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A SECOND SAUROPTERYGIAN CONVERTED INTO
OPAL, FROM THE UPPER CRETACEOUS OF
WHITE CLIFFS, NEW SOUTH WALES.

WITH INDICATIONS OF ICHTHYOPTERYGIANS
AT THE SAME LOCALITY.

By R. ETHERIDGE, Jun., Curator.

(Plates xlii.—xlv.)

The discovery of the remains of *Cimoliosaurus leucoscopelus*, Eth. fil.,¹ in the White Cliffs Opal deposit has been followed by that of another Sauropterygian referable to *Cimoliosaurus*, closely allied to *C. sutherlandi*, McCoy². The remains of this reptile have passed into the possession of the Trustees, by purchase, and are now described. The skeleton consists of the following parts:—Thirty-six vertebral centra, a number of rib pieces, a tooth, the distal end of a humerus, two femora, one nearly complete, and other fragments.

The mode of preservation is similar to that of *C. leucoscopelus*, the bones being converted into opal of one variety or another. In most instances the conversion is complete, but in a few cases traces of bone tissue still remain. Most of the centra are converted either into white opaque opal, or colourless translucent opal with blue patches, passing into indifferent "magpie" opal; here and there traces of precious opal make their

¹ Etheridge—Rec. Austr. Mus., iii., 2, 1897, p. 19.

² McCoy—Ann. Mag. Nat. Hist., (3), xix., 1867, p. 356; Trans. R. Soc. Vict., viii., 1, 1868, p. 42

appearance. In fact, this description will hold good for nine-tenths of the bones, the small cervical pleurapophysis (Pl. xliv., fig. 6 and 7) containing more precious opal than any of the other fragments. For richness of colour these bones bear no comparison with those of *C. leucoscopus*.

Vertebral Centra.—The whole of these are faintly amphicelous, but in some cases the double cupping is so faintly marked that the anterior and posterior articular surfaces may be described as amphiplatamous, and many with a marked central boss, but without any trace of peripheral rugosity. In outline the articular surfaces vary from oval to ellipsoidal—the anterior cervical and dorsal oval, the posterior cervical (? pectoral) ellipsoidal—and the lateral surfaces, speaking broadly, are slightly concave longitudinally. The ventral surfaces of the anterior cervical are rather flattened, and those of the pectoral (?) and dorsal convex in varying degree; from all the neural arches and pleurapophyses have been removed. The venous foramina are well marked and large, both dorsally and ventrally, whilst the central boss of the articular surfaces in the pectoral (?) and dorsal centra is not only large, but possesses a central depression of its own. The floor of the neural canal in the cervical centra is shown as a biconate scar, and on the pectoral (?) and dorsal as an hour-glass-shaped scar. The neurapophysial facets are ellipsoidal, deep, and more or less horizontal excavations on the anterior cervical centra, becoming broader as the column is descended, and there confined strictly to the dorsal surfaces of the bones. On the pectoral (?) centra these scars are even wider transversely, oblique, and descend on to the lateral surfaces, but on the dorsal centra, they, to all intents and purposes, again assume the same characters as those of the anterior cervicals; none of the neurapophyses are preserved *in situ*.

The pleurapophysial facets, or costal pits, are in every case single, and on the more anterior cervical centra are faint, elongated (fore and aft) scars, and situated low down on the lateral surfaces. On several of the centra, immediately in front of those I assume to be pectorals, these facets take on a very definite and rounded outline, showing a fractured projecting surface. On the pectoral (?) centra the pleurapophysial facets are compressed longitudinally, and project laterally. I distinguish the dorsal centra by the absence of these scars. There are three much worn centra, shorter (*i.e.* fore and aft), that may be caudals, although I cannot satisfactorily detect facets for the attachment of chevron bones.

The following are measurements of typical centra from the five parts of the column as here distinguished:—

Centrum.	Height of Centrum.	Width of Centrum.	Length (fore and aft) of Centrum.	Width of neurapophysial facet. (Transverse.)	Length of pleura-pophysial facet (fore and aft).	Height of pleura-pophysial facet.	Width of neural canal at centre of floor.
Anterior cervical	18 mm.	24 mm.	21 mm.	8 mm.	12 mm.	5 mm.	—
Median ...	31 mm.	43 mm.	30 mm.	18 mm.	16 mm.	10 mm.	—
Pectoral (?)	34 mm.	46 mm.	27 mm.	22 mm.	10 mm.	—	11 mm.
Dorsal ...	35 mm.	45 mm.	28 mm.	15 mm.	—	—	10 mm.
Caudal ...	26 mm.	37 mm.	17 mm.	11 mm.	—	—	9 mm.

The articular surfaces in the posterior cervical centra are practically flat; in the pectorals (?) there is a faint degree of concavity, whilst in the dorsal centra, the surface from the periphery for about one-fourth of the centrum diameter (longitudinally) is flat, the remainder of the surface within this margin, being slightly concave.

