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PUBLICATION 159.

GEOLOGICAL SERIES.

VOL. IV, No. 2.

NEW OR LITTLE KNOWN TITANOTHERES
FROM THE LOWER UINTAH
FORMATIONS

WITH NOTES ON THE STRATIGRAPHY AND DISTRIBUTION OF FOSSILS.

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CHICAGO, U. S. A.

June, 1912.

NEW OR LITTLE KNOWN TITANOTHERES FROM THE LOWER UINTAH FORMATIONS

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BY E. S. RIGGS

In the summer of 1910 the writer was authorized by the Museum to make an expedition into the Uintah Basin of northeastern Utah for the purpose of collecting vertebrate fossils. Accordingly, a party consisting of Mr. J. B. Abbott of the Museum and Mr. M. G. Mehl, a student of the University of Chicago, was organized. This party proceeded by way of Dragon, Utah, thence overland to Vernal, where the necessary equipment and supplies were obtained. A camp was then established near Well 2 at the foot of Coyote Basin. Six weeks were spent in working the exposures within driving distance of this camp, after which a "dry camp" was pitched at the margin of White River Canyon. From this base work was continued in the exposures of the canyon wall during the remainder of the summer. Great difficulties were experienced on account of the scarcity of water and feed for horses, and on account of the extreme hardness of the formation. In excavating fossils the use of drills and blasting materials was often necessary.

The result of this expedition was a large collection of skulls, jaws, and two partial skeletons belonging to the family *Titanotheridæ*. This family is represented in the collection by the genera *Mesatirhinus*, *Metarhinus*, *Dolichorhinus*, *Rhadinorhinus* and *Sthenodectes*. A special interest attaches to representatives of the first four genera because of the more complete representation of their Uintah species and the inter-relationship of the genera which the collection brings out. Many of these species were obtained from a lower fossil-bearing horizon which has hitherto been little explored. Other genera represented in the collection are *Eobasileus*, *Uintatherium*, *Amynodon*, *Triplopus*, *Protelotherium*, *Protylopus*, *Stylinodon*, *Mesonyx* and *Harpagalestes*.

The genus *Rhadinorhinus* is new, *Mesatirhinus* and *Stylinodon* are for the first time reported from the Uintah formations, and *Eobasileus* is first reported from skulls capable of identification.

STRATIGRAPHY

The Uintah formations, or "Uintah Group," were primarily subdivided by the U. S. Geological Survey upon an evident change in the lithological structure of the beds. This division separated the lower

brown sandstones from the upper red clays. The lower series was designated* by C. A. White as Bridger and treated as a continuation of that series from the better known Bridger Basin. The upper series was designated† by King as true Uintah. The lower series was further subdivided§ by Peterson into two horizons designated as A and B, while the upper series or true Uintah was designated as horizon C.

The correlation of the Uintah formation with other Tertiaries has proceeded slowly as evidence has from time to time been adduced from its fossil fauna. The fauna has hitherto been best known from the middle and upper measures. Scott, in his admirable monograph on the Mammalia of the Uintah formation, concludes by pointing out its affinities with the Bridger, or middle Eocene, fauna. At the same time he confirmed the generally accepted view that the Uintah group should be placed at the summit of the Eocene, forming the transition to the White River Miocene. Osborn, in his "Age of Mammals," has put forth a careful series of correlations between the Bridger and Washakie horizons on the one hand and the Uintah formation on the other.

It is the purpose of this paper to bring out a little known titanotheria fauna from the middle and lower horizons and to add something in detail concerning the range of various fossil forms. In connection with this the following notes on the stratigraphy of the Lower Uintah Beds are offered in order to more clearly define the known range of these forms.

The subdivision of the Lower Uintah Beds has been somewhat vague, owing to the absence of strata which could be defined or traced through any considerable distance. As will be seen, the sandstone systems are chiefly of fluviatile origin and though often numerous and massive, the ledges are of limited lateral extent. They therefore offer no well marked datum-planes. These heavy ledges of river sandstones are the chief fossil-bearing horizons of the lower Uintah. Being often separated by long barren stretches, it is only with great difficulty that fossil-bearing levels can be traced from one locality to another. It therefore appears necessary to base the subdivisions upon faunal distribution — the method resorted to in nearly all inland Tertiaries. While employing this method of subdivision the present writer will depart from the accepted classification only so far as is necessary in making clear distinctions.

The White River Canyon offers the most favorable opportunity for examining the strata of the lowermost Uintah horizon. A fissure

* Hayden Survey, 1876, p. 37.

† U. S. Geological Exploration of Fortieth Parallel, Map 1.

§ Bull. Amer. Mus. Vol. VII, pp. 72-74.

deposit of *Gilsonite* which cuts deep into the canyon wall three miles below the mouth of Evacuation Creek and extends some miles to the northwestward offers a convenient point for making a section. Actual measurements were not made, but the contour lines of the U. S. Survey maps made it possible to estimate with some degree of accuracy the vertical dimensions. Figure 1, representing this section, is based upon these estimates.

LOWER METARHINUS ZONE. The shaly gray sandstones of lacustrine origin which have been more or less provisionally referred to the Green River series* dip slightly below the bed of White River at this point. Upon these shales, with no very evident line of demarcation, lies the Uintah Series. The lower two hundred feet of this series is largely made up of friable, sandy shales, interspersed with layers of nodules and thin ledges of sandstone. Occasionally these shales are interrupted by massive ledges of sandstone of limited extent. The latter are usually coarse-grained, cross-bedded in places but in the thicker ledges quite homogeneous. They vary in color from a light gray in the thinner layers to dull brown in the weathered surfaces of the more massive ledges. These shales weather in rather steep slopes, marked by the horizontal outcroppings of nodular or sandy layers.

Above the shales at this point lies a series of columnar sandstones some three hundred feet in thickness. They weather in the form of bold cliffs, standing out as buttresses along the canyon wall. (Pl. IV.) These sandstones consist of relatively thin ledges of fine-grained, often calcareous, sand varying somewhat in hardness and presenting rugged bandings in the face of the cliff. The color is slightly more grayish than the underlying shales but brown predominates.

This lower five hundred feet of the Uintah Formation is comparatively barren of fossils. Some days' search in the vicinity of this section revealed only occasional fragments of turtle shells. Mammals have been found in these measures at other points along White River. The type specimens of *Metarhinus* and of *Sphenocaelus* are said to have been collected from the lower levels. The first has never been duplicated, the second is represented by a fragment. While the occurrence of these two genera in the lower measures is a matter of record, the rarity of individual representatives, as well as the small number of forms found in this horizon, may justify its being designated as relatively barren.

UPPER METARHINUS ZONE. The succeeding four hundred feet is made up chiefly of massive ledges of sandstone alternating with layers of sandy shales or indurated clays. The sandstones vary in thickness from five to thirty feet. They are of limited extent, usually playing

* White, Op. cit.; Scudder, Tert. Insects.

