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EMBOLOTHERIUM, GEN. NOV., OF THE ULAN GOCHU, MONGOLIA^{1 2}

BY HENRY FAIRFIELD OSBORN

The Oligocene titanotheres discovered in the seasons of 1922 and 1923 were first described and figured in previous numbers of *Novitates* and are fully monographed in the appendix of the U. S. Geological Survey Monograph No. 55, "The Titanotheres of Ancient Wyoming, Dakota, and Nebraska," pp. 895-945 (now in press). They embrace genera and species discovered in three formations and life zones, as below. At the time it was thought that the Ardyn Obo formation (500 ft. in thickness, containing *Brontops gobiensis* and *Menodus mongoliensis* of supposed Lower Oligocene age) represented the close of the Titanotherium dynasty in Mongolia. Accordingly the succession of horizons given below (p. 2) was published in 1925-1927.

DISCOVERY OF TWO NEW FORMATIONS AND LIFE ZONES

The seasons of 1924 and 1925, however, closed with the discovery of two new and highly fossiliferous Oligocene formations on the Ulias-sutai-Sair Usu-Kalgan trail lying conformably above the Shara Murun formation; these formations were first described in field notes as *Upper Shara Murun*. The workings (Fig. 1, Sect. 4) at Ula Usu (1923-1925) yielded *Menodus mongoliensis* and *Brontops gobiensis* as of typical Oligocene age (Ardyn Obo formation); in August and September of the same year Granger notes at Ula Usu, in the formations "Shara Murun and Upper Shara Murun" titanotheres numbers 566 (hind foot), 569 (fore foot), 570 (fore foot), and 571 (front of skull), from "red beds" underlying the fossiliferous "gray beds" bearing titanotheres, also a titanotherium skeleton of *Dolichorhinus* type.

Titanotherium skeleton. Uncovered but not taken. *Dolichorhinus* type. The posterior portion of skull and jaws; the entire column back to the 8th caudal; the scapulæ, humeri, one femur and the pelvis, with all ribs of one side and several of the other side in the bank. Other parts evidently had been present but eroded

¹Preliminary popular description in *Natural History*, Vol. XXIX, No. 1, 1929, pp. 2-16.

²Publications of the Asiatic Expeditions of The American Museum of Natural History. Contribution No. 88.

THREE SUCCESSIVE TITANOTHERES—BEARING FORMATIONS OF MONGOLIA

Formation	Estimated Thickness	Geographic Region	Life Zone	Probable or Estimated Age
Ardyn Obo	<i>Feet</i> 500	Uliassutai trail	Brontops gobiensis zone; Menodus mongoliensis	Lower Oligocene
Shara Murun	500	Uliassutai trail	Protitanotherium mongoliense zone; Dolichorhinus, Telmathierium, Manteoceras	Summit of Eocene. Titanotheres very abundant
Irdin Manha	40-100	Iren Dabasu basin	Protitanotherium grangeri zone; Dolichorhinus elseni, Telmathierium berkeyi.	Upper Eocene. Titanotheres present

away. Bone very soft; vertebral centra rather badly flattened. No teeth. Found by Dr. Loucks in red clays west of camp at Ula Usu—1 mile. August 15th. 5×7 photograph taken. Vertebral formula: 7:17:4:3:8+.

[Field No.] 573 Miscell. Mammals. From various points along the northeastern face of the Ula Usu peneplane—mostly from two pockets, four and eight miles north of Baron Sog Lamasery. August 16—Party. As far as possible only such bones as come from the lower gray beds (true Shara Murun) are recorded under this number.

[Field No.] 574 Artiodactyl. Upper teeth and foot bones. Aug. 18—Olsen. From Upper Red beds [=Ulan Gochu formation].

[Field No.] 575 Miscell. Mammals etc. From an upper horizon exposed along the eastern face of the peneplane from the Baron Sog Lamasery northward for 4 miles [Baron Sog beds]. Probably Oligocene (light gray beds). August—Party.

From the above citations, to be compared with figures 1 and 2 and Granger's "Record of Fossils, Mongolia, 1925," pp. 43–66, it appears that Granger in 1925 discovered and clearly demarcated *two new and rich faunal horizons* without naming them, i.e., the *Baron Sog* and the *Ulan Gochu*. He also recognized as a new form of titanotheres the anterior portion of a cranium (Field No. 595, Amer. Mus. 21610—Figs. 9, 10), discovered in the base of the "upper red beds," four miles north of Baron Sog, to which in the present *Novitates* is assigned the name *Embolotherium loucksii*, in honor of Dr. Harold Loucks, the discoverer of this unique specimen. This bears the inscription (Granger's "Record of Fossils, Mongolia, 1925," p. 56):

[Field No.] 595 Horned Perissodactyl. Portion of skull with horn and last molar tooth of right side. From base of Upper Red Beds [=Ulan Gochu] 4 miles north of Baron Sog Lamasery. Sept. 2—Granger. Found by Loucks. [= *Embolotherium loucksii*.]

These two new faunal horizons are:

Baron Sog Formation (Granger, 1925, 1928). Estimated thickness 35 feet, containing numerous new and undescribed baluchitheres—Field Nos. 731, 732, 744, 745, 753, 773, and 780, also undescribed entelodonts, lophiodonts, rhinocerotids, chalicotheres, etc. No record of titanotheres or embolotheres.

Ulan Gochu Formation (Granger, 1925, 1928). Estimated thickness min. 132 feet, max. 195 feet; containing embolotheres—Field Nos. 595 (type of *Embolotherium loucksii*), 750 (type of *Embolotherium andrewsi*), 735 (*Embolotherium andrewsi* ref.), 708 (*Embolotherium andrewsi* ref.), 770 (type of *Embolotherium grangeri*), 756 (*Embolotherium grangeri* ref.), and 673 (*Embolotherium grangeri* ref.); also numerous undescribed embolotheres—Field Nos. 740, 741, 742, 746, 751, 755, and 782, as well as undescribed lophiodonts, rhinocerotids, artiodactyls, and carnivores. No baluchitheres thus far certainly recorded.

A *sharp unconformity* (Fig. 2, Sects. 1, 2, 3) between the Ulan Gochu (oblique shading) and the overlying Baron Sog indicates that a long interval in geologic time elapsed between these two formations.

