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First mandible and deciduous dentition of juvenile individuals of *Sinomastodon* (Proboscidea, Mammalia) from the Early Pleistocene Renzidong Cave of eastern China

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ABSTRACT

Sinomastodon (Proboscidea, Mammalia) is a unique brevirostrine trilophodont gomphotheriid from Eurasia, which mainly occurs in China during the Plio-Pleistocene. Although much is known about adult individuals, the morphology of juveniles of this taxon is still poorly understood due to the scarcity of pertinent fossils. The present contribution represents the first detailed systematic study of the mandible and deciduous dentition of juvenile individuals of *Sinomastodon jiangnanensis* from the early Early Pleistocene (2.14–2.15 Ma) Renzidong Cave of eastern China. Based on morphological comparisons, the Renzidong juvenile mandible bears, on one hand, the transitional characteristics between the typical long-jawed trilophodont and elephantoid proboscideans, and, on the other hand, more primitive features than adult mandibles of *Sinomastodon*. This study of juvenile individuals of *S. jiangnanensis* provides new information to enhance the diagnosis of *S. jiangnanensis*, and confirms the validity of the species. It also provides evidence to show that the morphological transition of genus *Sinomastodon* from Neogene to Quaternary is mirrored in adult and juvenile individuals.

1. Introduction

Sinomastodon (="Chinese mastodon"; Gomphotheriidae, Proboscidea, Mammalia), is a unique brevirostrine trilophodont gomphotheriid from Eurasia (Shoshani and Tassy, 2005). With a brevirostrine, high and antero-posteriorly compressed cranium, no lower tusks and simple bunodont and trilophodont intermediate molars, *Sinomastodon* is distinct from other gomphotheres (Tobien et al., 1986; Chen, 1999; Wang et al., 2012).

The genus *Sinomastodon* was erected by Tobien et al. (1986) based on *Mastodon intermedius* (Teilhard de Chardin and Trassaert, 1937). To date, *Sinomastodon* mainly occurs in China during the Plio-Pleistocene (Chen, 1999; Wang et al., 2012). The Pliocene-age *Sinomastodon intermedius* (type species) and *Sinomastodon hanjiangensis* are known from Shanxi and Shaanxi provinces, northern China (Tobien et al., 1986; Zong et al., 1989), and a rare occurrence in the Hengduan Mountains, southwest China (Zong et al., 1996). Most of the isolated *Sinomastodon* teeth discovered in the early Pleistocene karst cave or fissure deposits in southern China have been identified as *Sinomastodon yangziensis* (Xu et al., 1974; Han et al., 1975; Pei, 1987; Huang and Fang, 1991; Zheng, 2004; Wang, 2009; Jin et al., 2009a; Wang et al., 2013), which coexisted with the large hominoid, *Gigantopithecus blacki*.

The cranium, mandible, and permanent molars (M1-M3, m1-m3) of a trilophodont gomphothere from Renzidong Cave were described as a new species, *Sinomastodon jiangnanensis* (Wang et al., 2012). The present study continues this systematic research by focusing on the juvenile fossil remains of *S. jiangnanensis* from Renzidong Cave.

The Paleolithic site of Renzidong Cave (31°5′23″N, 118°5′46″E), discovered in 1998, is situated near the south bank of the Yangtze River (Fig. 1B). The cave is located on the southeast slope of Laili Hill (Fig. 1A), about 10 km northwest of Fanchang County, Anhui Province, eastern China (Jin and Liu, 2009).

Although much is known and continues to be described about adult *Sinomastodon* remains, the morphology of the cranium, mandible, and deciduous dentition of juvenile individuals is still poorly understood due to the scarcity of material. The current study is significant for supplementing the diagnosis of *S. jiangnanensis*

