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Gomphotherium wimani from Wushan County, China, and its implications for the Miocene stratigraphy of the Tianshui area

WANG Shi-Qi[1]　LIU Shan-Pin[2]　XIE Guang-Pu[3]　LIU Jia[2]
PENG Ting-Jiang[2]　HOU Su-Kuan[1]

(1 *Key Laboratory of Vertebrate Evolution and Human Origin of Chinese Academy of Sciences, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences* Beijing 100044 wangshiqi@ivpp.ac.cn)

(2 *Key Laboratory of Western China's Environmental Systems* (*Ministry of Education*), *Research School of Arid Environment & Climate Change, Lanzhou University* Lanzhou 730000)

(3 *Gansu Provincial Museum* Lanzhou 730050)

Abstract　A fragmentary juvenile mandible referable to *Gomphotherium wimani* is described in this report. It was discovered at the Nanyucun Locality, Simen Township, Wushan County, Tianshui area, Gansu Province. Both the left and right p3, dp4, and m1 are completely preserved in this specimen. The cheek teeth show characters that are derived within the genus *Gomphotherium*, such as anteroposterior compression of lophids associated with wide interlophids, presence of weak posttrite central conules, multiplication of mesoconelets and central conules, and weak cementation. These features are consistent with the diagnosis of *G. wimani*. *G. wimani* was originally discovered in the Middle Miocene of Gansu, and the fossiliferous horizon within the Nanyucun exposures that yielded *G. wimani* can be correlated with strata at neighboring Middle Miocene localities. Therefore, the *G. wimani* horizon at Nanyucun should be dated to the Middle Miocene. In combination with palynological data, the discovery of *G. wimani* at the Nanyucun Locality implies that the paleoenvironment of the Tianshui area in the Middle Miocene was probably relatively warm and humid, suitable for large populations of brachyodont mammals such as gomphotheres.

Key words　Tianshui area, Gansu; Middle Miocene; proboscidean, *Gomphotherium wimani*; biostratigraphy

1　Introduction

Gomphotherium is an extinct proboscidean genus. The genus represents a critical intermediate between the ancestral *Phiomia* and derived elephantoids in the context of proboscidean evolution (Andrews, 1906; Maglio, 1973; Shoshani and Tassy, 2005; Tassy, 1996a). This genus first appeared in Chilga, Ethiopia, eastern Africa during the Late Oligocene (Kappelman et al., 2003), entered Eurasia by the Early Miocene (Tassy, 1996b), and reached

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North America by the Middle Miocene (Lambert, 1996). During the Early-Middle Miocene, *Gomphotherium* was widespread throughout Africa and Eurasia, and the genus survived until the Late Miocene in America (Lambert, 1996). Because of its broad distribution and rapid evolution, *Gomphotherium* is usually considered a good basis for stratigraphic correlations (Qiu and Qiu, 1995).

In the present article, the term "gomphotheres" is used in a broad sense to refer to the Gomphotheriidae Hay, 1922, which is approximately equivalent to the bunodont-trilophodont mastodonts of Tobien (1973a). The genus name *Gomphotherium* is used in the narrow sense, referring to the stem-group long-jawed mastodonts that are closely related to the Oligocene *Phiomia* and ancestral to the elephantoids (Andrews, 1906; Maglio, 1973; Shoshani and Tassy, 2005; Tassy, 1996c). *Gomphotherium* is diagnosed by the oval or pyriform cross-section of the lower tusk and the presence of trilophodont intermediate cheek teeth (DP4, dp4, M1, m1, M2, and m2)(Tobien, 1973a); however, the lower tusks are often preservationally separated from the cheek teeth. In China (and elsewhere), numerous isolated gomphotheriid cheek teeth from Neogene strata have been identified as belonging to the genera *Gomphotherium*, *Trilophodon*, and *Serridentinus* (Chow and Zhang, 1974), the last two of which are now regarded as junior synonyms of *Gomphotherium* (Tobien, 1973a). However, these identifications are unreliable, as gomphotheres in the broad sense (including *Choerolophodon*, *Platybelodon*, *Sinomastodon*, and so on) share common cheek tooth characters with the genus *Gomphotherium*. In the present paper, we follow Tobien (1973a) and only consider cheek teeth showing gomphothere plesiomorphies (having large simple conules, without secondary trefoils on the posttrite half-lophids) to be referable to *Gomphotherium*, which includes the species *G. annectens*, *G. angustidens*, *G. browni*, *G. osborni*, *G. productum*, *G. steinheimense*, *G. republicanum*, *G. mongoliensis*, *G. connexum*, *G. wimani*, and *G. shensiense*.

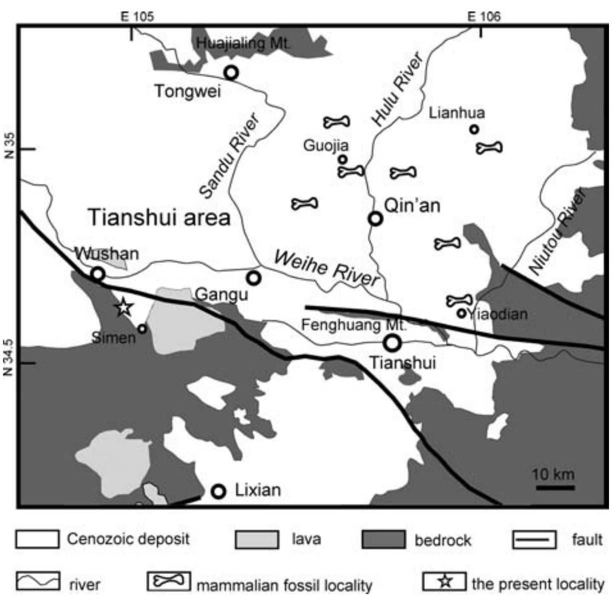

Fig. 1 Position of the fossil locality on a geological map of the Tianshui area

During recent field work in the Tianshui area, a juvenile gomphotheriid mandible was collected. The specimen was discovered in the Neogene strata of the Nanyucun Locality, which is situated in the northern part of Simen Township, Wushan County (Fig. 1). The mandible is interpreted as that of a derived species of *Gomphotherium*, and is referable to *Gomphotherium wimani*. The specimen not only provides sufficient information to allow it to be identified, but also contributes new data on the morphology of the genus.