Fig. 1. Section of Metarhinus Beds, as exposed in the north wall of White River. See pages 19 and 22.

Fig. 2. Panoramic section of the Amynodon Beds, from Kennedy's Basin to White River Canyon. See pages 22 and 24.

out and being replaced by other ledges at slightly different levels. The thicker ledges are made up, for the greater part, of fine-grained sands firmly cemented by calcareous material, gray when freshly broken but weathering to a reddish brown. In every ledge there are traces of cross-bedding, evidenced by diagonal veins of coarser sands. Near the base or above a second bedding plane, there is often a coarser layer of river sand containing pebbles of quartzose materials, sandstone, and clay shales. This layer is invariably cross-bedded, often interrupted and replaced at nearly the same level. In these coarser strata occur as fossils disarticulated bones, branches and sometimes trunks of trees. In the upper series the sandstones weather into vertical, or often over-hanging walls, with accumulations of fallen blocks at the base. (Pl. V, Fig. 1.) In the lower levels they are quite as often exposed in steep slopes half covered with a shaly talus. Many of the calcareous ledges disintegrate where exposed to the weathering agencies and flake away more rapidly.

These two series, designated as Lower and Upper Metarhinus Zones, include, as nearly as the writer can determine, Horizon A of Peterson and Osborn. Probably they include a little more than was originally so designated. The lower division is best defined as including the whole of those sandstones in which the genus *Metarhinus* occurs. This genus is by far the most distinctive fossil of this horizon and is apparently confined to it, though at certain levels *Dolichorhinus* was found equally abundant. In the three months of careful work and record by our party no trace of *Metarhinus* was found above the sandstones described. However, the habitat of this animal appears to have limited its occurrence to the river sands.

Five miles up the canyon from the line of this section a single ledge (Pl. V, Fig. 1) a half-mile in extent yielded so many specimens of this genus as to be designated by our collectors as the *Metarhinus* Sandstone. However, six other genera of mammals, one of crocodile and various turtles are recorded from these beds.

The term "*Telmatherium megarhinum* Beds," originally applied * to this series, being no longer applicable†, it is here proposed to designate the series as the *Metarhinus* Beds, in honor of the form, which was first described from them and is still their most characteristic fossil. The beds may be further divided into a Lower and an Upper *Metarhinus* Zone as indicated in Figure 1.

AMYNODON BEDS. Above the *Metarhinus* Beds, or Horizon A, lies a series of three hundred feet of shales and clays including occasional ledges of fluviatile sandstone. They are best represented some five miles farther up White River from the last section. At this point the formation is exposed in the more open country in a series of eroded ledges dipping to the northwestward at an angle of two or three degrees. Gilsonite Vein No. 2, which extends several miles in a northwesterly direction from the canyon's northern edge, may be taken as the basis of the section (Fig. 2). This vein is marked by a series of mines and prospect holes easily recognized. The section extends from the canyon rim to the mesa bordering Coyote Basin on the northward. This includes substantially the same vertical series as Horizon B of Peterson and Osborn so far as the writer has been able to interpret them.

These beds are composed of sandy shales and brilliantly colored clays with occasional ledges of sandstone and included lenses of more limited extent. The series is capped by a massive ledge which appears at the brow of the mesa bounding Coyote Basin on the northwest. This may fittingly be designated as the *Amynodon* Sandstone.

Between the uppermost ledge of the *Metarhinus* Beds and the *Amynodon* Sandstone lie a series of clays and lenticular sandstones of variable character. The *Metarhinus* Sandstones are succeeded by one hundred feet of bluish or grayish shales including thin ledges of sandstone. These are overlain by forty feet or more of homogeneous fine red clays, capped by a ledge of sandstone five or six feet in thickness. Then come fifty feet of dark grayish clays including lenticular sandstones of rather coarse-grained, ferruginous character. These sands weather in slopes quite as flat as the clays in which they are included. They are rich in mammalian fossils, of which *Dolichorhinus longiceps*,

* Bull. Am. Mus., Vol. VII, p. 95.

† The specimen alluded to was later made the type of *Metarhinus fluviatilis*, see Bull. Am. Mus., Vol. XXIV, p. 609.

Sthenodectes incisivum and *Amynodon intermedius* were recorded. The remaining seventy-five feet below the Amynodon Sandstone consist of light gray or greenish clays little indurated and weathering in the form of typical bad lands. These contain a varied fossil fauna but having been exploited by earlier collectors, little attention was given to them. However, specimens of *Uintatherium* (?), *Stylinodon* sp., *Amynodon intermedius* and *Protylopus* were recorded. Capping this as the "rim-rock" of the basin is the massive Amynodon Sandstone before mentioned. It reaches in places a thickness of twenty feet, thins out and sometimes disappears entirely but is replaced again by a similar ledge at approximately the same level. These ledges are perhaps the richest in vertebrate fossils of any horizon noted. *Amynodon* and *Crocodylus* are common; *Protelotherium uintense* also was found.

RANGE AND OCCURRENCE OF FOSSILS

Some observations upon the range and occurrence of fossil mammals in the Lower Uintah formations are worthy of mention. A careful record was kept of the exact geological horizon of every specimen collected. Attention was also given to the character of the formations in which the various fossils occur, their sequence and the association with plant and invertebrate fossils, in order to throw any possible light upon the condition of deposition or the habits of the animal. The geological distribution as indicated in Figs. 1 and 2 is based entirely upon the collection made by this expedition. With a few exceptions the data are based upon material sufficiently complete to be preserved as museum specimens and accurately identified. In no case was a record made from fragments not *in situ*. The Lower Metarhinus Zone is indicated as relatively barren.

Five genera of mammals have been reported* by Osborn from the entire Horizon A. Mr. Peterson, who made the collection, has assured the writer that the type specimens of *Metarhinus fluviatilis* and *Sphenocelus uintensis* came from the lowermost levels of that horizon. In the lower zone typical fossil-bearing ledges occur, but much less frequently than in the upper. A number of ledges examined by our party proved quite barren. In the upper strata fragments of turtle shell were noted. It is quite probable that somewhere in these channel deposits fossil-bearing "pockets" may be discovered. Upon such discoveries rests the hope of further light upon the fauna of the Lower Metarhinus Zone. The sandy shales such as make up the larger part of this series do not offer conditions favorable for the preser-

* Bull. Am. Mus., Vol. VII, p. 75.

vation of any mammalian fauna which may have found its way into the Uintah basin at this stage.

