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内蒙古二连盆地早始新世脑木根组上部的奇蹄类1)

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摘要:描述了内蒙古二连盆地脑木根组上部(早始新世伯姆巴期)两种奇蹄类:脊齿貘类的二连明镇貘(新属新种) *Minchenoletes erlianensis* gen. et sp. nov. 和蹄齿犀类的 *Pataecops parvus*。二连明镇貘区别于其他脊齿貘类的特点是:个体小,颊齿齿冠低,齿脊相对不发育,牙齿较横宽(长宽比小),M3 相对较长。两种化石分别将脊齿貘科和犀超科的化石记录提前到最早始新世。最新的地层资料表明,明镇貘仅发现于脑木根组上部,相当于伯姆巴期的地层中;施氏貘(*Schlosseria*)和脊齿貘(*Lophialetes*)则分别发现于阿山头组和伊尔丁曼哈组。因此,这些化石在生物地层对比和早期奇蹄类演化研究中具有重要价值。依据二连地区的新资料和中亚考察团的野外记录,我们认为蒙古的 *Pataecops parvus* 标本可能来自比 Kholobolchi 动物群大多数种类更低的层位,可能相当于伯姆巴期。

关键词:内蒙古,早始新世,奇蹄目,脊齿貘科,蹄齿犀科,生物地层学

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EARLY EOCENE PERISSODACTYLS (MAMMALIA) FROM THE UPPER NOMOGEN FORMATION OF THE ERLIAN BASIN, NEI MONGOL, CHINA

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Abstract Two species of perissodactyls from the upper part of the Nomogen Formation (Bumbanian, Early Eocene) in the Erlian Basin, Nei Mongol, China are described: the lophialetid tapiroid *Minchenoletes erlianensis* gen. et sp. nov., and the hyracodontid rhinocerotoid *Pataecops parvus*. *M. erlianensis* differs from the known lophialetids in having smaller size, lower crowned cheek teeth, less developed lophs, smaller length/width ratio in M1-2, and proportionally longer M3. Both taxa extend the fossil records of the Lophialetidae and the Rhinocerotoidea to the earliest Eocene. Recent stratigraphic data shows that *Minchenoletes* is only found from the upper part of the Nomogen Formation (Bumbanian), while *Schlosseria* and *Lophialetes* occurred respectively in the Arshanto and the Irdin Manha formations, enhancing their significance in biostratigraphic correlations and understanding of early evolution of perissodactyls. Based on the new stratigraphic data and review of the fieldnote of the CAE we consider that the Mongolian specimens of *Pataecops parvus* probably came from a lower stratigraphic level than most taxa of the Kholobolchi fauna, possibly correlative to the Bumbanian age.

Key words Nei Mongol, Early Eocene, Perissodactyla, Lophialetidae, Hyracodontidae, biostratigraphy

1 Introduction

Perissodactyls are an ordinal group of mammals first appeared at the earliest Eocene in the Holarctica. Taxa of this age are critical in understanding of the origin and early radiation of the group, although most of them are represented by fragmentary materials. Some major lineages of perissodactyls have been documented in the earliest Eocene in Asia, including the hippomorph *Propachynolophus hengyangensis* and the isectolophid tapiroid *Orientolophus hengdongensis* from the Lingcha Formation in the Hengyang Basin, southern China (Li et al., 1979; Ting, 1993; Young, 1944), the isectolophid tapiroids *Homogalax wutuensis* and *Chowliia laoshanensis*, the ? lophialetid tapiroid *Ampholophus luensis*, and the eomoropid chalicotheroid *Pappomoropus taishanensis* from the Wutu Formation in Shandong, China (Chow and Li, 1963, 1965; Tong and Wang, 2006; Wang and Tong, 1996), and the isectolophid tapiroid *Orientolophus*? *namadicus* and the eomoropid chalicotheroid *Protomoropus gabuniai* from the Bumban Member of the Naran Bulak Formation in the Nemegt Basin, Mongolia (Dashzeveg, 1979a, b; Hooker and Dashzeveg, 2004; Ting, 1993). All these taxa are considered as members of the Bumbanian faunas (Ting et al., 2011).

