II. A NEW TITANOTHERE FROM THE UINTA EOCENE.

By O. A. Peterson.

During the summer of 1912, while collecting fossils for the Carnegie Museum and seeking for data bearing upon the geology of the Uinta Basin, the writer was so fortunate as to find in the upper portion of Horizon B, near Myton, on the Duchesne River, Uinta County, Utah. a number of specimens pertaining to a phylum of the true Titanotheres, The material is new to science, and bears directly upon important questions discussed in his Memoir upon the Titanotheriidæ by Professor Henry Fairfield Osborn, now, as we are informed, nearing completion. In order that these additional data may be published early enough to be incorporated in Professor Osborn's work, it has been decided, at his suggestion, to print this paper in the Annals without waiting foı the fuller account of the fauna of the Uinta which is in contemplation.

In the December issue of the *American Naturalist*, 1895, the late J. B. Hatcher published a new species of Diplacodon (*D. emarginatum*, suggesting for his species a new generic name (*Protitanotherium*) "should futuıe discoveries show that there are hornless forms with the same dental character as *Diplacodon*." Whether or not the true *Diplacodon elatum* Marsh[1] has horns, is still, I believe, an open question. Professor Osborn in his "New and Little Known Titanotheres from the Eocene and Oligocene,"[2] has accepted Hatcher's proposed genus *Protitanotherium* without much comment.[3] We anticipate that in his forthcoming work he will give his reasons for accepting the genus.

From the studies of Osborn, Earl, Hatcher, Douglass, and Riggs, we see that the Titanotheres of the Upper Eocene were already well differentiated. In fact it appears that the family had at this time reached its highest polyphyletic development, the survivors in the lower Oligocene being restricted to only those with true horns already developed. As was foreshadowed by Hatcher from the remains which he found in Horizon B ("cornutum beds"), it is now apparently

[1] Marsh, O. C., *Amer. Jour. Sci.* (3), IX, 1875, p. 247.

[2] *Bull. Amer. Mus. Nat. Hist.*, Vol. XXIV, 1908, p. 615.

[3] In a letter from Professor Osborn, dated November 20, 1912, he stated that the true *Diplacodon* is a slender form, while *Protitanotherium* is a robust animal.

well-established that the types with true horns and truly titanotheroid cranial structure are of earlier origin than has been hitherto believed. At the same time it appears that the structure of the limbs and feet of these predecessors is more nearly identical with that of the contemporary genera *Telmatherium*, *Metarhinus*, *Dolichorhinus*, etc., and undoubtedly further removed from *Titanotherium* than are *Diplacodon elatum*, *Protitanotherium emarginatum*, etc., from a later horizon of the Uinta sediments. We learn from the material collected in the Uinta Eocene by the Princeton Expedition of 1886[4] that the remains referred to *Diplacodon* are much further advanced in the direction of the Oligocene titanotheres. Comparisons made will be referred to in their proper places in the following description.

I desire to thank Dr. W. J. Holland for his kindness in allowing me to work up the material on which this paper is based, and for his revision of the manuscript for publication. I am also under obligation to Professor Charles Schuchert and the staff of the Peabody Museum of Natural History for much assistance in connection with the study of Professor Marsh's type of *Diplacodon elatum*. Mr. Sydney Prentice of the Staff of the Carnegie Museum made the drawings reproduced in this paper, and the photographs were made by Mr. Arthur S. Coggeshall.

Diploceras osborni[5] gen. et sp. nov.

Type:—Front of skull, lower jaws, portion of pelvis, atlas, portion of axis, fragments of scapula and foot-bones, No. 2859.

Paratypes:—Front of skull No. 2858; vertebral column, fragments of ribs, limb- and foot-bones, No. 2860; crowns of two upper molars, No. 2860a; humerus, No. 2861; tibiæ No. 2862.

Horizon:—Upper B, Uinta Eocene.

Locality:—On Duchesne River, near Myton, Uinta County, Utah.

GENERIC CHARACTERS:—Dentition: $I\frac{3}{3}$ $C\frac{1}{1}$ $P\frac{4}{4}$ $M\frac{3}{3}$; *Premolar series proportionally long; $P\frac{3}{}$ with two distinct internal tubercles; horn-cores well developed; limbs relatively long and slender; tibial trochlea not extended back on the calcaneum. Astragalus high, with long neck, calcaneal and cuboidal facets laterally located.*

Specific Characters:—*Alveolar borders of the premaxillaries extending well in front of the canines; nasals long and relatively thin, their anterior*

[4] Scott, W. B., and Osborn, H. F., "The Mammalia of the Uinta Formation," *Trans. Amer. Philos. Soc.*, Vol. XVI, 1889, pp. 512–518, pls. IX–X.

[5] In honor of my early teacher, Professor Henry Fairfield Osborn.

portion abruptly turned downwards and convex on the anterior border; incisors well in front of the canines and relatively subequal in size; canines proportionally small.

SKULL.

Plates VI–VIII.

In comparing the recently discovered material with the best preserved remains of *Protitanotherium* (*P. emarginatum* Hatcher) a number of important differences are at once observed. The nasals of the new species are longer, thinner, somewhat narrower (especially in specimen No. 2859); furthermore the lateral borders of the nasals are much less thickened, and instead of the broadly emarginated area at the free end of the nasals in *P. emarginatum*, the termination of the nasal of the present form has an abrupt downward turn, resembling that of *Megacerops coloradensis* Leidy, and its anterior margin is very convex transversely, instead of concave, as is the case in *P. emarginatum*. Upon the whole the nasals of the species we are describing extend further forward. There seems to be a considerable variation in the development of the horn-cores; thus, in skull No. 2858 this protuberance appears to have a development comparable to that of some of the titanotheres found in the Oligocene, while in specimen No. 2859 these osseous bosses aie very much smaller, more conical, and in proportion more like those of *P. emarginatum*, in spite of the fact that the skull we are considering pertains to an old individual (see Pl. VII). This varied development of the horn-cores is no doubt due to sexual differences, or possibly to individual vaiiation. The premaxillaiies extend well in front of the maxillaries, and are separated in front, forming a deep median notch, as in *P. emarginatum*, so that the median pair of incisors are wide apart, while fuither back they are firmly coössified and also solidly fused with the maxillaiies. The infraorbital foramen is also of large size as in *P. emarginatum* and located above $P^{\underline{4}}$ as in the latter species. The maxillary is on the whole very robust, and shows that it had advanced well towards the condition found in *Diplacodon* and *Titanotherium*. This is also true of the jugal, the prominent lower border of which has the downward and backward sweep in front of and under the orbit, which is characteristic of Titanotherium. The zygomatic arch, though widely expanded behind, is, however, less robust than in the Oligocene genus, and agiees better with the type of *Diplacodon elatum* described by

Marsh. The postorbital processes on the frontal and jugal are of large size, in this respect unlike *Titanotherium.* The postorbital process on the frontal of the latter genus is usually located further back and is much smaller in proportion. The external portion of the glenoid cavity is preserved in No. 2858, and is somewhat less convex in the antero-posterior direction than in the latter genus. As in *Titanotherium* the anterior palatine foramina are small round openings, which in the present genus are situated further back from the alveolar border of the incisors. The palate is of the deep concave form usually met with in the Titanotheres, and the posterior narial opening extends approximately as far forward as in the Oligocene genus, reaching to the posterior portion of $M^{\underline{2}}$.

That the type of the skull was saddle-shaped is very evident from the material under study, but whether or not the characteristically broad superior aspect of the parietals and the heavy and broad occiput seen in *Titanotherium* had been attained to the same degree as the similarity of the anterior region in the two genera suggests might have been the case, will not be completely known until the posterior region of the skull of the Uinta representatives of this phylum is found. It is highly probable that the similarity presented by the anterior region will be preserved throughout the cranium, which will then reveal more exactly the features of a true titanothere than was anticipated. From the type of *Protitanotherium emarginatum* at Princeton University, Hatcher[6] was apparently able to determine that the sagittal crest is absent, and that the dorsal surface of the skull is probably slightly concave antero-posteriorly.

MANDIBLE.

Plate VII.

The lower jaw is somewhat depressed by crushing, but allowing for this fact, it appears that the horizontal ramus of *Diploceras osborni* is shallower than in *P. emarginatum.* Characteristics which may further be noted, are: the more rounded under surface of the symphysis, and the constriction of the lower jaws in the area between the canine and the premolars which is greater than in *P. emarginatum.* As in the latter, the symphysis is strong and the mental foramen is large, located well down on the ramus, directly below $P_{\overline{2}}$. The lower jaw is broken off back of M .

[6] *The American Naturalist*, Vol. XXIX, 1895, p. 1085.

MEASUREMENTS.

Skull.

	No. 2858, Mm.	No. 2859, Mm.
Diameter from incisors to posterior border of glenoid cavity	470	
Diameter from incisors to anterior border of orbit	180[7]	179[7]
Antero-posterior diameter of orbit	67	67[7]
Vertical diameter of orbit	55	
Diameter from incisors to anterior border of posterior nares	260	256
Transverse diameter at the canines	93[7]	86
Transverse diameter at diastema between the canines and the premolars	67[7]	67
Transverse diameter across the horn-cores	290[7]	136

Lower Jaw.

