

Article XXXVIII.—STUDIES ON THE PERMIAN TEMNOSPONDYLOUS STEGOCEPHALIANS OF NORTH AMERICA.

BY ROBERT BROOM.

Mr. D. M. S. Watson has recently shown the extreme importance of the hitherto imperfectly understood group of Carboniferous Stegocephalians, which includes *Pteroplax*, *Anthracosaurus*, and *Loxomma*. In all the textbooks these are grouped with the typical Stereospondylous Labyrinthodonts. Watson has, however, shown that they differ very greatly from the better known Triassic Labyrinthodonts in having, among other characters, a single basioccipital condyle, a small parasphenoid, pterygoids which meet in the middle line, and embolomorous vertebræ; and that they are in many characters as closely related to the Cotylosaurian reptiles as to the typical Labyrinthodonts. The group is of great importance not only from the light it throws on the origin of the Labyrinthodonts, but also of the reptiles, and further from the evidence it yields as to the relationships of the Stegocephalians to the Osteolepidotous Crossopterygians.

The larger European Carboniferous forms, though well preserved, are few in number and only show us one or two of the many types of structure that must have existed in the early amphibians. In view of the new light thrown on the Carboniferous forms, it becomes of special interest to re-examine the Permo-carboniferous American types to see if anything further might be made out of them.

The best known American forms, *Cricotus*, *Eryops*, and *Trimerorachis*, were described by Cope a good many years ago. Case in 1910 reëxamined all Cope's types. Besides bringing together all that had been previously done on the American Permian amphibians, he described a number of new forms and added much to our knowledge, especially of the post-cranial skeleton.

Branson has made a study of the skull of *Eryops*, and for the first time attempted the very difficult task of tracing the cranial sutures.

Broili has published a number of important papers dealing with the Permian amphibia, and he has contributed a number of new facts to our knowledge of *Eryops*.

Williston, with the exception of Cope, has contributed more to our knowledge of the Permian forms than any other palæontologist. He has fortunately been able to describe complete skeletons of *Cacops*, *Trematops*, and *Dissorophus*.

The most recent worker on the group has been v. Huene, who in 1911 made a study of the more important specimens in the American Museum, and has given a description with original figures of the principal cranial details of *Eryops*, *Trimerorachis*, *Cricotus* and others.

It might be assumed that, considering the large amount of work that has been done on Cope's original specimens, there would be little left to do; but anyone who has worked with American Permian material will readily understand the nature of the matrix and the great difficulty there frequently is in tracing sutures. So difficult is it to make out the cranial sutures in many of the amphibia that Cope was apparently unable to make anything of the elements in *Eryops* or much in *Trimerorachis*, and notwithstanding the discovery of beautiful skulls of *Cacops* and *Trematops*, Williston has not ventured far in the determination of the cranial elements. Branson has given a fair interpretation of the skull of *Eryops*, and Case has endeavored to trace the cranial elements in *Trimerorachis*, *Cricotus*, *Zatrachis*, and others. V. Huene has also given interpretations of the skulls of *Trimerorachis*, *Cricotus* and others. Still very much remains to be done. In the present paper I give the results of my examination of the American Museum specimens. Though much of the work has been of the nature of repetition, it is well to have the work of a previous writer confirmed, or where two previous workers have differed, to have a third opinion.

***Cricotus* Cope.**

In the American Museum are two skulls of this remarkable amphibian which possibly belong to two different species, but it is difficult to say how these specimens are to be named from Cope's having taken as the types of his five described species of *Cricotus* portions of the vertebral column. The type of *Cricotus discophorous* is a single intercentrum. Two of the five species he afterwards discarded. One regrets that he did not drop all five as indeterminate and make the two skulls his types. As the best known skull is with little doubt that of the smaller of the skeletons (No. 4550a Am. Mus.), which Cope made the type of *Cricotus crassidiscus*, I think it best to take this skull and skeleton as the type.

The skull is well preserved though crushed slightly, and only lacks the tip of the snout. It has been figured by Cope, Case and v. Huene, and as there are differences in the restorations of each, a new drawing will not be regarded as superfluous.

The parietal and frontal regions are in almost perfect condition, and most of the sutures can be easily seen. Both squamosal regions are buckled in

under the "supratemporal" region, and much of the surface of the bones is weathered off. Both suborbital regions are satisfactorily preserved. The whole snout is fairly well preserved, but though much of the surface of the bones is cracked off, it is possible, I think, to be pretty certain where each suture is. In the restoration I give, the sutures of the preorbital region are probably in no case more than a few millimetres out.

The parietal is a large triangular bone; the two together forming the greater part of the top of the back of the skull. There is a fair sized pineal foramen. On the outer side each parietal articulates with four bones — the postfrontal, postorbital, suprasquamosal, and tabulare. In front it articulates with the frontal and behind with the postparietal or dermo-supraoccipital.

The postfrontal is a long narrow bone which forms most of the upper orbital margin. It articulates with the prefrontal in front and the postorbital behind. It is correctly figured by Cope and Case, but v. Huene has failed to observe the suture between it and the postorbital, and has included the greater part of this latter in his postfrontal.

The postorbital is an oval shaped bone lying behind the postfrontal. The suture between the two can be clearly made out on both sides, but that between the postorbital and the jugal is only partly seen, but is probably as restored.

Behind the postorbital is

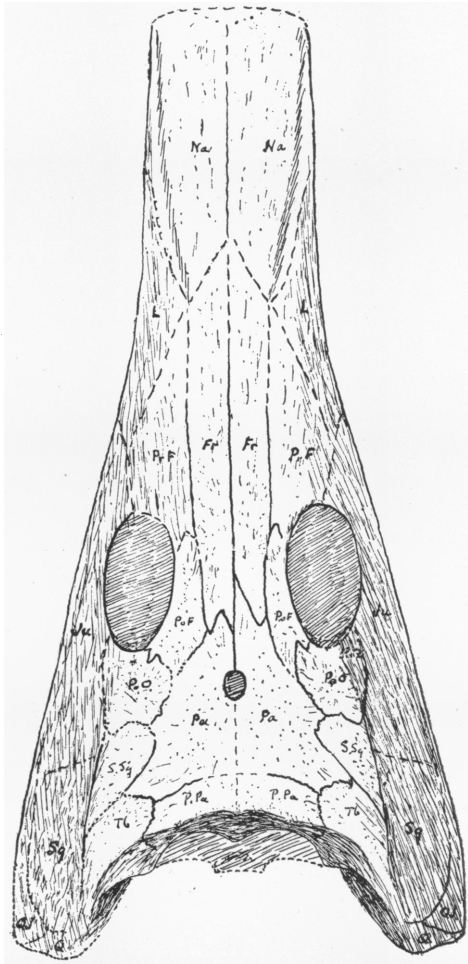


Fig. 1. Skull of *Cricotus crassidiscus* Cope. $\frac{2}{3}$ nat. size. All the sutures in clear line can be distinctly seen in the specimen. Those in broken line are practically certain as regards position, but owing to crushing and weathering the exact line of suture is lost. The suggested appearance of the premaxillary on the point of the snout is hypothetical. The dotted sutures are restored from those of the opposite side.

a bone which has received a number of different names. In most Stegocephalian skulls there are situated between the parietal and the quadrato-jugal two bones, one of which is undoubtedly the squamosal. Those who have

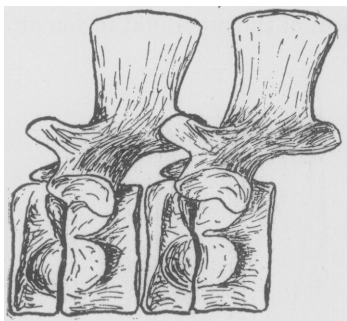


Fig. 2. Restoration of two dorsal vertebrae of *Cricotus hypantricus* Cope. About $\frac{1}{2}$ nat. size.

regarded the upper as the squamosal have termed the lower supratemporal or pro-squamosal. Those who believe that the lower is the squamosal term the upper bone the supratemporal.

Hitherto I have been inclined to consider the upper as squamosal for reasons which I need not state as I now regard the evidence as practically conclusive that it is the lower bone which supports the quadrate and is usually closely related to the end of the pterygoid that is the homologue of the mammalian squamosal. The homology has been traced

from the mammal down through the Therapsida, and when we consider the condition in *Pareiasaurus*, it seems manifest that the squamosal is the lower bone. This being so, the question arises as to the best name for the upper. Supratemporal would be appropriate enough, but unfortunately it has been used for so many different bones. Besides being used for two entirely different bones in the amphibians, it is used at present for at least three others in the fishes. There will be least confusion caused by entirely dropping the term "supratemporal" and for the upper bone using Owen's term "suprasquamosal." The term dates back to at least 1860, and though in *Archegosaurus* he uses it wrongly by mistaking the quadratojugal for the squamosal, he applies it correctly to the upper bone in the skull of *Ichthyosaurus*.

The suprasquamosal or "supratemporal" is a triangularly shaped bone articulating by its bases with the postorbital and parietal, and having its apex pointing backwards towards the quadrate. It is almost correctly figured by Cope, but Case's figure makes it pass much more outwards than I believe it does. On the left side the edge of the supra-squamosal seems to show an unbroken edge where I have figured it.