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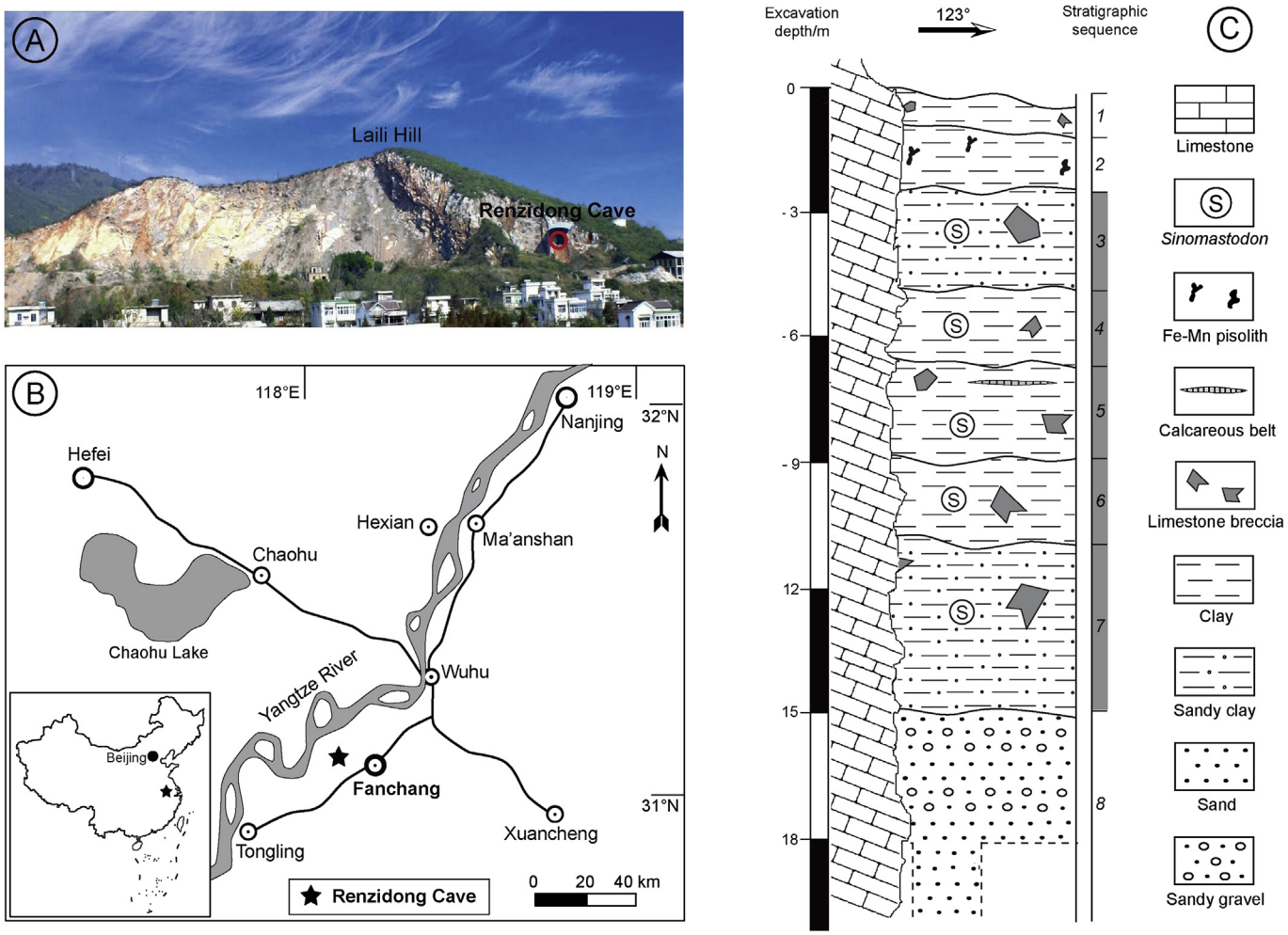

Fig. 1. Maps showing geomorphological landscape (A), geographical location (B) and stratigraphic sequence (C) of Renzidong Cave.

and for documenting the ontogeny of the species, as well as to clarify the systematics and evolution of the genus in East Asia during the Quaternary.

2. Geological and faunal setting

The deposits in Renzidong Cave can be divided into two sedimentary cycles, reflecting different depositional and environmental conditions (Jin and Liu, 2009). The first seven layers, from top to bottom, with a thickness of approximately 15 m, comprise the upper part of the sediments, and are composed mainly of brown clay or sandy clay with calcareous breccia (Fig. 1C). These deposits yielded an abundance of mammalian remains, including the *Sinomastodon* material described here. The lower part consists of the eighth layer, composed of gray sand and sandy gravel with few fossils.

The sediments have yielded numerous mammalian fossils in association with artifacts. Jin and Liu (2009) listed 74 mammalian species from Renzidong Cave, including both Palaearctic and Oriental fauna. The fauna includes some Neogene relics, such as *Villanyia fanchangensis* (Zhang et al., 2008), *Beremendia jiangnanensis* (Jin et al., 2009b), and *S. jiangnanensis* (Wang et al., 2012), as well as several primitive species from the Quaternary, such as *Ailuropoda microta* (Jin et al., 2007), *Tapirus sanyuanensis* (Jin and Liu, 2009), and *Diplothrix yangziensis* (Wang et al., 2010). Based on biochronology, the Renzidong fauna is estimated to be early Early Pleistocene in age (Jin and Liu, 2009), which is consistent with the paleomagnetic data (2.14–2.15 Ma) (Wang et al., 2012). The Renzidong fauna, situated in the transitional zone between the Palaearctic and the Oriental zoogeographical regions, is associated with a cooling event at the beginning of the Quaternary, leading to the southward migration of *Sinomastodon* and the speciation of *S. jiangnanensis* (Wang et al., 2012).

3. Terminology and abbreviations

Here we follow Ferretti (2010) and Tong (2010) for the measurements to be taken on the mandible of *Sinomastodon* (Fig. 2), and Tassy (1996) for terminology of gomphotheriid deciduous premolars.

As a derived trilophodont gomphotheriid, the dental formula of *Sinomastodon* is different from that of the typical long-jawed gomphotheriids which bear premolars (P2–P4/p2–p4), and is more similar to that of modern elephants. The dental formula of *Sinomastodon* is as follows: I 1/0, M1-M3/m1-m3 in the permanent dentition and DI 1/0, DP2-DP4/dp2-dp4 in the deciduous dentition. The pattern of dental replacement in *Sinomastodon* is the same as that of elephantoids: each cheektooth (DP2/dp2-M3/m3) is replaced one after the other in horizontal progression (horizontal tooth displacement) and no more than two functional teeth are usually present at any one time in each jaw quadrant (Ferretti, 2008). Here, we use the term "elephantoid" according to the definition by Shoshani and Tassy (2005).