	No. 2858, Mm.	No. 2859, Mm.
Total length of jaw fragment		380
Diameter from incisor to $P_{\overline{1}}$		67
Vertical diameter of ramus at $P_{\overline{1}}$		70[7]
Vertical diameter of ramus at $M_{\overline{2}}$		80[7]
Vertical diameter of ramus at $M_{\overline{3}}$		92

DENTITION.

Plates VI–VII.

The upper incisors and canines are well preserved, though much worn in the two crania under description. The molar-premolar series is less completely preserved in No. 2858, while in 2859 the superior dentition is completely represented. The lateral incisor and the canine of the right mandible and the complete molar-premolar series of the left ramus are also present in the latter individual.

As stated above, the median upper incisors are widely separated by the deeply excavated median notch of the premaxillaries. As seen in the illustration, the incisor series is placed well in front of the canine and the arc of the circle, which their arrangement represents, is more convex than in *P. emarginatum.* Their crowns are nearly circular in outline, covered with a heavy coat of enamel, bluntly conical, with a prominent cingulum at their posterior bases. They perhaps increase in size more gradually from $I^{\underline{1}}$ to $I^{\underline{3}}$ than in *P. emarginatum.* The canine is relatively smaller than in the latter genus, which imparts a much lighter looking aspect not only to this region of the dentition, but also to the entire outline of the anterior portion of the muzzle in the paratype No. 2858, as well as in the type, No. 2859. Furthermore the crown of the canine (especially in No. 2859) is shorter,

[7] Approximate measurements.

blunter, and the lateral ridges are less developed in the present species than in either *P. emarginatum* or *Diplacodon elatum*. *D. elatum* has the canine more nearly of the same proportion as in *P. emarginatum*. The diastema back of the canine is relatively longer and its border much thinner than in *P. emarginatum*, in which respect it is more nearly like *Diplacodon elatum*.

The crown of $P^{\underline{1}}$ is so much worn that its characters cannot be made out. It is, however, of greater antero-posterior than transverse diameter, and undoubtedly had a simple structure like that of *P. emarginatum*. $P^{\underline{2}}$ is also much worn especially along the external portion. The external face of the ectoloph is subdivided by a deep vertical groove and is much convex both antero-posteriorly and supero-inferiorly. This deep groove adds greatly to the antero-posterior convexity of the proto- and tritocones. The general outlines of the tooth are less quadrate than in *Titanotherium*, which is apparently due to the lack of development of the antero-internal angle in the species under consideration. In the type of *Diplacodon elatum* $P^{\underline{1}}$ is lost, while the external portion of $P^{\underline{2}}$ is broken off. In the present species, the deuterocone of $P^{\underline{2}}$ is less ridge-like than in *D. elatum*, the two internal tubercles being somewhat better indicated and the ridge between them distinctly less developed. $P^{\underline{3}}$ is more quadrate in outline than the preceding tooth, and has two distinct internal tubercles on the crown, which are separated by a shallow groove, while in *Diplacodon elatum* these tubercles are united into a solid internal ridge, revealing a distinct differentiation from what is seen in the present species (compare Pls. VI, VII, and IX). On the other hand $P^{\underline{4}}$ both in the type we are describing and in *D. elatum*, are similar, there being two internal tubercles, deutero- and tetartocones, the former considerably the larger.[8] The more important differences in the dentition of the two forms, so far as they can now be compared, seems to be in the proportion of the canines, the difference in the length of the premolar series, and the detailed structure of $P^{\underline{3}}$. The greater length of the premolar series is naturally to be expected in a form from a lower geological level.

The detailed characters of the molar series of the genera here com-

[8] In No. 2858, the paratype, there is only one internal tubercle, the deuterocone, which may by some be regarded as of sufficient importance to constitute a specific difference. For the present I prefer to regard this character as possibly representing a reversion.

pared present no differences of importance. The two Uinta forms agree in the obscure or feeble development of the cusp-like elevations on the anterior face of the molars near the inner angle, more conspicuously developed in *Titanotherium*. At the postero-internal angle of the cingulum of $M^{\underline{3}}$ in the Oligocene forms there is sometimes a distinct tubercle, which is indicated in the Uinta forms by only a slight swelling of the cingulum.

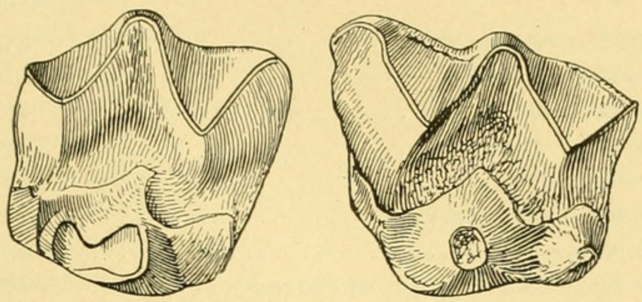


FIG. 1. Crown view of two upper molars *Diploceras osborni* Peterson. (Paratype. No. 2860*a*.) $\times \frac{1}{2}$. These isolated teeth were found with the Paratype, No. 2860.

In proportion the inferior incisor dentition is further in advance of the canine than in *P. emarginatum*. $I_{\overline{1}}$ and $I_{\overline{2}}$ are represented only by a portion of their roots buried in the symphysis. $I_{\overline{3}}$ has a very prominent cingulum posteiiorly. Notwithstanding the much smaller size of the specimen, its crown has very nearly the same diameter as in *P. emarginatum*, which would indicate that the inferior incisors were possibly larger in proportion, and more nearly equal in size. The crown of the canine is injured, but its diameteis appear to be equal to those in the superior series, though relatively smaller than in *P. emarginatum*. $P_{\overline{1}}$ has a single root and a simple conical crown, which has not received any wear due to its somewhat inferior position. $P_{\overline{2}}$ is submolariform and in its general characters does not differ from the same tooth in *P. emarginatum*. $P_{\overline{3}}$ is quite molariform, while $P_{\overline{4}}$ has a complete molar pattern.

There is no difference in the general features of the lower molars in the two genera here compared, and in turn the molars of *Diplacodon* are on the whole quite similar in their detailed structure to those of the Oligocene genus.

The proportion of the alveolar border occupied by the lower premolars of this species is in accord with the upper series, i. e. of a greater antero-posterior diameter than in *P. emarginatum* and *D. elatum.*[9] Judging from the type (lower jaw) of *Protitanotherium superbum* Osborn, recently described,[10] that species also has the same proportion of the molar-premolar series as the two latter, while *Telmatherium? altidens* of the same publication has a longer premolar series and more nearly agrees with the present genus.

MEASUREMENTS.

	No. 2859. Mm.	No. 2858. Mm.
Length of superior incisor series	34	33
I^1. Antero-posterior diameter	11	11
I^1. Transverse diameter	10	10
I^2. Antero-posterior diameter	12	12
I^2. Transverse diameter	12	12
I^3. Antero-posterior diameter	15	15
I^3. Transverse diameter	14	14
Canine. Antero-posterior diameter at the base	19	20
Canine. Transverse diameter at the base	18	18
Length of molar-premolar series	246	
Length of superior premolar series	101	
P^1. Antero-posterior diameter	19	
P^1. Transverse diameter	12	
P^2. Antero-posterior diameter	22	23
P^2. Transverse diameter	25	26
P^3. Antero-posterior diameter	30	
P^3. Transverse diameter	31	
P^4. Antero-posterior diameter	33	31
P^4. Transverse diameter	38	36
Extent of superior molar series	146[11]	
M^1. Antero-posterior diameter	38	
M^1. Transverse diameter	45	
M^2. Antero-posterior diameter	52	
M^2. Transverse diameter	54	
M^3. Antero-posterior diameter	57	
M^3. Transverse diameter	51	
I_3. Antero-posterior diameter	14	
I_3. Transverse diameter	12	
Canine. Antero-posterior diameter, approximately	17	
Transverse diameter, approximately	14	

[9] In remeasuring the molar series of Prof. Marsh's type of *Diplacodon elatum* it would seem that he was in error in regard to the measurement, which should read 167 instead of 152 mm.

[10] Osborn, Henry F., "New and Little Known Titanotheres from the Eocene and Oligocene," *Bull. Amer. Mus.*, Vol. XXIV, 1908, p. 615.

[11] Professor Marsh's measurement of the molar series of the type of *D. elatum* is an error.

	No. 2859, Mm.
Length of inferior molar-premolar series	255
Length of inferior premolar series	94
Length of inferior molar series	160
$P_{\overline{1}}$. Antero-posterior diameter	14
$P_{\overline{1}}$. Transverse diameter	10
$P_{\overline{2}}$. Antero-posterior diameter	24
$P_{\overline{2}}$. Transverse diameter	14
$P_{\overline{3}}$. Antero-posterior diameter	28
$P_{\overline{3}}$. Transverse diameter	18
$P_{\overline{4}}$. Antero-posterior diameter	29
$P_{\overline{4}}$. Transverse diameter	20
$M_{\overline{1}}$. Antero-posterior diameter	38
$M_{\overline{1}}$. Transverse diameter	26
$M_{\overline{2}}$. Antero-posterior diameter	49
$M_{\overline{2}}$. Transverse diameter	30
$M_{\overline{3}}$. Antero-posterior diameter	78
$M_{\overline{3}}$. Transverse diameter	32

VERTEBRAL COLUMN.

The atlas of the type (No. 2859) is quite complete. There is also the greater portion of an atlas with the paratype No. 2860.