During this interval may possibly have occurred to the east (Houldjin) and to the northwest (Hsanda Gol) the deposition (3,000 ft.) of the Hsanda Gol and (30 ft.) of the Houldjin (*Baluchitherium grangeri* zone), because both Andrews and Granger believe that the undescribed *Baluchitherium* sp. of the Baron Sog formation belongs to a specific and perhaps generic stage more advanced than *Baluchitherium grangeri*.

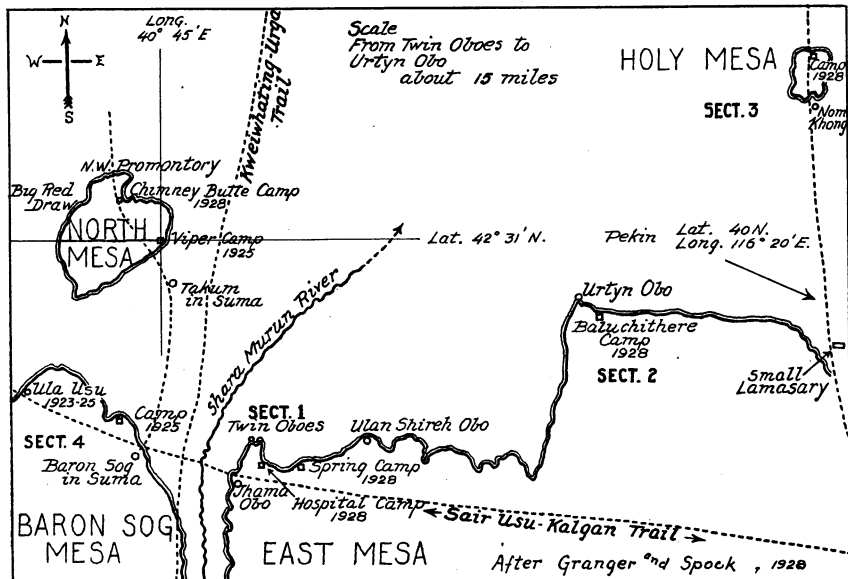
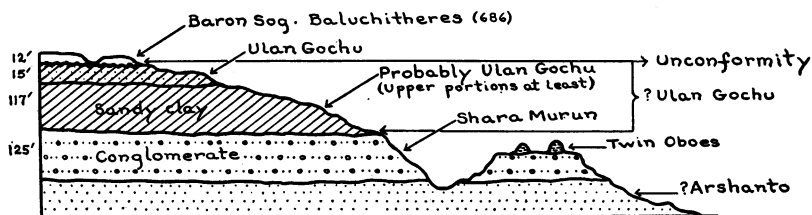


Fig. 1. Sketch map by Granger and Spock (1928) along the Sair Usu-Kalgan trail, 15 miles east and west, displaying exposures of typical Shara Murun, and 'upper Shara Murun' or the new 'Ulan Gochu' and 'Baron Sog' formations explored by the American Museum parties of the years 1924-1925 and 1928. After sketch by Walter Granger.

From the summit of the Ulan Gochu downward there are no apparent breaks. Granger writes (letter, Peking, December 31, 1928):

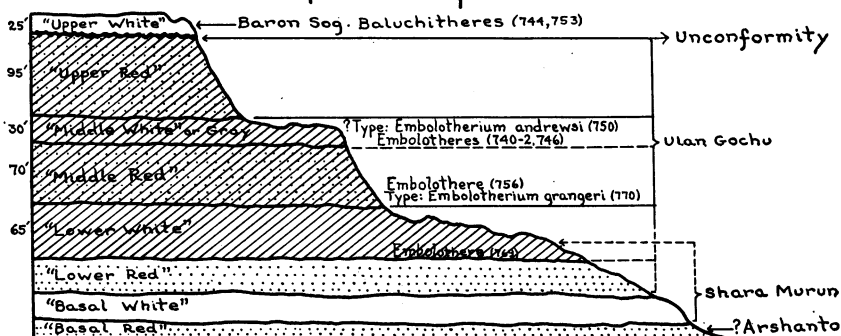
You will notice from these sections [Fig. 2] that we have no sharp line between the Ulan Gochu beds and the Shara Murun. The geologists have not been able to discover any stratigraphic break between the top and the base of these Eocene sediments of the Shara Murun region and we have set off the 'Ulan Gochu beds' from the 'Shara Murun' on the basis of faunal change only. I have used the name, 'Ulan Gochu,' to cover such strata as contain the new type of titanotherium [*Embolotherium loucksii*], and certain advanced artiodactyls which do not occur in the typical Shara Murun of Ula Usu. The whole fauna of these Ulan Gochu beds will probably show a



Section through East Mesa at Twin Oboes.

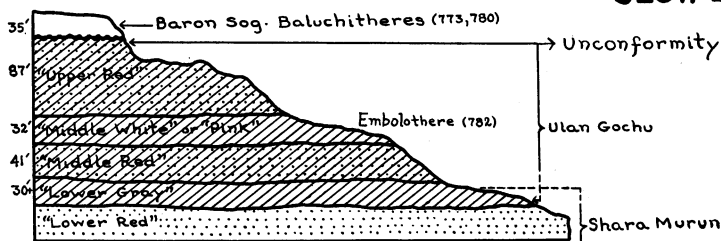
Hospital Camp.

SECT. 1



Section at Urtyn Obo. Baluchithere Camp.

SECT. 2



Section at Nom Khong Shireh.

SECT. 3

Holy Mesa Camp.

After Granger and Spock

Fig. 2. Sections through the Shara Murun, Ulan Gochu, and Baron Sog formations at the points indicated in figure 1. After sketch by Walter Granger. Theoretic limits of the 'Ulan Gochu' formation, Embolotherium zone, in oblique shading.

Sect. 1. Through East Mesa at Twin Oboes, Hospital Camp (1928).

Sect. 2. At Urtyn Obo, Baluchithere Camp (1928), type locality of *Embolotherium andrewsi* and of *E. grangeri*.

Sect. 3. At Nom Khong Shireh, Holy Mesa Camp (1928).