Descriptions of occlusal structures

of gomphotheriid cheek teeth, and mandibular measurements, given in this paper follow the terminology and conventions established by Tassy (1996c:fig. 11.2).

Institutional abbreviations IVPP, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing; LZU, Key Laboratory of Western China's Environmental Systems (Ministry of Education), Research School of Arid Environment & Climate Change, Lanzhou University, Lanzhou; PMU, Palaeontological Museum, Uppsala.

2 Geological settings

The fossil was found embedded in a steep slope forming one side of a small gully known as the Nanyucun Locality (N34°40'7.5", E104°57'52.2", Fig. 1). The Nanyucun section (Fig. 2) is up to 235 meters in thickness, and is divided into 21 layers.

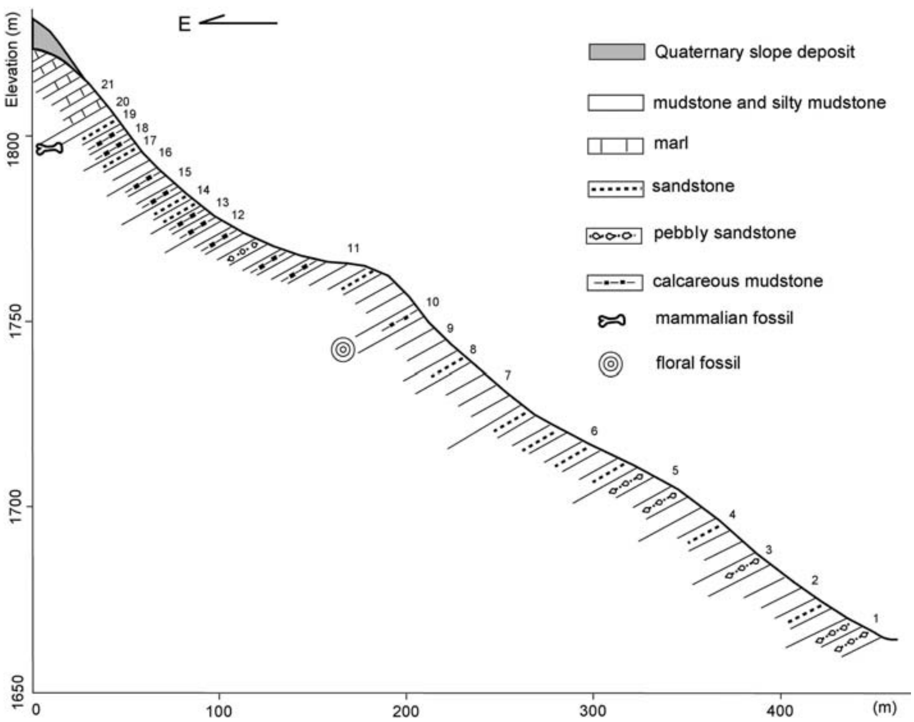

Fig. 2 Stratigraphic sketch of the Nanyucun section, with the fossiliferous layer indicated

Description of the Nanyucun section (from top to bottom):

Upper part of middle member

21.	Brownish-red mudstone (4−5 m thick) interbedded with grayish-green marl (1−2 m thick), with well developed horizontal bedding, overlain by Quaternary slope washes	>10 m

Lower part of middle member

20.	Grayish-green silty mudstone, intercalated with thin layers of brownish-red mudstone and grayish-green marl; contains *Gomphotherium wimani*	~ 3.5 m
19.	Lens of grayish-green glutenite	1 m
18.	Yellowish-brown and grayish-green silty mudstone, intercalated with thin layers of grayish-green sandstone (3−5 cm) and brownish-red mudstone (10−40 cm)	7.5 m
17.	Lens of grayish-green glutenite	1−2 m
16.	Grayish-green calcareous silty mudstone, with bands of brownish-red mudstone, grayish-green and brownish-red sandstone, and grayish-green marl (5−10 cm)	24 m
15.	Brownish-red mudstone, intercalated with bands of brownish-yellow silty mudstone and grayish-green marl	10 m
14.	Grayish-green sandstone interlayered with brownish-red mudstone	5 m
13.	Brownish-red mudstone intercalated with thin layers of grayish-green calcareous mudstone	3 m
12.	Grayish-green calcareous mudstone intercalated with thin layers of brownish-red mudstone	4 m
11.	Brownish-red mudstone intercalated with grayish and yellowish-brown calcareous mudstone and calcareous siltstone, with occasional thin layers of sandstone and pebbly sandstone	40 m
10.	Light grayish-green, gray, and brownish-red calcareous siltstone and silty mudstone, rich in fossilized plant roots (ranging in diameter from 2 to 20 cm)	1.5 m
9.	Brownish-red mudstone intercalated with gray calcareous mudstone and yellowish-brown silty mudstone, and occasionally with thin layers of grayish-green marl	13 m
8.	Gray and grayish-green sandstone intercalated with brownish-red mudstone	5 m
7.	Brownish-red mudstone intercalated with yellowish-brown sandstone and silty mudstone	20 m
6.	Grayish-green, brownish-red, and gray sandstone with pebbly sandstone, intercalated with brownish-red mudstone and silty mudstone	15 m
5.	Gray pebbly sandstone intercalated with brownish-red mudstone, yellowish-brown silty mudstone, and thin layers of grayish-green sandstone	19 m
4.	Brownish-red mudstone intercalated with grayish-green and brownish-red sandstone	25 m
3.	Interbedded grayish-green and brownish-red pebbly sandstone intercalated with bands of conglomerate	3 m
2.	Brownish-red mudstone intercalated with thin layers of grayish-green sandstone	20 m
Lower member		
1.	Gray pebbly sandstone intercalated with white conglomerate layers; the gravels are relatively large and poorly rounded, and the bottom of this bed is obscured	>5 m