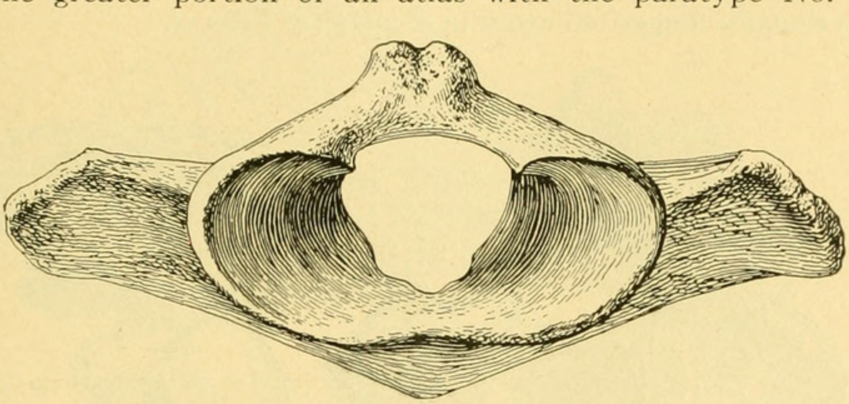


FIG. 2. *Diploceras osborni* Peterson. (Type. No. 2859) × ⅓. Anterior view of atlas.

With regard to the posterior division of the arterial canal it may be said that there appears to be some variation in the Uinta species. Thus it is seen that in the type the base of the transverse process is pierced by a small foramen, see Fig. 3, while in the paratype there is no evidence of this foramen on the posterior face of the transverse process. Of the later Uinta forms there is apparently no atlas known. In comparing the Oligocene Titanotheres, with the Uinta specimens before us, there is a corresponding variation. The atlas of the Oligocene types further varies in the antero-posterior diameter, and in the prominence of the neural spine and the transverse processes.

In *Diploceras osborni* the antero-posterior diameter of the atlas is rather small, while transversely it is proportionally greater than in the Oligocene forms. This is due in a great measure to the longer

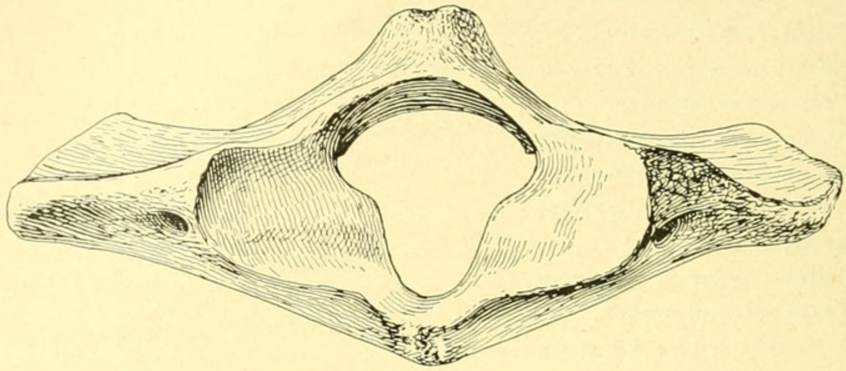


FIG. 3. *Diploceras osborni* Peterson. (Type. No. 2859.) × ⅓. Posterior view of atlas.

transverse process of the Uinta form. The cotyle for the occipital condyle is also deeper and the groove for the odontoid process of the axis extends further forward on the inferior arch due probably to the proportionally longer odontoid in *Diploceras osborni*.

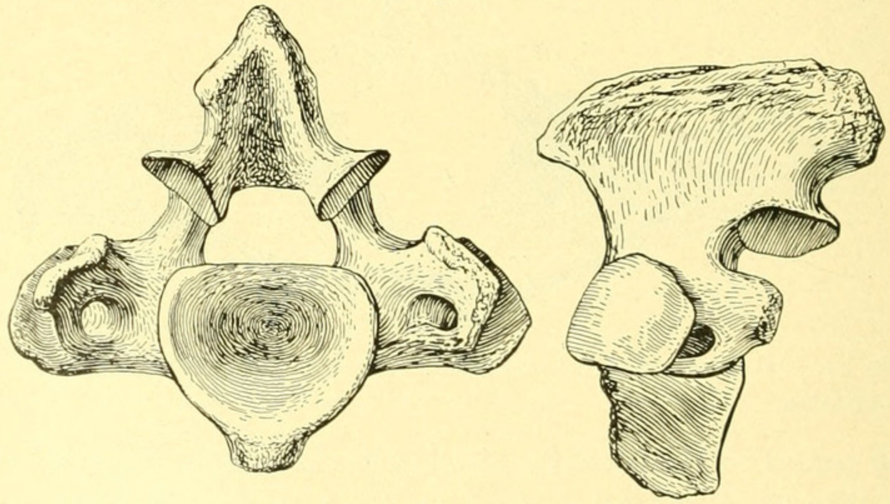


FIG. 4. *Diploceras osborni* Peterson. (Type. No. 2859.) × ⅓. Posterior and lateral views of axis.

Axis.—The axis of the type is represented by a portion of the centrum, the complete neural arches, and the spinous process. The arch is somewhat depressed by crushing, but it is evidently of rather large size. The vertebra as a whole possibly has a smaller antero-posterior diameter than is the case in most of the Titanotheres of the

Oligocene; the articulating surface for the atlas is located more laterally, and the postzygapophysis has a greater vertical obliquity and a more nearly rounded outline than in the latter. In the Princeton specimen[12] it is seen that the arterial canal is located back of the posterior edge of the articulation for the atlas, while in *Diploceras osborni* the foramen is, on a direct side view, partially hidden by the backwardly extended process of the articulation. I judge that the axis, as a whole, in the present form is relatively shorter than in the Princeton specimen. In more minute details the description of Scott and Osborn (*l. c.*, p. 514) agrees well with the parts preserved, in the specimen before me, *i. e.*, the heavy spine overhanging the postzygapophyses, the inner turn of the transverse process, and a prominent inferior keel.

The succeeding four cervical vertebræ in the paratype, No. 2860, are represented only by fragments. They appear to have short opisthocœlian centra, as in *Diplacodon*, described by Marsh and Osborn, and a prominent ventral keel.

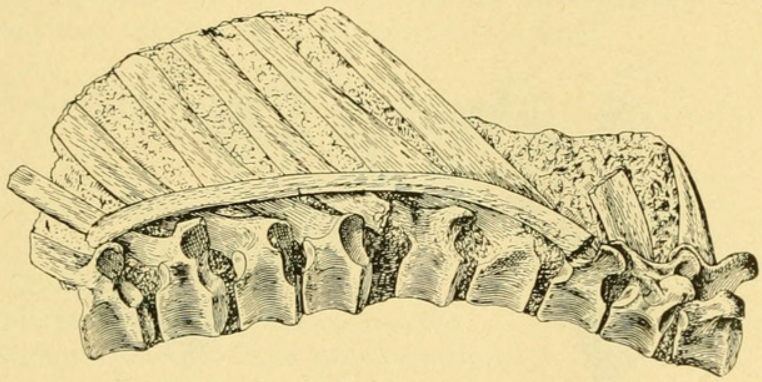


FIG. 5. *Diploceras osborni* Peterson. (Paratype. No. 2860.) × $\frac{1}{9}$. Last cervical and dorsal vertebræ.

The seventh cervical vertebra is completely worked out in half relief and shows the chief characteristic features, Fig. 5. The long and pointed spinous process is well shown, as is also the neural arch and the centrum. The pre- and post-zygapophyses are, as in the axis, located quite laterally and face directly upward and downward as in *Titanotherium*. The transverse process shows a tendency to develop the broad round termination found in *T. validum* of the Oligocene.

There are eight dorsal vertebræ which are worked out in half

[12] Scott, W. B., and Osborn, H. F., "The Mammalia of the Uinta Formation," *Trans. Amer. Philos. Soc.*, Vol. XVI, Part III, 1889, p. 514, Pl. IX, Fig. 15.

relief and rest on the original block of sandstone on which they were found. The neural spine of the first dorsal is broken off about ten centimeters above the neural arch, but judging from the size of the fracture, the spinous process attained a length equal, and perhaps even proportionally greater, than was the case in *T. validum*, with which the Uinta remains have been compared. The second, third, fourth, and fifth dorsals have their spines very nearly complete. In proportion they agree quite well with those of the Oligocene genus, but are more strongly inclined backward. As in *Titanotherium* the transverse processes are not extremely heavy and the capitular facets for the ribs are of large size, while the sides of the centra are deeply concave. The latter are deeper than broad and the inferior borders, especially the posterior ones, are distinctly more keeled than in *Titanotherium*.

Back of the eighth dorsal there is a break in the vertebral column and a number of bones are lost. A second block, which was found, together with the one just described, contains portions of six posterior dorsals and three lumbar vertebræ (see Fig. 6). The neural spines of

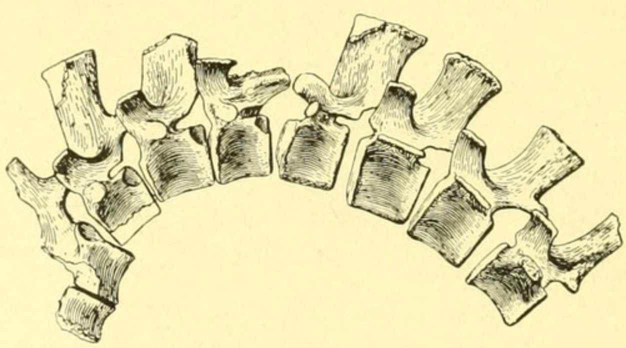


FIG. 6. *Diploceras osborni* Peterson. (Paratype. No. 2860.) × 1/9. Posterior dorsals and the lumbar vertebræ.

the dorsal series are prominent and quite lumbar-like in their general character. The zygapophyses are also of the interlocking lumbar type and there are prominent metapophyses. The centra are somewhat mutilated, but enough is preserved to indicate that they are deep and of comparatively small transverse diameter.