There is a sharp unconformity and erosional interval between the *Ulan Gochu* and overlying *Baron Sog*. The *Ulan Gochu* passes insensibly below into the *Shara Murun*.

distinct advance over that of the Shara Murun beds but I have just used these two as guide fossils. One titanotheres skull from the Ulan Gochu beds (No. 742) is not of the *Embolotherium* type but is much like your *Brontops gobiensis* from the Ardyn Obo beds and I have been wondering if we do not have in the Shara Murun region sediments a transition, without break, from the Eocene to the Oligocene.

The discovery of these two new formations reveals a survival of the titanotheres in Mongolia, after their extinction in America, and renders probable a new theoretic sequence of life zones as below (p. 7).

THE ULAN GOCHU OR EMBOLOTHERIUM LIFE ZONE

The present *Novitates* is based upon eight specimens only, referable to three very distinct species of *Embolotherium*. Other specimens when received may reveal relationships to *Brontops gobiensis* or to other Lower Oligocene titanotheres such as *Menodus*. The characterizations are in a high degree preliminary.

As shown in Fig. 2, Sect. 2, at Urtyn Obo, the levels are divided as follows:

95' "Upper Red." *Embolotherium* No. 673. (Base of: *Embolotherium loucksii* type.)

30' "Middle White" or "Gray," or "Pink." *Embolotherium andrewsi* type (No. 750), *E. andrewsi* ref. (No. 708), also *Embolotherium* (Nos. 740-742, 746).

70' "Middle Red." *Embolotherium grangeri* type (No. 770), also *Embolotherium* (No. 756).

65' "Lower White." *Embolotherium* (No. 683).

The levels of all the *Embolotherium* and other titanotheres remains have been carefully recorded and the vertical succession and evolution of the species will doubtless become evident and clear when the entire collection can be examined. Some of the specimens labeled "Titanotheres" may prove to belong to other genera than *Embolotherium*.

All the remaining embolothere specimens, besides the eight herein described, have been prepared in the laboratory at Peking and are now on their way to the American Museum. We had hoped to receive these fossils in order to make the preliminary description more complete, but the long delay has compelled the writer to base his present description and figures on the materials in hand and on photographs and data relating to the specimens in Peking, kindly forwarded by Mr. Granger.

Fig. 3. Comparison of type crania.

Fig. 4. *Embolotherium andrewsi* type (Amer. Mus. 26001). After original.

Fig. 5. *Embolotherium andrewsi* ref. After photograph.

Fig. 6. *Embolotherium andrewsi* ref. Skull presented to the Chinese Geological Survey Museum.

NEW THEORETIC SEQUENCE (1929) OF MIDDLE OLIGOCENE TO UPPER EOCENE FORMATIONS

Formation	Estimated Thickness	Geographic Region	Life Zone	Probable or Estimated Age
Baron Sog Hsanda Gol Houldjin Ulan Gochu Ardyn Obo Shara Murun Irdin Manha	<i>Feet</i> 35 3,000 30 {Min. 132 Max. 195 500 500 40-100	Uliassutai trail Eastern Altai Iren Dabasu basin Uliassutai trail Uliassutai trail Uliassutai trail Iren Dabasu basin	Baluchitherium n. sp. Baluchitherium grangeri zone Baluchitherium grangeri? zone Embolotherium andrewsai zone; E. loucksi, E. grangeri Brontops gobiensis zone; Menodus mongoliensis Protitanotherium mongoliense zone; Dolichorhinus, Telmathierium, Manteoceras Protitanotherium grangeri zone; Dolichorhinus olseni, Telmathierium berkeyi	Lower and Middle Oligocene Lower and Middle Oligocene Lower and Middle Oligocene Extinction of titanotheres Lower Oligocene Summit of Eocene. Titanotheres very abundant Upper Eocene. Titanotheres present

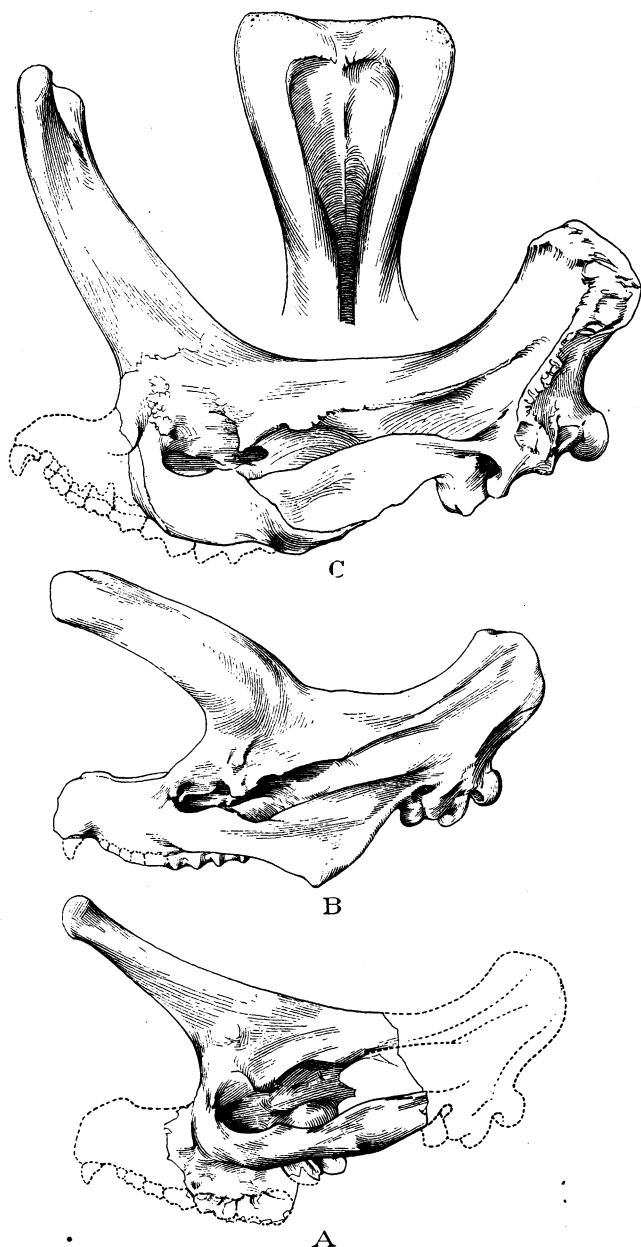


Fig. 3. Comparison of type crania of:
 C, *Embolotherium andrewsi* type (Amer. Mus. 26001, Field No. 750).
 B, *Embolotherium grangeri* type (Amer. Mus. 26002, Field No. 770).
 A, *Embolotherium loucksii* type (Amer. Mus. 21610, Field No. 595).
 One-tenth natural size.