3 Systematic paleontology

Order Proboscidea Illiger, 1811

Family Gomphotheriidae Hay, 1922

Genus *Gomphotherium* Burmeister, 1837

***Gomphotherium wimani* (Hopwood, 1935)**

Holotype PMU-M 3649, a palate with both M1 (deeply worn), both M2 (fully worn), and both M3 (partly in alveoli)(Hopwood, 1935:pl.5, fig. 3; Tobien et al., 1986:fig. 7).

Specimen referred to *G. wimani* in the present article LZU 201002, a pair of fragmentary lower jaws preserving p3, dp4, and m1, and unerupted p4 (Figs. 3,4; Tables 1,2).

Table 1 Select measurements* of the mandible of *Gomphotherium wimani* (LZU 201002) (mm)

Mandibular width taken at root of ascending ramus	198
Width of horizontal ramus taken at root of ascending branch	65
Width of horizontal ramus taken at anterior of alveolus (or grinding tooth if alveolus is entirely resorbed)	38
Posterior symphyseal width	97
Minimal width of rostral trough	18
Internal width between anterior alveoli (or grinding teeth if alveoli are resorbed)	31
Maximal height of horizontal ramus (measurement taken perpendicular to the ventral border of the ramus)	79
Height of horizontal ramus taken at root of ascending ramus (measurement as above)	60
Mid-alveolar length taken on buccal side between anterior alveolus (or grinding tooth if alveolus is resorbed) and root of ascending ramus	138

* After Tassy, 1996d.

Table 2 Cheek tooth measurements of *Gomphotherium wimani* (LZU 201002) (mm)

	L	W	H	I (W×100/L)
p3 l.	24	16 (lophid1)	13(protoconid)	66.67
p3 r.	27	17.5(lophid1)	15(protoconid)	64.81
dp4 l.	60	37(lophid3)	—	61.86
dp4 r.	63.5	37(lophid3)	—	61.65
m1 l.	—	41(lophid1)	37(posttrite2)	—
m1 r.	—	40(lophid1)	33.5(posttrite2)	—

Diagnosis See Hopwood, 1935:19 and Tobien et al., 1986:131.

Emended diagnosis Cheek teeth display mostly gomphothere plesiomorphies (the pretrite half loph(id) is trifoliated and the posttrite one is simple); tooth crowns also show patterns that are derived within the genus *Gomphotherium*, such as presence of posttrite central conules, multiplication of mesoconelets and central conules, and only a small amount of cementum.

Descriptions Mandible (Fig. 3): This bone is from a juvenile and has a deeply weathered surface. The horizontal ramus is robust. The trigonum retromolare is broken, and