The venous foramina are close together on the venters of the anterior cervical centra, and far apart on the posterior cervical, pectoral (?), and dorsal centra, separated in some instances by an interforaminal flat or gently convex surface of from ten to fifteen millimetres; there is no dividing ridge, and on the dorsal surface only one foramen exists throughout the entire series of centra.

It is possible that the centra I have termed pectoral should be included in the cervical series proper, at the same time they to some extent agree with Mr. R. Lydekker's definition³ of these bones, in having the costal articulation partly on the arch and partly on the centrum. In the present case the costal pits, although not strictly on the arch form one with the neurapophysial facets, as in the centra of *C. planus*, Owen⁴ and which Sir Richard placed amongst the posterior cervicals.

Neural Spines.—Only two portions of detached neural spines remain. One, a cervical, is minus its apex, and below is broken off across the ceiling of the neural canal, but retains the fractured zygapophysial facets; in its present condition it is forty-one millimetres long, with a maximum fore and aft measurement of twenty-two millimetres. The other specimen is a very much stouter bone, with less of the spine proper remaining, but a larger proportion of the neural arch (Pl. xliii., fig. 3) and from its lateral spread, I am inclined to regard it as the remains of a dorsal spine, with the zygapophyses broken off.

Pleurapophysis.—In Pl. xliv., figs. 6 and 7 is represented a small bone, with a flat and spreading oblique base, a short constricted neck, and an expanded distal portion which is a little curved, gently convex on one side, slightly concave on the other. This want of bilateral symmetry removes it from the category of a neural spine, and I can only conclude that it is part of a cervical pleurapophysis. The length over-all is twenty-two millimetres, the width of the expanded portion fourteen millimetres, and the greatest diameter of the head nine millimetres.

Palange.—Only one of these bones is present in the collection. It is short and stout, strongly hour-glass-shaped, twenty-one

³ Lydekker—Nicholson's Man. Pal., 3rd. Ed., 1889, p. 1068.

⁴ Owen—Mon. Foss. Reptilia Cret. Formations, Suppl. iv., 1864, p. 3, pl. i., f. 5-7.

millimetres long, and nine millimetres in diameter at the median constriction. It closely resembles some of the phalanges of *C. leucoscopus*.

Ribs.—Numerous pieces of ribs are present, fractured portions similar to those of *C. leucoscopus*; typical examples will be found represented in the description of that species.

Humerus.—One fragment may be that of a portion of the distal end of a humerus exhibiting the greater part of an articular surface, and measures seventeen millimetres at its widest point (Pl. xlv., figs. 2 and 3), the breadth of articular surface being twenty-seven millimetres.

Femora.—Two bones, neither actually complete, accompany the other portions of the skeleton, which I believe are femora. They correspond in general outline with Owen's figure of the femur of *Cimoliosaurus neocomiensis*, Cpche⁵. One lateral edge of this bone is nearly straight, the other is concave. The proximal ends in both instances are lost, but the distal are fairly complete. The more complete of the two measures eighty-five millimetres in length, and forty-one millimetres transversely across the articular surface (Pl. xlv., fig. 1.)

Tooth.—Bones of the head are entirely wanting. One tooth, beautifully converted into translucent white and blue opal is present. It is defective at the base, but still measures twenty-two millimetres along the curve, and has a diameter of five millimetres at its stoutest part. The crown, gracefully curved, is thirteen millimetres long, with twenty-five sharp flutings, but leaving a longitudinal space on the arched or convex side devoid of ridges, but showing them in the opal-substance of the tooth; the apex of the crown is fine and acute. A similar bare track to the above is also present in the teeth of *Cimoliosaurus leucoscopus*.

The present cervical centra generally resemble in outline those of the Liassic *C. rostratus*, Owen⁶, but still more those of our Australian *C. sutherlandi*, McCoy⁷ (Pl. xlv., fig. 1.), as already stated, although in the present instance there is not even the hardly perceptible concentric depression of the articular surface visible in McCoy's species.

The outlines of the centra I have termed pectoral closely

⁵ Owen—Mon. Foss. Reptilia Cret. Formations, Supl. iv., 1864, pl. vi., f. 12.

⁶ Owen—Mon. Foss. Reptilia Liassic Formations, Pt. i., 1865, pl. x., f. 4 and 5.

⁷ Etheridge—Ann. Rept. Dept. Mines N.S. Wales for 1887 (1888), pl. i., f. 1-4.

accord with those of *C. planus*, Owen⁸, from the Cambridge Greensand, but are more strictly oval, the neural canal is much wider, judging by its floor, and the pleurapophysial facets rather lower in position.