There are, as stated, three lumbar vertebræ present in the paratype, No. 2860. These bones are fortunately found in position succeeding the last dorsal vertebra, and for the first time apparently furnish data as to the correct number of the lumbar vertebræ of the Titanotheriidæ.

That the last one of this series is the last lumbar vertebra, there is but little or no doubt, inasmuch as the neural spine is very suddenly reduced in its fore-and-aft dimension, and also shows the presence of the very heavy transverse process and the well-expanded postzygapophysis to meet the correspondingly broad surfaces of the sacrum. Unfortunately the greater portion of the centrum is weathered away, but from what remains it appears that it was more depressed than are those in front of it. Of the first and second lumbars the centra are large, sharply keeled, and the transverse processes, though generally broken off, are seen to have been prominent, though attenuated. There are large metapophyses, and the neural spines are high and of great antero-posterior diameter.

MEASUREMENTS.

Atlas.

	No. 2859, Mm.	No. 2860, Mm.
Greatest antero-posterior diameter	90	95
Greatest transverse diameter	250	250
Greatest transverse diameter of articulation for occipital condyle	140	138
Vertical diameter of articulation for occipital condyle	60	60

Axis.

Greatest height	138[13]	
Greatest transverse diameter	158	
Transverse diameter of postzygapophyses	70	
Length of centrum of a median cervical vertebra		37
Depth of centrum including inferior keel, approximately		45
Seventh cervical. Greatest height when vertebra is in position		195
Seventh cervical. Length of spine		120
Seventh cervical. Antero-posterior diameter of centrum		70
Second dorsal. Greatest height when vertebra is in position		300
Second dorsal Length of spine		325[13]
Seventh dorsal. Greatest height when in position		200
Seventh dorsal. Length of spine		165
Last dorsal. Greatest height when in position		165
Last dorsal. Length of spine		90
Second lumbar vertebra. Greatest height when in position		165
Second lumbar vertebra. Length of spine		95[13]
Caudal belonging to middle region of tail, length		29

[13] Approximate measurements.

The sacrum is not represented. The caudals appear to be short and heavy and in other respects like those of the Oligocene forms.

The ribs are represented only by a few fragments and there are no sternebræ.

FORE LIMB.

The greater portion of the scapula is represented with No. 2859. The upper and lower ends were found separately imbedded in the sandstone ledge, but in working out the two portions it is seen that they pertain to the same side of two individuals. The bone as a whole, so far as comparison may be made, presents characters not unlike those in the Princeton specimen referred to *Diplacodon*. However, in the specimen under description (possibly a female) the coracoid is seen to be relatively smaller than in the latter. The groove between the base of the coracoid and the border of the glenoid cavity is larger in proportion than in *Titanotherium*, and the excavation on the coracoid border, immediately above the coracoid, has a less abrupt curvature. This is due to the smaller development of this angle in *Diploceras*. The coracoid border is otherwise quite straight, as in *Titanotherium*. The superior portion of the glenoid border is broken off, but in the region of the break there is a similar broad extent of the superior portion of the blade. The spine is damaged, but it was apparently overhanging like that in *Diplacodon* described by Osborn, and thus less extended over the postscapular fossa than in *Titanotherium*.

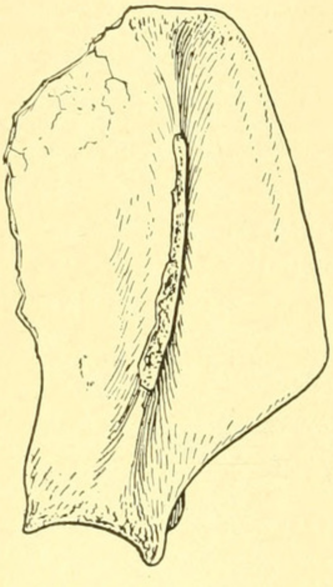


FIG. 7. Scapula of *Diploceras osborni* Peterson. (Type. No. 2859.) × $\frac{1}{6}$.

In comparing the humerus of the present form with that of *Titanotherium validum*, the difference most noticeable is the relative robustness and the length. In the Oligocene form the bone is short and very heavy, while in the present genus the bone is longer in proportion and also lighter. Superiorly the greater tuberosity extends higher above the head than in *Titanotherium*, but is not so robust, the proximal end as a whole being more delicately proportioned. The deltoid groove is deep and well defined, as in the Oligocene genus. On the other hand the deltoid ridge, though very prominent, does not terminate in the heavy recurved process as in *T. validum*, but descends much more gently towards the supratrochlear fossa. Distally there is less variation between the two forms here compared. The anconeal fossa in the species under description is relatively broader and the supinator ridge is less rugose. The trochlea is slightly deeper, but not more oblique than in *T. validum*.

The humerus as described and figured by Osborn holds an intermediate position between the Oligocene genus and the present form. This is especially shown in the development of the deltoid ridge, which in the Princeton specimen is considerably more developed than in the genus under description.

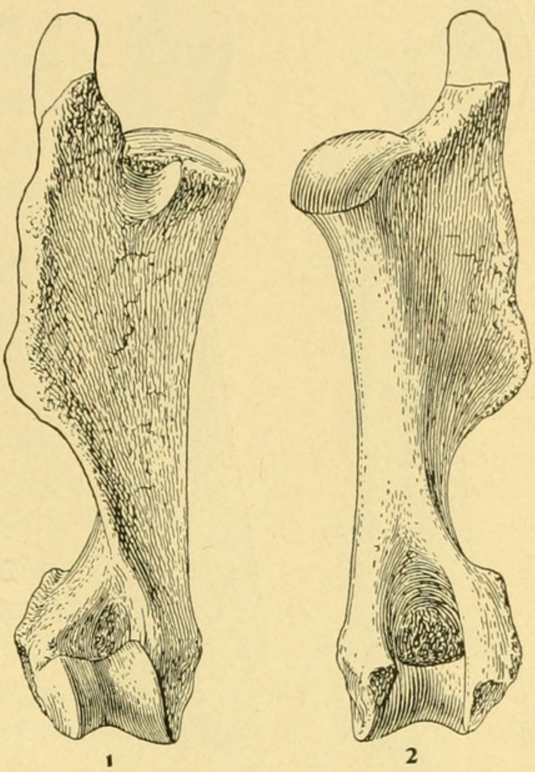


FIG. 8. *Diploceras osborni* Peterson. (Paratype. No. 2860.) × ⅓. Humerus. 1, anterior view; 2, posterior view.

MEASUREMENTS.

Humerus.

	No. 2860, Mm.	No. 2861, Mm.
Length from head to distal end	365	365
Transverse diameter of lower part of deltoid ridge	108[14]	110[14]
Transverse diameter at broadest portion of supinator ridge	115	113
Transverse diameter of distal trochlea		78

Both radii and ulnæ are represented in No. 2860. A third radius was also found in the same sandstone ledge in close proximity to the spot where Nos. 2858 and 2859 were found.

The radius and ulna are long and relatively slender, when compared with those of the Princeton specimen of *Diplacodon* and the Oligocene

[14] The shafts of the two bones are more or less crushed and the measurement is only approximately correct.

genus *T. validum.* Thus the fore arm of the new genus is actually a little longer than in *Diplacodon* and is very nearly as long as that of *T. validum,* notwithstanding the much smaller size of the Uinta form of which we are speaking. Another striking difference between the forms here compared is the lateral expansion of the proximal and distal ends of the radius. In the Oligocene form the shaft of the radius is more rounded in the middle region, while more proximally and distally a sudden expansion takes place, which is also well displayed in the Uinta specimen described and illustrated by Scott and Osborn. In *Diploceras osborni* the shaft is flatter, more uniform throughout, and the proximal and distal ends comparatively little expanded.

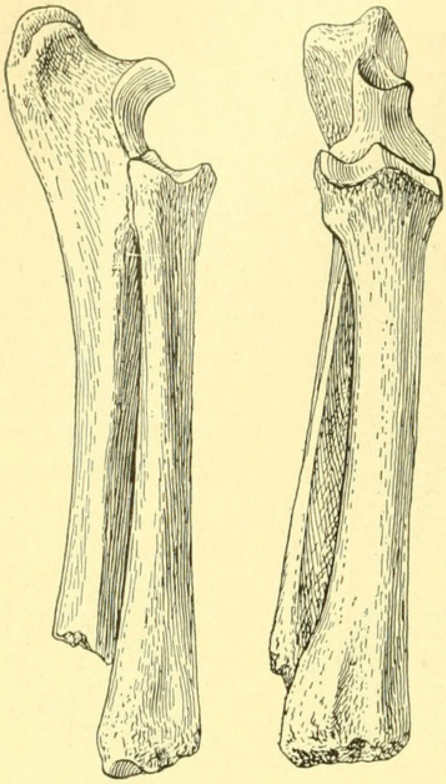


FIG. 9. *Diploceras osborni* Peterson. (Paratype. No. 2860. × 1/6.) 1, lateral; 2, anterior views of radius and ulna.