Here we report some new materials from the upper part of the Nomogen Formation in the Huheboerhe area of Nei Mongol (Inner Mongolia), China. Specimens described here were collected from two localities: the Nuhetingboerhe and the Wulanboerhe. Both localities were previously known as 9.6 km (6 miles) west of Camp Margetts and 11 km (7 miles) at 235° of Camp Margetts, respectively (Granger, 1930; Meng et al., 2007; Wang et al., 2010). Reported associate mammals include a mimotonid *Gomphos elkema* (Meng et al., 2004), a ctenodactyloid rodent *Yuanomys zhoui* (Meng and Li, 2010), an omomyid euprimate *Baataromomys ulaanus* (Ni et al., 2007), and an arctostylopid *Anatolostylops zhaii* (Wang et al., 2008). The fauna was correlated to the Mongolian Bumbanian fauna and considered as the Early Eocene in age (Meng et al., 2004; Wang et al., 2010), which is supported by paleomagnetic results (Bowen et al., 2005; Sun et al., 2009).

Terminology of tooth description follows that of Dashzeveg and Hooker (1997), with the exception of the metalophid of them, which we prefer to call the cristid obliqua. The classification of here described taxa follows McKenna and Bell (1997). Abbreviations: AMNH, American Museum of Natural History, New York; IVPP, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing.

2 Systematic paleontology

Order Perissodactyla Owen, 1848
Suborder Tapiromorpha Haeckel, 1866
Infraorder Ceratomorpha Wood, 1937
Superfamily Tapiroidea Gray, 1825
Family Lophialetidae Matthew & Granger, 1925
***Minchenoletes* gen. nov.**

Type species *Minchenoletes erlianensis* gen. et sp. nov.

Included species Only the type species.

Diagnosis As for the type and only species.

Etymology The genus is named after the late Prof. Dr. Minchen Chow (Zhou Mingzhen) in recognition of his contributions to Chinese paleomammalogy and his pioneer work on fossil mammals of the Nomogen Formation where the type species comes.

Distribution The Bumbanian Asian Land Mammal Age (ALMA) of the Early Eocene; Huheboerhe Area in the Erlian Basin, Nei Mongol, China.

Minchenoletes erlianensis gen. et sp. nov.

(Fig. 1)

Holotype IVPP V 14683, a fragmentary right maxilla with M1–2.

Paratype V 14686, a right M3.

Referred specimens V 14684, a fragmentary left maxilla with M1–2 and roots of P4; V 14685, a fragmentary left maxilla with DP4–M1; V 14687, a right M3; V 14688, a fragmentary right maxilla with P4–M1; V 14689, a right DP3; V 14694.1–2, a fragment of a left lower jaw with m1 and an isolated lower incisor; V 14695, a right lower jaw fragment with dp4.

Horizon and localities All specimens are from the *Gomphos*-bearing bed (NM-3) in the upper part of the Nomogen Formation, which is considered to be Bumbanian in age (Meng et al., 2004; Wang et al., 2010) and occurs within Chron C24r of the Geomagnetic Polarity Timescale (Bowen et al., 2005; Sun et al., 2009). The type specimen (V 14683), V 14684–14685, V 14688–14689, and V 14694–14695 were collected at Nuhetingboerhe, while the other two (V 14686–14687) were found at Wulanboerhe (formerly Ulan Bulak). Both localities are in the Erlian Basin, Nei Mongol, China (Meng et al., 2007; Wang et al., 2010).

Diagnosis Small lophialetid. Differing from other lophialetids in having a much smaller size (at least 20% smaller in length of molars, except *Breviodon minutus*), lower crowned cheek teeth, less developed lophs, smaller length/width ratio in M1–2 (0.81 ~ 0.83), and proportionally longer M3 (length/width ratio = 0.93 ~ 0.95).

Etymology The specific name derives from Erlian, a name for both the city and the geological basin where the new materials were collected.

Description The specimens referred to this species are fragmentary. All the cheek teeth are relatively low crowned. The upper and lower teeth are associated on the basis of their occurrence, general morphology and sizes.

DP3 (Fig. 1H) is represented by an isolated tooth. It is nearly triangular in occlusal view and wider posteriorly than anteriorly. The paracone and metacone are distinct but connate on the ectoloph. A small protocone is present on the lingual side of the tooth, with a low protoloph extending anterolabially along the tooth margin.