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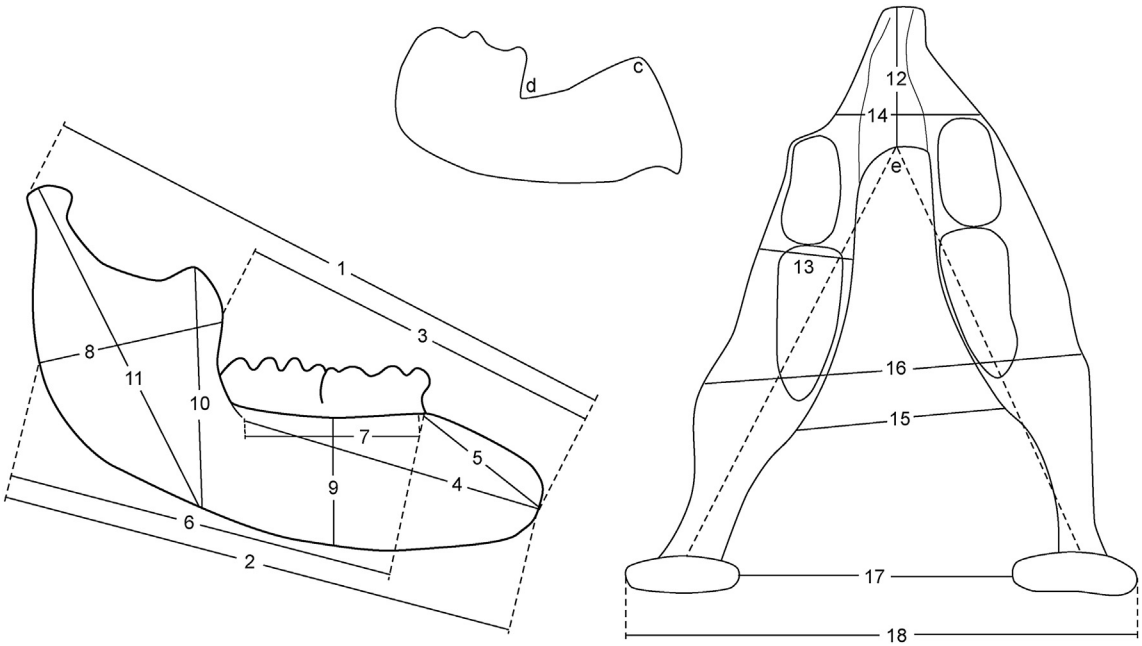

Fig. 2. Schematic sketch of measurements of *Sinomastodon* mandible (for details see Table 1).

The institutional abbreviations are as follows:

AMNH: American Museum of Natural History, New York, USA;
BNNR: Xi Shuang Ban Na National Nature Reserve, Yunnan, China;
CV: Chongqing Natural Museum, Chongqing, China;
IVPP (V): Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China;
MNHN: National Museum of Natural History, Paris, France, France;
NMR: Swedish Museum of Natural History, Stockholm, Sweden;
SBV: Geological Museum of Shaanxi, Xi'an, China;
THP: Tianjin Natural History Museum, Tianjin, China;
UF: Florida Museum of Natural History, Gainesville, USA.

4. Systematics

Class Mammalia Linnaeus, 1758
Order Proboscidea Illiger, 1811
Family Gomphotheriidae Hay, 1922
Subfamily Sinomastodontinae Wang et al., 2012
Genus *Sinomastodon* Tobien et al., 1986
S. jiangnanensis Wang et al., 2012

4.1. Holotype

One relatively complete cranium and mandible with DP4/dp4 and M1/m1 (IVPP V 18221).

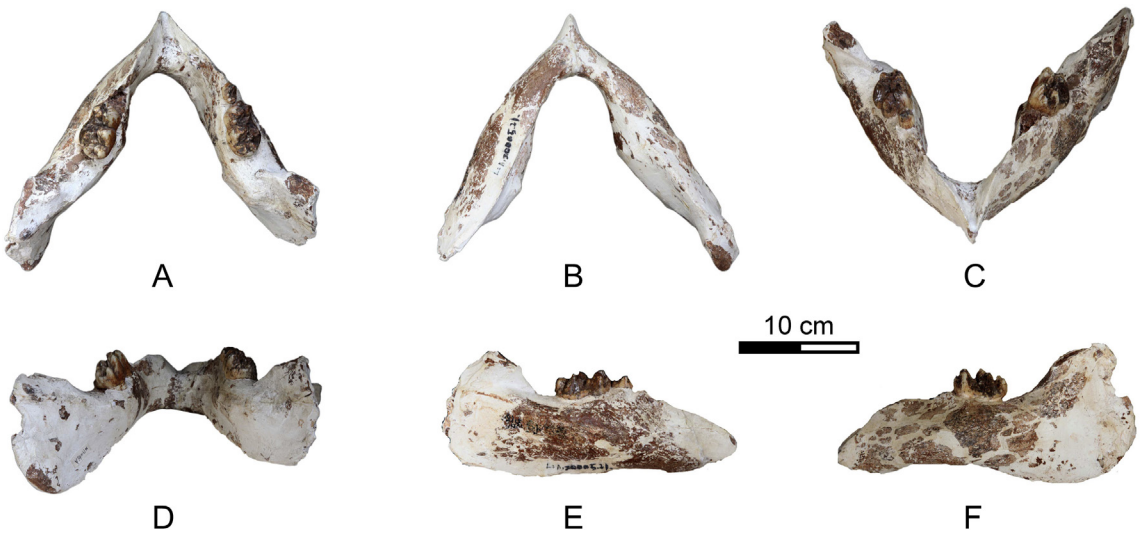

Fig. 3. The juvenile mandible of *Sinomastodon jiangnanensis* from Renzidong Cave (V14011.1). A, superior view; B, ventral view; C, anterior view; D, posterior view; E, F, labial views.