The proportions of the ulna conform to the radius and it is consequently slenderer and proportionally longer than in *Diplacodon* and *Titanotherium.* In detail the bone is otherwise quite similar to that in the two latter genera, including the well defined tendinal groove on the anterior superior angle of the olecranon process so characteristic of the ulna of *Titanotherium validum,* but apparently less developed in the Princeton specimen, judging from the illustration Pl. IX, Figs. 10–10*c*, (*l. c.*).

MEASUREMENTS.

Radius.

	No. 2862, Mm.
Greatest length	380
Transverse diameter at middle of shaft	40
Transverse diameter of head	78
Transverse diameter of distal end	77

Ulna.

Length of olecranon process	100

The forefoot of No. 2860 is represented by the scaphoid, pisiform, trapezoid, Mc. II, IV, and V, and one or two phalanges. No. 2859 has also Mc. IV and V represented.

As might be anticipated from the description of the limb, it is found that the foot is higher than in *T. validum* of the Oligocene. Thus the scaphoid is higher in proportion, and narrower than in the latter species, but is of considerable fore-and-aft diameter. In detail there are only such differences as one might expect from the general outlines described, *i. e.*, the different articulating surfaces of the distal face are narrow and long, while the articulation for the radius is less concave antero-posteriorly than in the Oligocene form. The pisiform has a similar long attenuated shaft terminating in an obtuse tuberosity of considerable vertical diameter, but transversely rather thin.

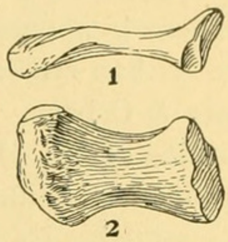


FIG. 10. *Diploceras osborni* Peterson. (Paratype. No. 2860.) × ⅓. Pisiform. 1, superior view; 2, lateral view.

Besides the greater height of the trapezoid, the small posterior superior facet for the magnum, which is characteristic of *Titanotherium*, is practically wanting in the present form. Judging from the facet on the postero-radial angle there is present in the new Uinta genus a trapezium of considerably larger size.

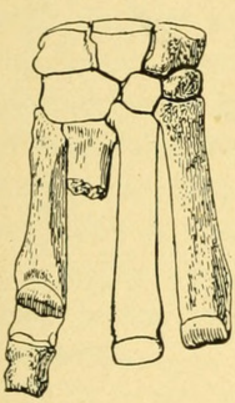


FIG. 11. *Diploceras osborni* Peterson. (Paratype. No. 2860.) × ¼. Dorsal view of manus.

Mc. II is long, quite broad, but of small antero-posterior diameter, which is in part due to crushing. The proximal end is partly broken off, so that the different facets cannot be accurately compared. The shaft is of quite uniform width until the distal articulating surface is reached, where there is on the radial face a sudden expansion. This character is less apparent in the Oligocene forms and also apparently less than in the metacarpus of the Princeton specimen from the Uinta, as figured by Scott and Osborn.

Mc. IV is, as stated, represented by fragments in both type and paratype, and displays no features of especial importance.

Mc. V is longer and slenderer than the same element in *T. validum* and that referred to *Diplacodon* (*l. c.*, Pl. IX, Fig. 13). Proximally and distally the bone is expanded much as in *Titanotherium*, and the shaft, though relatively longer, is of a similar cylindroid character. The facet for Mc. IV is located more laterally than in the Oligocene genus and the dorsal and ulnar faces are less deeply grooved for muscular attachments. Near the distal end is a flange on the postero-ulnar angle, which is similar to that already described on Mc. II and is not generally present in the Oligocene Titanotheres.

There is apparently more inequality in size between Mc. II and Mc. V than represented in the figure of the manus of *Diplacodon* by Scott & Osborn. This is very probably due, to some extent, to the crushing of Mc. II of the specimen in the Carnegie Museum. In the specimen at Princeton the complete length of Mc. V is apparently represented. Its measurements appear to be only about 13 mm. longer, though nearly one-third broader, than that of the specimen before us.

The phalanges are short, broad, and in every respect titanotheroid.

MEASUREMENTS.

	No. 2860, Mm.
Scaphoid. Vertical diameter	35
Scaphoid. Transverse diameter	33
Scaphoid. Antero-posterior diameter	53
Pisiform. Total length	60
Trapezoid. Vertical diameter	20
Trapezoid. Transverse diameter	26
Trapezoid. Antero-posterior diameter	36
Mc. II. Greatest length	153
Mc. II. Transverse diameter of head, approximate	37
Mc. II. Transverse diameter of middle of shaft, approximate	30
Mc. II. Transverse diameter of near distal end, approximate	42
Mc. V. Greatest length	125
Mc. V. Greatest transverse diameter of head	36
Mc. V. Greatest transverse diameter of middle of shaft	20
Mc. V. Greatest transverse diameter of near distal end	33
Proximal phalanx, length	31
Proximal phalanx, transverse diameter of proximal end	29
Proximal phalanx, transverse diameter of distal end	26

HIND LIMB.

The pelvis of No. 2859 is represented by the greater portion of the ilium. It is quite broad across the gluteal surface, but the point of the ilium probably did not project laterally as much as in *T. validum*. The constricted portion of the neck is actually longer than in the latter species, and also longer than in the Princeton specimen of *Diplacodon* as represented on Pl. VIII in Scott and Osborn's work. The pelvis as a whole was consequently proportionally longer and probably narrower than in the Oligocene genus. The ischium and pubis are not represented.

In No. 2860 the lower half of the femur is present. The tibial and dorsal faces of the shaft are convex, while posteriorly it presents a flat surface. On the fibular angle may be seen the lower portion of the prominent ridge below the third trochanter, which decreases in prominence in its downward course. Near the distal end the fibular border presents a roughened area for muscular attachment, back and below which is the rather shallow supracondylan fossa. Distally the condyles are rather well separated by the deep and broad intercondylar fossa. The lateral sides of the distal end (especially the fibular) is well marked by the rugose attachment for muscles. The rotular trochlea is proportionally deeper and narrower than in *Titanotherium* and the fossa immediately above it is much deeper and better defined. In this respect the present genus agrees better with Fig. 5 on Plate VIII of Scott and Osborn's publication.

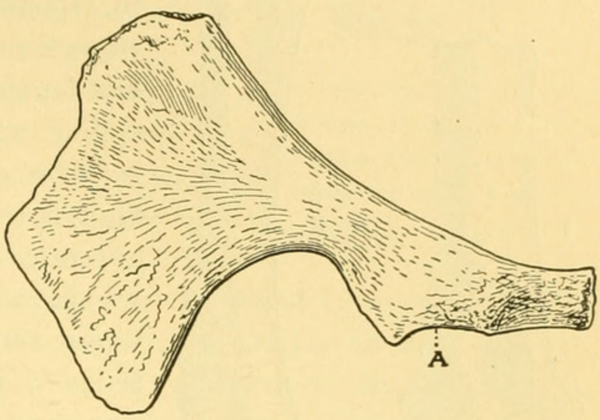


FIG. 12. *Diploceras osborni* Peterson. (Type. No. 2859.) $\times \frac{1}{6}$. Lateral view of pelvis.

MEASUREMENTS.

Femur.

	No. 2860 Mm.
Total length of the fragment	280
Transverse diameter of shaft about the middle region of the fragment	60
Transverse diameter of distal end	108
Antero-posterior diameter of distal end	110

The greater part of the tibia is represented in the paratype No. 2860, but it is badly crushed. Another individual No. 2862 has both tibiæ present and is approximately of the same size as the individuals we are describing. The bone is very nearly as long as in *T. validum*. The ends are not expanded as in the latter form, while the shaft is flatter, due in part to crushing. The superior end carries a heavy and bifid spine, while the upper anterior extremity displays the broad groove for the patellar ligament as in *Titanotherium*. The cnemial crest, though prominent, does not descend low on the shaft, another feature recalling what may be observed in *T. validum* and in the Uinta specimen figured by Scott and Osborn.[15] The anterior border of the distal trochlea was found weathered off, but the posterior surface is complete and presents a very prominent descending process on the median ridge of the articulating trochlea very similar to what is seen in the later Uinta form and in *Titanotherium*.

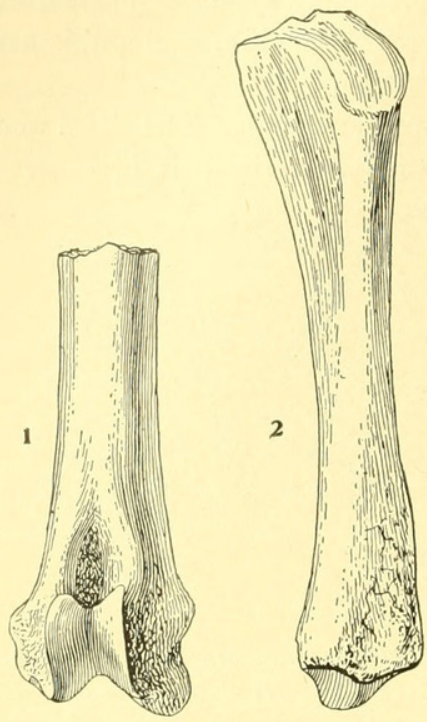


FIG. 13. *Diploceras osborni* Peterson. 1, Distal end of femur. (Paratype. No. 2860.) × $\frac{1}{6}$. 2, Dorsal view of tibia. (Paratype. No. 2862.) × $\frac{1}{6}$.