Fossils in the Upper Metarhinus Zone are found almost without exception in the sandstone ledges, rarely in the shales which alternate with them. Sometimes they occur in the homogeneous, fine-grained sandstone but more often they are confined to the narrow, coarse-grained, cross-bedded layers which often occur near the base, sometimes at the top, of massive ledges. Skulls are often embedded in semi-gravelly layers and have their narial or orbital cavities filled with pebbles which could be carried only by rapidly flowing water. Another evidence of stream action lies in the complete dissociation of the various skeletal elements. Seldom are the lower jaws associated with the skulls, or so much as two vertebrae found articulated. There are exceptional instances where whole skeletons are found but little disturbed. In the few instances noted these were embedded in a fine-grained, homogeneous sandstone apparently deposited in more quiet water such as deep pools or eddies.

The Upper Metarhinus Zone presents a much more varied fauna. It includes, along with the low-ground titanotheres, a number of forms whose structure indicates greater activity and which may have inhabited woodlands or open plains. Throughout this series there appears an ever-increasing percentage of upland forms. The titanotheres genera *Metarhinus* and *Dolichorhinus* are equally well represented. Their fossil remains are usually found associated in the same ledges and apparently deposited under the same conditions. In the one instance in which a large part of a *Dolichorhinus* skeleton was found articulated, a skeleton of a young *Metarhinus* was mingled with it in such a manner that it was at first mistaken for the young of the same form. There is one notable exception to the parallel occurrence of these two forms in the Upper Metarhinus Zone. An isolated ledge of sandstone represented at the base of Section 2 (Fig. 2) yielded *Metarhinus* skulls and jaws in relative abundance. Four specimens of *M. riparius* and three of *M. earlei* are recorded from this ledge but no trace of *Dolichorhinus* was found in it. It is significant that such titanotheres as *Telmatherium* and *Mesatirhinus superior* also occur in this ledge. It was noted also that *Dolichorhinus* was found only in heavy sandstone systems. Apparently this animal was confined to the vicinity of large streams.

Other genera common to the Upper Metarhinus Zone are the more rare and probably upland *Rhadinorhinus*, the gigantic *Eobasileus*, the small hyracodont *Triplopus*, and two large creodonts, *Mesonyx* and *Harpagolestes*. Occasional crocodiles and numerous turtles are found,

also beds of fresh-water clams. Reeds, leaves, and branches of trees are abundant in the upper sandstone in association with representatives of the upper fauna.

The Amynodon Beds represent a transitional stage both in their stratigraphy and in the characters of the fauna. The river sandstones rapidly give place to shales and clays. Fossils occur in the heavier sandstones very much as in the Upper Metarhinus Beds; at the same time they become more abundant in the shales and clays as we pass upward in the series. In the lower sandy shales but few evidences of mammals are recognized, though in certain narrow strata fragments of *Eobasileus* occur with comparative frequency. The lenticular sandstones, apparently of quiet water deposition, are rich in the remains of low-ground mammals such as *Amynodon*, *Sthenodectes* and *Dolichorhinus*. These sands show little evidence of water currents. Skulls with mandibles and parts of skeletons are found associated.

The gray clays yield a mixed fauna of lowland and plains forms. *Dolichorhinus* and *Amynodon* are common; other genera recognized are *Uintatherium* (?), *Stylinodon* and *Protylopus*. Little attention was given to these beds. It is probable that a careful search would reveal a much larger number of fossil forms than are here recorded. The massive sandstones forming the upper series of the Amynodon Beds yield *Amynodon* and *Dolichorhinus* as the most characteristic fossils. *Protelotherium* and *Crocodylus* are also recorded from them.

The Upper Uintah Beds (Horizon C) are not included in this reconnaissance. It may be noted that this series is ushered in by an even more marked transition than the last. Red clays and friable sandstones predominate. Massive sandstones are rare and of limited extent. The fauna is known from the researches of Marsh, Scott, Osborn, Hatcher and Douglass.

Subfamily DOLICHORHINÆ

Middle Eocene titanotheres having nasals elongate and deeply recessed laterally, face shorter than cranium, an infra-orbital process more or less developed, and molars only moderately expanded.

This group is proposed in order to designate those long-nosed titanotheres which evidently sprang from a common stock and form a natural and homogeneous group. It includes the following genera:

Mesatirhinus

Metarhinus

Dolichorhinus

Rhadinorhinus

MESATIRHINUS* Osborn.

Type species *M. megarhinus* Earle.

Range, Bridger C and D, Washakie A and B, now extended to include Uintah A.

The generic characters may be modified as follows: Skull length 354–485 mm., frontals relatively narrow, rounded and not overhanging the orbits, sagittal crest progressively reduced.

M. superior, sp. nov.

Type specimen, No. 12188, Field Museum. (Pl. VI.)

Type locality: Upper Metarhinus Sandstones, White River divide.

Specific characters: Skull 485×255 mm., molar series 182 mm., nasals free to a point over last premolar, infra-orbital process present, arches slender anteriorly, nasals infolded at margins, sagittal area expanded, canines small, P² and P³ oblique to axis of series. Molars relatively small, strong hypocone on M³, posterior nares opening opposite the anterior margin of last molar.

This genus, reported for the first time from the Uintah formations, is apparently indigenous to the Bridger and Washakie basins. It is represented in the Field Museum collections by a single specimen — an incomplete skull collected by Mr. J. B. Abbott from the top of the Metarhinus Sandstones near Gilsonite Vein No. 2. The right arch is wanting, together with the basi-occipital and condyles. The dentition is anatomically complete excepting the incisors.

The skull presents striking similarities with the earlier representatives of *Dolichorhinus*. From the dorsal view, the nasals, facial and supra-cranial regions appear very similar, though the cranial region does not have the pronounced downward curve characteristic of *Dolichorhinus*. In the palatal view more marked differences are noticeable. The premolars are more primitive, the molars smaller, and the posterior narial opening is unmodified. In these characteristics the specimen in hand resembles *D. heterodon*† from Upper Uintah B more closely. However, it differs from that species in having a strong hypocone on the last molar, and in the whole facial profile. In our present knowledge of these many closely related forms, this species may be regarded as the largest and most highly specialized representative of *Mesatirhinus*. Further measurements of the type specimen are given on page 39.

* Bull. Amer. Mus., Vol. XXIV, p. 608, 1908.

† Douglass, Annals Carnegie Museum, Vol. VI, p. 810, 1909.

METARHINUS Osborn

The genus *Metarhinus* is based upon a series of specimens from the Uintah *Metarhinus* Beds. It has for its type a skull (Am. Mus. No. 1500) from the lowermost horizon* of these beds. Two other species, *M. earlei* and *M. diploconus* have been referred to this genus.† The former species from the Upper Washakie Beds is recognized from the Upper *Metarhinus* Beds of the Uintah. The differences between the type of *M. diploconus* and other species more directly in line with the generic type appear to warrant its removal from this genus.§

The Field Museum collection includes a more complete series of specimens referable to *Metarhinus* than has hitherto been known. Among these are seven adult skulls, and one of a young individual, together with two associated and various isolated mandibles. These specimens come from higher levels and represent more advanced stages of development than the type species.