Behind the parietals are the four bones usually seen in Stegocephalian skulls. These are the pair of postparietals or dermosupraoccipitals, and the outer pair of tabulares. Each of these four bones folds over and forms a considerable part of the occiput — the postparietal articulating with apparently a cartilage bone which may be exoccipital and the tabulare with probably the paroccipital, though it is not preserved on either side of the specimen.

The squamosal is fairly large and forms most of the lateral portion of the back of the skull. It articulates with the quadrate and quadratojugal behind and most probably also with the pterygoid. In front it articulates with the jugal and the postorbital.

The quadratojugal is a small bone which articulates with the quadrate and passes forwards to meet the jugal and possibly the maxilla. It is overlapped by the squamosal, and only forms a small part of the lateral wall.

The jugal is the largest bone of the skull. It forms nearly the whole of the suborbital region and extends forwards and behind the orbit for a distance equal to the long diameter of the orbit. In front it runs to a point between the maxilla and the lacrymal, but behind has a broad attachment to the squamosal.

The prefrontal is long and moderately broad. It forms most of the anterior margin of the orbit and extends forwards between the frontal and the lacrymal as far as the nasal.



Fig. 3. Right ilium of *Cricotus crassidiscus* Cope. $\frac{2}{3}$ nat. size.

The frontal is a long, narrow bone. From an articulation with the parietal nearly opposite the posterior margin of the orbit, it passes forwards in front of the orbit for twice the length of the orbital diameter. It has an oblique articulation with the nasal.

The lacrymal is situated mainly between the nasal and the maxilla. The meeting of the jugal and the prefrontal prevents its coming near the orbit. In front the bone tapers out to a narrow strip which most probably reaches the nostril. This anterior slender portion has a longitudinal canal running along inside it, doubtless for the lacrymal duct.

The maxilla is a very slender bone, which runs forwards from opposite the posterior margin of the orbit.

The premaxilla is very small and not preserved in the specimen. In the larger skull, though the sutures cannot be made out, the length of the snout can be seen.

The nasal is large and forms the most of the upper side of the anterior half of the snout. The nostrils are not preserved in the specimen, but in the larger specimen they are seen to be lateral and nearly terminal.

The mandibles are preserved in both skulls, but are not in a very satisfactory condition. Most of the sutures of the outer side can be made out. The splenial is rather large and comes as in *Trimerorachis* and *Eryops* to the outer side. The preangular is also well developed and forms the lower part of the middle third of the jaw. This element of the Stegocephalian jaw

which I have discovered first in *Trimerorachis* and *Eryops* will be figured in these genera in which it is seen in perfect condition. The angular is large and extends far forward. The surangular is evidently small. The dentary is long and slender. The articular is not unlike that of "*Loxomma*" and *Eryops*, there being no postarticular process. Much of the prearticular can be seen in the case of the larger skull, but the sutures cannot be made out. There is a very large opening probably between it and the angular and preangular as figured by Case. This opening is probably homologous with the two openings seen in the jaws of *Trimerorachis* and *Eryops*. In *Pteroplax* there are two large openings with a little bridge of bone dividing them. These two openings are most probably the two seen in *Eryops*. If the little bridge were lost, the condition would be practically as in *Cricotus*.

The vertebræ have been figured by Cope and Case, and there is not much to add to their descriptions. In all regions the centra and intercentra are fully formed discs. In both Zittel's and Smith Woodward's books on Palæontology it is stated that in the presacral region the pleurocentra and hypocentra are horseshoe-shaped. I cannot trace how this error has arisen as Cope in 1886 figures both the cervical and the dorsal vertebræ with the complete centra and intercentra.

In only one important point do I differ from Cope and Case as regards the vertebral structure. I do not agree to there being any hyposphene articulation. On the front of each arch there is by the sides of the neural canal a pair of processes that at first sight look as if they articulated with some structure in the next vertebra. But it will be seen from the figure I give that this is quite impossible. Were there no large intercentral disc, the processes would articulate with the next vertebra, but the presence of the intercentrum prevents this, and there is no trace of any corresponding structure on the back of the arch. It seems quite manifest that the structures are merely developments to hold the intercentrum in place and prevent it coming up against the spinal cord.

The shoulder girdle is not well preserved. There is a long cleithrum with a spatulate upper end, but the structure of the cartilaginous elements is not shown clearly.

The pelvis is fairly well preserved in two specimens, but a good view cannot be obtained of the pubis or ischium. The ilium has, as pointed out by Cope, a very marked reptile-like long posterior extension. The pubis and ischium are both large and reptile-like.

It seems probable that *Cricotus* is more closely allied to the Carboniferous types, such as *Pteroplax*, than to the other Permian types like *Eryops* and *Trimerorhachis*.

Trimerorhachis *Cope.*

Next to *Cricotus* the most interesting genus of extinct amphibians preserved in the American Museum is *Trimerorhachis*. It is represented by a large series of remains. One or two good skulls have been developed from the matrix, and a number more still remain to be developed. The best skulls have been already figured and described by Cope, Case and Von Huene, and it might almost be thought unnecessary to refigure them, but a

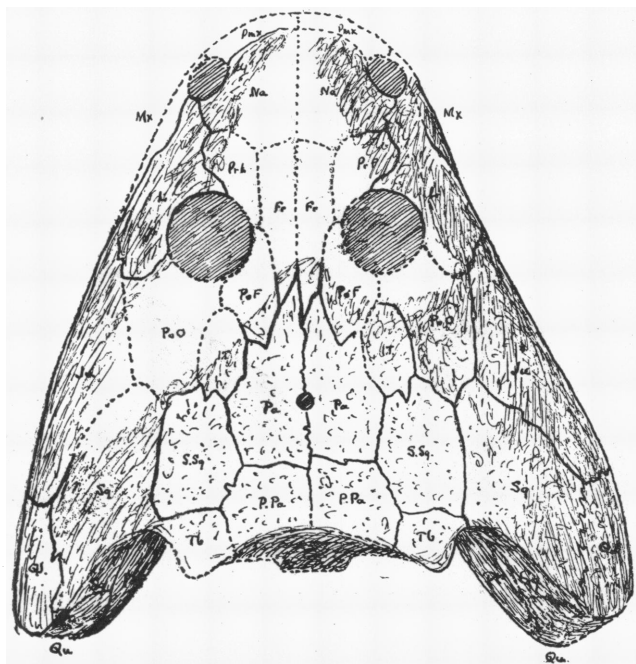


Fig. 4. Upper view of skull of *Trimerorhachis insignis* Cope. $\frac{1}{2}$ nat. size. The drawing is of Am. Mus. spec. No. 4570. All the sutures in line are those seen in this specimen; those dotted are from the opposite side or from one of two other specimens in the American Museum.

careful comparison of the figures of Cope, Case and v. Huene will show that there is much difference of opinion as to the limits of the various skull elements and even as to the elements themselves. I therefore think it advisable to give still another interpretation of the skull.

I have been able in one or other of the three best specimens to trace every suture. In specimen No. 4570 the large majority of the bones of the upper side of the skull are beautifully seen, and every suture is sufficiently clear to be traced without a shadow of doubt. The only sutures not seen in this

the frontals and pre-frontals. In the figure given by v. Huene of the skull of *Trimerorhachis* [Fig. 57] the suture he gives between the nasal and the lacrymal [his "adlacrymal"] is taken from what I refer to as the third specimen. It is merely a transverse fracture of the bone and not the suture which can be easily seen further out as I have shown in Fig. 5, A.

The lacrymal is in some respects the most interesting bone of the upper side of the skull owing to its unusual situation. It has been clearly traced in quite a number of specimens and there is no doubt whatever as to its borders. It extends from the nostril to the orbit outside of the nasal and prefrontal, and forms more than half of the lower border of the orbit. Posteriorly it has a broad articulation with the postorbital, thus completely shutting the jugal out from the orbit. Inferiorly the lacrymal has a long articulation with the maxilla and a somewhat shorter articulation with the jugal. In one of Case's figures [Fig. 36A] the lacrymal is shown fairly correctly, but in his Fig. 36B, taken from specimen No. 4570, he has placed the letters *mx* in the situation of the lacrymal. V. Huene's figure of the lacrymal [adlacrymal] is in error both in front and behind.

The jugal is, with the possible exception of the squamosal, the largest bone of the upper surface of the skull. It extends from the lacrymal in front to the quadrato-jugal behind. Its upper edge articulates with the postorbital and the squamosal; while its lower border articulates with the maxilla. Case figures the jugal in Fig. 36A nearly correctly, and in 36B the back part correctly. In front, however, he shows the jugal reaching to the orbit, which it never does in any specimen. V. Huene's figure of the jugal is accurate posteriorly, but anteriorly it is entirely in error, he making the jugal form the lower half of the orbital margin.

The prefrontal forms the upper and anterior corner of the orbital margin and extends forwards to meet the nasal between the lacrymal and the frontal. It is a small element and is correctly figured by v. Huene, while Case does not figure it at all.

The frontal does not touch the orbital margin. It lies between the nasal in front and the parietal behind. Its anterior border being almost in a line with the prefrontal-nasal suture and its posterior near the plane of the posterior orbital margin. In the third specimen the suture is certainly in front of the post-orbital plane, but in specimen No. 4570 it is a short distance behind the orbital plane.

The postfrontal is rather larger than the prefrontal and forms the inner and posterior corner of the orbital margin. It articulates with the prefrontal in front, the frontal and parietal internally, and the intertemporal and post-orbital behind.