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4.2. Referred material (Figs. 3–5, Tables 1 and 2)

One well-preserved juvenile mandible with dp2/dp3s (V14011.1), one fragmentary maxilla with right DP2/DP3 (V14011.04), one DP2 (V14011.05), one DP3 (V14011.06), three DP4s (V14011.09, 10, 11), one dp2 (V14011.13).

Table 1
Measurements of the juvenile mandible of *Sinomastodon jiangnanensis* from Renzidong Cave (in mm)

Measurements	1	2	3	4	5	6	7
Mandible	253 (ca.)	246 (ca.)	178	161	85	174	66
Measurements	8	9	10	11	12	13	14
Mandible	92 (ca.)	54	103 (ca.)	125 (ca.)	52	47	59
Measurements	15	16	17	18	∠c	∠d	∠e
Mandible	100	178	204 (ca.)	243 (ca.)	140°	120°	65°

Note: for methods of measurement see Fig. 1; 1, Length: most aboral margin of condyle-infradentale; 2, Length: gonion caudale-infradentale; 3, Length: infradentale-most oral point of the anterior margin of the corpus; 4, Length: infradentale-anterior origin of corpus; 5, Length: infradentale-oral border of the anterior grinding tooth; 6, Length: gonion caudale-oral border of the anterior grinding tooth; 7, Length: oral border of the anterior grinding tooth -anterior origin of corpus; 8, Length: gonion caudale-most oral point of the anterior margin of the corpus; 9, Height of the mandible corpus at midpoint of the cheektooth row; 10, Oral height of ramus: gonion ventrale-corion; 11, Aboral height of ramus: gonion ventrale-highest point of condyle; 12, Horizontal antero-posterior diameter of symphysis projection in sagittal plane; 13, Greatest thickness of the mandible corpus at midpoint of cheektooth row; 14, Maximum breadth between interalveolar crests; 15, Breadth between the most lingual points of the trigoni retro-molari; 16, Breadth between anterior margin of corpus; 17, Breadth between most lateral points of the condyles; 18, Mandibular breadth: gonion laterale-gonion laterale; ∠c, Angle between the front wall and the edge of the alveolus; ∠d, Angle between the mandibular body and the ramus; ∠e, Angle between the condyles and the symphysis projection. ca., estimate.

Table 2
Measurements of deciduous premolars of *Sinomastodon jiangnanensis* from Renzidong Cave (in mm)

No.		L[a]	W[b]	H[c]	W1[d]	W2	W3	Wt[e]
V14011.04a	R DP2	27.8	23.1	18.1	19.8	23.1	/	14.2
V14011.5	L DP2	31.8	27.4	20.4	20.9	27.4	/	16.8
V14011.04b	R DP3	44.1	36.2	26.6	30.8	36.2	/	21.8
V14011.6	R DP3	43.1	37.3	26.7	32.6	37.3	/	24.4
V14011.9	R DP4	67.6	44.6	31.2	41.4	44.6	43.5	27.3
V14011.10	L DP4	72.1	52.4	29.1	52.4	51.9	46.7	/
V14011.11	L DP4	68.7	45.1	25.7	41.4	45.1	42.5	26.8
V14011.13	L dp2	23.3	13.3	17.8	13.3	12.4	/	2.8
V14011.1a	R dp2	18	12.9	12.8	12.9	8.7	/	2.5
V14011.1c	L dp2	16.2	12.1	12.6	12.1	9.1	/	2.7
V14011.1b	R dp3	48.3	31.2	23.4	25.1	31.2	20.2	7.7
V14011.1d	L dp3	49.2	31.6	24.5	25.6	31.6	20.9	7.9

[a] L, length of the crown.
[b] W, width of the crown.
[c] H, height of the crown.
[d] W1, width of the 1st loph/lophid.
[e] Wt, width of the talon/talonid.

4.3. Locality

Renzidong Cave, Fanchang County, Anhui Province, eastern China.

4.4. Geological age

The early Early Pleistocene (2.14–2.15 Ma).

4.5. Description

4.5.1. Juvenile mandible

V14011.1 (Fig. 3) is a well-preserved mandibular corpus, except for some damage on the upper part of the rami. The first two deciduous teeth (dp2/p3) on both sides are intact. All the lophids of dp2 and dp3 are slightly worn.

In labial view, the mandibular corpus is relatively elongated and moderately inflated. The ramus is slightly posteriorly inclined. Its anterior and posterior borders are estimated to be almost parallel to one another. Based on the orientation of the ramus, the coronoid process is estimated to have been relatively posteriorly positioned, with the mandibular body and ramus forming an obtuse angle (∠d). The edge of the alveolus and interalveolar crest (e.g., van den Bergh, 1999, p.33) also form an obtuse angle (∠c). The mandibular angle is rounded and posteriorly protruding. The dentary becomes slightly deeper at the level of the anterior and posterior parts of the corpus. The symphysis is short ("brevirostrine"). The mental foramen is located beneath the anterior margin of the dp2 on the right ramus.