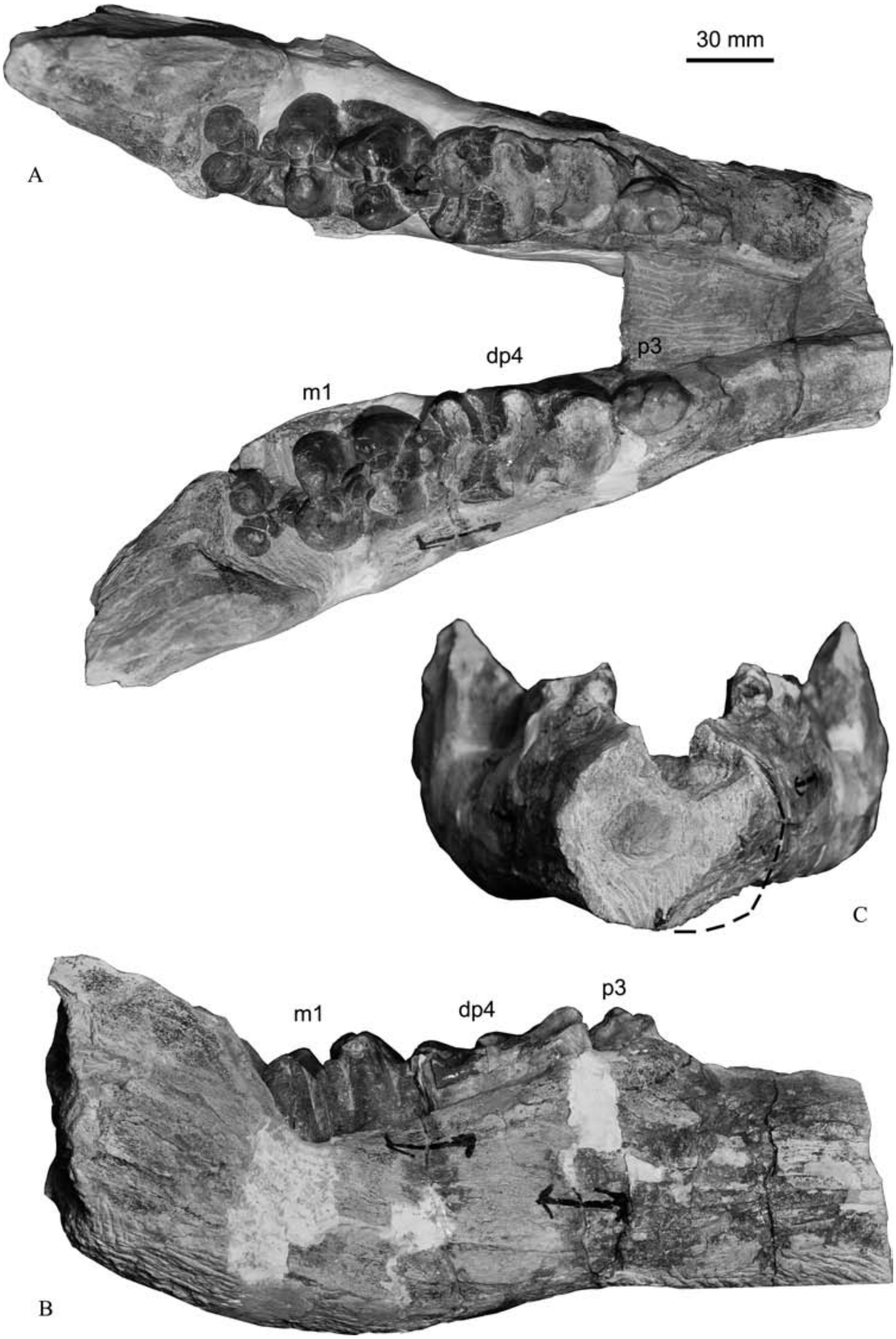

Fig. 3 Mandible of *Gomphotherium wimani* (LZU 201002)
A. in dorsal view; B. in lateral view; C. in proximal view, showing the cross-sectional shape of the proximal part of the mandibular symphysis

mental foramina could not be recognized. Most of the mandibular symphysis is absent, only the posterior end being preserved. The lower tusks are not preserved, and the cross-section of the anterior part of the mandible is subcircular. A strong, longitudinally aligned dorsal crest is present anterior to each dental row, and the median groove between the two crests is deep. The left and right ascending rami are both broken, but arise at the level of the second lophid of the m1.

p3 (Fig. 4): The p3 is fairly small, and is oval in shape with four blunt main cusps (protoconid, metaconid, hypoconid, and entoconid). The protoconid and metaconid are much higher than the hypoconid and entoconid. Another small conule is present between the protoconid and hypoconid, and is connected to both of them. A weak conule is present on the anterior cingulid, and three or four small conules extend from the posterior end of the main pretrite conules of the second lophid to form the posterior cingulid. A thin layer of cementum covers the crown.

dp4 (Fig. 4): The dp4 is deeply worn, and much of the root has been highly exposed, so the tooth can be interpreted as ready to be shed. Three lophids and a weak cingulid are preserved on the crown, although two of the lophids are almost completely worn away. On the third lophid, both the pretrite and posttrite halves of the third lophid are inclined anteriorly as they approach the midline, forming a chevron pattern (Tobien, 1973b). Two or three conules form the weak posterior cingulid, and the cementum is very thin.

m1 (Fig. 4): The m1 is unworn, and the posterior cingulid and part of the third lophid are preserved in the alveolus. The first two pretrite half lophids are trifoliate and inclined anteriorly as they approach the midline, forming a chevron pattern. The posterior central conule is strong, serrated, and widely separated from the main cusp. The corresponding posttrite half lophids

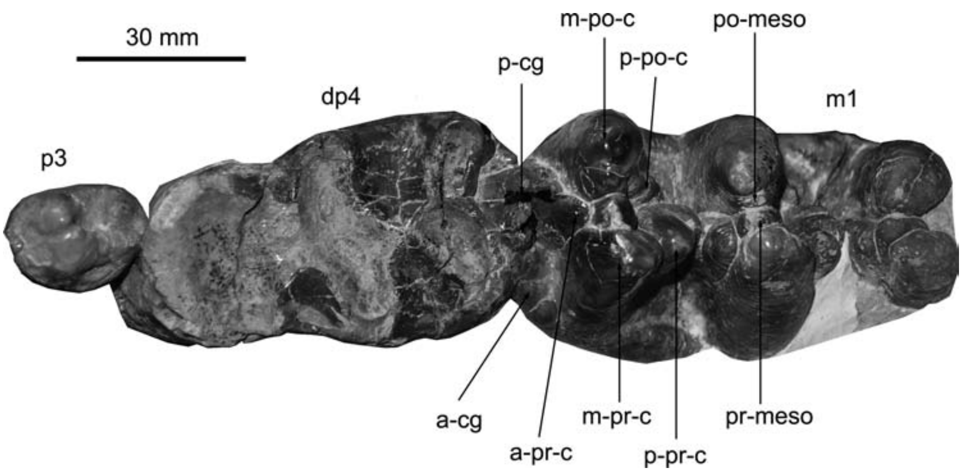

Fig. 4 The left p3, dp4, and m1 of *Gomphotherium wimani* (LZU 201002)
Abbreviations: a-cg. anterior cingulid前齿带; a-pr-c. anterior pretrite central conule主齿柱侧前中心小尖; m-po-c. main posttrite cusp副齿柱侧主尖; m-pr-c. main pretrite cusp主齿柱侧主尖; p-cg. posterior cingulid下后齿带; p-po-c. posterior posttrite central conule副齿柱侧后中心小尖; p-pr-c. posterior pretrite central conule主齿柱侧后中心小尖; po-meso. posttrite mesoconelet副齿柱侧中附锥; pr-meso. pretrite mesoconelet主齿柱侧中附锥

are simple and perpendicular to the longitudinal axis of the tooth. A weak tendency towards multiplication can be observed in the posttrite mesoconelets, and weak posterior central conules are outlined posterior to the posttrite half lophids. The crown is covered by a thin layer of cementum, and the buccal and lingual cingulids are both prominent.