Fig. 7. *Embolotherium grangeri* type (Amer. Mus. 26002). After photograph of cranium from Peking laboratory. *Embolotherium grangeri* ref. After photograph from Peking laboratory.

Fig. 8. *Embolotherium grangeri* ref. After photograph from Peking laboratory.

Fig. 9. *Embolotherium loucksii* type (Amer. Mus. 21610). After original.

Fig. 10. Photographic view of same.

EMBOLOTHERIINÆ, subfam. nov.

One of the most surprising results of the Fifth Central Asiatic Expedition of the season of 1928, under the leadership of Roy Chapman Andrews and Walter Granger, was the discovery of an entirely new type of titanotheres.

The subfamily Embolotheriinae, typified by the characters observed in three distinct species of *Embolotherium*, probably represents a purely Asiatic phylum, no members of which have thus far been discovered in North America; nor do the three species of *Embolotherium* herewith described from the Ulan Gochu formation seem to be related to the titanotheres discovered in the three older geologic formations previously described; they appear rather to represent immigrants into the central Gobi region, whose ancestors lived farther north in central Asia.

In all, at least fourteen individual specimens of *Embolotherium* were found in the Ulan Gochu formation associated with the remains of lagomorphs and other rodents, carnivores, creodonts, hyænodonts, rhinocerotids, lophiodonts, and entelodonts characteristic of Lower to Middle Oligocene age. As shown in three sections (north of the bluffs on the Sair Usu-Kalgan trail, lat. 42° 31' N.) prepared by Granger and Spock (Fig. 2), the Ulan Gochu formation has a thickness of 132 feet at Twin Oboes, 195 feet at Urtyn Obo, and 190 feet at Holy Mesa, thus representing a long period of geologic time.

EMBOLOTHERIUM, gen. nov.

Genotypic species *Embolotherium andrewsi*, sp. nov.

GENERIC CHARACTERS.—Premaxillaries elongate (*Embolotherium grangeri*), reduced (*E. andrewsi*); elevated anterior bony protuberances or nasal horns expanded at the summits, moderately broad (*E. loucksii*), extremely broad (*E. andrewsi*); frontals normal not entering into nasal protuberances. Broad postorbital expansion of vertex; zygomata extremely broad. Premolars with prominent tetartocones and partly separate metalophs; M 3 with prominent hypocone (*E. andrewsi*).

The generic name *Embolotherium* is given in reference to the unique structure of the forward portion of the cranium. The name is derived from the Greek ἐμβολή, "battering ram." As the 'brontothere' used