In superior view, the mandibular corpus is relatively slender. The symphysis is clearly retracted. The groove on the internal surface on the symphysis is narrow and shallow. There is no lower tusk or vestigial tusk alveolus. The lateral and medial walls of the mandibular corpus are joined at the symphysis to form a blade-like section. The acute angle between the condyles and the symphysis projection (∠e) means that the tooth rows diverge posteriorly.

In ventral view, the middle part of the mandibular corpus is swollen while other parts are more slender. The posterior face of the symphysis is semicircular in shape.

In anterior view, the symphysis is composed of a V-shaped valley and the snout is directed anteriorly instead of inferiorly. Both mandibular corpora are inclined laterally, which means the angle e is wide.

4.5.2. Deciduous premolars

4.5.2.1. DP2 (n-2). **V14011.05** (Fig. 4A) is a complete bunodont DP2 with a brachyodont crown composed of an anterior cingulum, two lophs and a talon. The crown is triangular in occlusal outline. The first loph is significantly narrower than the second. The parastyle is developed between the anterior cingulum and protocone. The width and height of the pretrite half-loph are not as great as those of the posttrite half-loph, so the paracone and metacone are better developed than the protocone and hypocone. There are distinct cristae (i.e., epicrista, postparacrista and postmetacrista) connecting the paracone/metacone to the interloph valley. There are four main cusps and no development of a mesoconelet, resulting in the absence of the trefoil pattern. The posterior talon is composed of the metastyle and a series of serrated cingula. The metastyle and cingula are connected by two cristae. The tooth enamel is relatively thin. The labial and lingual cingula are relatively weak.

V14011.04-a (Fig. 4F) is also an intact DP2. The basic characteristics are consistent with those of V14011.05. The slight differences are as follows: the posttrite is heavily worn, while the pretrite is slightly worn; the anterior and lingual cingula are better developed.

4.5.2.2. DP3 (n-2). **V14011.06** (Fig. 4B) is a near-complete bunodont DP3 with a patent median sulcus and brachyodont crown composed of two lophs and a talon. The crown is rectangular due to slight wear. The development of the pretrite is inferior to that of posttrite. The serrated anterior cingulum is located on the anterior wall of the first loph. The unattached protocone and hypocone result in weak mesoconelets of the pretrite. There are well-developed oblique ridges on the anterior and posterior walls of the protocone and hypocone. The trefoil pattern can be observed on

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the pretrite. The mesoconelets of the posttrite are better developed than those of the pretrite, and are separated into several small cones. There are well developed oblique ridges on the posterior wall of the paracone and the anterior wall of the metacone. On the talon, the main cusp of the pretrite is relatively large and nearly equivalent in size to the protocone/hypocone, while a series of papillae of the posttrite are present. The labial and lingual cingula are relatively weak.

V14011.04-b (DP3, Fig. 4F) is nearly identical to V14011.05. The posttrite is heavily worn, while the pretrite is slightly worn.

4.5.2.3. DP4 (n-3). **V14011.09** (Fig. 4C) is a complete bunodont DP4 with a clear median sulcus. The brachyodont crown, composed of three lophs and a talon, is rectangular and slightly worn. The pretrite and posttrite are nearly parallel and they intersect almost orthogonally with the median sulcus. The serrated anterior cingulum is located on the anterior wall of the first loph. The main cusps on the pretrite are relatively isolated, while the mesoconelets are better developed than those of the DP3. The ridge-like anterior/posterior central conules of the pretrite are well developed. The trefoil pattern can be observed after wear. The mesoconelets on the posttrite side are separated into several small cones, while the anterior/posterior central conules are absent or very weak. The talon is composed of a series of papillae.

V14011.10 (Fig. 4D) is a DP4 with a damaged talon. The trefoil pattern on the pretrite is present. There are relatively weak labial and lingual cingula. **V14011.11** (Fig. 4E) is morphologically very similar to V14011.09.

4.5.2.4. dp2 (n-3). **V14011.13** (Fig. 5A) is a complete lophodont dp2 with a single root. The crown is composed of two lophids with slight wear. The first loph is significantly higher than the second in lingual view. There is a clear paracristid on the steep anterior wall. The four main cusps are isolated while the metaconid and entoconid on the lingual side are better developed than the protoconid and hypoconid on the labial side. There is a cristid obliqua connecting the protoconid to the hypoconid. The hypoconulid is developed on the posterior part of the crown. There are weak labial and lingual cingula.

V14011.01-a/c (dp2s, Fig. 5B) resembles V14011.13 in morphology, but is smaller. The lophodont crown is more distinctive.

4.5.2.5. dp3 (n-2). **V14011.01-b/d** (Fig. 5C) are the corresponding dp3 antimeres associated with the same juvenile mandible, with almost identical morphology. The bunodont crown, with a rectangular shape and clear median sulcus, is composed of three lophids with slight wear. One isolated cone is located on the anterior cingulum. The second loph is wider than the others. The mesoconelet and anterior/posterior central conule of the pretrite half-loph are well developed to form the trefoil pattern. On the posttrite side, the mesoconelet is divided into several small cones while the anterior/posterior central conule are virtually absent. The talonid is weak and composed of three tiny conelets.