From the material at hand it is shown that the hind limb of *Diploceras osborni* corresponds well in length with the fore limb.

MEASUREMENTS.

Tibia.

	No. 2862, Mm.
Greatest length, approximate	415
Transverse diameter of head	100
Transverse diameter of shaft, middle region	48
Transverse diameter of distal end, approximate	75

The hind foot of No. 2860 is represented by the calcaneum, the astragalus, and the second and fourth metatarsals.

When compared with the Princeton specimen from a higher Uinta level and also with the Oligocene genera, the tuber of the calcaneum in

[15] If the illustration on Pl. VIII, Fig. 6, in Scott and Osborn's publication is $\frac{1}{5}$ of nature, as is that of the femur in the same plate, the tibia of that form is actually shorter than that in the genus here described.

the present form is seen to be as long in proportion and compressed laterally to the same extent, while that portion carrying the sustentacular facets is longer. The fibula also apparently articulates with the calcaneum, but the posterior portion of the tibial trochlea did not touch the calcaneum as in *Diplacodon* and *Titanotherium*. The astragalus is higher and narrower, and the metatarsals are longer and much slenderer than in the latter genera.

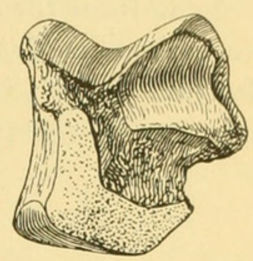


FIG. 14. *Diplocera osborni* Peterson. (Paratype. No. 2860.) × ⅓. Posterior view of astragalus.

When compared in more detail there are a number of differences between the genera here compared. On the calcaneum of the genus under description the proximal astragalar facet is not raised as high above the surface as in *Titanotherium*. The greater process of the distal end extends lower down and the facet for the cuboid is more oblique than in *Titanotherium*. As already stated, the astragalus is higher and narrower, the trochlear groove is deeper with the articular surfaces of the two condyles steeper, and the neck separating the distal end from the trochlea longer than in the astragalus of the Oligocene form, and also somewhat longer than in *Diplacodon* as figured by Scott and Osborn. Furthermore, the distal end of the astragalus of the present form is more unequally divided by the navicular and cuboid facets than in the Oligocene genus. These facets of the astragalus in *Titanotherium* are more nearly subequal in size, the cuboid facet having increased in size, as well as being located more distally on the bone, while in *Diploceras* this facet occupies a comparatively narrow area on the fibular angle and is placed laterally.

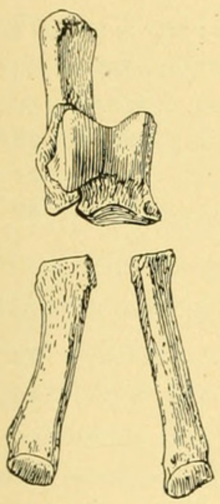


FIG. 15. *Diploceras osborni* Peterson. (Paratype. No. 2860.) × ¼. Dorsal view of pes.

The most noticeable difference of the astragalus of *Diploceras osborni* and that of the Princeton specimen as figured (*l. c.*, Pl. VIII, Fig. 8*b*) seems to be in the three distinct astragalar facets (viz. ectal, sustentacular, and cuboidal) of the latter, while in the present form the ectal, besides extending higher, unites with the cuboidal facet without distinct separation, the two forming a perfect right angle apparently similar to that in *Mesatirhinus*.[16]

Aside from the greater proportionate length, the metatarsals differ from those in *Titanotherium* by being arched forward to a greater degree. The shaft of Mt. IV is more cylindrical and the facet for the cuboid more oblique.

MEASUREMENTS.

Astragalus.

	No. 2860, Mm.
Total length	71
From lower end of external condyle to distal end	26
Greatest transverse diameter	68
Transverse diameter of trochlea	56
Calcaneum.	
Greatest length	124
Length of tuber	64
Vertical diameter of tuber	45
Transverse diameter of tuber	22
Transverse diameter at sustentaculum	70
Mt. II.	
Length	150
Transverse diameter at head	28
Transverse diameter of shaft, median region	21
Transverse diameter of distal end	26
Mt. IV.	
Length	41
Transverse diameter of head	38
Transverse diameter of shaft, median region	22
Transverse diameter of distal end	34

RESTORATION OF *Diploceras osborni*.

Plate X.

The restoration here attempted is obtained from the material described in the preceding pages and it is chiefly based on two individuals. As previously stated, the front of the skull, the lower jaws, atlas, axis, pelvis, and a few fragments of the feet pertain to one individual, the type, while the rest of the vertebral column, a few ribs and limb-bones, as well as a number of foot-bones belong to a second individual, one of the paratypes.[17] The dotted lines represent

[16] Osborn, H. F., *Bull. Amer. Mus. Nat. Hist.*, Vol. XXIV, 1908, p. 68.

[17] There was no other material found with the remains of *Diploceras* described in the preceding pages, except a few fragments of turtles. All the material was found within a radius of about 20 feet.

estimated diameters and are consequently conjectural as to proper contour outlines. This is especially true of the posterior portion of the skull, the sacrum, the ischium, the upper half of the femur, and the caudal region. There are inserted two cervicals, two dorsals, the sacrum, and the greater part of the caudal region. The vertebral formula as represented in the illustration is the same as that of the articulated skeleton of *Titanotherium* from the Oligocene now in the Carnegie Museum. The vertebral formula of *Diploceras osborni* is in part therefore tentative and is as follows: Cervicals seven, dorsals seventeen, lumbars three, sacrals four, caudals eighteen. The ribs are conjectural.

The illustration is effected for the purpose of ascertaining, at a glance, the general proportions of the animal. Each part represented by the solid lines is drawn directly from the bones themselves, by the assistance of the pantograph, and the illustration as a whole is fairly reliable.

MEASUREMENTS.

	Cm.
Total length of the vertebral column from the premaxillary to the end of the sacrum, all curves of the backbone included	252
Height of skeleton at fore limb	138
Height of skeleton at hind limb	114

TAXONOMIC POSITION OF *Diploceras osborni*.

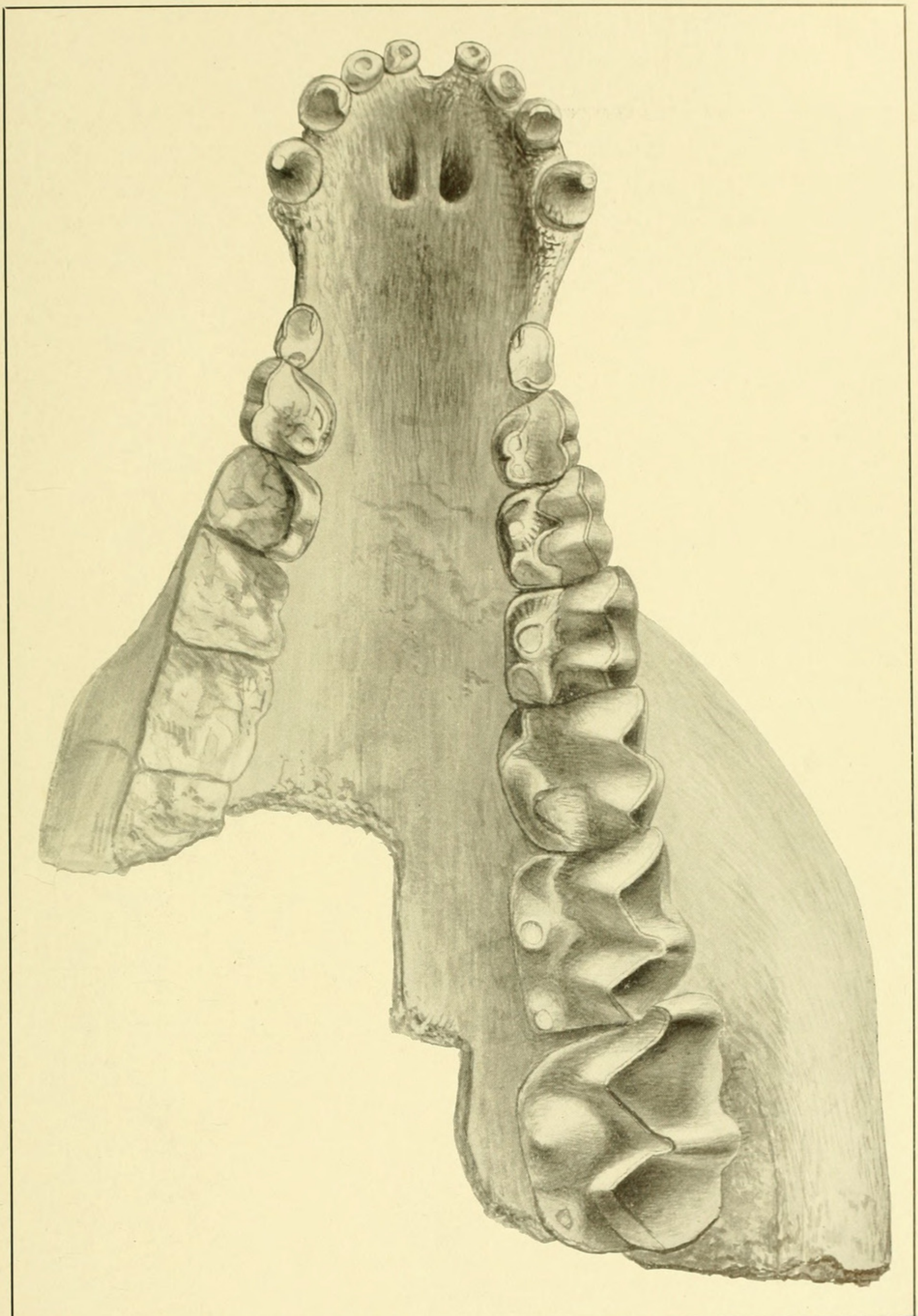
From the foregoing introduction and description it appears that *Diploceras osborni* should be placed in a phylum leading to the long-limbed animals of the Oligocene, which Osborn refers to typical *Titanotherium* Leidy.[18] Moreover, we are now more certain that true horned forms of this family were already well established in horizon B, and possibly also in the preceding horizon A of the Uinta Eocene formation. As had been anticipated by some and conclusively shown by Osborn and staff[19] the Washakie and the Uinta sediments were formed contemporaneously. No remains of these true horned types have as yet been found in the upper Washakie sediment, though they undoubtedly existed at that time. Characters of the foot-structure available for comparison, show that *Diploceras* of the Uinta B is quite similar to *Mesatirhinus* from the base of the Washakie, namely, the astragalus with neck elongated, ectal and cuboidal facets continuous,