The dorsal centra are by no means unlike the mid-dorsals of *C. planus*, Owen⁹, but the neurapophysial facets are proportionally longer (fore and aft) to their width. Like the cervical centra of *C. neocomiensis*, Cpche¹⁰, they possess a central mammilla. Speaking of this species Owen said:—"I am inclined to think that the mammillate character of the terminal articular surfaces shown in the cervical vertebræ may, like other characteristic modifications, be less strongly manifested in the dorsal vertebræ, or in some of the dorsal vertebræ of the same individual¹¹." If I am correct in referring the whole series of centra now described to one individual, we find such a modification carried to an extreme, in that the mammillæ are confined to the dorsal centra.

The three centra separated as caudal in position also present some features in common with those of *C. planus*.¹² They possess the same short fore and aft measurement, and a generally similar outline, but the neural canal floor is wider, and below the venous foramina closer together.

The identity of this reptile is a point of some difficulty, although the previously described opalized form *C. leucoscopus* may be dismissed with brief remarks. Throughout the series of thirty-six centra there is not one that corresponds with the deeply amphi-celous articular surfaces of that species. Not only are the present centra amphiplatamous, but the relative proportions of height to breadth are quite dissimilar. In fact the two reptiles belong to different groups of the genus as defined by Lydekker¹³, *C. leucoscopus* to the Cœlospondyline Group, the present fossil to the Typical Group. The relation of the latter to those bones named *Plesiosaurus sutherlandi* by the late Sir F. McCoy is the point at issue; this belongs to the second group and is a typical Cimoliosaurian. I have already figured¹⁴

⁸ Owen—Mon. Foss. Reptilia Cret. Formations, Sup. iv., 1864, pl. i., f. 5-7.

⁹ Owen—*Loc. cit.*, pl. i., f. 12-15.

¹⁰ Owen—Mon. Foss. Reptilia Cret. Formations, Sup. iv., 1864, pl. vi., f. 1-11.

¹¹ Owen—*Loc. cit.*, p. 12.

¹² Owen—*Loc. cit.*, pl. 1, f. 16-19.

¹³ Lydekker—Cat. Foss. Reptilia and Amphibia Brit. Mus., Pt. ii, 1889, p. 182 and 211.

¹⁴ Etheridge—Ann. Report Dept. Mines N. S. Wales for 1887 (1888), pl. i., f. 1-4.

a cervical centrum of this species, and now give (Pl. xlv., fig. 1) as a means of further comparison an illustration of a reproduction of a typical cervical vertebra of *C. sutherlandi*, with nearly flat articular surfaces, a portion of the neural arch, and pleurapophysial facets; this was supplied to me by Sir Frederick some years before his death. A glance will suffice to indicate how remarkably close is the resemblance between the latter and, in miniature, the corresponding bones of the present form. At the same time I may parenthetically remark that the degree of ellipsoidality is greater in the cervicals of *C. sutherlandi* than here. Either, therefore we are dealing with a small individual of McCoy's species, or a distinct although closely allied form.

McCoy believed his *C. sutherlandi* to be "most nearly allied" to *C. australis*, Owen,¹⁵ from New Zealand. In this species the terminal articular surfaces of the caudal vertebræ are "nearly flat, with obtuse margins, and a distinct central pit;"¹⁶ the dorsal centra are a full oval with sharp edges, and two pairs of small foramina.

In another New Zealand species, *C. crassicosatus*, Owen¹⁷, which Lydekker unites¹⁸ with *C. australis*, Owen, the cervical centra are a constricted oval in outline and moderately concave; the dorsal are more circular in outline and possess a central mammilla.¹⁹

Although there are some points of resemblance between the centra from White Cliffs and those of the previously described Australian and New Zealand species, there are equally well marked differences. I hardly think the former can be regarded as portions of a small individual of *C. sutherlandi*, McCoy. In the face of this element of doubt, and as marking a certain well-known geological horizon in our Cretaceous formation, I propose to call this reptile *Cimoliosaurus maccoyi*, in honour of my deceased friend, Prof Sir F. McCoy, F.R.S., &c.

OTHER BONES.

With the remains already described occur certain other bones that appear to be too large for inclusion with the former as portions of one reptile. They are as follows:—

Humerus and Femur.—Pl. xliii., fig. 5 is probably a portion of the proximal end of a humerus. It represents the greater part of an articular surface and a part of

¹⁵ Owen—Brit. Assoc. Rept. for 1861 (1862), Pt. 2, p. 122.

¹⁶ Hector—Trans. N.Z. Inst., vi., 1874, p. 340

¹⁷ Owen—Geol. Mag., vii., 1870, p. 50, pl. iii., f. 4-5.

¹⁸ Lydekker—Cat. Foss. Reptilia and Amphibia Brit. Mus., Pt. ii., 1889 p. 220.