V14011.12 (Fig. 5D) is a dp3 comprising only two lophids. On the pretrite side the protoconid and hypoconid are connected by a crest due to heavy wear. The labial cingulum is well-developed.

5. Comparisons

5.1. Comparisons with other related taxa of Gomphotheriidae and Elephantidae

Sinomastodon is an unusual proboscidean taxon with a high and antero-posteriorly compressed cranium, a short jaw, and bunodont cheek teeth. Three indices of the mandible (angles c, d and e in Fig. 2) have been developed to compare the juvenile mandibles from Renzidong with those of other related taxa of Gomphotheriidae and Elephantidae. This helps to contextualize the evolutionary grade of *Sinomastodon*.

Based on the measurements presented (Table 3), the typical long-jawed gomphotheres, such as *Rhynchotherium*, have relatively larger angles c and d, while Elephantidae, such as *Elephas* and *Mammuthus*, normally have correspondingly smaller angles c and d. The brevirostrine gomphotheres (e.g., *Sinomastodon* from Eurasia and *Stegomastodon* from North America) have intermediate angles c and d. Thus, the coronoid process is more posteriorly positioned and the mandibular corpus is more elongate on the typical long-jawed gomphotheres, while the coronoid process is longer anteriorly and the dentary deeper on elephantoids. On the other hand, the difference in angle e among comparative taxa is not so distinctive.

Table 3
Comparison of measurements of the juvenile mandible of *Sinomastodon jiangnanensis* and other related taxa.[a]

Taxa	Gomphotheriidae			Elephantidae	
	Sinomastodon jiangnanensis	*Rhynchotherium shepardi*	*Stegomastodon nebraskensis*	*Mammuthus trogontherii*	*Elephas maximus*
No.	V14011.01	AMNH 18216B	AMNH25722	V18010.01	BNNR-2
∠c	140°	150°	140°	110°	105°
∠d	120°	125°	115°	110°	95°
∠e	65°	–	65°	60°	60°

[a] Measurements correspond to those in Table 1.

Based on the comparisons presented in Table 3, the Renzidong juvenile mandible possesses the transitional characteristics between the long-jawed trilophodont and elephantoid forms. The juvenile mandible of *Rhynchotherium shepardi* is readily distinguishable from that of Renzidong *Sinomastodon* in possessing a long jaw and lower tusks. Although the juvenile mandible of the North American brevirostrine trilophodont *Stegomastodon nebraskensis* closely resembles that of Renzidong in basic morphology, the former differs in having a more stout mandibular corpus, with a broad groove, and obtuse snout on the symphysis.

The Renzidong deciduous premolars, especially DP2/dp2, retain features that can be found on permanent premolars (P2–P4/p2–p4) of *Phiomia* (AMNH 13450, AMNH 13468), a basal elephantiform proboscidean from the Oligocene of North and East Africa. For example, there are two bunodont lophs, distinct main cusps with a single root, existence of a well developed parastyle and metastyle, and cristae connecting the paracone/metacone to the interloph valleys on DP2. In addition, the dp2 exhibits two lophodont lophids, distinct paracristid on the anterior wall and a hypoconulid on the posterior part of the crown, and oblique cristaea connecting the main cusps to the interloph valleys.

Although retaining primitive features on DP2/dp2 as listed above, the Renzidong DP3/DP4 and dp3, are clearly more derived than the deciduous premolars of the typical Neogene long-jawed trilophodont proboscidean, such as *Gomphotherium wimani* (AMNH 21877), *Platybelodon grangeri* (AMNH 26464, AMNH 26465), and *R. shepardi* (AMNH 18216A, AMNH 18218). They are derived in the following respects: three lophs/lophids, relatively large crown size, relatively weak or missing labial and lingual cingula, clear trefoil pattern on the pretrite side, and the mesoconelets separated into several small cones on the posttrite side.

The North American short-jawed trilophodont gomphotheriids, such as *Stegomastodon superbus* (AMNH 11191, AMNH 25722) and *Cuvieronius hyodon* (UF 22585, UF 5137 and UF 118699, Fig. 6 in

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Lucas, 2008; NMR 4429, MNHN 1234, Fig. 1 in Ferretti, 2008), are distinct from the Renzidong *Sinomastodon* in the following features of the deciduous dentition: rectangular DP2 due to the more developed first loph, weak cristae connecting the main cusps to the interloph valleys on DP2; three lophs on DP3; bunodont dp2; more developed mesoconelets on the pretrite side, developed secondary trefoil and plicate enamel (ptychodonty) and the alternate configuration between successive pretrite and posttrite half-loph(id)s (anancoidy) on some progressive specimens.

5.2. Comparisons with other specimens of Sinomastodon

Compared with adult mandibles of *S. jiangnanensis*, *S. intermedius* and *S. hanjiangensis*, the Renzidong juvenile mandible displays relative large angles c, d and e (Table 4). The analysis presented here reveals that the mandibular corpus of the Renzidong juvenile is relatively elongate and slender, the coronoid process is posteriorly positioned, the dentary becomes slightly deeper, and both of the mandibular corpora are distinctly diverging posteriorly. All of the above features highlight the plesiomorphic characteristics of the mandible in the juvenile individuals from Renzidong, and imply that they have more primitive features than do the adults.