[18] *Bull. Amer. Mus. Nat. Hist.*, Vol. XXIV, 1908, p. 611–613.
[19] *Bull. Amer. Mus.*, Vol. XVI, 1902, p. 92.

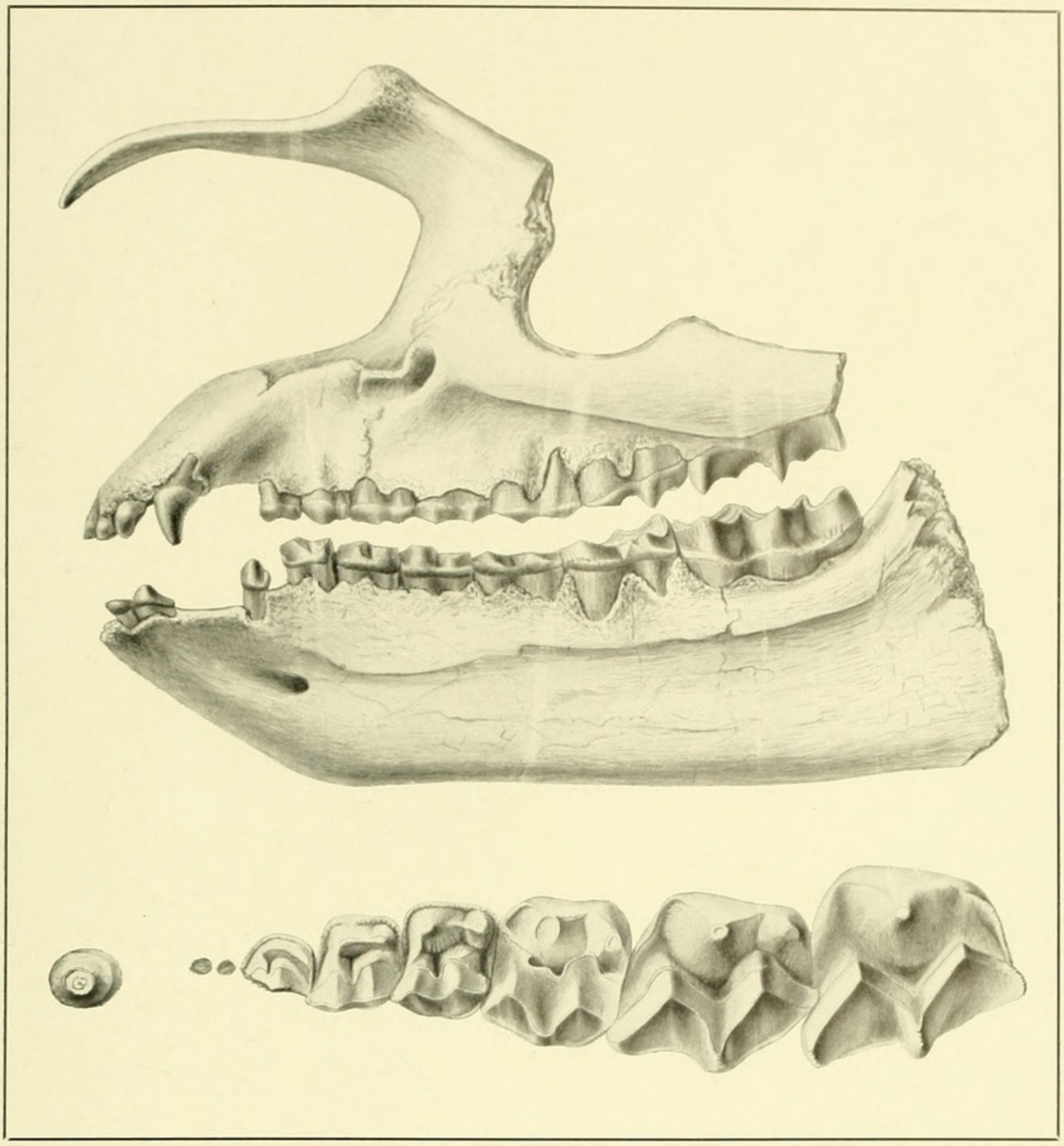
the two forming a perfect right angle; metapodials slender. Although *Palæosyops laticeps* from the Bridger, and *Telmatherium validum* from the Washakie appear, as Hatcher thought, to be the most likely ancestors of the true horned types of the Uinta and the Oligocene, it is rather questionable whether or not we may accept these as the true ancestors of this line of the Titanotheriidæ. The constant progress of new discoveries in paleontology tends to make it more and more apparent that the branches of the "phyletic trees" seem to extend further and further back through the Tertiary strata in an independent manner.

Note.—The malar bone in the restoration, Plate X, has at the post-orbital process been slightly increased in its relative perpendicular diameter, because of the crushing sustained by the original.

CARNEGIE MUSEUM,
June 19, 1913.

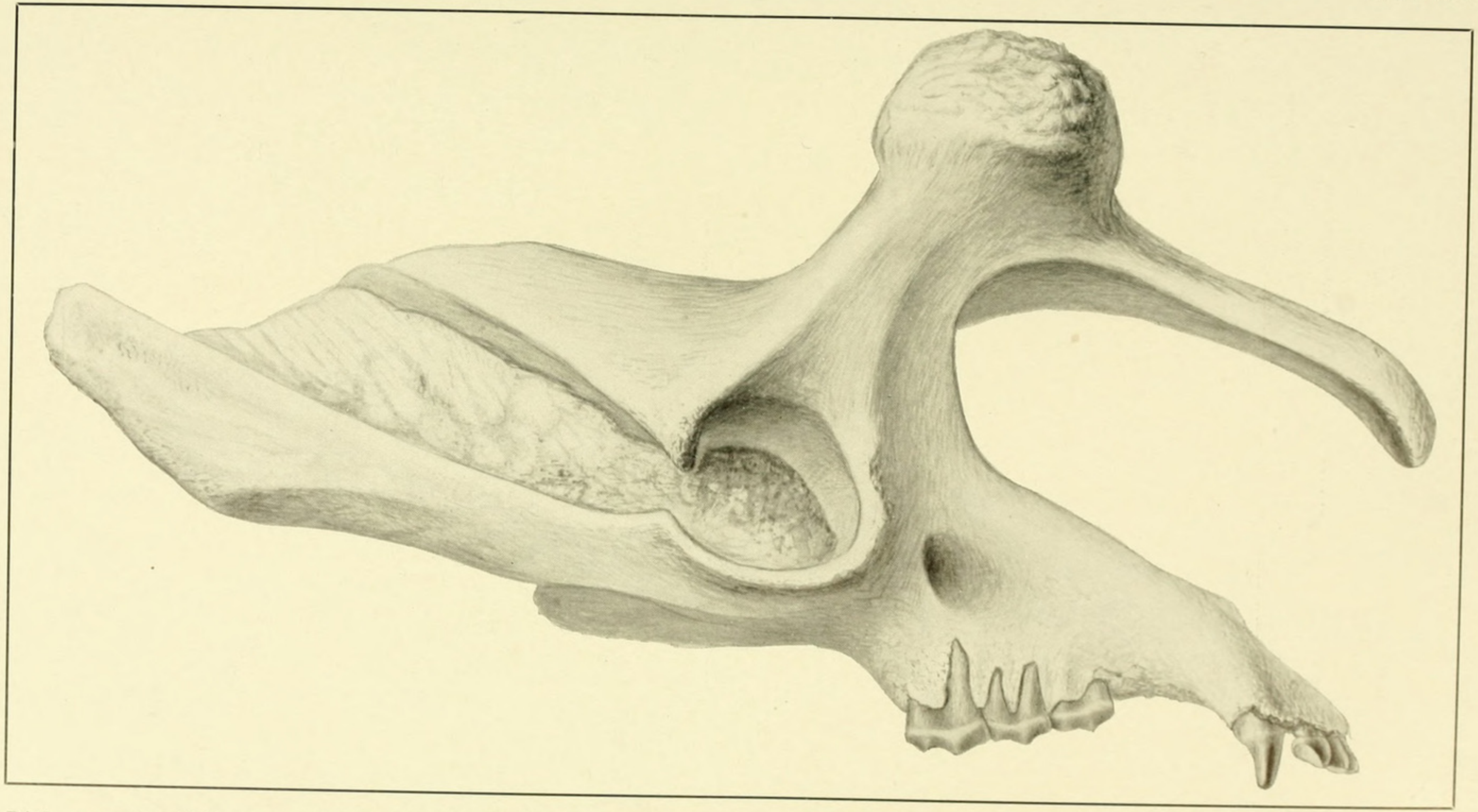


Diploceras osborni Peterson. Type. No. 2859 C. M. Cat. Vert. Foss. $\times \frac{1}{2}$.