¹⁹ Hector—Trans. N. Z. Inst., vi., 1874, p. 342.

the expanded surface of the bone, which is grooved and pitted; across the former it measures thirty-four millimetres at its widest part. If Pl. xlv., figs. 2-3, represent a part of the humerus of *C. maccoyi*, it not only differs very widely from that of *C. leucoscophylus*, but belongs to a smaller individual than that now figured (Pl. xliii., fig. 5) as the distal end of a humerus. Pl. xliii., fig. 6 seems to be the proximal end of a femur. It consists of a rounded and slightly constricted head, with a portion of the shaft. In all, the fragment is one hundred and eighteen millimetres long, the head fifty-two millimetres in longest diameter, and the shaft fifty-seven millimetres a short distance below the constricted head.

Pleurapophyses.—These are two in number, and are stout slightly curved bones, with rather large expanded articular surfaces and roughly rhomboidal section. One side is sub-angular and convex, the other sub-angular and concave; the concave sides bear shallow grooves. The lengths are fifty-three and forty-six millimetres respectively, with greatest diameters of the shafts at the middle, of seventeen and eighteen millimetres respectively. Unless these are pleurapophyses of middle or post-cervicals I am unable to place them, with the material at my disposal for comparison.

Ribs.—Some of the rib pieces appear to be too large in comparison to the other bones of this skeleton, and may belong to another reptile; such are represented in Pl. xlv., fig. 8.

Teeth.—Some months ago Mr. A. E. Goldstein, a jeweller, of this city, submitted to me a fine opalized Sauropterygian tooth, a very beautiful object. It is seventy-eight millimetres long, and must represent a Plesiosaur of large dimensions; the length of the crown, less the apex removed, is forty-eight millimetres. The enamel ridges extend all round the crown, alternately larger and smaller, and appear to be equally well developed on all parts. A cast is preserved in this museum (Pl. xlv., fig. 2).

Later, the opalized crown of an equally large tooth was purchased by the Trustees. This fragment, less the apex again, is forty-five millimetres long, with the enamel ridges beautifully preserved, and as in the first instance longer and shorter alternately. Both specimens are from White Cliffs.

ICHTHYOPTERYGIAN REMAINS FROM WHITE CLIFFS.

The collection of the Mining and Geological Museum contains two small opalized centra from the column of an *Ichthyosaurus*, casts of which are deposited here. The form and dimensions, position of the diapophysial tubercles, and presence of hemapophysial scars, lead me to regard these centra as caudal in position.

These bones (Pl. xlv., figs. 4-7) are faintly octagonal in outline, markedly amphicœlous, very much antero-posteriorly compressed, with the sinking of the terminal articular face commencing at the peripheries to small central pits; there is no marginal convexity nor flattening. On the dorsal or neural side the centra are truncate, the remainder of the outline being rounded, but with a faint tendency to form seven other faces, two dorso-lateral, two mid-lateral, two ventro-lateral, and a ventral or hæmal. The peripheries, or edges, of the terminal articular surfaces project, leaving the sides of the centra concave. The truncated dorsal surface is twelve millimetres long (fore and aft), and eighteen millimetres wide. The neurapophysial joint surfaces, or facets, are deep and pit-like, five millimetres wide, and the floor of the neural canal, or myelonal surface is flat and eight millimetres in width. The di-parapophysial facets are situated at the bottom of the ventro-lateral angles of the centra; they are not sessile processes, or buttons, but again depressions or pits. The hæmapophysial facets are faintly indicated as long somewhat thickened inflexions of the peripheral edges. The vertical and transverse measurements are the same, forty-three millimetres.

The Trustees have obtained by purchase a third opalized centrum and portions of a fourth. These are highly amphicœlous, and exhibit both dia- and pleurapophysial tubercles. The dorsal surfaces of both, and the ventral surface of the more complete specimen (Pl. xlv., fig. 3) are too crushed to afford any characters. The consequent distortion renders measurements of little value, but as an indication of size, the more perfect is thirty millimetres in length (fore and aft), and sixty-nine millimetres between the dorsal and ventral margins. The peripheries of the terminal articular faces are prominent and sharp, and the lateral surfaces more or less excavate. In the better preserved specimen of the two, one of the neurapophysial facets is faintly outlined, and in juxtaposition to it is a well marked diapophysial tubercle, and below well separated from it, at about the middle of the centrum, and as near as possible in the middle line of the lateral surface is a well marked pleurapophysial tubercle. In consequence of the position of these facets, I take these to be anterior vertebræ,²⁰ and as to species closely allied to the centrum I formerly described as that of *I. australis*, McCoy,²¹ from the Lower Cretaceous of Queensland, but occupying a more advanced position in the vertebral column.

²⁰ See Owen—Mon. Foss. Reptilia Liassic Formations, Pt. iii., 1881, pl. xxii., f. 1.

²¹ Etheridge—Rec. Austr. Mus., iii., 3, 1897, p. 66.

I believe this to be the first notice of Ichthyopterygian remains from the White Cliffs Opal deposits.

SAUROPTERYGIAN OPALIZED REMAINS SO FAR DESCRIBED FROM
WHITE CLIFFS.