The intertemporal is a bone which has not been recognized by v. Huene

nor by Case in *Trimerorhachis insignis*, but Case figures it and refers to it in *Trimerorhachis conangulus*. It is pretty certainly present in *Trimerorhachis insignis*. In v. Huene's figure it is included in the post-frontal.

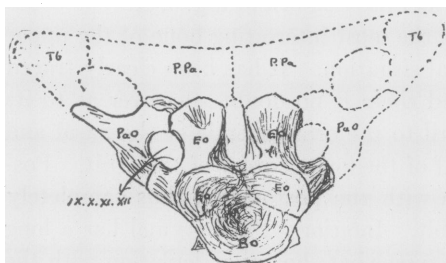


Fig. 6. Occiput of *Trimerorhachis insignis* Cope. Nat. size. The left paroccipital is slightly restored in position.

As I shall presently show, it is very clearly seen in a new species of *Trimerorhachis* which I shall describe. Unfortunately each of the three best specimens of *Trimerorhachis insignis* has some injury just along the anterior part of the intertemporal, but most of the sutures of the bone can be clearly made out.

The postorbital is much larger than either of the preceding two bones. It forms

most of the postorbital margin and extends back to articulate with the suprasquamosal and squamosal.

The parietal is a much larger bone than the frontal. It has been satisfactorily figured by Case and v. Huene.

On the outer side of the parietal lies a bone which has been called squamosal by Case and supratemporal by v. Huene. This is the bone that in the description of a skull of *Cricotus* I have called suprasquamosal, using Owen's old term. It is correctly figured by Case and v. Huene.

Outside of the suprasquamosal lies the large squamosal which forms the greater part of the temporal region. It articulates in front with the postorbital and jugal, and inferiorly with the quadratojugal, and posteriorly with the pterygoid and quadrate.

The quadratojugal is comparatively small. It articulates with the squamosal by a saw-like suture, correctly figured by Case. It overlaps the quadrate.

Behind the parietal is a large postparietal or dermosupraoccipital. Besides forming a large part of the upper surface, it forms a considerable part of the occiput.

Behind the suprasquamosal and outside the postparietal is a small tabulare.

In addition to the four dermal bones of the upper side of the skull, the occiput is formed of five cartilage bones. These are the basioccipital, the two ex-occipitals and the two paroccipitals [opisthotics]. The occipital condyle is a broad, irregularly oval, concave structure. Its margins are moderately level except immediately below the foramen magnum. The

centre is fairly deeply excavated. In the American Museum collection there are a large number of detached and fragmentary occipital condyles, and from these every detail of the structure can be made out. The lower two-thirds of the condyle are formed by the basioccipital, which is usually completely ankylosed to the exoccipitals, but in many specimens the line of division can be readily made out, and the dividing suture is as indicated in the figure. The under side of the basioccipital is somewhat loosely articulated with the parasphenoid. Though the condylar portion of the basi-occipital is always

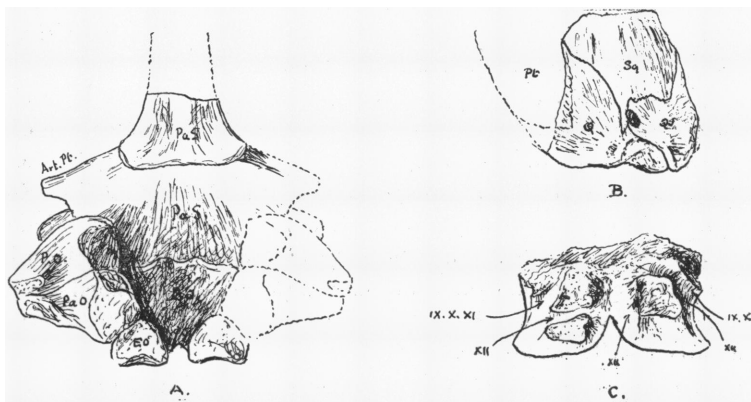


Fig. 7. A. Basicranial region of *Trimerorhachis insignis* Cope, seen from above. Nat. size. The paroccipital and prootic of the right side are preserved but somewhat more crushed, and the right side bones have therefore been restored from those of the left side. Art. Pt. Facet for articulation of the Pterygoid; B. o. Basioccipital; Pa. S. Parasphenoid; Pa.O. Paraoccipital; P. o. Prootic.

B. Qu. Right quadrate and related bones of *Trimerorhachis insignis* Cope. Nat. size.

C. Exoccipitals of *Trimerorhachis insignis* Cope. $\frac{1}{2}$ nat. size. The upper parts of the bones are broken across showing the foramina for the nerves.

very well ossified, the bone does not extend very far forward, not usually more than 20 mm. and generally only about 12. It seems probable that the anterior portion of the element remained cartilaginous.

The ex-occipitals form the upper and outer quarters of the condyle, and the lateral walls of the foramen magnum. Though no specimen in the Museum collection shows the whole occiput in undisturbed condition, there can be no doubt that the exoccipitals articulate above with the post-parietals. The articulation, however, must have been quite loose as the upper ends of the exoccipitals have manifestly been cartilaginous. Laterally the exoccipitals articulate with the paroccipitals, as shown in the figure. Between the exoccipital and the paroccipital there is a large oval foramen which doubtless gave exit to the IXth, Xth, XIth and XIIth nerves. In some specimens the exoccipital is broken across on a level with the lower portion

of the foramen magnum, and it is manifest that a canal runs through the bone from the brain cavity to the outside near the outer opening of the foramen between the exoccipital and the paroccipital. There can, I think, be little doubt that this canal is for the XIIth nerve.

The paroccipital [opisthotic] is well preserved on both sides of the type specimen figured by Cope and Case. On the right side the bone is considerably displaced, but on the left only slightly crushed down. In my drawing of the occiput, I have shown it in correct articulation with the exoccipital. It is manifest that it has also articulated above with the postparietal, and that its outer corner has articulated with the tabulare. In front the paroccipital has a large articulation with the prootic.

The prootic is about as large as the paroccipital and like it probably articulating at its outer corner with the tabulare. The under side of the paroccipital rests on the basioccipital, and though in the specimen the prootic appears to rest on the parasphenoid, it is probable that it originally rested on a cartilaginous basisphenoid. The inner sides of both otic bones are somewhat excavated for the reception of the membranous labyrinth, and it is pretty certain that the whole of this region has remained cartilaginous.

There is a well-developed stapes.

The parasphenoid is a large bone which forms almost the whole of the base of the brain region. Here it is irregularly quadrangular in shape. It articulates, as has been above stated, with the basioccipital. Laterally it supports the otic region, and in front it is continued forwards as a moderately strong bar to support the sphenethmoid. A little in front of the otic region the parasphenoid has an outward process for articulation with the pterygoid. This process has an anteriorly-directed, broad, convex surface on which the pterygoid could have moved. I am of the opinion that the basisphenoid was completely unossified. There is a part of the parasphenoid near the base of the anterior bar which looks like basisphenoid, but there is certainly no distinguishing suture, and I think the whole of the ossification is parasphenoid.

In no specimen is the sphenethmoid at all well preserved, but in two specimens there is clear evidence of the existence of this element. Probably in general structure it agreed with that of the better-known *Eryops*, but was less developed.

The pterygoid is a large bone which with the broad transverse, concave articulation moved on the parasphenoid. A large posterior process passed back and articulated with the quadrate behind and the squamosal above. A long anterior process passed forward to meet the prevomer. In no specimen is the palate completely shown. It is manifest, however, that the

anterior processes of the pterygoid carried numerous small, but not minute, teeth, and also that the inter-ptyergoid vacuity is wide. Probably in essentials the palate resembled that of *Eryops*, though undoubtedly the prevomers must have been much smaller, and the palatines and transpalatines were also probably small.

The lower jaw of *Trimerorhachis insignis* I have recently described elsewhere [Anatomischer Anzeiger], but may here briefly refer to its structure. The dentary forms most of the upper part of the outer side of the jaw. Posteriorly it articulates with a small surangular. Forming most of the lower half of the back of the jaw is a large angular. In front of this is a long, slender bone which, besides forming a considerable part of the outer side, forms much of the inner. This bone has not I believe until recently been previously recognized in the Stegocephalian jaw. It is clearly distinct

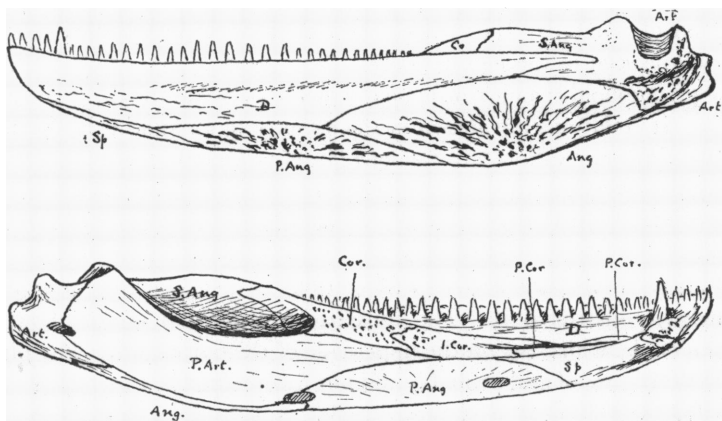


Fig. 8. Mandible of *Trimerorhachis insignis* Cope. $\frac{2}{3}$ nat. size.

from the angular behind and from the splenial in front. I have named it the preangular. In front of the angular is a well developed splenial, which appears more on the inner side of the jaw than the outer.