From a comparative study of all the materials referred to *Metarhinus* the genus may be characterized as follows:

Type species, *M. fluviatilis*.‡

Range: Uintah *Metarhinus* Beds (Horizon A) and Washakie B.

Generic characters: Small titanotheres (skull length 355-415 mm.) having orbital region unusually prominent, nasals expanded distally and free to a point above the anterior margin of the orbit, incipient horn-cores at fronto-nasal suture, posterior nares opening opposite second molar, sagittal crest more or less reduced, molars with low crowns, hypocone on M³ present or reduced. Mandible with narrow, straight ramus, first lower premolar single-rooted or absent.

The genus includes two phyla, which are apparently distinct but so far as is now known merit no more than specific rank. The first phylum includes *M. fluviatilis* from the Lower, and *M. riparius* from the Upper *Metarhinus* Beds. These are clearly indigenous types known from the Uintah only. In their dental characters they are the more primitive. The canine is large, the premolars more diagonal and the hypocone on M³ present, often prominent. The molars in adults are usually deeply worn. The second phylum includes forms relatively short-headed, broad in the frontal region, with more rectangular premolars, broad

* *Fide* Peterson.

† Bull. Amer. Mus., Vol. XXIV, p. 610.

§ *Vide infra*.

‡ Bull. Amer. Mus., Vol. XXIV, p. 609, 1908.

faced molars usually little worn in the adult and with no trace of a hypocone in M^3 . The earlier forms of both phyla have high sagittal crests. The expanding cranial areas in the more advanced forms develop differences which become more and more evident.

Metarhinus fluviatilis, Osborn.* Type of genus.

Type specimen, No. 1500 Amer. Mus.

Type locality, base of Metarhinus Beds, White River Canyon.†

This is much the smaller and more primitive species of the genus. It may be readily distinguished by the small size (355×200 mm.), the short basi-cranial region, the long sagittal crest and the prominent hypocone on M^3 . No specimen referable to this species was secured by the Field Museum.

Metarhinus riparius, sp. nov.

Type specimen, No. 12186 Field Museum. (Pl. VII, Fig. 1).

Range: Entire Upper Metarhinus Beds, White River Canyon and divide.

Specific characters: Skull long and narrow (405×210 mm.). Anterior cranial region expanded, sagittal crest short. Inter-orbital region relatively narrow and rounded, rudimentary horn-cores above orbits, canines large, molar series short (88–93 mm.), hypocone usually present on M^3 , mandible straight in the ramus, lower canine long and recurved.

This is the most common species in the Metarhinus Beds. Four skulls, two associated lower jaws and one isolated, in the Field Museum collections are referred to it. (Nos. 12174, 12183, 12191, 12195, 12196.)

Metarhinus cristatus, sp. nov.

Type specimen, No. 12194 Field Museum. (Pl. IX, Fig. 3).

Type locality: Upper Metarhinus Beds (Horizon A), White River Canyon.

Specific characters: Skull, length approximately 380 mm., molar series 94 mm. Frontal region broad, sagittal crest long and high, molars short-crowned, no hypocone on M^3 , arches relatively heavy. Represented by a single skull lacking the nasals and the premaxillaries.

* Bull. Am. Mus., Vol. XXIV, p. 609, 1908.

† Fide Peterson.

*Metarhinus earlei** Osborn.

Type specimen, No. 13166 Amer. Mus.

Type locality: Washakie B and Upper *Metarhinus* Beds (Horizon A).

A splendid skull (No. 12187, Field Museum, Pl. VIII), two mandibles (Nos. 12178 and 12189) and a distorted skull (No. 12169), all from the uppermost *Metarhinus* Sandstones, are referred to this species. From these referred specimens, as well as from the type, the following characters are derived:

Skull, short and broad in frontal region, length 388-405 mm., breadth 245-255 mm. Molar series broad and low-crowned, no hypocone on M³; linea aspera uniting by regular curves above posterior margins of zygomata to form a short, thickened sagittal crest; canines slender, diastema short, P² oblique, P³ and P⁴ sub-rectangular in outline, molars broad and low-crowned, no hypocone on M³, mandible with ramus slightly curved.

Metarhinus represents a rapidly expanding and comparatively short-lived group. Its known vertical range in the Uintah is less than one thousand feet. As before indicated, the genus early divides into two lines which run parallel through the greater part of Horizon A and disappear at the top of the heavy river sandstones. In general these two phyla may be characterized as the broad-headed and the narrower-headed forms.

There is a considerable increase in size between the earlier and later known forms indicated by the comparative length of skulls (352-406 mm). The most evident specialization undergone during the development of this genus is the reduction of the sagittal crest, the expansion of the nasals distally, the strengthening of the squamosal element of the arch, the appearance of incipient horns at the fronto-nasal suture, the increase in size of the molar teeth and the relative reduction and modification of the premolars. The incisors are so seldom preserved that few deductions can be drawn from them. The canines, strong in the generic type, continue so in the narrower-headed form, *M. riparius*. In the broader-headed species, *M. cristatus* and *M. earlei*, the canines become much reduced in size. The post-canine diastema is quite short in all species. P¹ is a simple cone implanted by two roots; P² retains its primitive oblique position in this series. P³ and P⁴ have become sub-quadrate in outline and approach, in the broad-headed forms, the transverse position in the series. The hypocone on M² which is prominent in *M. fluviatilis* persists in the later representatives of *M. riparius*

* Bull. Amer. Mus., Vol. XXIV, p. 610, 1908.

but in reduced size. In the broader headed *M. cristatus* there is a trace of this element but in the later skulls of *M. earlei* it is wanting entirely. In the lower dental series there is a corresponding strengthening of M^2 and M^3 , a reduction, sometimes a loss, of P^1 and a slight elongation of the post-canine diastema. The Uintah representatives of this species are somewhat broader headed and more massive than the Bridger type.