Table 4
Comparison of measurements of mandible within the genus *Sinomastodon* [a]

Taxa	Juvenile	Adult		
	Sinomastodon jiangnanensis	*Sinomastodon jiangnanensis*	*Sinomastodon intermedius*	*Sinomastodon hanjiangensis*
No.	V14011.01	V18221	V2878	SBV84006
∠c	140°	120°	140°	145°
∠d	120°	90°	100°	95°
∠e	65°	–	55°	35°

[a] Measurements correspond to those in Table 1.

Only a few isolated deciduous premolars of *Sinomastodon* (DP2, DP3/dp3 and DP4/dp4) have been reported from the Pliocene of Shanxi and Shaanxi provinces (Tobien et al., 1986; Zong et al., 1989) and the Early Pleistocene cave or fissure deposits of southern China (Xu et al., 1974; Han et al., 1975; Pei, 1987; Huang and Fang, 1991; Zheng, 2004). Specifically, the localities include Yushe Basin, Hanzhong Basin, Liucheng Juyuandong Cave, Wushan Longgupo Cave, Jianshi Longgudong Cave and Liuzhou Bijiashan Cave (Fig. 1 in Wang et al., 2012, Fig. 4 in Wang et al., 2013).

The single dp4 (THP 10443) of the type species *S. intermedius* from the early Pliocene Yushe Basin is difficult to compare due to the extremely heavy wear. Compared with those of *S. hanjiangensis* (SBV 84008) from the Late Pliocene Hanzhong Basin, the Renzidong DP4 is more derived with better developed mesoconelets, which are separated into several small cones on the posttrite side.

The only DP2 of *S. yangziensis* from Liucheng Juyuandong Cave (V 1732) differs from that from Renzidong Cave by bearing a trapezoidal crown instead of a triangular one, broad first loph, and a weak parastyle and metastyle. The four DP3s from Liucheng Juyuandong Cave (V 1733, V 1734 and V 1735) and Wushan Longgupo Cave (CV 768) differ from those of Renzidong in having a relatively narrow crown and better developed talon. The three dp3s from Liucheng Juyuandong Cave (V 1722) and Jianshi (V 13483.01, V 5102.01) are distinct from those from Renzidong Cave due to their more slender crowns and possession of three lophids. The DP4s (V 1728, V 1729 and V 5184) from Liucheng Juyuandong Cave, Liuzhou Bijiashan Cave and Jianshi are different from those from Renzidong in having a relatively narrow crown, with distinct mesoconelets on the pretrite side, and a better-developed anterior/posterior central conule of the posttrite side.

The juvenile *Sinomastodon* remains from Renzidong Cave should be assigned to *S. jiangnanensis*. The taxon is more derived than the Pliocene *S. intermedius* and *S. hanjiangensis* in the cranium, mandible, and DP4 morphology, but it is more plesiomorphic than

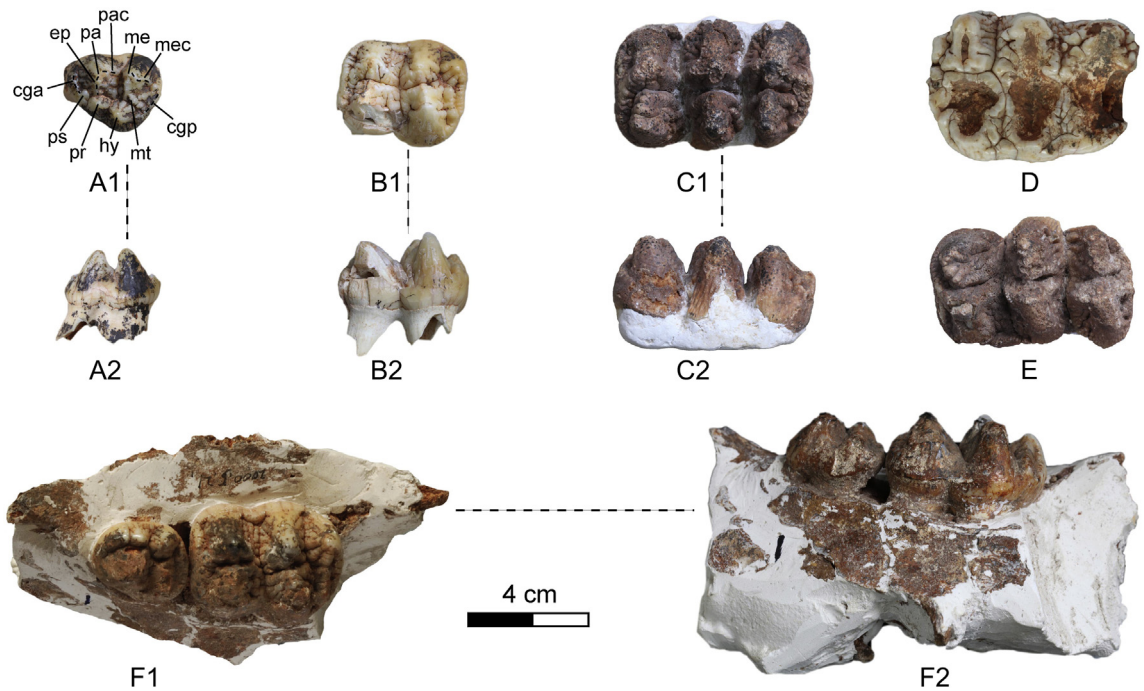

Fig. 4. The upper deciduous premolars of *Sinomastodon jiangnanensis* from Renzidong Cave. A, DP2 (V14011.05); B, DP3 (V14011.06); C, DP4 (V14011.09); D, DP4 (V14011.10); E, DP3 (V14011.07); F, one fragmentary maxilla with right DP2/DP3 (V14011.04). 1, occlusal views; 2, labial views. Abbreviations: cga, anterior cingulum; cgp, posterior cingulum; pa, paracone; pr, protocone; me, metacone; hy, hypocone; ep, epicrista; ps, parastyle; pac, postparacrista; mec, postmetacrista; mt, metastyle.