On the inner side of the jaw, the largest bone is the pre-articular, which forms most of the inner side of the back part of the jaw. Between it and the dentary and forming the front of the suprameckelian fossa, is a small coronoid bone bearing a large number of small teeth. In my recent paper I described the coronoid as passing well forward towards the front of the jaw. A further examination made after the jaw of *Eryops* had been studied revealed the fact that the supposed coronoid is really divided into two distinct elements by a suture near the anterior part of the dentigerous area. As I show in the various figures there are really three bones along the upper part

of the inner side of the jaw. The posterior one is manifestly, I think, the true coronoid. The most anterior I have already called the "precoronoid" and it will be appropriate to call the middle one the "intercoronoid." These three bones are probably homologous with the "splenial" and the two "anterior splenials" of the jaw of *Amia* and probably many other primitive fishes. Osborn has found a bone inside the upper part of the dentary in *Tyrannosaurus* which he has called the "supradentary plate." This is probably the same bone as was previously found by Nopcza in the Ornithopodous Dinosaurs and named by him "os accessorium." Williston has also found a similar bone in the Pelycosaur jaw. Whether the reptilian bone is homologous with the bone I have called "precoronoid," or with that I call "intercoronoid" it is impossible with the present evidence to decide. Not improbably it will prove to be my precoronoid.

The intercoronoid is about the same size as the coronoid, but differs in having very few teeth. Its relations to the coronoid, precoronoid and other bones will be seen in the figures given.

The precoronoid is a narrow bone wedged in between the dentary and the splenial. Its relations are shown in the surface views and in the section.

The articular is a short, strong bone largely covered on the inner side by the prearticular and on the outer side by the surangular and angular.

The vertebræ are of the well known Rhachitomous type. In the dorsal region the arch is wide and the spine probably tipped with cartilage. The notochord has been very large and the various elements surrounding it have only slightly constricted it. The united arches form an arc of about one-third of a circle, which lay on the upper side of the notochord. The pleuro-centra are very small and probably did not form more than an eighth of the circle. The inter-centra are large and wide and form arcs which are about semicircles. It seems probable that these bony elements are ossifications of considerably larger cartilaginous elements. The inter-centra are in most specimens a considerable distance apart, and it seems not improbable that the small pleuro-centra are merely ossifications of cartilage elements which may have formed nearly complete rings round the notochord.

The axis has a large powerful spine, and the pleuro-centra in connection with it are larger than those of the dorsal vertebræ. The inter-centrum between it and the atlas is also large. Its outer edge has an articular surface for a rib. The atlas has the two sides of the arc separated from each other; each rests against the spine of the axis. The pleuro-centra are moderately large. The inter-centrum is smaller than the other inter-centra of the vertebræ.

Case has figured a number of the limb and girdle bones. The limbs are relatively feeble and the girdles imperfectly ossified. While ilia are abun-

dant in the scrap material of the Museum, I have not recognized any bones which might be pubes or ischia, and it is possible that these elements remain cartilaginous. The clavicles, inter-clavicle and cleithra are of the usual Stegocephalian type.

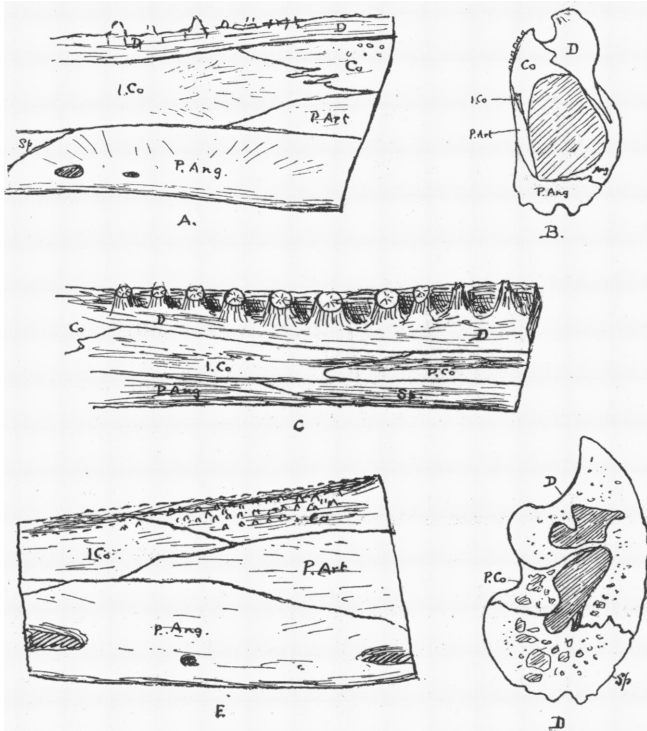


Fig. 9. Details of the mandible of *Trimerorhachis insignis* Cope. Figs. A. B. C. E. nat. size. Fig. D, twice nat. size.

A. A middle portion of right mandible showing suture between coronoid and intercoronoid. The surface has been slightly ground down.

B. Section seen on posterior end of Spec. A.

C. Middle portion of left mandible showing suture between the intercoronoid and precoronoid.

D. Section seen at anterior end of Spec. C. $\times 2$.

E. Middle portion of right mandible showing relations of intercoronoid to coronoid, prearticular and preangular.

***Trimerorhachis medius* sp. nov.**

This new species of *Trimerorhachis* I found on a small skull in a collection of the American Museum. Though considerably crushed, the whole of the upper surface of the skull is preserved except between the two eyes and a

small portion behind the orbit, which are missing. In general structure the agreement of the elements with those of *Trimerorhachis insignis* is sufficiently

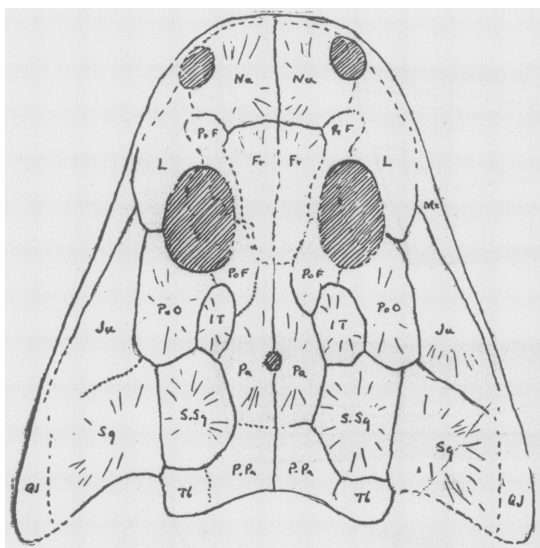


Fig. 10. Skull of *Trimerorhachis medius*. Nat. size. The sutures in the line are those seen in the specimen.

close to render it unnecessary to do more than point out the differences. The frontals, of which the anterior parts are preserved, are relatively wider than in *T. insignis*. The lacrymal is in general shape as in *T. insignis*, forming most of the outer orbital wall. The jugal comes considerably nearer to the orbit but does not enter it. The inter-temporal is very similar to that in *T. insignis*, as is also the supra-squamosal is relatively rather larger and the parietal smaller. The squamosal is also relatively smaller in *T. medius*. It will be seen from the figure that while the elements in general relation agree closely with those in *T. insignis*, the proportions of the skull differ considerably. The eyes are slightly further back, and the whole skull is relatively narrower.

***Trimerorhachis conangulus* Cope.**

This beautiful small skull shows most of the sutures of the elements of the cranium. Case expresses a doubt as to whether it is really a species of *Trimerorhachis*, and though perhaps he is right in considering that it does not belong to this genus, it is certainly closely allied to it. It differs from *T. insignis* and also from *T. medius* in the proportions of many of the bones. Quite certainly it cannot be a young *T. insignis*.

The most striking feature of the skull is the great size of the parietals and the great reduction of the postparietals. The intertemporal is very clearly distinct, as noted by Case, and quite like that of *T. insignis*. The parietal foramen is small.

Eryops Cope.

The best known of the American Permian Stegocephalians is the genus *Eryops* of Cope. Many excellent skulls have long been known. In the American Museum there are about a dozen fine skulls besides a large number of others in an imperfect and fragmentary condition. From this rich material every detail of the cranial structure can be clearly made out.