MEASUREMENTS OF SKULLS OF METARHINUS IN MILLIMETERS							
	<i>M. flavitatis</i> , Type, Am. Mus. 1500	<i>M. riparius</i> , Type Field Mus. 12186	<i>M. riparius</i> Field Mus. 12183	<i>M. cristatus</i> Field Mus. 12194	<i>M. earlei</i> , Type Am. Mus. 13166	<i>M. earlei</i> Field Mus. 12187	<i>M. earlei</i> Field Mus. 12168
Skull, length incisors to condyles.....	352	406	406	385*	390	388	405*
“ breadth across arches.....	205	210†	220*	240	237	245	255*
“ “ between orbits.....	112	114†	107	145	137*	142	220*
“ post-orbital process to condyles	214	205	212	215	198	...	220*
“ last molar to condyles.....	...	189	193	195	182	184	...
“ length of free nasals.....	107*	128*	115	...	...	120	130*
“ greatest breadth of nasals.....	...	68	68	...	...	74	...
“ post-glenoids to condyles (median line).....	...	87	89	...	...	73	...
“ breadth across condyles.....	...	79	82	90	75	79	80*
“ greatest depth of arch.....	...	55	51	...	...	50	...
“ length of molar-premolar series..	145	160	155	...	169	158	170
“ “ molar series.....	86	93	93	92	104	100	103
“ “ crown of canine.....	...	24	29	...	...	29	30
“ diameter crown of canine.....	18	18	20	...	...	15	16
“ length of diastema.....	9	11	10	...	11	8	11
“ narrowest point in sagittal area	...	10	...	4	6	9	17
“ breadth of orbito-nasal area....	39	41	39	43	50	42	50

LOWER JAWS		No. 12195 Field Mus.			No. 12179 Amer. Mus.	No. 12189 Field Mus.	No. 12178 Field Mus.
Mandible, length condyles to incisors...	...	338	330	...	330	315*	340
“ height, condyles above angle	...	133	125	...	157	135	148
“ length of molar-premolar series.....	...	172	162	...	171	168	170
“ length of molar series.....	...	110	102	...	107	110	105
“ “ crown of canine....	...	34	32*	...	...	...	...
“ diameter crown of canine....	...	21	19	...	20	...	18
“ depth of ramus from base of P ₃	...	52	49	...	45	48	54
“ depth of ramus from base of M ₂	...	60	60	...	82	60	69

*Estimated. †Distorted.

DOLICHORHINUS Hatcher

Type species (*D. cornutus* Osborn) *hyognathus* S. & O.

Range: Upper Bridger, Washakie and Lower Uintah.

Original characterization:* "Distinguished from *Manteoceras* and *Telmatherium* by the reduced number of incisors, presence of incipient horns, presence of infra-orbital shelf and the position of posterior nares."

Further knowledge of the genus has proved that the reduction in the number of lower incisors is not constant. The genus may now be characterized as follows:

Middle Eocene titanotheres progressively dolichocephalic, nasals elongate and laterally infolded, cranial region strongly convex, incipient horn-cores above the orbits, a shelf-like infra-orbital process, occiput broad and low, condyles broad. Dentition complete, premolars relatively progressive, first pair of upper incisors separated by median diastema, posterior nares opening back of last molars.† Vertebral formula: Cerv. 7, Dors. 17, Lumb. 4, Sac. 4.

The elongate skull, 440-600 mm., with deeply recessed nasals and wide sagittal area strongly convex in the cranial region, everywhere distinguishes this genus. The specimens examined by the writer all bear evidence of a recession of the posterior nares by a secondary bridging of the palate. The nasals are laterally recessed to a point over the first molar. They may be expanded in the distal third or uniformly tapering. The infra-orbital process is thickened and rugose at the extremity. The median diastema between the first pair of incisors is a notch-like recess at the suture, varying from ten to fifteen millimeters in breadth. The upper canines differ considerably in size and in direction, varying from procumbent to recurved types. The grinding teeth are longer in the crowns than in any of the other Lower Uintah titanotheres. The last molar bears a more or less developed hypocone. The post-glenoid processes are massive and elongate antero-posteriorly.

D. cornutus§ Osborn.

Type specimen, No. 1851 Amer. Mus.

Type locality: Uintah B.

Synonym‡ of *D. hyognathus* S. & O. from Washakie B.

* Amer. Nat., Vol. XXIX, p. 1090, 1895.

† *D. heterodon* offers a possible exception to this rule.

§ Bull. Amer. Mus., Vol. VII, p. 90, 1895.

‡ Bull. Amer. Mus., Vol. XXIV, p. 611, 1908.

To the present writer the abandoning the name of *D. cornutus*, the original type of the genus, appears undesirable. This species is based upon a well-preserved skull with characteristics easily recognizable. It appears to the writer to be a direct successor of *D. longiceps* which is now traced through the upper half of Horizon A and lower Horizon B. The two species apparently represent a line of titanotheres indigenous to the Uintah formations. *D. hyognathus*, with which *D. cornutus* has been made synonymous, is a Washakie species based upon an isolated mandible.* No skull associated with a similar mandible has been described. The mandible indicates a much larger individual than the type of *D. cornutus*. The relative length of the molar-premolar series (208:245 mm.) in the types of the two species indicates a considerable disparity in size. There are also apparent differences in proportions. In view of the variation in this genus and the number of species referred to it, it would appear unwise to correlate the two species until an associated skull and mandible referable to the one or the other species is known.

D. intermedius† Osborn.

Type specimen, No. 1837 Amer. Mus.

Type locality: Uintah B (after Peterson).

This is apparently the smallest member of the genus described from the Uintah formations. So far as the writer is able to determine, no specimen in the Museum collection is referable to this species.

D. heterodon§ Douglass.

Type specimen, No. 2340 Carnegie Museum.

Type locality: Upper Uintah B or lower C (after Peterson).

This form as illustrated presents the characters of a somewhat specialized *Dolichorhinus* with the posterior narial opening in the primary position as in *Mesatirhinus*. Further comparison between this species and the type of *D. intermedius* is needed in order to determine their relationships.

D. longiceps‡ Douglass.

Type specimen, No. 12167 Carnegie Museum.

Type locality: Uintah B (after Peterson).

Four skulls (Nos. 12175, 12182, 12193, 12200 Field Mus.) collected by the Museum expedition from the Upper Metarhinus Beds are refer-

* Scott & Osborn, Trans. Amer. Phil. Soc. Vol. XVI, p. 513. Earle, Jour. Acad. Nat. Sci. Phila., Vol. IX, p. 348, Pl. II.

† Bull. Am. Mus., Vol. XXIV.

§ Annals Carnegie Mus., Vol. VI, p. 310.

‡ Op. cit., p. 312, 1909.

able to this species. These specimens are somewhat smaller and less specialized than the type. They vary in length from 525 to 560 mm. One of the largest, a splendidly preserved skull, is figured in Plate IX. The canines as indicated by the alveoli of the type are smaller, and the premaxillaries are somewhat narrower. There is little evidence of incipient horn-cores. The nasals in this group of skulls overhang the margin of the premaxillaries. They are laterally infolded, slightly expanded in the distal third and taper to an emarginate end. They are separated from the maxillary border by a wide recess. Compared with *D. intermedius* the smaller skull (No. 12193) approaches closely in size, the dental series is similar in length, the premolars are more advanced, and the cranial region is more elongate in comparison with the face. However, there is a considerable variation in these proportions between the several individuals referred to this species. In the palatal bones of these specimens there is an offset between the last molars corresponding to the position of the narial margin in other closely related titanotheres. This is evidently a vestige, marking the former position of the narial opening. It has been bridged over by the outgrowth of thinner plates from the lateral margin of the palatal bones so that the nares have receded to a point behind the hamular processes of the pterygoids. The plates of this secondary palate are so thin that they are often broken through and so the vestigial offset may be mistaken for the narial margin. The secondary palate in this species is pierced by a pair of foramina; its posterior extension is an enfoliate process free from the lateral walls and probably attached to the inferior margins of the vomer.