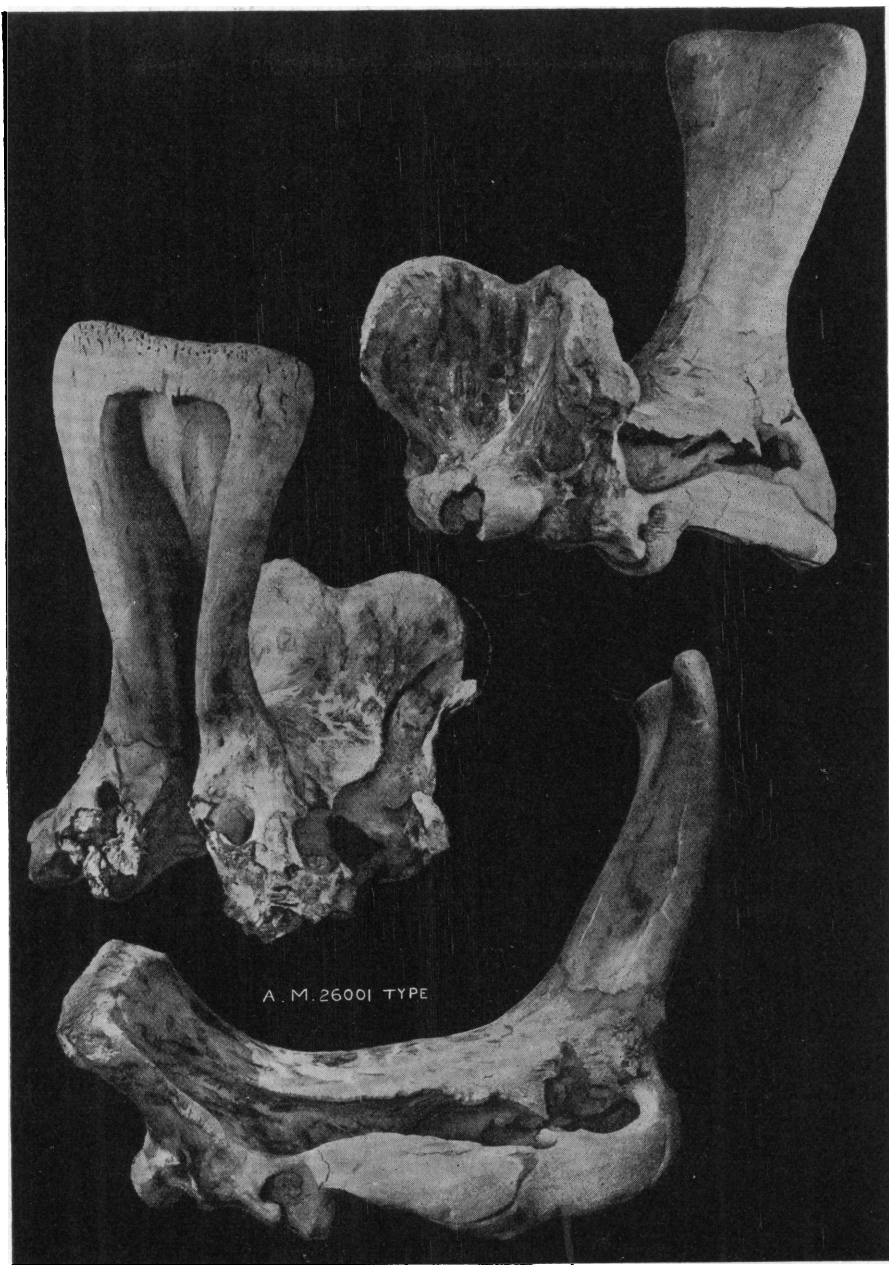


Fig. 4

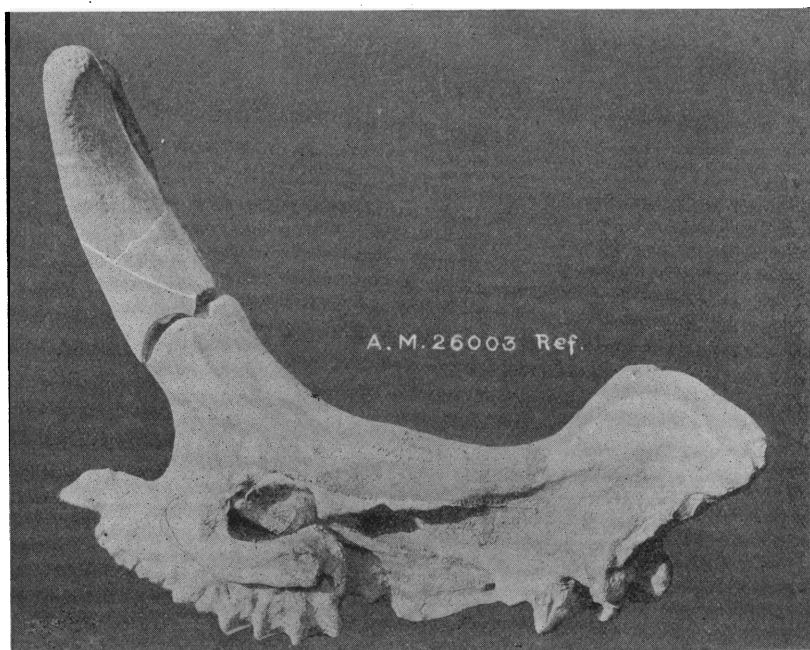


Fig. 5. *Embolotherium andrewsi* Osborn, ref. Field No. 735, 1928 Coll., Amer. Mus. 26003. Ulan Gochu formation, Urtyn Obo section, level unrecorded. Adult cranium of very large size, length from tips of complete premaxillaries to occipital crest, 940 mm. or 3 ft. 1 in. Prepared in the Peking laboratory and repasted for shipment. One-tenth natural size.

Fig. 4. *Embolotherium andrewsi* Osborn, type. Field No. 750, 1928 Coll., Amer. Mus. 26001. Ulan Gochu formation, Urtyn Obo section, "middle white" or "gray" beds, 125 ft. below Baron Sog unconformity. Cranium with maxillary rostrum wanting, dentition damaged, lateral, oblique, posterior, and anterior aspects. One-tenth natural size. Compare figure 6.

PRINCIPAL MEASUREMENTS

Length:	
Summit of nasals to summit of occipital crest.....	1028 mm.
Base of nasals to back of occipital crest.....	852
Auditory opening to front border of orbit.....	518-532
Height:	
Occipital condyles to occipital crest.....	370
Lacrymal foramen to summit of nasals.....	594
Width:	
Maximum width of nasals.....	342
Minimum width of nasals.....	180
Transverse of zygomatic arches.....	318
Transverse of occipital crest.....	440
Transverse of occipital condyles.....	194