4 Discussion

Although the Nanyucun specimen consists only of a fragmentary juvenile mandible, the complete left and right p3, dp4, and m1 are all well-preserved. Therefore, the most important morphological features of the specimen are clear. The lower p3 is rarely preserved in gomphotheres, but has been reported in the Early Miocene species *Platybelodon dangheensis* (Wang and Qiu, 2002), *Gomphotherium connexum* (Hopwood, 1935; Tobien et al., 1986), *G. angustidens*, *Archaeobelodon filholi* (Tassy, 1985) and *G. subtapiroideum* (Göhlich, 2010). This tooth has not been recovered in any Middle Miocene platybelodont (Wang and Qiu, 2002) or Early-Middle Miocene choerolophodont (Wang and Deng, 2011a). Although the p3 in the Nanyucun specimen is small, this tooth is complex in structure relative to its counterparts in *P. dangheensis*, *G. angustidens* and *G. connexum*, in which the p3 is composed only of a main cusp and small anterior and posterior conules (Wang and Qiu, 2002:fig. 2; Hopwood, 1935). However, the crown structure of the p3 is similar to that seen in *G. subtapiroideum* from Sandelzhausen and *A. filholi* from Bézian.

The preserved proximal portion of the mandibular symphysis in the Nanyucun specimen implies that it represents a longirostrine gomphothere, rather than a brevirostrine one such as *Sinomastodon* (Tobien et al., 1986). However, the preserved part of the symphysis is relatively narrow and high rather than wide and low as in *Platybelodon* (Wang et al., in press). The cheek tooth structure in the Nanyucun specimen is bunodont-trilophodont and fairly simple, with secondary trefoils and pseudo-anaicody either rudimentary or absent rather than relatively strong as in *Protanancus* and *Platybelodon* (Wang and Deng, 2011b). Choerolophodonty and cementodonty are also either rudimentary or absent in this specimen, rather than relatively strong as in *Choerolophodon* (Wang and Deng, 2011a). These characters exclude the Nanyucun specimen from other bunodont-trilophodont gomphotheriid genera known from China, such as *Choerolophodon*, *Protanancus*, *Platybelodon*, and *Sinomastodon*, and indicate that the specimen should be referred to *Gomphotherium*.

The genus name *Gomphotherium* was often used excessively during its taxonomic history, and has been synonymized with *Trilophodon* Falconer, 1846 and *Serridentinus* Osborn, 1923 (Tobien, 1973a). Numerous specific names have been published within the genera *Gomphotherium*, *Trilophodon*, and *Serridentinus*, causing much taxonomic confusion (Osborn, 1936; Tobien, 1973a). Tobien (1973a) revised the genus *Gomphotherium*, finding some specific names to be junior synonyms and transferring other species to different genera (i.e. *S. filholi* and *T. angustidens kisumuensis* into *Platybelodon*). He considered most *Gomphotherium* specimens from Europe and Africa to belong to *G. angustidens* (i.e. *T. olisiponensis*, *T. depereti*, *S. lusitanicus*, and *S. estremadurensis*) and most specimens from America to belong to *G. productum* (i.e. *G. cimarronis*, *T. pojoaquensis*, *T. fricki*, *T.* (*Tatabelodon*) *riograndensis*, *T. simpsoni*, and *G. cingulatum*). In Tobien's account, *Gomphotherium* possesses mainly gomphothere plesiomorphies, such as lower tusks that are pyriform in transverse section and structurally simple molars in which no secondary trefoil develops on the posttrites (Tobien, 1973a).

Likewise, Tobien (1973a) considered the known *Gomphotherium* material from Asia to belong to the *G. angustidens* group due to the rather simple cheek tooth structure. In a further study of the trilophodont mastodonts of China, Tobien et al. (1986) discussed Chinese *Gomphotherium* in detail. By the 1990s, more than ten species within *Gomphotherium* had been established, including *G. connexum* (Hopwood, 1935), *G. wimani* (Hopwood, 1935), *G. spectabilis* (Hopwood, 1935), *G. hopwoodi* (Young & Liu, 1948), *G. elegans* (Young & Liu, 1948), *G. quinanensis* Chow & Chang, 1961, *G. changzhiensis* Zhai, 1963, *G. watzeensis* Hu, 1962, *G. xiaolongtanensis* Chow & Chang, 1976, *G. hypsodontum* Li, 1976, *G.* cf. *G. macrognathum* (Pilgrim, 1913), *G. shensiensis* Chang & Zhai, 1978, *G. tongxinensis* Chen, 1978, *G. yangziensis* (Chow, 1959), *G. guangxiensis* (Chow, 1959), *G. wufengensis* (Pei, 1965), and *G. serridentoides* Pei, 1974 (Chang and Zhai, 1978; Chen, 1978; Chow and Zhang, 1974; Hopwood, 1935; Li, 1976; Pei, 1987). Among these species, Tobien et al. (1986, 1988) reassigned *G. elegans* and *G. changzhiensis* to *Choerolophodon*[1]; *G. spectabilis*, *G. hopwoodi*, and *G. hypsodontum* to *Platybelodon*; *G. xiaolongtanensis* to *Tetralophodon*[2]; *G. watzeensis* to *Paratetralophodon*; *G. quinanensis* to *Stegotetrabelodon*; and *G. yangziensis*, *G. guangxiensis*, *G. serridentoides*, and *G. wufengensis* to *Sinomastodon*. Furthermore, Ye and Jia (1986) referred *G. tongxinensis* to *Platybelodon*. Therefore, Tobien et al. (1986) considered the genus *Gomphotherium* to retain only three species, *G. connexum*, *G. wimani*, and *G. shensiensis*, and to be restricted to the Early-Middle Miocene.