A mandible associated with an incomplete skull (No. 12200) is relatively strong, curved in the ramus and broad at the angle. (Pl. IX, Fig. 2.) There is also a large part of a skeleton associated with this specimen which is not yet prepared for study. A detailed description of this entire specimen will be given in a later publication.

D. fluminalis sp. nov.

Type specimen, No. 12205 Field Museum. (Pl. X, Figs. 1-3).

Type locality: Amynodon Sandstone, Uintah B.

Specific characters: Skull, small and narrow (520x230 mm.), facial region much shorter than cranial, nasals narrow and slightly tapering, posterior nares opening between hamular processes, post-orbital process of jugal back of the last molar, molar-premolar series 171 mm.; canines short and recurved, incipient horn-cores in the form of high narrow ridges.

This species is represented by a single splendidly preserved skull with almost complete dentition, collected by M. G. Mehl. The skull

is slender, light and complex in structure as compared with the massive and rounded *D. cornutus*. The molar teeth are no longer in the crown than those of *Metarhinus earlei*. The jugal process of the maxillaries arises at a point back of the last molar rather than beside it as in *D. longiceps*. There is no offset in the palate between the last molars, though the primary position of the posterior narial opening is marked by a slight rugosity.

D. fluminalis is most nearly related to *D. intermedius*. The skull exceeds in length the type of that species in the ratio of 520 : 465 mm. The molar teeth are proportionately much smaller; the series measures relatively 99 : 109 mm. The position of the posterior narial opening is the most distinctive character, appearing much farther back in *D. fluminalis* than in any other described species. The two forms agree more closely in the tapering form of the nasals and in the narrow recess separating them from the maxillaries.

MEASUREMENTS OF DOLICORHINUS. IN MILLIMETERS	<i>D. longiceps</i> , Type No. 2347 Carnegie Mus.	<i>D. cornutus</i> No. 12167 Field Mus.	<i>D. longiceps</i> Field Museum				<i>D. fluminalis</i> , Type No. 12205 Field Mus.
			No. 12175	No. 12176	No. 12193	No. 12200	
Skull, length incisors to condyles.....	545*	595	550	560*	530	535*	520
“ breadth across arches.....	260	285	247	255	240*	...	233
“ “ above orbits.....	...	...	134*	130	...	132	116
“ post-orbital process to condyles.....	310*	...	305	305	295	264	...
“ last molar to condyles.....	...	300	263	280	258	259	...
“ length of free nasals.....	152	...	170	160*	...	...	137
“ greatest breadth of nasals.....	81	...	79	...	...	...	57
“ post-glenoids to condyles (median line).....	...	140	122	121	115	114	...
“ length of molar-premolar series..	224	214	212	200	192	198	171
“ “ molar series.....	140	135	131	124	121	122	105
“ crown of canine.....	...	40	24	...	...	...	32
“ diameter crown of canine.....	...	22	17	...	16	...	18
“ length of diastema.....	15	16	14	...	23	...	...
“ narrowest point in sagittal area	40	...	52	40	45	54	44
“ breadth of orbito-nasal area....	...	...	...	67	...	...	...
Mandible, length condyles to incisors..	...	...	...	...	...	400	...
“ height, condyles above angle	...	...	...	...	...	159	...
“ length of molar-premolar series.....	...	...	...	...	...	209	...
“ length of molar series.....	...	...	...	...	...	123	...
“ crown of canine.....	...	...	...	...	...	29	...
“ diameter crown of canine....	...	...	...	...	...	16	...
“ depth of ramus from base of P ₃	...	...	...	...	...	70	...
“ depth of ramus from base of M ₃	...	...	...	...	...	57	...

* Estimated.

In its Uintah representatives *Dolichorhinus* is one of the most conservative of the titanotheres groups. Its greater specialization apparently occurred at an earlier date. The essential characters of the genus are well established in the earliest known representatives. Within its Uintah range there is comparatively little variation between those individuals which may be regarded as in the line of sequence.

D. longiceps is one of the most common Uintah species. It occurs in relative abundance in the upper half of Horizon A, less frequently in Horizon B. It has a known vertical range of 700 feet. In the lower horizon, in the vicinity of Section 1 (Fig. 1) this species was traced through a vertical series of 400 feet. The several specimens of *Dolichorhinus* collected from this locality all belong to one species. They display some variation in size and in structure. The variation in size is indicated by the length of skulls in millimeters (525-560). The smallest skull came from the top of the series, a larger one from near the base. There is a more noticeable variation in the size of canines, breadth of the premaxillary region and of the sagittal area. (See table of measurements.) These differences are evidently due in a great measure to sex. The type specimen described from Horizon B is similar in size to the larger specimens from Horizon A. The premaxillaries are broad, the alveolus indicates larger canines. In the development of horn-cores this species is less advanced than any other of the genus. There is a rounded angle over the eye in the vicinity of the fronto-nasal suture, but in no specimen observed is there a prominent excrescence or rugosity.

The type specimen of *D. cornutus** is a somewhat more highly specialized form than *D. longiceps*. This specialization appears in the greater breadth of the supra-cranial area, in the more highly developed horn-cores, and the elongation of the cranial, as compared with the facial, region. At the same time there are those elements of similarity between the two which suggest a common stock. The present writer would, therefore, regard the type of *D. cornutus* as a more advanced stage of the phylum which includes *D. longiceps*. This appears to be an indigenous line extending through the greater part of the Lower Uintah series.

The species *D. heterodon* and *D. fluminalis* must be regarded as aberrant forms. The former species as figured† shows no indication of the backward shifting of the posterior nares so characteristic in other species of the genus. If this figure of the nares is correct the great convexity in the supra-cranial region is the chief distinction between this form and *Mesatirhinus superior*. The position of the nares

* Bull. Amer. Mus., Vol. VII, p. 90.

† Annals Carnegie Mus., Vol. VI, p. 310.

would designate *D. heterodon* as a primitive form; the position assigned to it geologically indicates that it is the most recent yet described. It is apparently one of those rare forms, immigrants or adaptations under stress, which characterize the transitional stage.