Exclusive of the fossils treated of in the present paper, the following are the opalized bones described from White Cliffs, so far as they are known to me: —

CIMOLIOSAURUS LEUCOSCOPELUS, *Eth. fil.*

C. leucoscopelus, *Eth. fil.*, *Rec. Austr. Mus.*, iii., 2, 1897, p. 24, Pls. v.-vii. Large portion of the skeleton.

CIMOLIOSAURUS, sp.

Sauropterygian vertebra, *Eth. fil.*, *loc. cit.*, p. 22.

Half a centrum.

A centrum split medianally in the direction of its length (fore and aft). Both the terminal articular surfaces are concave, and the lateral surfaces are excavate or hollow. None of the apophyses are preserved. It is sixty-four millimetres in length, by fifty-four in height (dorsal to ventral), and is evidently a portion of a large vertebra.

CIMOLIOSAURUS (?), sp.

Humerus of a Plesiosaurian, Seeley, *Quart. Journ. Geol. Soc.*, liv., 1898, p. cvi.

Humerus.

On the 6th April, 1898, Prof. H. G. Seeley exhibited at a meeting of the Geological Society of London the "humerus of a Plesiosaurian" replaced by opal, from the "opal mines of New South Wales," rather a wide locality. "So far as he was aware, it was the only example of a fossil bone in this condition." My description of *Cimoliosaurus leucoscopelus* was published on 5th August, 1897.

CIMOLIOSAURUS, sp.

Centrum.

Plesiosaurus, sp., Gürich, *Neues Jahrb., Beil.-Bd.*, xiv., 1901, p. 492, pl. xix., f. 8a-d.

A cervical centrum, the terminal articular surfaces roughly hexagonal or roundly deltoid in outline, apparently slightly amphicælus, and the sides rather excavate. On the dorsal surface are two longitudinally elongated venous foramina close together, and the two deep neuropophysial facets separated by

a very narrow neural canal floor. The ventral, or hæmal surface bears a central hour glass-shaped fore and aft ridge bounded by a deep depression on each side, and on the flanks of the ridge are the two large and rather wide-apart venous foramina. The pleurapophysial facets, or costal pits, are large, situated latero-ventrally, and adjoin the deep depressions already mentioned; the position of these costal pits indicates this bone as a cervical centrum. The terminal articular surfaces appear to be more or less flat peripherally graduating inwards to a central hollow.

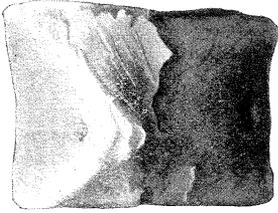
This centrum has some features in common with the corresponding centra of both *C. leucoscapulus* and *C. maccoyi*.

EXPLANATION OF PLATE XLII.

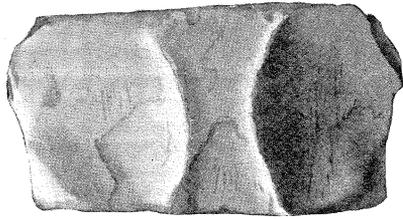
CIMOLIOSAURUS MACCOYI, *Eth. fil.*

- Fig. 1. Posterior cervical centrum, dorsal view.
,, 2. Lateral view of the same.
,, 3. Ventral view of the same.
,, 4. Pectoral (?) centrum, dorsal view.
,, 5. Lateral view of the same.
,, 6. Ventral view of the same.
,, 7. Terminal articular surface of the same.
,, 8. Median cervical centrum, dorsal view.
,, 9. Ventral view of the same.
,, 10. Lateral view of the same.

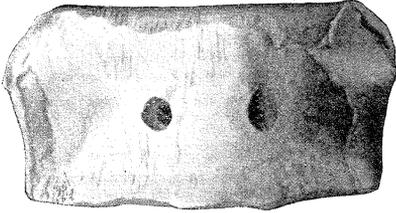
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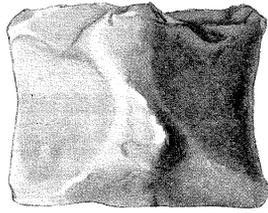
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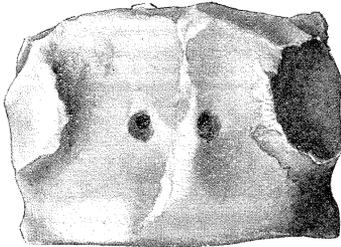
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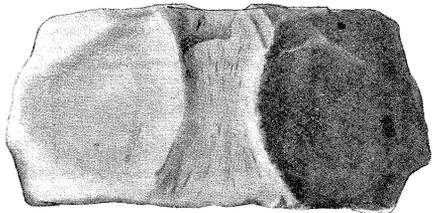
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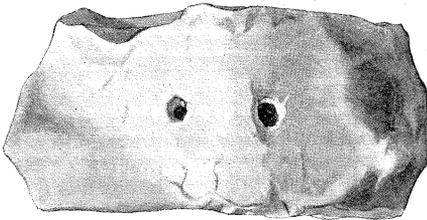
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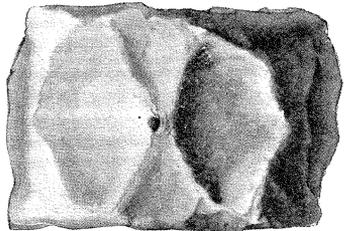
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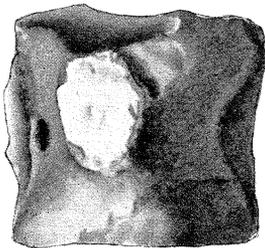
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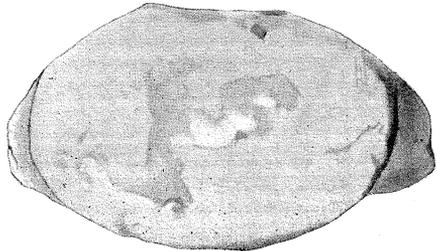
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10