Gomphotherium connexum is a small species with reduced lower tusks and an archaic cheek tooth structure. Hopwood (1935) considered the geological age of this species to be "Miocene", but this assessment was not made on the basis of detailed stratigraphy. The cusps on the lower molars of *G. connexum* are fairly prominent and rounded, taking up most of the space between the interlophids. The pretrite posterior central conules are strong and widely separated from the main cusps, and there is no tendency to multiply mesoconelets and central conules. The rounded cusps, anteroposteriorly compressed interloph(id)s, and absence

1) These reassignments may be not proper because these two species show few choerolophodont characters (also see the discussion about "choerodonty" and "choerolophodonty", below), and precise identification is difficult because of the limited morphological and stratigraphic information available.

2) Tobien et al. (1986) assigned the material in question to *Gomphotherium* sp. However, *G.* cf. *G. macrognathum* should probably be referred to *Tetralophodon*.

of multiplication of mesoconelets and central conules are points of similarity to the Early Miocene *G. mongoliensis* from Loh, Mongolia (Osborn, 1924:fig. 1). However, rounded cusps and compact interloph(id)s are common features among Early Miocene gomphotheres, such as *G. angustidens*, *Afrochoerodon kisumuensis*, and cf. *Archaeobelodon* from Moghara, Egypt (Sanders and Miller, 2002:figs. 3,4), *Platybelodon dangheensis* from Xishuigou, China (Wang and Qiu, 2002:fig. 2), and *Choerolophodon guangheensis* from Dalanggou, China (Wang and Deng, 2011a:fig. 5). Conversely, the loph(id)s are often anteroposteriorly compressed with wide interloph(id)s in Middle Miocene gomphotheres such as *Protanancus macinnesi*, *Choerolophodon ngorora*, and *C. pygmaeus* (Maglio, 1974; Pickford, 2004; Tassy, 1986). This suggests the geological age of *G. connexum* may be Early Miocene.

Another species, *Gomphotherium wimani*, is a middle-sized *Gomphotherium* from the Middle Miocene of Gansu (Hopwood, 1935, Qiu et al., 1997). As Tobien et al. (1986) discussed, the molars of *G. wimani* show a derived pattern superimposed on the common cheek tooth characters of *Gomphotherium*. Hopwood (1935) assumed that the cheek teeth were heavily cemented; however, as noted by Tobien et al. (1986), none of the cheek teeth assigned to *G. wimani* display strong cementodonty. Hopwood's assumption was merely based on the hypothesis that cementum was easily lost preservationally. However, there is no direct evidence to support his hypothesis, and species may in fact show a tendency towards cementodonty. Tobien et al. (1986) also demonstrated that the cheek teeth of *G. wimani* show some "choerodonty", entailing multiplication of mesoconelets and central conules on the cheek teeth; however, this example of so-called "choerodonty" may not be homologous to that seen in true choerolophodont taxa, in which the cheek tooth pattern was described as "choerolophodonty" by Tassy (1983). Such teeth are characterized by the presence of a fused and anteriorly displaced anterior pretrite central conule and mesoconelet, and by inclination of the posttrites anteriorly and toward the midline so that the loph(id)s take on a "V" shape with the apex of each "V" directed forward. Because these characters do not correspond to those of *G. wimani*, Tobien et al.'s (1986) assertion of a relationship between *G. wimani* and *Choerolophodon* is not supported here. *Choerolophodon* was present in northern China by the Early Miocene and had an evolutionary history independent from that of *Gomphotherium* (Wang and Deng, 2011a). Additionally, Teilhard de Chardin and Trassaert (1937) attributed several teeth from the Pliocene of Yushe, Shanxi, to *G.* cf. *G. wimani*. However, as discussed by Chen (1999), these teeth should be assigned to *Sinomastodon* and have no close relationship to *G. wimani*.

The third species of Chinese *Gomphotherium* is *G. shensiensis*. This species is represented only by a single relatively complete skull, and is characterized by large size and the absence of an enamel band on the upper tusks (Chang and Zhai, 1978; Tobein et al., 1986). The skull was recovered from the Middle Miocene of Lantian, Shaanxi. Tobien et al. (1986) considered the species to be a derived form, closely related to *G. wimani*. The further multiplication of mesoconelets and central conules seen in this taxon, as well as the thicker cementum, suggest that this species is more derived than both *G. wimani* and the Nanyucun specimen.

The cheek teeth (mainly m1s) of the Nanyucun specimen are clearly derived rather than primitive in structure. The lophids of m1 are anteroposteriorly compressed, and the interlophids are wide; posttrite posterior central conules are present; multiplication of mesoconelets and central conules is present; and little cementum is present. These features are very similar to those present in an m3 referred to *G. wimani* by Hopwood (1935:pl.IV-1). Although it is unknown whether or not enamel bands are present on the tusks of the Nanyucun specimen (thick enamel bands are present on the upper tusks of *G. wimani*), the absence of extensive cementum and extensive multiplication of mesoconelets and central conules suggests that this individual is more likely to belong to *G. wimani* than to *G. shensiensis*. However, only limited comparisons are currently possible because of the nature of the material.

The Neogene deposits north of Simen Towship can be correlated with those of other regions in the Tianshui area. For example, the red clay interlayered with marl in Guojia and Lianhua townships, Qin'an County, which dates to the Middle Miocene and is horizontally equivalent to the fossiliferous deposits of the Nanyucun section, has also yielded gomphotheres (Zhai, 1959, 1961). The fossiliferous layer in the Nanyucun section can thus be identified as Middle Miocene, like the strata at other localities in Tianshui area. The paleoenvironment of Tianshui area during the Middle Miocene is interpreted as probably relatively warm and humid, suitable for large populations of brachyodont mammals such as gomphotheres. This inference is consistent with palynological data for this area (Hui et al., 2011).