D. fluminalis displays a high degree of specialization in the post-narial characters. The nares are bridged over so as to obliterate almost all evidence of their primary position. In this process the opening has receded to a point back of the hamular processes. This recession, noted in less degree in other species, is evidence of a secondary adaptation to aquatic habits of feeding. Other characters of the skull in this species would not indicate that this animal was aquatic in its general habits. Like many other terrestrial mammals it probably fed upon submerged plants. The slenderness and delicate modeling of the skull would suggest an animal lighter of limb and more active than other species of this genus. In the development of horns the type of this species is more advanced than the type specimen of *D. cornutus*. Its narrower sagittal area, its strongly recurved canines and much smaller molars readily distinguish it from that species.

RHADINORHINUS gen. nov.

Type species: *R. abbotti*.

Range: Metarhinus Beds, Middle Eocene.

Generic characters: Titanotheres with slender skulls, nasals deeply recessed laterally and tapering, molars long-crowned, P^2 , 3 , 4 , sub-rectangular, a wide median area between the incisors, no infra-orbital process. The name "Rhadinorhinus" alludes to the tapering nasals which characterize this genus.

R. abbotti, sp. nov.

Type specimen, No. 12179 Field Museum. (Pl. XI, Figs. 2-3).

Type Horizon: Upper Metarhinus Beds.

Specific characters: Length of skull 435 mm., molar-premolar series 168 mm., nasals shorter than premaxillaries, thickened at suture and tapering toward a terminal rugosity. Arches slender, posterior nares open opposite middle of M^2 . Sagittal crest long and narrow. Hypocone of M^3 vestigial, diastema short.

This interesting specimen was discovered by Mr. J. B. Abbott, in whose honor it is named. It indicates a form closely related to both *Mesatirhinus* and *Metarhinus*, but probably differing from them in habits. The skull is slighter in construction, the arches more slender and the teeth longer in the crowns throughout. The frontal region is

rounded, the post-orbital process elongate. The nasals are convex on the inferior surface owing to the thickening at the sutural line. The molar teeth are long in the crown having inner cones nearly equal in height to the ectoloph. The molar-premolar series is well preserved and unworn in the type specimen. The canines are broken at the alveolus; half of the incisors are preserved. The dentition as a whole is more highly specialized than that of *Metarhinus*. The first and second incisors have short, rounded, semi-conical crowns indented by cups on the posterior surface. The third incisor has a more elongate crown (23 mm.), the cup is suggested by a prominent cingulum on the posterior margin. An interval of six millimeters separates the third incisor from the canine. The latter is eighteen millimeters in diameter and circular at the alveolar section. The elongate third incisor would indicate a long-crowned canine. The first premolar is a simple, blunt cone with an internal cingulum and emplaced by two roots. Premolars ², ³, ⁴ increase steadily in length of ectoloph and deutercone; strong internal cingula persist. The last three have taken on the sub-rectangular outline indicating a stage in dental specialization similar to that of *Sthenodectes*. The molars are long-crowned; the protocone increases steadily in height from first to third. The hypocone is more prominent in the second and reduced to a vestige in the cingulum of the third. The entire molar-premolar series is more curved than in any other Uintah titanotheres.

In its general proportions the skull of *R. abbotti* is similar to that of *Metarhinus riparius*. Somewhat longer and more slender in the arches, the skull suggests a longer-limbed and more active animal. The facial and palatal aspects differ more widely. The anterior narial opening is high and the nasals are not infolded at the base. They terminate above the anterior margins of the canines. There is no antorbital fossa, the muzzle is broad and the canines evidently elongate.

R. diploconus.

Type specimen *Telmatotherium diploconum* Osborn.

Horizon: Uintah Metarhinus Beds.

This species should be removed from *Metarhinus* because of the highly specialized dentition associated with a narrow sagittal crest and the absence of an infra-orbital process. The absence of the nasals from the type specimen leaves its affinities somewhat in doubt. Until these shall be known it is proposed to refer the species to *Rhadinorhinus*. It differs from *R. abbotti* in having a more concave profile, somewhat larger molars and a well-developed hypocone on M³.

STHENODECTES Gregory

This generic name has recently been applied* to a form of short-headed, massive-jawed titanotheres known from the Amynodon Beds (Horizon B) of the Uintah. So far only three specimens have been recorded, all of which are from the same locality and belong to the same species.

A skull (No. 12165) and a pair of lower jaws (No. 12166) are included in the Field Museum collection. They were discovered by Mr. Abbott in the lenticular sandstones near Well 2 at the foot of Coyote Basin. The skull (Pl. XII, Figs. 1-2) is shorter than the type of *S. incisivum* but has the broad, low-crowned molars and massive incisors of that species. At approximately the same level and a half mile distant was found the mandible referred to this species. (Pl. XII, Fig. 3.) It belongs to an older individual, as is evident from the worn molars and incisors. The crowns of the incisors are almost worn away. The mandible is ten millimeters shorter than would be required to fit the skull, but the dentition matches closely. The molars have the strength necessary to oppose the massive upper series; the canines and incisors, though not so massive as those above, show such wear as would be expected in this form. The canines are worn away diagonally at the point of contact with the third upper incisor, but very little from contact with the upper canines. There is a short diastema between canines and premolars. The mandible as a whole is titanotheres-like — deep through the ramus, broad at the angle, concave in the tooth-line and tapering toward the anterior extremity. The coronoid is short and recurved at the tip.

* Science, Vol. XXXV, p. 546.

MEASUREMENTS OF RHADINORHINUS, MESATIRHINUS AND STHENODECTES IN MILLIMETERS	<i>Rhadinorhinus</i> <i>abbotti</i> , Type No. 12179 Field Mus.	<i>R. diploconum</i> , Type No. 1863 Amer. Mus.	<i>Mesatirhinus petersi</i> , Type No. 12184 Amer. Mus.	<i>Mesatirhinus superior</i> , Type No. 12168 Field Mus.	<i>Sthenodectes incisum</i> , Type No. 2398 Carneg. Mus.	<i>S. incisum</i> No. 12168 Field Mus.
Skull, length incisors to condyles	426	440	435	585	488	460
" breadth across arches	224	210*	215	240	305	300
" " between orbits	134	...	115	120	170	160
" post-orbital process to condyles	240	262	220	276	261	262
" last molar to condyles	196	...	210	260	197	190
" length of free nasals	102	...	95	138	...	...
" greatest breadth of nasals	...	...	...	68	64	...
" post-glenoids to condyles (median line)	88	...	...	...	74	86
" breadth across condyles	84	82*	...	...	89	101
" greatest depth of arch	38	...	...	36	...	...
" length of molar-premolar series	164	172	165	184	271	211
" " molar series	103	110	105	105	130	132
" " crown of canine	...	...	...	23	56	47
" diameter crown of canine	...	15	20*	18	25	27
" length of diastema	7	6	10	15	0	0
" narrowest point in sagittal area	4	...	...	26	...	...
" breadth of orbito-nasal area	46	47	...	52	94	...
LOWER JAWS						
Mandible, length condyles to incisors	...	...	...	...	...	360
" height, condyles above angle	...	...	...	...	...	168
" length of molar-premolar series	...	...	...	...	...	215
" length of molar series	...	...	...	...	...	130
" " crown of canine	...	...	...	...	...	30*
" diameter crown of canine	...	...	...	...	...	19
" depth of ramus from base of Pm. ₂	...	...	...	...	...	60
" depth of ramus from base of M ₃	...	...	...	...	...	84

* Estimated.