7



EXPLANATION OF PLATE XLIII.

CIMOLIOSAURUS MACCOYI, *Eth. fil.*

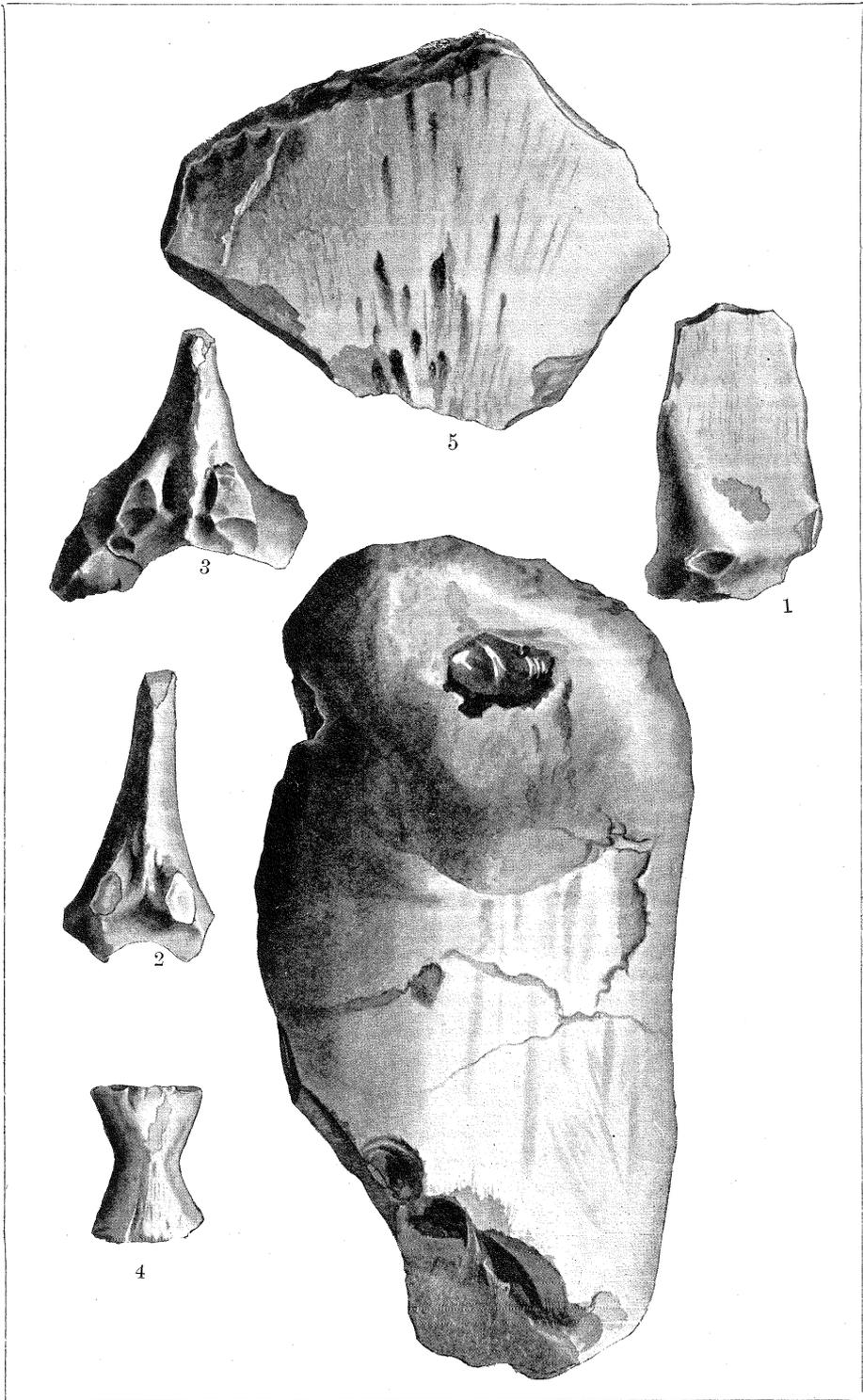
- Fig. 1. Cervical neural spine in part, side view.
,, 2. The same fragment, anterior view.
,, 3. Dorsal (?) neural spine with broken zygopophyses, anterior view.
,, 4. Phalange.

