thought might belong to *G. crassidens*, were now shown to be quite different, and would both be included in the species *G. simus*, one of them having been so named by Owen. He alluded to the fact (first recognized by Huxley, and later on by Hulke) that the position of the posterior nares, far back upon the palate, in these Wealden crocodiles was an intermediate one between those of the Lower Jurassic crocodilians, in which these openings were farther forward, and those of the Tertiary crocodilians, where, by the closing-over of the pterygoids, the nares came to be placed on the hinder aspect of the skull, as in recent crocodiles.

Dr. C. W. ANDREWS congratulated the Author, both on his good fortune in finding such valuable material, and on the paper that he had read. The chief interest of the specimen described seems to be that it completes our knowledge of *Goniopholis crassidens*, and shows that that species is in several respects intermediate between *G. simus* and the modern Crocodilia. Indeed, some of the characters distinguishing it from *G. simus* seem to be of sufficient importance to justify the separation of the latter species as a distinct genus.

The AUTHOR, in reply, said that he agreed with the last speaker that the characters of the nasals, palatines, and supratemporal fossæ were perhaps sufficient to separate the other described species from the genus *Goniopholis*; but, as the teeth of all the specimens agreed in possessing serrations and lateral carinæ—the characters laid down by Owen, he thought that it was better to leave them as they were for the present, rather than to multiply genera. The Author returned thanks for all the kind remarks that had been made in regard to his paper and his work.