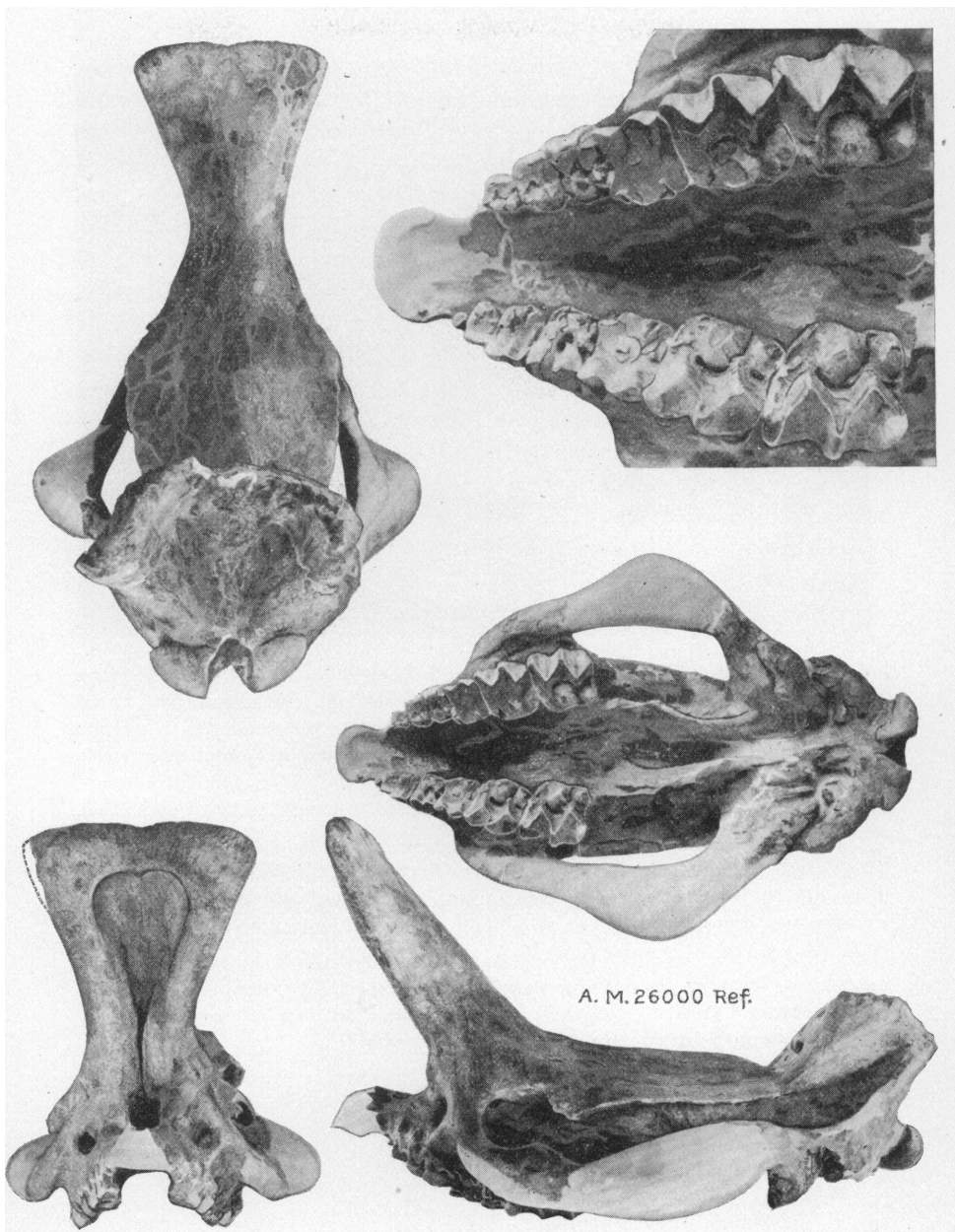


Fig. 6

its horns in tossing, the 'embolothere' used its horns for battering, assaulting, attacking, and tossing. Hence the name "battering-ram-nosed titanothere" seems appropriate. From the front part of the face there arises a single bony horn, of completely novel form, composed of elongated and uplifted nasal bones; these bones are supported on a firm base of the frontals and maxillaries. In the genotypic species, *Embolotherium andrewsi*, the nasal horn rises to a height of 28 inches (Fig. 4) and expands very broadly at the summit into a rugose bony prominence, on the under surface of which is an upward extension of the anterior nares. This single nasal protuberance is totally different in structure from the paired frontonasal bony horn of all previously known titanotheres as shown by comparison with the frontonasal horn in the juvenile skull of *Brontops brachycephalus* or with that in the adult skull of *Brontotherium platyceras*. This profound structural difference was not realized until the juvenile skull of *E. andrewsi* revealed this wide contrast between *Embolotherium* and *Brontotherium*.

***Embolotherium andrewsi*, sp. nov.**

TYPE.—Amer. Mus. 26001, figure 4. Cranium with maxillary rostrum wanting, dentition damaged.

LOCALITY.—East Mesa, "middle white" or "gray" beds, Mongolia.

HORIZON.—Ulan Gochu.

SPECIFIC CHARACTERS.—Premaxillo-maxillary rostrum reduced, abbreviate, bony horn rising above and anterior to the orbits, extremely broadened at the summits, infolding nasal chamber inferiorly. Known from three complete crania and other specimens found in the levels of the Ulan Gochu formation.

Fig. 6. *Embolotherium andrewsi* Osborn, ref. Field No. 708, 1928 Coll., Amer. Mus. 26000. Ulan Gochu formation, channel deposit, Ulan Shireh Obo section, top of "gray" beds or of "middle white" beds. Fully adult skull with complete nasals and fractured rostrum, and finely preserved grinding teeth. Presented to the Chinese Geological Survey Museum, December, 1928. Superior, anterior, lateral, and palatal aspects. One-tenth natural size.

PRINCIPAL MEASUREMENTS

Length:	
Premaxillæ to condyles.....	780 mm.
Occipital crest to center of nasal tip.....	770
Lacrymal process of orbit to tip of nasals.....	370
Premolar-molar series, P 1-M 3.....	310
Width:	
Transverse of nasal extremities.....	260
Transverse across zygomatic arches.....	500
Vertex across postorbital process.....	310

This superb animal, as fully represented in figures 4, 5, and 6, constitutes one of the greatest surprises in the long palæontologic history of the titanotheres, because it differs from all previously known forms in the single rather than the paired structure of the bony horn and in its composition, which is clearly shown in the young individual (Amer. Mus. 26040, *E. grangeri*), see figure 8. Whereas in all other titanotheres the bony horn arises from the frontals, overlapping the nasals which are gradually reduced in size, in the present animals no frontal horn is known to have developed, but the nasals (*Na*) composed the entire anterior prominence, carrying forward on the lower surface (Figs. 3, 4 and 8) the prolongation of the anterior nares. In brief, in all previously known titanotheres the frontals form the chief element in the horn and the nasals are reduced; in these embolotheres a complete change of function takes place, i.e., the nasals form the anterior bony horn. There was much speculation about this by the author and by Dr. W. K. Gregory and others until a photograph of the juvenile skull of *Embolotherium grangeri* reached the Museum, which appeared to settle the question.

Such bony composition of the nasal horn is apparently characteristic of all three species, which, however, differ widely in the shape of the horn and in the abbreviation (*E. andrewsi*) or elongation (*E. grangeri*) of the premaxillary rostrum.

In *Embolotherium andrewsi* we apparently have the most extreme stage of embolothere development, in which the single horn is the longest, widest, and most prominent and the premaxillaries are the smallest and most reduced, as shown in the referred specimen of *E. andrewsi* (Amer. Mus. 26003) represented in figure 5, after photograph in the pasted condition in the Peking laboratory.

***Embolotherium grangeri*, sp. nov.**

TYPE.—Amer. Mus. 26002, figure 7 (upper). Cranium with elongated rostrum.

LOCALITY.—East Mesa, "middle red" beds, Mongolia.

HORIZON.—Ulan Gochu.

SPECIFIC CHARACTERS.—Maxillo-premaxillary rostrum elongate, nasal bony horn extending upward and forward, slightly recurved on lower surface, with convex superior border, arising from mid-cranium somewhat posterior to orbit. Zygomatic arches very broad; summit of nasal protuberance moderately broad. Known from the type and other individuals found in the upper levels of the Ulan Gochu formation.