DP4 (Fig. 1I) is only preserved on V 14685. It is molarized. The anterior margin is distinctly narrower than the posterior one, giving it a trapezoidal outline. The ectoloph is broken, but the preserved portion clearly shows that the metacone is separated from the paracone. Weak cingula exist at the anterior and posterior sides of the tooth. The hypocone is larger and more

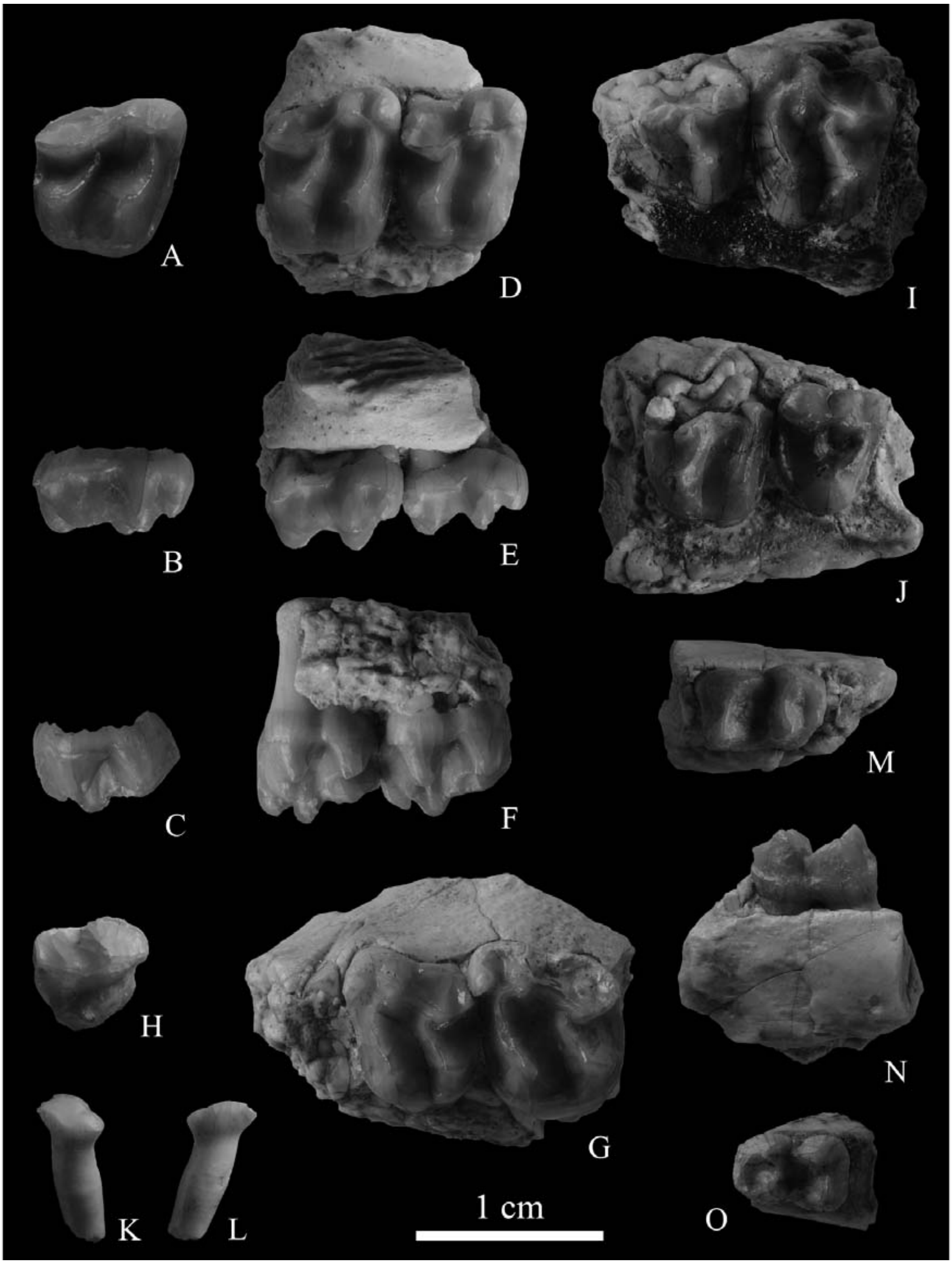

Fig. 1 *Minchenoletes erlianensis* gen. et sp. nov.
A–C. Right M3 (IVPP V 14686, paratype) ; D–F. Right maxilla with M1–2 (V 14683, holotype) ; G. Left maxilla with M1–2 and roots of P4 (V 14684) ; H. Right DP3 (V 14689) ; I. Left maxilla with DP4–M1 (V 14685) ; J. Right maxilla with P4–M1 (V 14688) ; K, L. Right i2 (V 14694. 2) ; M, N. Left lower jaw fragment with m1 (V 14694. 1) ; O. Right lower jaw fragment with dp4 (V 14695). A, D, G–J, M, O. in crown view; B, E, L, N. in labial view; C, F, K. in lingual view

lingually located than the protocone. The protoloph is shorter and extends more obliquely to the transverse axis than the metaloph.