5 Conclusions

(1) The Nanyucun specimen is referable to *Gomphotherium wimani* based on the relatively derived structure of the cheek teeth compared to other species of *Gomphotherium*. The cheek teeth of *G. wimani* show a combination of features common in Middle Miocene gomphotheres.

(2) *G. wimani* was originally discovered in the Middle Miocene of Gansu, and the fossiliferous horizon in the Nanyucun sections that contains *G. wimani* can be correlated with other Middle Miocene localities in the surrounding area.

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甘肃天水武山县南峪村的维曼嵌齿象及其生物地层学意义

王世骐[1*] 刘善品[2] 颉光普[3] 刘 佳[2] 彭廷江[2] 侯素宽[1]
(1 中国科学院古脊椎动物与古人类研究所，中国科学院脊椎动物演化与人类起源重点实验室 北京 100044 *通讯作者)
(2 兰州大学西部环境与气候变化研究院 兰州 730000)
(3 甘肃省博物馆 兰州 730050)

摘要：报道了甘肃天水地区武山县四门镇南峪村地点发现的一件残破的未成年维曼嵌齿象(*Gomphotherium wimani*)下颌，标本保存有完整的p3, dp4, m1齿列。颊齿齿冠显示出嵌齿象属(*Gomphotherium*)的一些进步特征，例如齿脊前后压缩，齿谷宽阔，副齿柱后中心小尖凸显，中附锥和中心小尖趋于分裂，有弱的白垩质发育，符合维曼嵌齿象的鉴定特征。维曼嵌齿象此前发现于甘肃的中中新统，而南峪村地点的含化石地层可与周围其他地点的中中新统对比，因此，南峪村地点维曼嵌齿象层位的地质时代为中中新世。同时，结合孢粉学研究的结果，可能说明中中新世时期，天水地区气候温暖湿润，适宜低齿冠的哺乳类如嵌齿象等动物生存。

关键词：甘肃天水，中中新世，长鼻类，维曼嵌齿象，生物地层
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References

Andrews C W, 1906. A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt. London: British Museum (Natural History). 1–324

Chang H T(张席褆), Zhai R J(翟人杰), 1978. Miocene mastodonts of Lantian and Lintung, Shensi. Prof Pap Stratigr Palaeont(地层古生物论文集), **7**: 136–142(in Chinese)

Chen G F(陈冠芳), 1978. Mastodont remains from the Miocene of Zhongning-Tongxin area in Ningxia. Vert PalAsiat(古脊椎动物学报), **16**(2): 103–110(in Chinese)

Chen G F(陈冠芳), 1999. *Sinomastodon* Tobien et al., 1986 (Proboscidea, Mammalia) from the Pliocene and Early-Middle Pleistcene of China. In: Wang Y Q, Deng T eds. Proceedings of the Seventh Annual Meeting of the Chinese Society of Vertebrate Paleontology. Beijing: China Ocean Press. 179–187(in Chinese with English summary)

Chow M C(周明镇), Zhang Y P(张玉萍), 1974. Chinese Fossil Elephantoids. Beijing: Science Press. 1–74(in Chinese)

Göhlich U B, 2010. The Proboscidea (Mammalia) from the Miocene of Sandelzhausen (southern Germany). Paläont Z, **84**(1): 163–204

Hopwood A T, 1935. Fossil Proboscidea from China. Palaeont Sin, Ser C, **9**: 19–25

Hui Z C, Li J J, Xu Q H et al., 2011. Miocene vegetation and climatic changes reconstructed from a sporopollen record of the Tianshui Basin, NE Tibetan Plateau. Palaeogeogr Palaeoclimatol Palaeoecol, **308**: 373–382

Kappelman J, Rasmussen D T, Sanders W J et al., 2003. Oligocene mammals from Ethiopia and faunal exchange between Afro-Arabia and Eurasia. Nature, **426**: 549–552

Lambert W D, 1996. The biogeography of the gomphotheriid proboscideans of North America. In: Shoshani J, Tassy P eds. The Proboscidea: Evolution and Palaeoecology of Elephants and Their Relatives. Oxford: Oxford University Press. 143–148

Li Y H(李有恒), 1976. A new species of *Gomphotherium* from Shanxi. Vert PalAsiat(古脊椎动物学报), **14**(1): 67–70(in Chinese)

Maglio V J, 1973. Origin and evolution of the Elephantidae. Trans Am Philos Soc New Ser, **63**(3): 1–149

Maglio V J, 1974. A new proboscidean from the Late Miocene of Kenya. Palaeontology, **17**(3): 699–705

Osborn H F, 1924. *Serridentinus* and *Baluchitherium*, Loh Fomation, Mongolia. Am Mus Novit, (148): 1–5

Osborn H F, 1936. Proboscidea: a Monograph of the Discovery, Evolution, Migration and Extinction of the Mastodonts and Elephants of the World. New York: The American Museum Press. 1–802

Pei W Z(裴文中), 1987. Carnivora, Proboscidea and Rodentia from Liucheng *Gigantopithecus* Cave and other caves in Guangxi. Mem Inst Vert Palaeont Palaeoanthrop, Acad Sin(中国科学院古脊椎动物与古人类研究所集刊), **18**: 5–134(in Chinese with English summary)

Pickford M, 2004. Partial dentition and skeleton of *Choerolophodon pygmaeus* (Depéret) from Ngenyin, 13 Ma, Tugen Hills, Kenya: resolution of a century old enigma. Zona Arqueologica: Miscelànea en Homenaje a Emiliano Aguirre Paleontologia, **4**(2): 428–463

Qiu Z X, Qiu Z D, 1995. Chronological sequence and subdivision of Chinese Neogene mammalian faunas. Palaeogeogr Palaeoclimatol Palaeoecol, **116**: 41–70