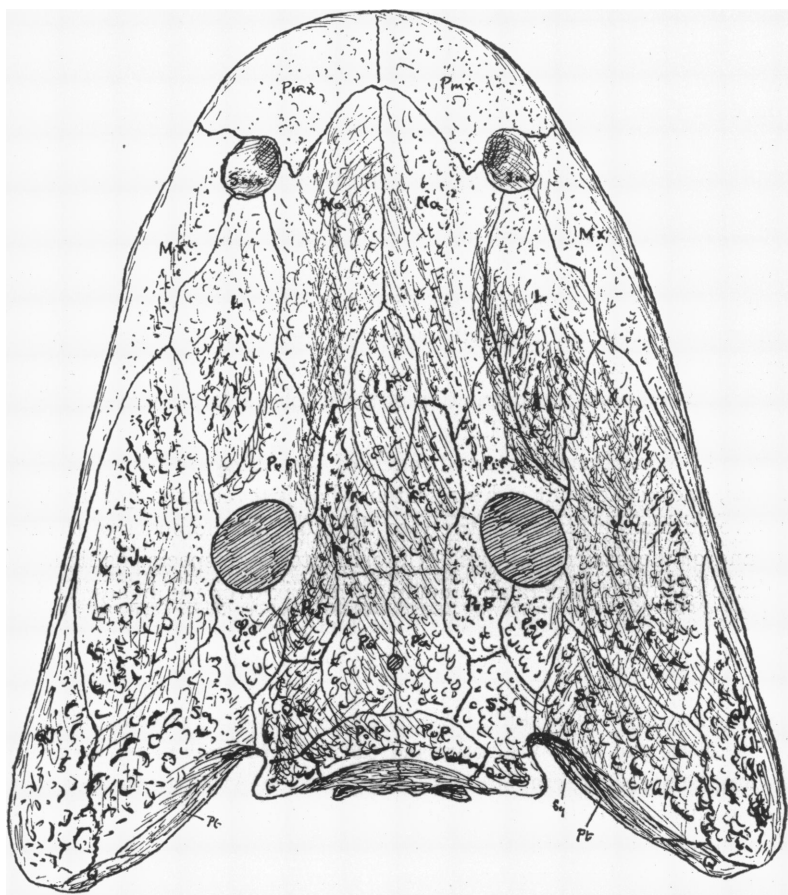


Fig. 11. Skull of *Eryops megacephalus* Cope. $\frac{1}{2}$ nat. size.

The first description of the skull was given by Cope, but though the skull he described is an excellent one, sutures are very difficult to make out, owing to the rough sculpturing, and Cope did not attempt to trace the limits

of the bones. Besides his description of the skull, he elucidated the structure of the vertebral column, of the girdles and the limbs.

In 1899 Broili redescribed the skull of *Eryops*,, figuring the lower jaw, the palate and the occiput, and giving some further details of the vertebræ. Unfortunately he made no attempt to trace the limits of the various cranial elements, nor has he done so in the palate.

In 1905 Branson, in connection with his paper on the American Labyrinthodonts, gave a figure of a restoration of the upper side of the skull of *Eryops*, of the occipital region and of the inner side of the lower jaw. These were, I believe, the first attempts to trace the cranial elements, and make a very important addition to our knowledge.

In 1911 Case reëxamined *Eryops* in connection with his revision of the permian amphibians of North America. He accepts in the main Branson's interpretation of the elements of the upper side of the skull of *Eryops megacephalus*, but in addition gives a drawing of the elements in a small species of *Eryops* [No. 4310 Am. Mus.]. Case's most important addition to our knowledge of the cranial structure consists in the figuring of a beautiful palate of *Eryops megacephalus* [No. 4673 Am. Mus.]. This specimen shows all the sutures between the palatal elements, and with one exception all have been correctly traced by Case. From specimens in the American Museum Case gave a complete reconstruction of the whole skeleton, and gave figures of the vertebræ, girdles and limbs.

In 1911 Von Huene examined much of the American Museum *Eryops* material, and his account of his researches has just recently appeared. He has devoted himself almost entirely to the study of the bones of the brain case, and of the basicranial axis. Unfortunately the specimens figured by him have each a considerable amount of matrix over the bones, and in a number of cases he has been unable to correctly delimit the elements, and in one or two points I believe he is in error in his interpretation of the cranial foramina.

In his account of the skull, Case has already pointed out how difficult it is in most cases to trace the sutures of the cranial elements among the pittings and bosses of the cranial sculpture. In some skulls the sutures cannot be made out, but in others they can be clearly traced with the aid of a lens, and in one skull or other of those in the American Museum collection, every cranial suture has been clearly followed. The figure I give of the upper side of the skull of *Eryops megacephalus* is mainly drawn from specimen No. 4190 and some sutures which cannot be clearly made out from this specimen have been added from specimens No. 4189 and others. Nearly every suture has been confirmed in more than one specimen.

The premaxillary bones have been already well figured by Case and Bran-

son. They form most of the prenasal region, meeting posteriorly the maxilla, the septomaxilla and the nasal.

The maxilla extends backwards from the premaxilla to the quadrato-jugal. Though well developed in front, it gradually tapers out to a very slender bone behind. It is correctly figured by both Branson and Case.

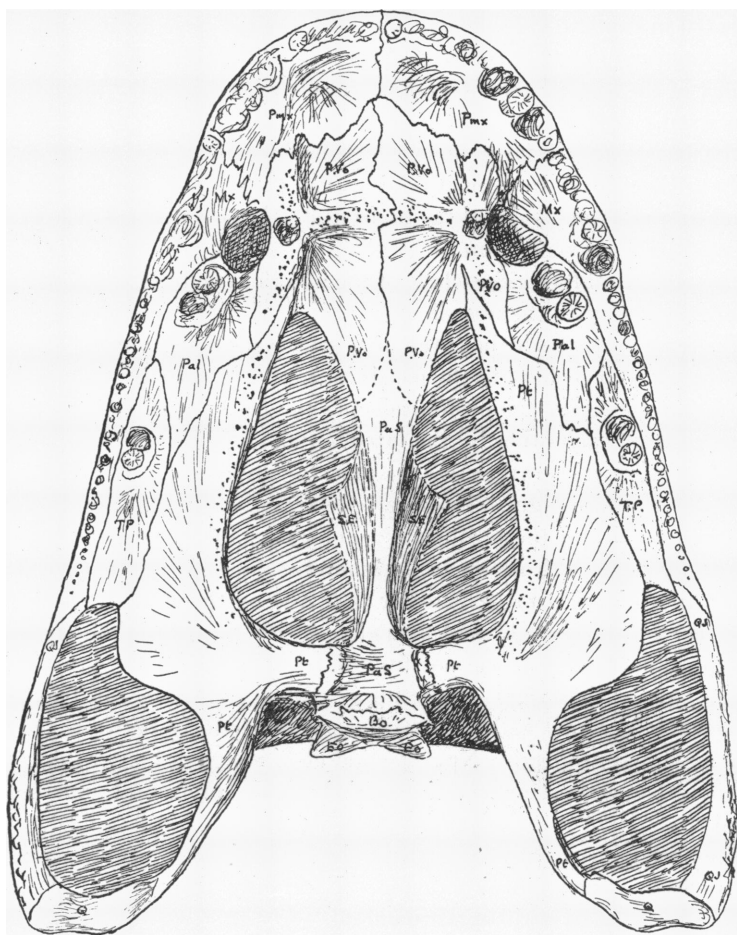


Fig. 12. Palate of *Eryops megacephalus* Cope. About $\frac{1}{4}$ nat. size.

The septomaxilla, which was first recognized by Case, forms most of the floor of the anterior nasal opening. It has been correctly figured by Case and v. Huene.

The nasal is a large bone which passes from the prefrontal and frontal

behind to the premaxilla in front. On the outer side it articulates with the lacrymal. Posteriorly it has a large articulation with the interfrontal.

The interfrontal is an oval shaped median element lying between the posterior portions of the nasal and the anterior halves of the frontal. It is present in all specimens of *Eryops*, and varies but little in shape. In some it is more pointed at the ends than shown in the figure; in others it is more truncated in front. This element has not previously, so far as I am aware, been recognized in any of the larger Stegocephalians, though it is well known in many of the smaller genera, and has recently been named "Inter-frontal" by Watson.

The lacrymal is a large bone which extends from the nostril in front nearly to the orbit. In front it lies between the maxilla and the nasal, and behind between the jugal and the prefrontal. It is considerably larger than indicated by Branson's figure.

The prefrontal forms the whole of the anterior orbital margin and passes forwards half way to the nostril.

The frontals are each about the same size as the interfrontal. They pass from the parietals behind to the nasals in front. Externally they articulate with the postfrontals, the prefrontals and the nasals, and in front they are separated from each other by the interfrontal.

The postfrontal is rather smaller than the prefrontal. It forms most of the upper orbital margin. Posteriorly it articulates with the parietal, the suprasquamosal and the postorbital; and articulating with the prefrontal shuts out the frontal from the orbital margin.

The postorbital is rather smaller than the postfrontal. It forms most of the postorbital margin and articulates with the jugal, the squamosal, the suprasquamosal and the postfrontal.

The jugal is the largest of the upper cranial elements. In front it lies between the lacrymal and the maxilla, and posteriorly between the squamosal and quadratojugal. Near the middle of its upper border it meets the orbit, and has a short articulation with both the prefrontal and the post-orbital.

The parietal is slightly larger than the frontal. Between the two bones is a moderate sized pineal foramen. Externally the parietal articulates with the postfrontal and suprasquamosal.

The suprasquamosal is a rather small bone about as long as broad. It articulates with the postorbital, postfrontal, parietal, postparietal, tabulare and squamosal.

The postparietal, or dermosupraoccipital, is situated behind the parietal. It forms a considerable part of the upper cranial surface and folding around the posterior cranial margin, it forms quite a large part of the occipital

surface. In Fig. 11 are seen its relations to the parietal, suprasquamosal and tabulare: in Fig. 13 are seen its relations to the exoccipital and also to the posterior portion of the tabulare. Its lower occipital border besides having a large articulation with the exoccipital also meets the paroccipital and a portion of the tabulare which has passed below the lateral occipital opening.

The tabulare is a curiously shaped bone which forms the upper outer angle of the occiput. It forms a small part of the upper cranial surface. Posteriorly and inferiorly it divides into two portions, the upper of which articulates with the occipital portion of the postparietal; the lower covering over the outer end of the paroccipital [opisthotic], and curving round below the lateral occipital opening, it again meets the postparietal.