The present species is readily distinguished from *Embolotherium andrewsi* by three characters: (1) The elongation of the maxillo-premaxillary rostrum; (2) the elevation of the horn from the middle region of the cranium somewhat posterior to the orbits, whereas in *E.*

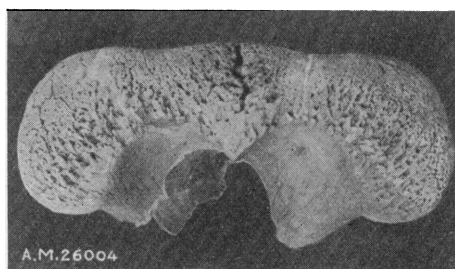
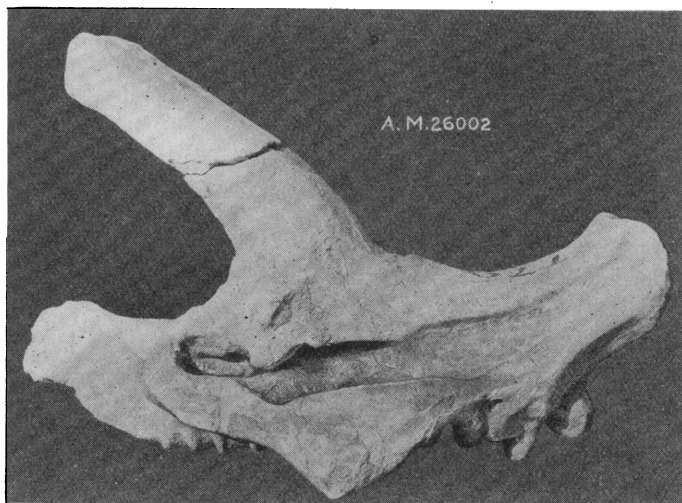


Fig. 7. (Upper) *Embolotherium grangeri* Osborn, type. Field No. 770, 1928 Coll., Amer. Mus. 26002. Ulan Gochu formation, Urtyn Obo section, base of "middle red beds," 195 ft. below Baron Sog, 65 ft. above Shara Murun. Type cranium with elongated rostrum, as prepared in the Peking laboratory and repasted for shipment. One-tenth natural size.

Fig. 7. (Lower) *Embolotherium grangeri* Osborn, ref. Field No. 756, 1928 Coll., Amer. Mus. 26004. Ulan Gochu formation, Urtyn Obo section, "middle red beds." A complete skull base with top weathered off; tip of nasals with median suture and heavy septum ridge; heavy rugose extremity, partly cartilaginous in this young individual (M^3 slightly worn). One-fifth natural size. Discovered on the level of *E. grangeri* type.

andrewsi the horn rises directly above the orbits as in other progressive genera of the titanotheres; and (3) the bony horn of *E. grangeri* presents a downward and forward curvature, being concave on the lower surface and convex on the upper or posterior surface, whereas in *E. andrewsi* the horn is convex anteriorly and concave posteriorly, as in the genus *Brontotherium*. As shown in side view the type of *E. grangeri* is a considerably smaller animal than *E. andrewsi*.

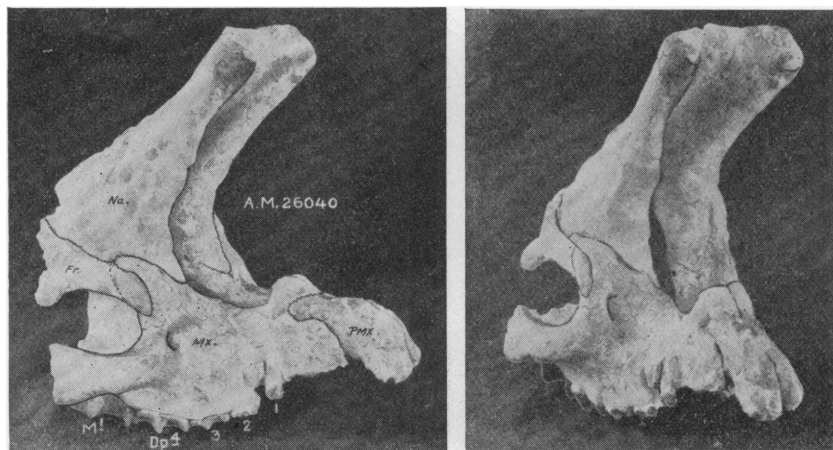


Fig. 8. *Embolotherium grangeri* Osborn, ref. Field No. 673, May 7, 1928 Coll., Amer. Mus. 26040. Ulan Gochu formation, Twin Oboes section. Juvenile cranium exhibiting sutures of *Na.*, *Fr.*, *Mx.*, *Pmx.*, in oblique frontal and lateral aspects. Lower edge of left nasal has been crushed downward and inward. About one-tenth natural size.

***Embolotherium loucksii*, sp. nov.**

TYPE.—Amer. Mus. 21610, figures 9 and 10. Anterior portion of adult cranium, female (?).

LOCALITY.—Base of "upper red beds," 4 miles north of Baron Sog Lamasery, Mongolia.

HORIZON.—Ulan Gochu.

SPECIFIC CHARACTERS.—Premaxilla elongate, nasal protuberance with upward and forward curvature arising from middle portion of vertex and directly above orbits, straight superior border, relatively narrow at summit. Known from type specimen only.

This specimen is the first one discovered and was at once recognized as a very peculiar animal, in fact, it proved to be difficult to compare it with other titanotheres because it was obvious that the composition of the bony horn was entirely different. As admirably represented in figures

9 and 10, the nasal horn prominence rises directly above the orbits and extends directly forward and upward, unlike the recurved horn of *Embolotherium andrewsi* or the decurved horn of *E. grangeri*. On the inferior surface, as shown in figure 9, the lateral portions of the nasals are brought together and the very broad narial channel observed in *E. andrewsi* (Fig. 4) is wanting; the anterior nasal opening is correspondingly reduced; the nasal bony horn terminates in a rounded club-shaped expansion, quite different from the broad plate characteristic of *E.*