HUMERUS.

- Fig. 5. Distal end in part of a larger humerus than that represented in Pl. xlv, figs. 2 and 3.

FEMUS.

- Fig. 6. Proximal end and portion of shaft of a large bone supposed to be a femur.



A. R. McCULLOCH, del.
Aust. Mus.

Patterson, Shugg and Co.,
Melbourne.

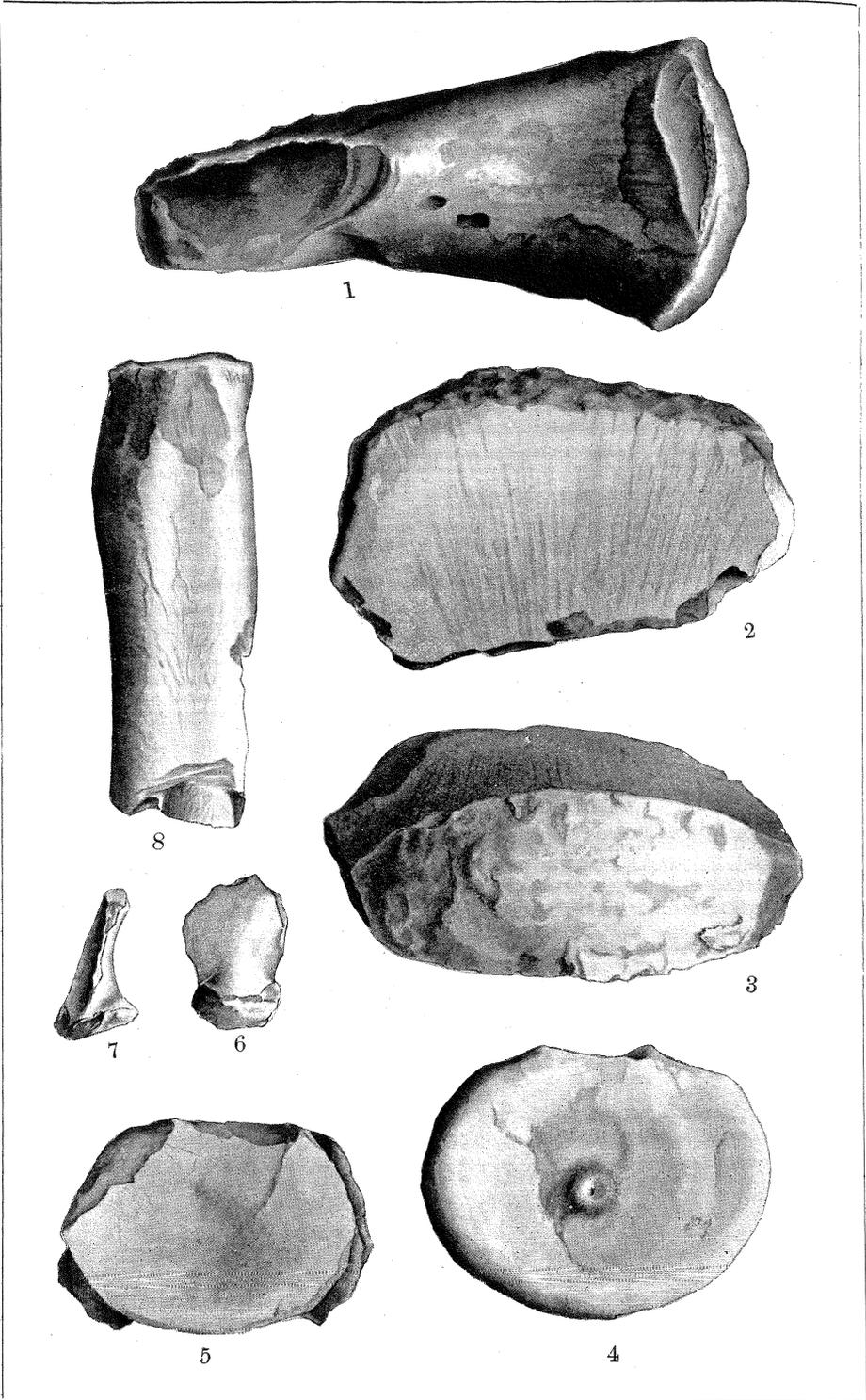
EXPLANATION OF PLATE XLIV.

CIMOLIOSAURUS MACCOYI, *Eth. fl.*

- Fig 1. Femur.
,, 2. Humerus, portion of the distal end.
,, 3. Humerus, distal articular surface.
,, 4. Dorsal centrum, terminal articular surface and central tubercle.
,, 5. Median cervical centrum, terminal articular surface, &c.
,, 6. Cervical pleurapophysis.
,, 7. Cervical pleurapophysis.