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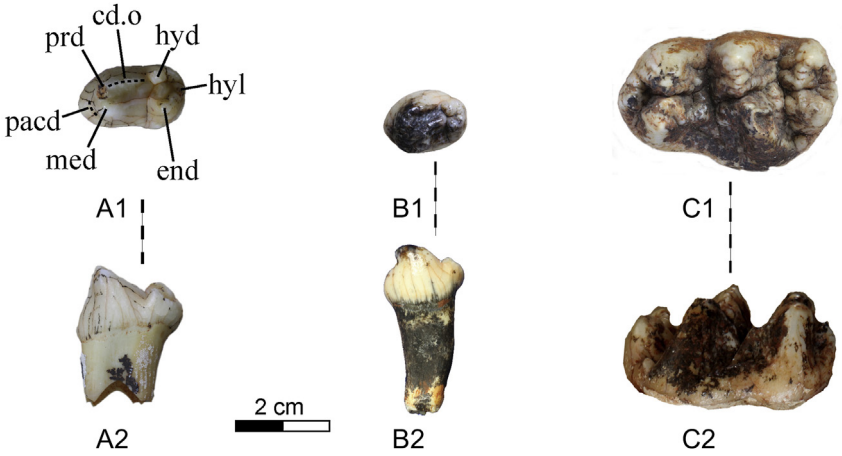

Fig. 5. The lower deciduous premolars of *Sinomastodon jiangnanensis* from Renzidong Cave. A, dp2 (V14011.13); B, dp2 (V14011.01-c); C, dp3 (V14011.01-d); D, dp3 (V14011.12); E, dp4 (V14011.11) 1, occlusal views; 2, lingual views. Abbreviations: prd, protoconid; med, metaconid; hyd, hypoconid; end, entoconid; pacd, paracristid; cd.o, cristid obliqua; hyl, hypoconulid.

the Pleistocene *S. yangziensis* in the permanent and deciduous dental morphology (Wang et al., 2012, 2013).

6. Discussion and conclusion

Sinomastodon is a unique brevirostrine trilophodont taxon with a high and antero-posteriorly compressed cranium and bunodont cheek teeth. Unfortunately, the morphology of juvenile individuals of this taxon has been poorly known due to the scarcity of material, compared to the relatively abundant remains of adult individuals. The analysis presented here provides a comparative account of a juvenile mandible and deciduous dentition of *S. jiangnanensis* from the Early Pleistocene Renzidong Cave. Consequently, the diagnosis of *S. jiangnanensis* is amended as follows: (1) Relatively larger size than *S. intermedius*, *S. hanjiangensis*, and *S. yangziensis*. (2) Cranium high, occipital and frontal region shortened, maxilla deepened, and premaxilla steepened. (3) Mandible of adults with short symphysis, articular process high, coronoid process more anteriorly placed, and corpus deepened. (4) On the mandible of juvenile individuals, the corpus is relatively slender, coronoid process is relatively posteriorly positioned, and the corpora diverge posteriorly. (5) M3 is characterized by 5 lophs while m3 is characterized by 5 lophids and an isolated talonid. (6) The posterior pretrite central conule develops into an isolated cusp. (7) The trefoil pattern is present on the pretrite half-lophs. (8) No cement is present in the transverse valleys. (8) The anterior cingulum is well-developed, while the posterior and lateral cingula are weakly expressed.

The Renzidong juvenile mandible, as with the adult cranium and mandible of *Sinomastodon* (Wang et al., 2012), exhibits transitional characteristics between the typical long-jawed trilophodont gomphotheriids and elephantoids, such as *R. shepardi* and *Elephas maximus*. However, more primitive features are present on the Renzidong juvenile mandible than on the adult mandibles of *S. jiangnanensis*, *S. intermedius*, and *S. hanjiangensis*.

The discovery and description of the first lower deciduous premolar from Renzidong Cave reveals the plesiomorphic features on lophodont dp2 of *Sinomastodon*. Furthermore, comparisons also show that the deciduous dentition of the North American short-jawed trilophodont gomphotheriids (Subfamily Cuvieroniinae) is more derived than that of Subfamily Sinomastodontinae (Wang et al., 2012).

The juvenile remains of *S. jiangnanensis* from Renzidong Cave are more derived than those of the Pliocene *S. hanjiangensis*, yet are more plesiomorphic than those of the Pleistocene *S. yangziensis*. The adult and juvenile remains from Renzidong Cave nicely illustrate that *S. jiangnanensis* represents a transitional species within *Sinomastodon* that occurs at the Neogene-Quaternary boundary.

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