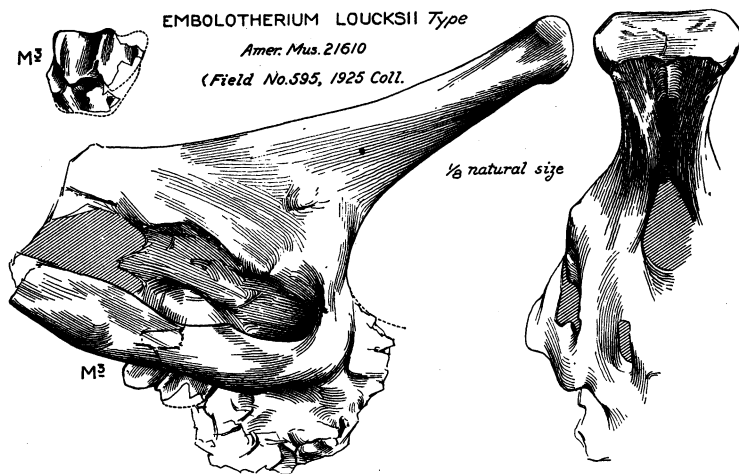


Fig. 9. *Embolotherium loucksii* Osborn, type. Field No. 595, 1925 Coll., Amer. Mus. 21610. Ulan Gochu formation, base of "upper red beds," four miles north of Baron Sog. Anterior portion of adult cranium, female (?). One-eighth natural size. See Fig. 10.

andrewsi. As further shown in the photograph of the type (Amer. Mus. 21610—Fig. 10) the nasal horn rises directly above and anterior to the orbits, instead of behind the orbits as in *E. grangeri*. It would appear that the premaxillary rostrum is elongated, but this point is difficult to determine in the specimen now in hand.

A striking fact is that the type of *Embolotherium loucksii* (Field No. 595, 1925 Coll., Amer. Mus. 21610) is reported by Granger as from the base of the "upper red beds," four miles north of Baron Sog. From this it would appear that the geologic level is about the same as that of *E. andrewsi*, although it may be hazardous to correlate these two levels at present.

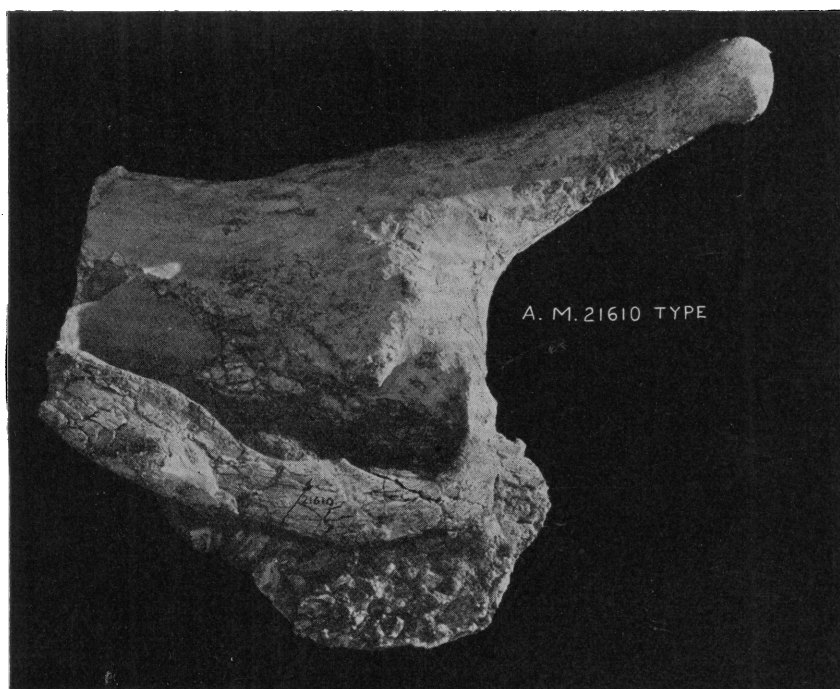


Fig. 10. *Embolotherium loucksii* Osborn, type. Field No. 595 (Amer. Mus. 21610). One-sixth natural size. See Fig. 9.

PRELIMINARY CONCLUSIONS

From the fundamental differences in cranial structure of the three species of *Embolotherium* above described, it seems without doubt that we have to do with three different subphyla of the genus *Embolotherium*, because it is certain that *E. loucksii* cannot be ancestral to *E. grangeri*, nor can either of these species be ancestral to *E. andrewsi*. Pending corroboration of this conclusion by the study of more complete materials, it appears that the Embolotheriinae embrace at least three different phyla, which, when we come to examine their dental structure, may prove to be of different generic rank. This preliminary notice may close with a citation from the first announcement of the discovery of this extraordinary new branch of the titanotheres family (see footnote, p. 1):

FIRST: Titanotheres, of Lower Oligocene age. Whereas in the Rocky Mountain region titanotheres reached their climax in the giant pair-horned *Brontotherium platycerus* of the Lower Oligocene, they survived and attained a superclimax in the

still larger and more unique battering-ram-nosed *Embolotherium* (Greek ἐμβολή, signifying 'a battering ram') of the Oligocene of the Desert of Gobi. This animal somewhat exceeds in size the largest *Brontotherium* ('flat-horned thunder beast') of North America and develops in the front part of its face an entirely novel nasal battering ram composed of combined nasal and frontal bones. As the 'bronto-



Fig. 11. Preliminary restoration of *Embolotherium andrewsi* based upon the structure of the cranium only. The other portions of the neck and body are restored with the characters of *Brontotherium platyceras*. About one-twentieth natural size.

therium' used its horns in tossing, the 'embolothere' used its horns for battering, assaulting, attacking, charging, and tossing. This bony horn rose 28 inches in the very front part of the face and was broadly expanded at the summit. . . . Roy Chapman Andrews informs us (August 22, 1928) that the ram-nosed titanotheres

'are from the Ulan Gochu region, probably Middle Oligocene, and belong to the same group as the front portion of the skull found in the Shara Murun by Harold Loucks in 1925, although the new skulls are much larger than the Loucks specimen and are comparable to the largest of our American Oligocene titanotheres. There are no true horns but the frontal and nasal bones are produced upwards and terminate in a transversely broad blunt and rugose end. Fully as impressive as our finest American skulls, they surely represent a distinct phylum of titanotheres.'

From the absence of any trace of embolotheres in previously described formations (Ardyn Obo, Shara Murun, and Irdin Manha) it would appear that they were from the first a separate branch of the superfamily Titanotherioidea, which developed in the plains region to the north of the Gobi Desert and finally migrated toward the end of Lower Oligocene time as far south as the southern Gobi where we meet their remains in great abundance and where they attained surpassing size and diversity. It also appears at present, but awaits corroboration, that they succeeded or replaced the genera and species of titanotheres common to the Asiatic and American plains, namely, *Brontops* and *Menodus*.