GENERIC RELATIONSHIPS

Under the subfamily *Dolichorhinæ* are included four genera which have in common the characteristics before designated. They are in general low ground or river forms although certain species suggest active habits. In most instances they bear evidence of incipient horn development but it is doubtful if any of these forms became true horn-bearing titanotheres. So far as is now known they die out with the close of the Washakie and the beginning of the Upper Uintah. However, there remains much to be learned of the titanotheres in their Upper Eocene development.

The most primitive genus included in this group is *Mesatirhinus*. This is evident from the molar and premolar pattern, the oblique position of the premolars in the series and the structure of the nasal and frontal region. The latter characters show affinities with *Palæosyops* to which group the type species was first referred. *Mesatirhinus* may therefore be regarded as standing in an ancestral relation to the other members of this subfamily, though there is little evidence that it actually gave rise to any of them. The relationships of the Bridger and Washakie members of the genus do not come within the province of this paper.

Metarhinus, as has already been observed, may be regarded as indigenous to the Uintah Basin. Its type specimen is the earliest mammal from this formation whose relationships have been determined. It attains a wide dispersal and becomes the most characteristic fossil in the lower subdivision of the Uintah Series. This genus in its most primitive Uintah representative is not far removed from the type and most primitive species of *Mesatirhinus*. As near as may be determined from the present limited knowledge of the lowermost Uintah fauna, the two type species are nearly contemporary. *Mesatirhinus* appears to be indigenous to the Bridger and Washakie basins, *Metarhinus* to the Uintah. Each, in its later development, is represented in the other's native formation by an immigrant species.

While the types of these two genera are similar in size and nearly contemporary, *Metarhinus* is in many ways more highly specialized. The dentition is more advanced in the general trend of titanother specialization, the nasal and facial region is likewise more specialized. On the contrary it retains in the high sagittal crest an equally primitive character which the most advanced species have not quite eliminated.

Dolichorhinus appears suddenly in the Lower Uintah Series as a highly differentiated form. It is earliest reported* from the Washakie

* Earle, Osborn Op. cit.

formation of a somewhat later stage and as an even more highly specialized form. It is thus a successor to *Mesatirhinus* in its geological range (Fig. 1), though *D. longiceps* occurs abundantly in the Uintah formation at a level 400 feet below the horizon from which the occurrence of *Mesatirhinus superior* is recorded. Members of these two species, though similar in size, have less in common than has the latter with *D. heterodon* of a later stage. These similarities are sufficient to suggest that *Dolichorhinus* probably sprang from some earlier and less specialized form of *Mesatirhinus*. The differentiations of the former may well have arisen with its adaptation to aquatic habits.

Rhadinorhinus apparently represents a side branch from the early *Metarhinus* stem. The facial and cranial regions and the zygomata are similar. The nasals indicate an early specialization in another direction. The dentition is more highly specialized than that of *Dolichorhinus* and in some respects resembles it. The posterior nares open a little farther forward than those of *Metarhinus*. The mere trace of an infra-orbital process also removes it somewhat from the long-nosed, low-ground titanotheres.

The broad-headed genus *Sthenodectes* appears in Horizon B as a well differentiated form. Its highly developed dental structure, short cranium and nasals offer only distant relationships with the more common Lower Uintah titanotheres. It would fall into another sub-family which should include the short-nosed, heavy-toothed forms which were evidently ancestors of the true horned titanotheres.

ACKNOWLEDGMENT

In the preparation of this publication Professor Osborn has accorded the writer the freest access not only to the type specimens, but also to the entire series of titanotheres collections brought together at the American Museum in the preparation of his forthcoming monograph on the Titanotheridæ. Dr. W. K. Gregory of the same Museum has given most valuable assistance in making comparisons and in furnishing unpublished data from these collections in order to facilitate identifications. Mr. O. A. Peterson of the Carnegie Museum has also furnished unpublished data from his field observations in regard to faunal horizons and other aids in establishing stratigraphic subdivisions. For these courtesies and aid the writer wishes to acknowledge his obligations.

Columnar Sandstone of Lower Metarhinus Zone exposed in the canyon of White River.

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EXPLANATION OF PLATE V

UPPER FIGURE

Green Clays capped by Amynodon Sandstone. Exposed at the northern boundary of Coyote Basin.

LOWER FIGURE

Fossil-bearing sandstone, Upper Metarhinus Zone, exposed on the divide between White River Canyon and Coyote Basin, in the vicinity of Section 2.

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EXPLANATION OF PLATE VI

MESATIRHINUS SUPERIOR, sp. nov., page 26.

Fig. 1. Side view of skull, type specimen.

Fig. 2. Top view of same.

Fig. 3. Palate view of same.

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EXPLANATION OF PLATE VII

METARHINUS RIPARIUS sp. nov., page 28.

Fig. 1. Side view of skull, type specimen.

Fig. 2. Upper view of jaws, cotype.

Fig. 3. Side view of same.

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EXPLANATION OF PLATE VIII

METARHINUS EARLEI, Osborn.

- Fig. 1. Side view of skull No. 12187, Field Museum.
- Fig. 2. Top view of same.
- Fig. 3. Palate view of same.

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EXPLANATION OF PLATE IX

- Fig. 1. Side view, skull of *Dolichorhinus longiceps*, No. 12175, Field Museum.
Fig. 2. Lower jaw of *D. longiceps*, No. 12200, Field Museum.
Fig. 3. Skull of *Metarhinus cristatus*, sp. nov., page 28.

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EXPLANATION OF PLATE X

DOLICHORHINUS FLUMINALIS sp. nov., page 33.

Fig. 1. Side view of skull, type specimen.

Fig. 2. Top view of same.

Fig. 3. Palate view of same.

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EXPLANATION OF PLATE XI

- Fig. 1. Lower jaw of *Metarhinus earlei* No. 12178, Field Museum.
Fig. 2. Skull of *Rhadinorhinus abbotti*, page 36.
Fig. 3. Top view of same.

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EXPLANATION OF PLATE XII

STHENODECTES INCISIVUM, Douglass.

- Fig. 1. Side view of skull and jaws.
- Fig. 2. Palate view of skull, No. 12168, Field Museum.
- Fig. 3. Upper view of jaws, No. 12166, Field Museum.

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