RIB PORTION.

- ,, 8. Portion of a large rib, possibly belonging to a larger reptile than *C. maccoyi*.



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EXPLANATION OF PLATE XLV.

CIMOLIOSAURUS SUTHERLANDI, *McCoy*, sp.

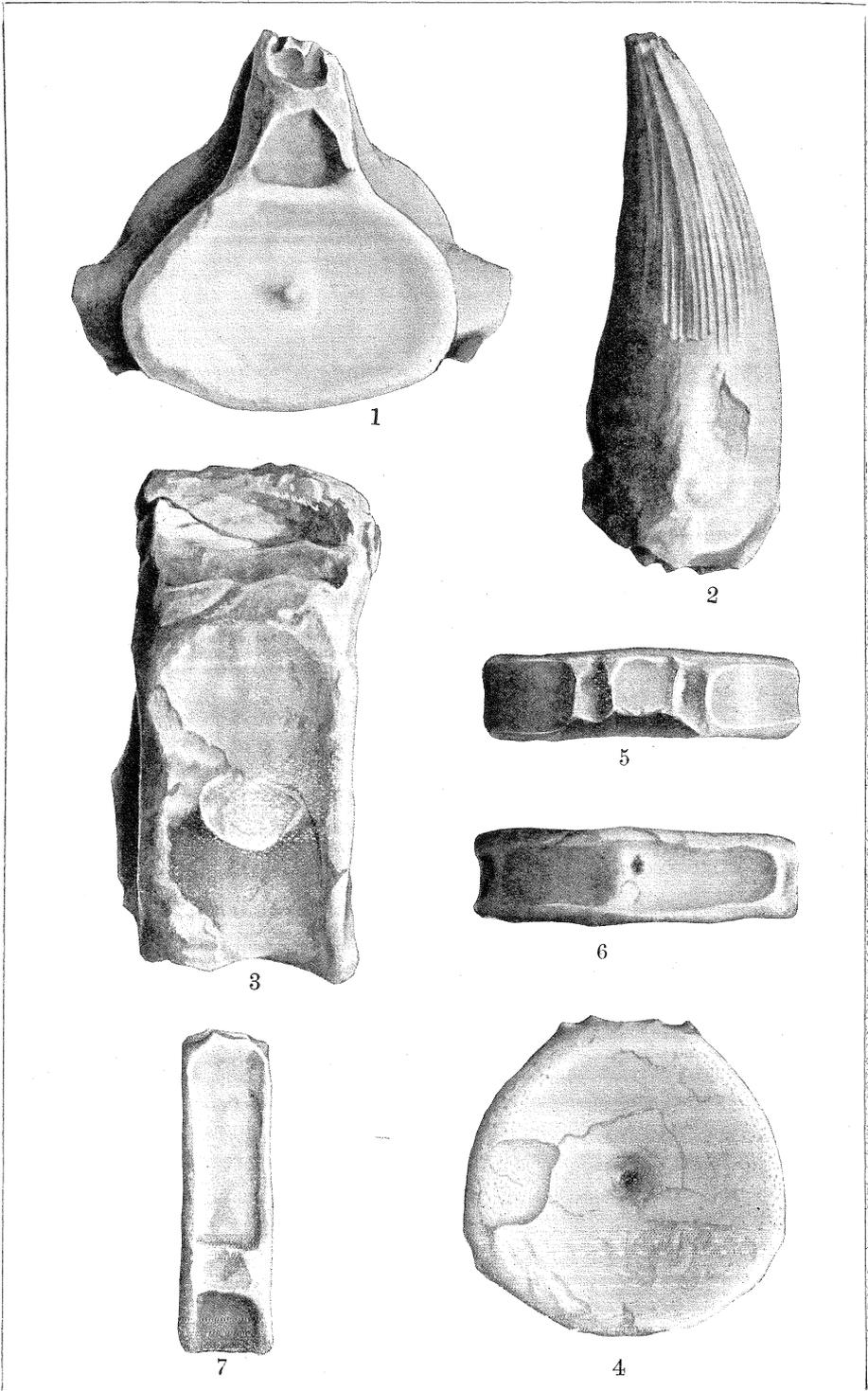
Fig. 1. Cast of a cervical vertebra with a portion of the neural arch and pleurapophyses— $\frac{1}{2}$ nat.

TOOTH.

Fig. 2. Cast of a large tooth, probably *Cimoliosaurus*.

ICHTHYOSAURUS, Sp.

- Fig. 3. Trunk vertebra, side view.
,, 4. Caudal vertebra, articular surface.
,, 5. Caudal vertebra, dorsal surface.
,, 6. Caudal vertebra, ventral surface.
,, 7. Caudal vertebra, lateral surface.



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