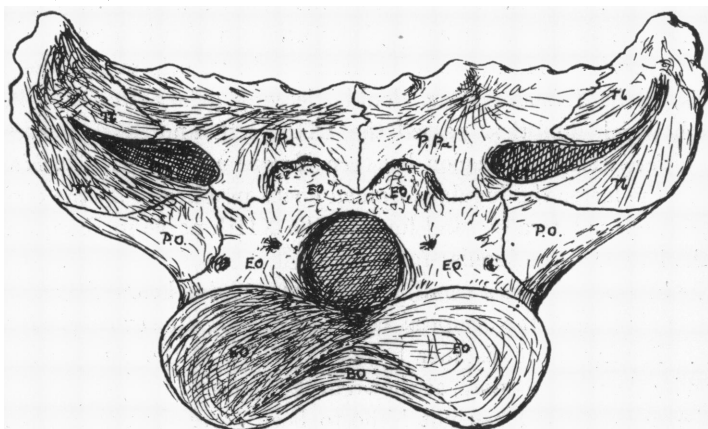


Fig. 13. Occiput of *Eryops magacephalus* Cope. $\frac{2}{3}$ nat. size.

The squamosal is a fairly large bone which passes from the postorbital, suprasquamosal and tabulare above to the quadratojugal and quadrate below. In front it has a long articulation with the jugal and posteriorly curves round and articulates with the pterygoid.

The quadratojugal is rather smaller than the jugal. It forms most of the upper side of the posterior outer angle of the skull. It passes between the jugal and the maxilla in front and overlies the quadrate behind.

The occiput has been figured by Broili, Branson and v. Huene. Broili, while giving a satisfactory figure of the general appearance of the bones, does not show the limits of the various elements. Branson's figure, though somewhat diagrammatic, is fairly correct. V. Huene gives a better drawing of the occiput than either Broili or Branson, but he has been unable to determine the limits of the elements, and is in error in regarding the outer

portion of the lower bar as paroccipital instead of tabulare, and also I think in finding a distinct supraoccipital.

The greater part of the occiput is formed by the large exoccipitals. Each bone articulates with the postparietal above and the paroccipital externally, and forms most of the lateral part of the condyle. Though the large occipital condyle is really single, the middle basioccipital portion is very much smaller than the large lateral exoccipital parts. These exoccipital facets look backwards, downwards and inwards. The articulation between the exoccipital and the postparietal is so close that no movement has been possible between the two bones, in this differing markedly from the condition in *Trimerorhachis*. On the posterior side of the exoccipital, a little above the articular surface of the condyle, are two foramina. These appear to be vascular. Passing through the bone from the brain cavity to the outside, near the back of the condyle, is a foramen which is most probably for the XIIth nerve. The articulation between the exoccipital and the paroccipital is, as in *Trimerorhachis*, double, leaving a large foramen between, through which doubtless passed the IXth, Xth and XIth nerves. The main difference in this region between *Eryops* and *Trimerorhachis* is that while in the latter the jugular foramen opens practically on the occiput, in *Eryops* it opens laterally; and further, the XIIth nerve in *Eryops* does not join the bunch in the jugular foramen.

The basi-occipital is a small, broad element lying below the exoccipitals. It forms about $\frac{1}{3}$ of the occipital condyle, uniting the exoccipital portions below. A very short distance behind the edge of the condyle it is overlapped by the parasphenoid, as shown in the figure.

The parasphenoid has not hitherto been correctly understood. Case identified the bony element immediately in front of the basioccipital and between the two pterygoids as parasphenoid: v. Huene regards this same structure as basisphenoid. A comparison with *Trimerorhachis* and the fact that the element is continuous into what is undoubtedly parasphenoid in front, leads me to believe that Case is correct in regarding the back part as also parasphenoid. This back part is a moderately thick bone and has two short, slightly descending, robust lateral processes for articulation with the pterygoids.

In v. Huene's paper, the figure he gives of this region [Fig. 4] tends to give a wrong impression, as the suture between the basioccipital and the supposed basisphenoid is much too far forward, and a large, supposed basi-ptyergoid process of the basisphenoid is largely formed by the pterygoid, the suture being about midway between the end of the process as drawn by him and the middle line. In front, it has hitherto been supposed that the large bone which passed forward and supported the bones of the upper side

of the cranium, was all parasphenoid, but in reality it is only the lower and middle portion of this structure that is parasphenoid; the rest, as will be shown later, is a large median cartilage bone which may be referred to as the sphen-ethmoid.

The pterygoid is a very large bone which from its articulation with the parasphenoid extends both backwards and forwards. The articulation with the parasphenoid is a large, rounded, irregular surface; a large number of bony processes from the parasphenoid interlocking with others from the pterygoid and rendering any movement between the two bones quite im-

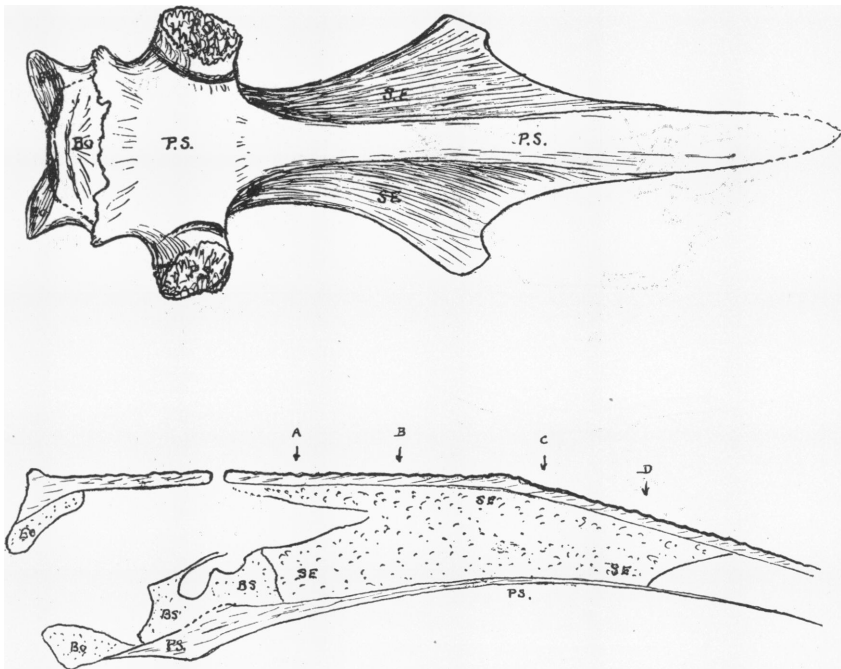


Fig. 14. Basicranial axis of *Eryops magacephalus* Cope. From below and in section. The upper figure is $\frac{1}{2}$ nat. size: the lower slightly larger. A. B. C. D. indicate the planes of the sections in Fig. 16.

possible. Behind the parasphenoid articulation the pterygoid has a deep posterior plate which passes upwards and backwards, having a long articulation with the squamosal and meeting posteriorly the quadrate. Anteriorly the pterygoid passes forwards to meet the prevomers, and externally it articulates with the palatine and the trans-palatine. This anterior process has along its inner and under border a large number of small teeth.

Outside of the pterygoid and a little in front of the pterygoid process, is a

small transpalatine bone. This bone was recognized by Case but believed by him to be the palatine. It carries a single large tooth.

In front of the transpalatine is the palatine. By Case this was believed to be part of the maxilla, but the suture dividing it from the maxilla can be easily traced on both sides of the skull. In the front of the palatine is single large tooth, as in most Labyrinthodonts. These large palatal teeth appear to be double, a new one developing where the old one has been shed. The palatine articulates with the transpalatine behind and the pterygoid and prevomer in front. It forms the posterior wall of the posterior nares.

The prevomer is a large bone, the two together lying between the posterior nares, and forming most of the front of the palate. It articulates with the premaxilla in front and with the palatine, pterygoid and parasphenoid behind. A well developed tooth of a similar character to the large palatine tooth, but much smaller, is situated on the prevomer close to the anterior end of the inner wall of the internal nares. Between the large teeth of the two prevomers there runs a prominent, though low, ridge carrying numerous small teeth, and other small teeth are situated on the bone, especially on a ridge running antero-posteriorly on the inner side of the posterior nares.

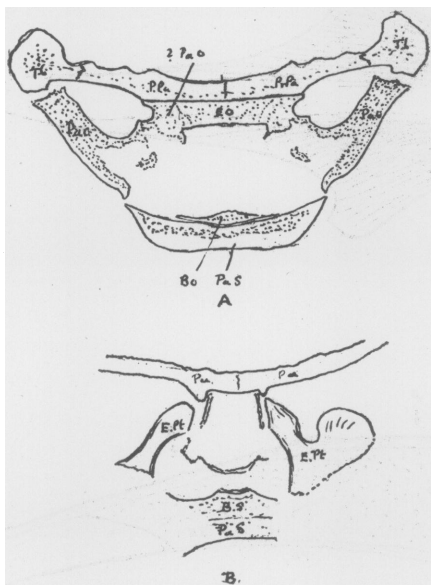


Fig. 15. A. Transverse section across brain case of *Eryops megacephalus* Cope, in region of labyrinth. The inner portions of the paroccipital (opisthotic) which lodged the labyrinth have been largely cartilaginous.