Qiu Z X(邱占祥), Wang B Y(王伴月), Qiu Z D(邱铸鼎) et al., 1997. Recent advances in study of the Xianshuihe Formation in Lanzhou Basin. In: Tong Y S, Zhang Y Y, Wu W Y et al. eds. Evidence for Evolution — Essays in Honor of Prof. Chungchien Young on the Hundredth Anniversary of His Birth. Beijing: China Ocean Press. 177–192(in Chinese with English Abstract)

Sanders W J, Miller E R, 2002. New proboscideans from the Early Miocene of Wadi Moghara, Egypt. J Vert Paleont, **22**(2): 388–404

Shoshani J, Tassy P, 2005. Advances in proboscidean taxonomy & classification, anatomy & physiology, and ecology & behavior. Quat Int, **126-128**: 5–20

Tassy P, 1983. Les Elephantoidea Miocènes du Plateau du Potwar, Groups de Siwalik, Pakistan. I[re] Partie: Cadre chronologique et géographique, Mammutidés, Amébélodontidés. Ann Paléont, **69**(2): 99–136

Tassy P, 1985. La place des mastodontes miocènes de l’ancien monde dan la phylogénie de proboscidea (Mammalia): hypothèses et conjectures. Thèse Doctoratès Sciences. Paris: UPMC. 1–861

Tassy P, 1986. Nouveaux Elephantoidea (Proboscidea, Mammalia) dans le Miocène du Kenya: essai de réévaluation systématique. Paris: Cahiers de Paléontologie. E'ditions du Centre National de la Recherche Scientifique (CNRS). 1–135

Tassy P, 1996a. Who is who among the Proboscidea. In: Shoshani J, Tassy P eds. The Proboscidea: Evolution and Palaeoecology of Elephants and Their Relatives. Oxford: Oxford University Press. 39–48

Tassy P, 1996b. The earliest gomphotheres. In: Shoshani J, Tassy P eds. The Proboscidea: Evolution and Palaeoecology of Elephants and Their Relatives. Oxford: Oxford University Press. 89–91

Tassy P, 1996c. Dental homologies and nomenclature in the Proboscidea. In: Shoshani J, Tassy P eds. The Proboscidea: Evolution and Palaeoecology of Elephants and Their Relatives. Oxford: Oxford University Press. 21–25

Tassy P, 1996d. Growth and sexual dimorphism among Miocene elephantoids: the example of *Gomphotherium angustidens*. In: Shoshani J, Tassy P eds. The Proboscidea: Evolution and Palaeoecology of Elephants and Their Relatives. Oxford: Oxford University Press. 92–100

Teilhard de Chardin P, Trassaert M, 1937. The proboscideans of south-east Shansi. Fossil Proboscidea from China. Palaeont Sin, Ser C, **13**: 6–26

Tobien H, 1973a. On the evolution of mastodonts (Proboscidea, Mammalia). Part 1: the bunodont trilophodont groups. Notizbl hess L-Amt Bodenforsch, **101**: 202–276

Tobien H, 1973b. The structure of the mastodont molar (Proboscidea, Mammalia). Part 1: the bunodont patterns. Mainzer Geowiss Mitt, **2**: 115–147

Tobien H, Chen G F, Li Y Q, 1986. Mastodonts (Proboscidea, Mammalia) from the late Neogene and Early Pleistocene of the People's Republic of China. Part I: historical account: the genera *Gomphotherium*, *Choerolophodon*, *Synconolophus*, *Amebelodon*, *Platybelodon*, *Sinomastodon*. Mainzer Geowiss Mitt, **15**: 119–181

Tobien H, Chen G F, Li Y Q, 1988. Mastodonts (Proboscidea, Mammalia) from the late Neogene and Early Pleistocene of the People's Republic of China. Part II: historical account: the genera *Tetralophodon*, *Anancus*, *Stegotetrabelodon*, *Zygolophodon*, *Mammut*, *Stegolodon*. Mainzer Geowiss Mitt, **17**: 95–220

Wang B Y(王伴月), Qiu Z X(邱占祥), 2002. A new species of *Platybelodon* (Gomphotheriidae, Proboscidea, Mammalia) from Early Miocene of the Danghe area, Gansu, China. Vert PalAsiat(古脊椎动物学报), **40**(4): 291–299(in Chinese with English summary)

Wang S Q, Deng T, 2011a. The first *Choerolophodon* (Proboscidea, Gomphotheriidae) skull from China. Sci China Earth Sci, **54**(9): 1326–1337

Wang S Q, Deng T, 2011b. The fossil gomphotheres (Proboscidea, Mammalia) discovered from the Early Miocene of Linxia Basin, China. In: World Conference on Paleontology and Stratigraphy, Abstract. Nakhon Ratchasima, Thailand: Nakhon Ratchasima Rajabhat University. 38–39

Wang S Q, He W, Chen S Q (in press). *Platybelodon* (Gomphotheriidae, Mammalia) from the Middle Miocene of Linxia Basin, Gansu, China. Acta Palaeont Pol, http://dx.doi.org/10.4202/app.2011.0009

Ye J(叶捷), Jia H(贾航), 1986. *Platybelodon* (Proboscidea, Mammalia) from the Middle Miocene of Tongxin, Ningxia. Vert PalAsiat(古脊椎动物学报), **24**(2): 103–110(in Chinese with English summary)

Zhai R J(翟人杰), 1959. Discovery of Miocene mammals from Ching-An, eastern Kansu. Vert PalAsiat(古脊椎动物学报), **1**(3): 139–140(in Chinese)

Zhai R J(翟人杰), 1961. On a collection of Neogene mammals from Ching-An, eastern Kansu. Vert PalAsiat(古脊椎动物学报), (3): 262–268(in Chinese with English summary)