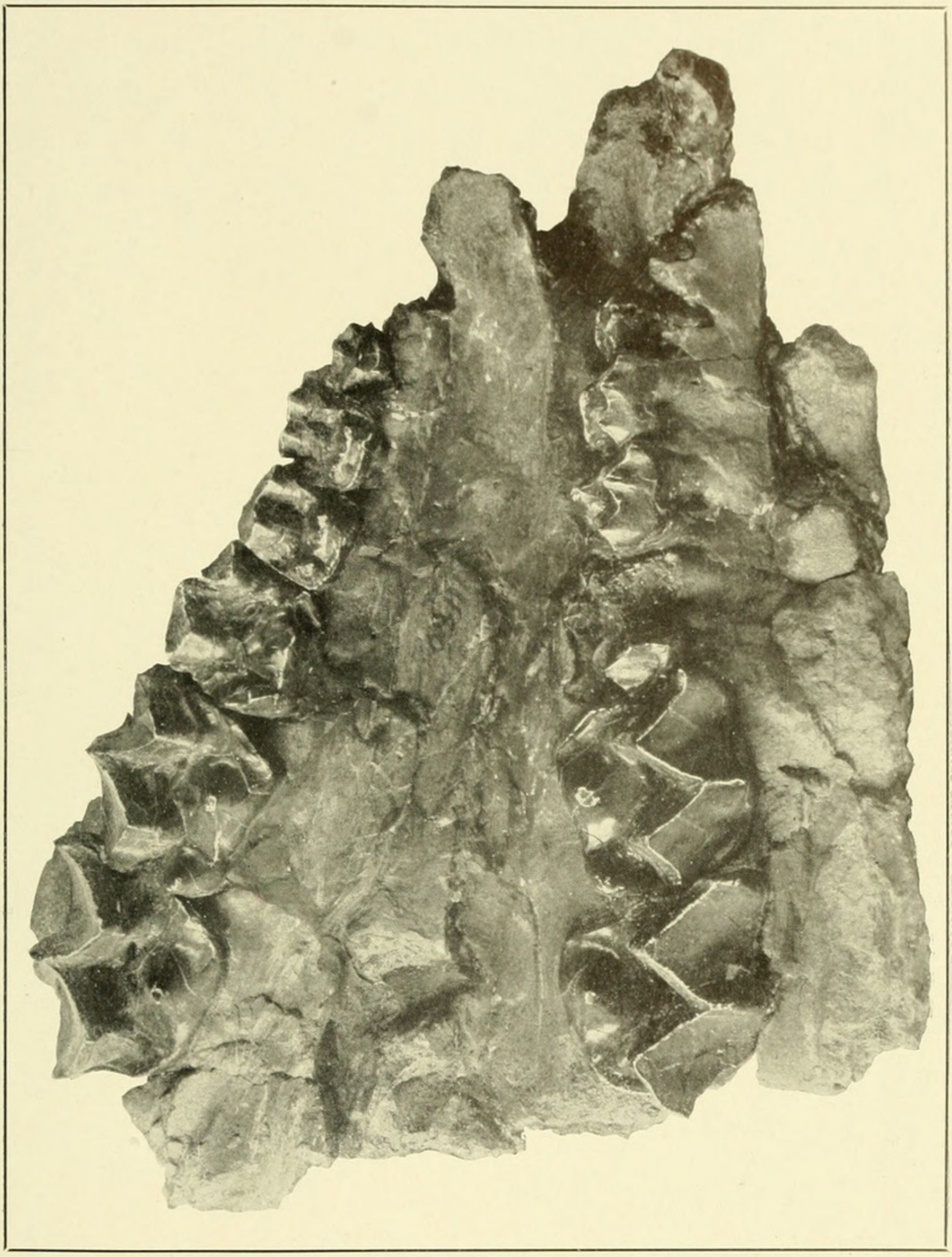


Diploceras osborni Peterson. Type. No. 2859. C. M. Cat. Vert. Foss. × $\frac{1}{4}$.

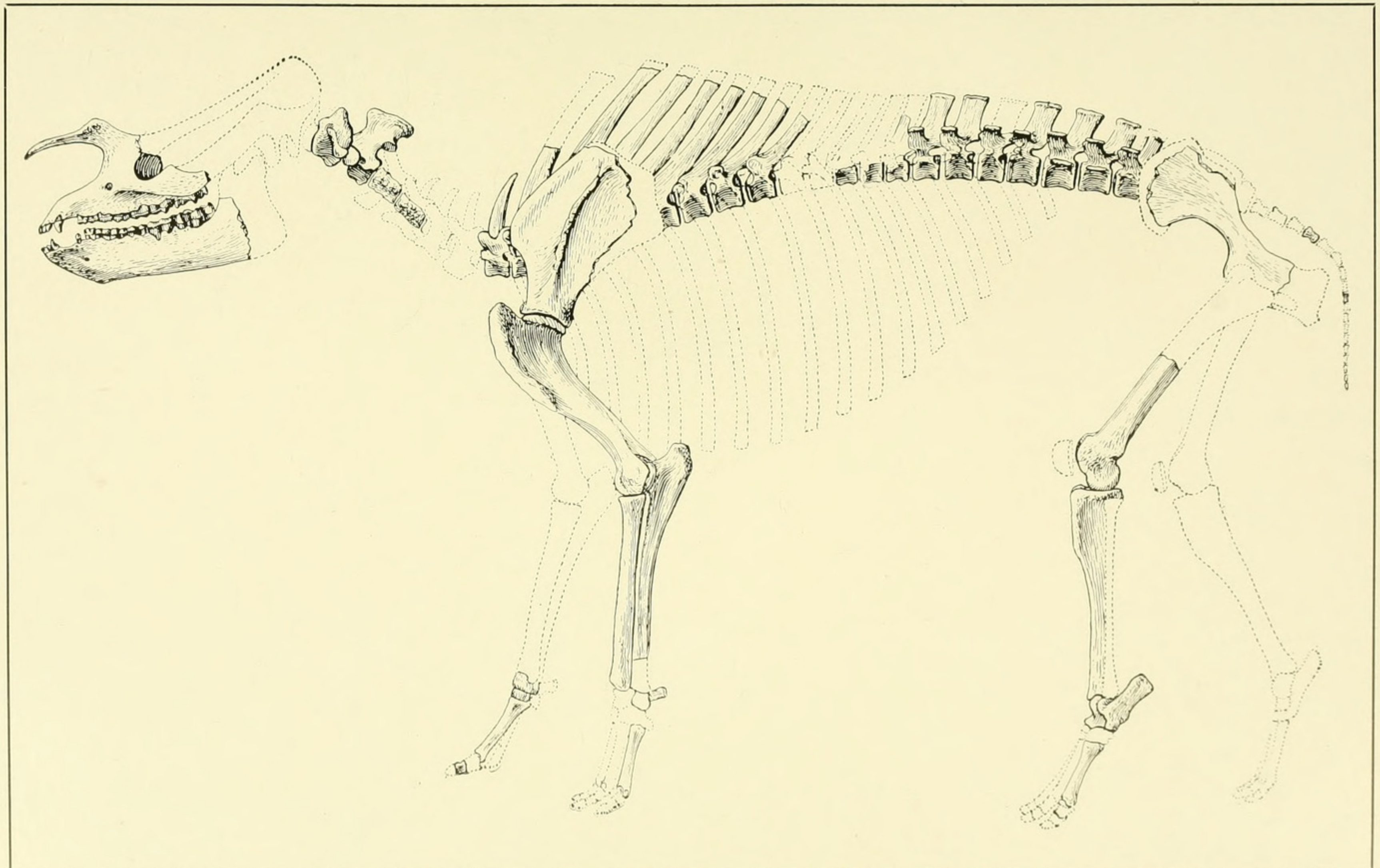
Superior dentition of *Diplacodon elatum* Marsh. Type. Peabody Museum, Yale University, No. 11,180. × $\frac{1}{3}$.



Diploceras osborni Peterson. Paratype. No. 2858 C. M. Cat. Vert. Foss. $\times \frac{1}{3}$. Back of the horn-core and lachrymal region perhaps too far back on account of crushing undergone by the specimen.



Type of *Diplacodon elatum* Marsh. Peabody Museum, Yale University, No. 1118a.
About $\frac{2}{5}$ nat size.



Restoration of skeleton of *Diploceras osborni* Peterson. $\times \frac{1}{16}$. (Representing type and paratype).