B. Transverse section of brain case of *Eryops megacephalus* Cope, in front of prootic, with view of the epipterygoids. The thin osseous walls are shown.

The premaxillary bones form a considerable part of the palate in front of the prevomer and the maxillaries a small part outside the posterior nares.

The bones of the brain case are a little difficult to accurately determine, owing to their being in parts imperfectly ossified. As already mentioned the basisoccipital lies on the parasphenoid at the back, and is laterally at the foramen magnum overlaid by the exoccipitals. Between the basioccipital and the basisphenoid a small gap is left, which has evidently remained cartilaginous.

In front of the exoccipital and external to it lies the large paroccipital, or opisthotic. As already mentioned, it forms part of the occiput, the external process passing out and being covered by the tabulare. Between the paroccipital and the lower part of the exoccipital is a large oval foramen for the IXth, Xth and XIth nerves. The upper part of the paroccipital forms a large, well developed, antero-posteriorly directed process, underlying the tabulare. The lower part of the paroccipital is feebly ossified. It lodges the greater part of the membranous labyrinth, and the portion of the bone separating the internal ear from the brain is so imperfectly ossified that it is practically impossible to clean out the brain case without opening into the ear.

The proötic is somewhat smaller than the paroccipital. Its upper portion forms a short, transversely-directed crest which underlies the back part of the parietal. Between the upper part of the proötic and the paroccipital is a moderately large oval foramen, probably for a blood vessel. The lower part of the proötic resembles in structure that of the paroccipital, being feebly ossified and lodging a large part of the labyrinth.

Between the anterior parts of the bases of the pro-otics and closely united to the parasphenoid is the basisphenoid. The lower part of this bone runs from near the anterior end of the basioccipital to the posterior end of the large sphenethmoid. Near its posterior part there is what appears to be a cella turcica. This is a thin little plate of bone concave on the upper side and which runs forward over a deep excavation in the basisphenoid. The anterior part of this excavation is presumably for the hypophysis, but the lower and hinder portion has possibly been for a *Saccus vasculosus* such as occurs in *Polypterus*. This latter cavity is freely open at the sides. It cannot be any nerve opening as it is only indirectly connected with the brain cavity through the hypophyseal region. From the slender cella turcica delicate bony walls pass upwards on either side, forming lateral walls for the brain case. The branches of the Vth nerve presumably pass through between this lateral wall and the proötic. Owing to the loose nature of the bone, it is impossible to be certain of these delicate lateral walls being parts of the basisphenoid. Most probably they represent the cartilaginous cranial wall seen in *Sphenodon* and most reptiles.

In front of the basisphenoid and lying on the anterior part of the parasphenoid is the sphenethmoid already referred to. This is a large cancellous bone which occupies the whole space between the parasphenoid and the bones of the upper side of the skull. Its posterior end is excavated for the cerebral hemispheres, and from the anterior ends of this excavation there passes forwards four canals as seen in section in the figures given. It is probable that the inner and lower two are for the olfactory nerves, the other

two being possibly for blood sinuses. The whole of this element appears to be one bone, there being so far as I have observed no sutures in any part of it. Whether this bone is to be regarded as homologous with the mammalian presphenoid or ethmoid, or with the amphibian sphenethmoid is uncertain. Its posterior border has an opening for the optic nerve, and one might readily believe that the lateral parts were orbitosphenoid, but there being no trace of any division between the lateral wall and the base, I incline to the opinion that the whole element represents the mammalian presphenoid. As, however, there can be comparatively little doubt that it is homologous with the bone that has been called "sphenethmoid" in the frog, it will be safer to use this same name for the bone in *Eryops*. In the *Anomodonts* there is in the frontal region a median cartilage bone which is pre-

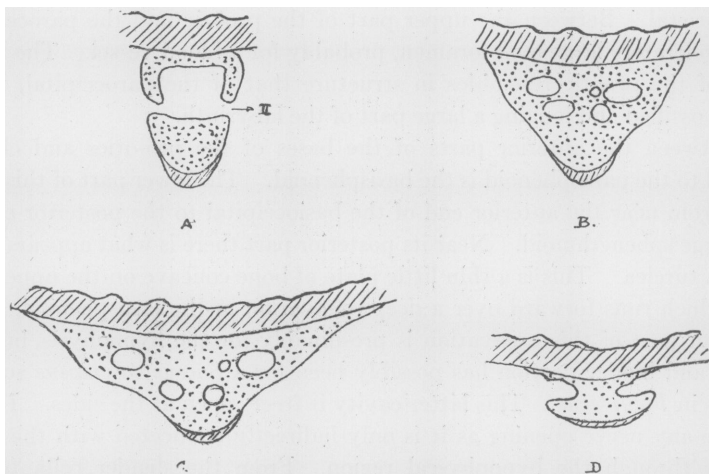


Fig. 16. Transverse sections through the sphenethmoid and parasphenoid at the points indicated in Fig. 15. About $\frac{2}{3}$ nat. size.

sumably also homologous. Along its lower side runs the parasphenoid or true vomer, and it has a pair of longitudinal canals for the passage of the olfactory nerves. As will be seen in the figures given, there is considerable resemblance between the section of these bones in *Dicynodon* and *Eryops*. Figs. 16 and 17.

From the inner end of each pterygoid there passes upwards and inwards a well developed epipterygoid bone. The upper part of the bone is a rounded rod which probably extends up to the parietal. Inferiorly the bone becomes much expanded into a wide plate which lies on the pterygoid, but also in part articulates with the parasphenoid.

Branson appears to be the only authority who has studied the lower jaw. He gives a photographic representation of the outer side and a diagram of the bones of the inner. Many of the sutures he has correctly traced, but a number he has missed, and his interpretation of the structure of the jaw requires considerable modification.

The dentary is a long bone which extends from the front of the jaw almost to the articulation. The anterior three-quarters of the bone are moderately deep, but posteriorly it ends in a long slender process which lies against the surangular.

Next to the dentary, the most conspicuous bone on the outer side of the jaw is the large angular. This forms the greater part of the outer side of the back part of the jaw, and is remarkable for the very coarse sculpturing on its surface, which radiates out from what might be regarded as the angle of the jaw. It is strikingly like the angular in most Stegocephalians. It articulates in front and above with the dentary. Above and behind it has a long articulation with the surangular. Internally it has a long articulation with the prearticular, and in front it meets by a relatively short articulation the preangular.

The preangular closely resembles the corresponding bone in *Trimerorhachis*, which I have already described. It forms the lower margin of the middle third of the jaw, articulating behind with the angular and in front with the splenial. On the outer side it has a long articulation with the dentary, and on the inside an almost equally long articulation with the prearticular. Its anterior upper angle on the inside meets the precoronoid. As in *Trimerorhachis*, there are on the inside of the jaw, near its lower edge, two large foramina. The posterior one lies between the angular and the prearticular. The anterior is completely in the anterior part of the preangular.

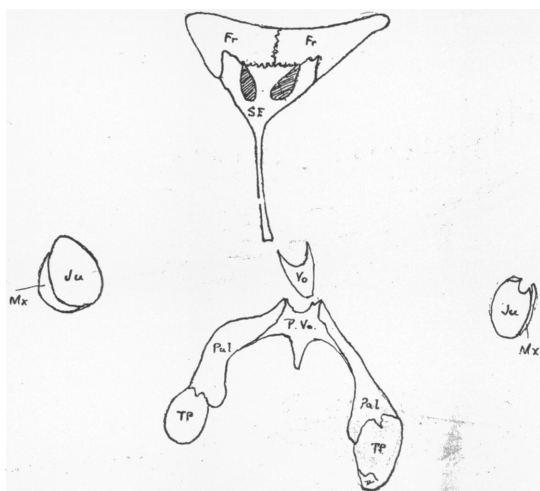


Fig. 17. Section across the skull of *Dicynodon* sp. showing the relations of the vomer (= parasphenoid) to the sphenethnoid (= ? presphenoid).

The splenial forms the lower margin of the anterior fourth of the jaw. It appears on both the outer and inner sides, but more on the inner than the outer. For the greater part of its length it articulates on the inside with the precoronoid. Posteriorly it has a long, oblique articulation with the preangular, and externally it has a long articulation with the dentary. It enters into the symphysis, but only forms the lower corner.

The largest bone on the inside of the jaw is the prearticular. It extends from close to the articulation to opposite the anterior foramen. Posteriorly it articulates with the articular. Its lower margin has a long articulation with the angular, and an equally long one with the preangular. It forms almost the whole of the inner wall of the supra-meckelian fossa. Near the anterior end of the fossa it meets the coronoid, and the whole of the rest of its anterior upper margin is in articulation with the coronoid and the intercoronoid.

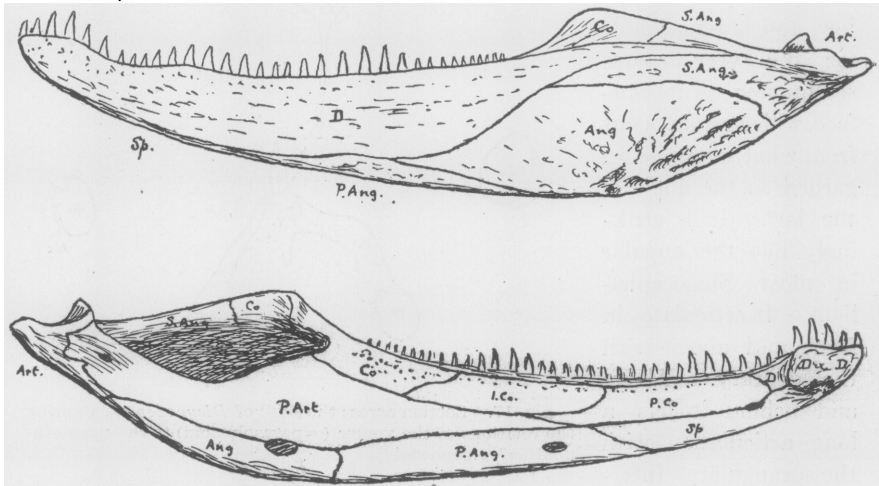


Fig. 18. Mandible of *Eryops megacephalus* Cope. About $\frac{1}{2}$ nat. size.

The coronoid bone forms the anterior margin of the supra-meckelian fossa, and a considerable part of its outer wall articulating with the surangular near the middle of the outer margin of the fossa. It passes forwards between the dentary and the prearticular a short distance to meet the intercoronoid as shown in the figure. The intercoronoid is slightly smaller than the coronoid. Its relations are shown in the illustration. In front of the intercoronoid is a distinct bone which in *Trimerorhachis* I have called the precoronoid. Though in *Trimerorhachis* it is relatively small, in *Eryops* it is almost as large as the intercoronoid. For the most part it lies between the splenial and the dentary. Posteriorly it articulates with the intercoronoid and with the prearticular.

***Eryops anatinus* sp. nov.**

This new species of *Eryops* is founded on specimen No. 4310 Am. Mus. It is a small skull previously figured by Case and referred by him to *Eryops* sp. The specimen differs too greatly from *E. megacephalus* to belong to that species, and the difference in the proportions of the bones such as to render it not improbable that the two belong to distinct genera. Still, as it is undoubtedly a near ally of *Eryops*, it will be more convenient to maintain it in this genus.

It will be unnecessary to describe all the bones in detail, and only the more striking features need be referred to.

The orbits are relatively larger and further forward than in *E. megacephalus*, and the articular region much narrower. The bones of the middle part of the skull, viz. premaxilla, nasal, inter-frontal, frontal, parietal and postparietal agree closely with those bones in *E. megacephalus*. The jugal differs markedly in forming a very much larger portion of the orbital margin, and the prefrontal does not extend so far down. The postfrontal, though well developed, only extends a short distance behind the orbit; while the postorbital differs very markedly from that of *E. megacephalus* in being less than a quarter of the size of the

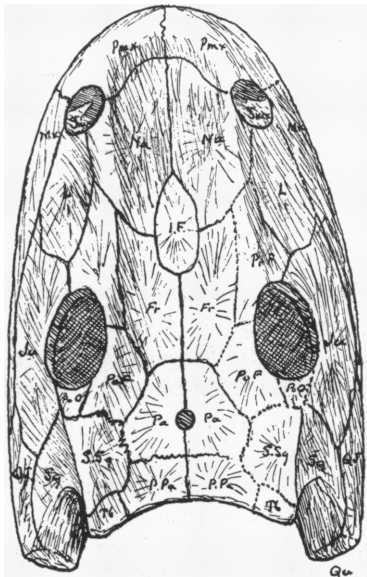


Fig. 19. Skull of *Eryops anatinus* Broom. About $\frac{1}{2}$ nat. size.

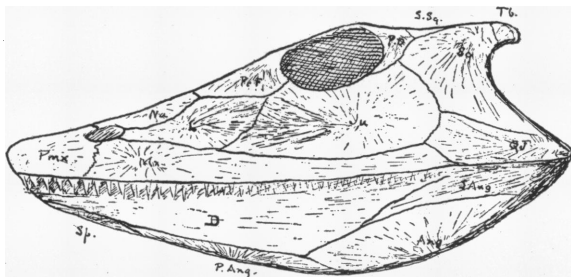


Fig. 20. Side view of skull of *Eryops anatinus* Broom. About $\frac{1}{2}$ nat. size.

orbit. The squamosal descends much more abruptly from the suprasquamosal; and the maxilla has a much more strongly developed posterior process.

Only the outer side of the mandible is well shown. The dentary is large and the angular well developed. The splenial and preangular, though well formed, do not show very much on the outer surface. The relations of these bones and the bones of the side of the head are shown in Fig. 19.

Zatrachys Cope.

One of the most interesting types represented in the American Museum collection is the genus *Zatrachys* of Cope. It is represented by two skulls of *Zatrachys microphthalmus* Cope, the one of which has lost the point of the snout and the other has not as yet been wholly freed from the hard matrix; by the beautifully preserved posterior half of the skull, which forms the type of *Zatrachys serratus* Cope; and the very imperfect posterior half of the skull which forms the type of *Zatrachys conchigerus* Cope. From the two specimens of *Zatrachys microphthalmus* every external detail of the skull structure can be clearly made out. The figure I give is drawn from specimen No. 4587 Am. Mus. with the point of the snout added from specimen No. 4586 Am. Mus.

Case has given figures of both the specimens of *Zatrachys microphthalmus* and has correctly traced a number of the sutures. V. Huene has given a drawing of the specimen in the American Museum No. 4873, under the name *Zatrachys microphthalmus*. The specimen is so covered by a hard incrustation of matrix that it is impossible to see any of the details of the structure, or to determine to what species it belongs. Not improbably it is a small specimen of *Eryops*. It is in my opinion not *Zatrachys*.

The skull is unusually flat, but the orbits rise up very prominently and there is a very deep pit between the orbit and the nostril, as shown by Case. In the arrangement of the bones of the upper side of the skull, *Zatrachys* differs from *Cricotus*, *Trimerorhachis*, and *Eryops*.

The most of the front of the snout is formed by a pair of very large flat premaxillaries. Between them lies the greater part of a large median oval vacuity through which can be seen the prevomer of the under side of the skull.

The two nostrils are placed fairly laterally and are considerably elevated. Between them lie the pair of large nasals. These nasals posteriorly articulate with the lacrymal, prefrontals and frontals, and externally meet for a short distance the maxillaries. In front the nasal has a large z-shaped suture

margin. It only extends forwards a very short distance in front of the transverse orbital plane; nor does it extend much behind the postorbital plane.

The postfrontal is rather smaller than the prefrontal. It forms most of the upper orbital margin and articulates posteriorly with the parietal, suprasquamosal and postorbital.

The postorbital is slightly larger and forms the postorbital margin.

The parietal is relatively small. The pineal foramen lies between the two bones near their anterior margin.

The suprasquamosal is rather larger than the parietal. It is surrounded by the parietal, postfrontal, postorbital, squamosal, tabulare and postparietal.

The postparietal is of a fair size and occupies the usual situation.

The tabulare is remarkable through forming a conspicuous posterior horn-like process.

The squamosal is a rounded bone which articulates with the tabulare, suprasquamosal, postorbital, jugal and quadratojugal, and probably also with the quadrate and pterygoid.

The quadratojugal like the tabulare forms a conspicuous posterior horn-like process. It is a moderately large bone, larger than the squamosal.

In *Zatrachys serratus* in addition to the tabulare and quadrato-jugal horns, there is a small horn-like process on each postparietal.

The occiput is well preserved in *Zatrachys serratus*, but the different elements cannot readily be made out. There are two small apparently exoccipital condyles, the basioccipital possibly uniting them as in *Eryops*. The exoccipital passes upwards to meet the very shallow postparietal, and apparently divides into an outer and an inner portion as in the Labyrinthodont *Capitosaurus*. The paroccipital passes upwards and outwards to meet the tabulare.

The parasphenoid is a well developed bone which differs from that of *Trimerorhachis* in the much greater development of its anterior portion, which is broad and carries innumerable small teeth.

The pterygoids are sutured apparently immovably with the parasphenoid. Though of the typical Stegocephalian form, the anterior portion is much shorter than usual, owing to the enormous development of the prevomers. Like the parasphenoid, they carry innumerable teeth on their anterior and transverse portions.

Nothing is known of the transpalatine or palatine, but the prevomers are seen to be of enormous size, forming practically the whole anterior half of the lower side of the skull. They are extremely thin plates, which are very closely united to the inner parts of the nasals and to most of the pre-

maxillaries. Like the pterygoids and parasphenoid, they carry a large number of small teeth.

The lower jaw is not displayed satisfactorily in any of the specimens, though much of it is seen in two. It probably agrees in essential structure with that of *Trimerorhachis*. There is a large prearticular forming much of the inner side of the jaw. The angular is very conspicuous through being covered with very coarse sculpturing. In front of it is a large preangular as in *Trimerorhachis* and *Eryops*. The coronoid is not seen in any specimen, but there is a bone near the middle of the jaw which is probably intercoronoid. It is extremely delicate and carries a row of minute teeth.

Case has called attention to the resemblance between *Zatrachys* and the English Permian Stegocephalian genus *Dasyceps*. He says:—"The genus *Dasyceps* seems to lack the deep pits between the orbits and nares, and *Zatrachys* does not have the median opening between the nares, but in other respects the skulls are almost identical." As I have shown, *Zatrachys* agrees with *Dasyceps* in having the large median vacuity, and if we allow for the imperfections in the English type, it is difficult to detect any important differences. One feels forced to conclude that the two are generically identical. The remarkable specialization of the quadrato-jugal is practically the same in both genera.