Of the upper premolars, only one P4 was found on specimen V 14688 (Fig. 1J). The P4 is non-molariform in being small and lacking the hypocone. The parastyle is relatively well separated from the ectoloph. The paracone and metacone are distinct and nearly equal in size. The ectoloph is relatively straight and a very shallow ectoflexus is present on its buccal surface. The protoloph is fairly developed and tapers anterolabially from the protocone. The metaloph is low and short. It is not connected to the protocone and does not form the U-shaped loop with the protoloph, unlike other lophialetids. The anterior and posterior cingula are well developed, but the ectocingulum is very weak.

The M1 and M2 (Fig. 1D–G) are almost identical in morphology, except that the M2 is larger in size. Both teeth are rectangular in outline with its width greater than its length. They have relatively large parastyles, convex paracones, and relatively long and flat metacones (the posterior portion of the ectoloph). The metacone is lower than the paracone and considerably deflected lingually. In occlusal view, the ectoloph runs antero-posteriorly anterior to the paracone, then postero-lingually from the paracone to the metacone, and bends postero-labially at the summit of the metacone. Both the protoloph and metaloph are well developed, and slightly convex anteriorly. The conules are absent. The protoloph connects the ectoloph at the point between the paracone and the parastyle, and the metaloph connects the ectoloph at the postcentrocrista. The paracone and metacone are subequal in size and height and are connected by a low, curved but continuous centrocrista (the middle portion of the ectopoph). The well-developed parastyle is anterior to the paracone and separated from the latter by a narrow notch. The metastyle is very weak or absent. The hypocone and the protocone are nearly of equal size. There is a distinct anterior cingulum and a weaker posterior cingulum. The lingual cingulum is absent and the ectocingulum is weak.

Two isolated upper molars (V 14686, Fig. 1A–C and V 14687) are identified as M3, because they have a slightly different outline from that of the M1–2. In addition, contact facets are present at their anterior surfaces, but absent at posterior ones. The subquadrate M3 is proportionally longer and posteriorly narrower than M1–2. Its metacone is deflected more lingually than that of M1–2. These features are consistent with the characters of M3 in the primitive forms of some perissodactyls.

The measurements of the upper cheek teeth are listed in Table 1.

Table 1　Measurements of the upper cheek teeth of *Minchenoletes erlianensis* gen. et sp. nov.　(mm)

	DP3		DP4		P4		M1		M2		M3	
	L	W	L	W	L	W	L	W	L	W	L	W
V 14689	6.14	6.03										
V 14685			7.16*	7.54*			7.71	9.36				
V 14688					5.40	6.54	7.27*	8.03*				
V 14683							6.95	8.44	7.46	9.08		
V 14684							7.02	8.70	8.02	9.66		
V 14686											8.20	8.67
V 14687											7.68	8.26

L. length; W. width; * estimated.

Only one incisor was found from the *Gomphos*-bed at Nuhetingboerhe, which is identified as i2 (Fig. 1K, L). Its crown is spatulate and bucco-lingually compressed. The dimension of the tooth crown is 3.58 mm×2.38 mm (length×width).

Two lower cheek teeth are identified as dp4 and m1. On the rectangular m1 (6.75 mm×4.32 mm), the paralophid is relatively long but low. The trigonid is narrower and shorter than the talonid. The hypolophid is distinctly lower than the protolophid. Both are nearly perpendicular to the crown longitudinal axis. The cristid obliqua is well developed, joining the protolophid at the center. The hypoconulid is small and connected to the hypolophid by a short posthypocristid. Both the anterior and posterior cingulids are present and the labial cingulid exists only at the ectoflexid (Fig. 1M, N). The fully molarized dp4 is similar to the m1 in morphology, but smaller in size (6.06 mm×3.84 mm). The dp4 is also different from the m1 in having a narrower trigonid compared to the talonid, the lower crown, the wider opened trigonid, and the less developed lophids (Fig. 1O). These differences are similar between the dp4 and m1 of *Schlosseria* from the Arshanto Formation.

Comparison and discussion The upper cheek teeth described above have the same morphological features and obviously represent the same species. The general morphology of the upper molars is most similar to that of the lophialetids and the primitive helaletids (such as *Heptodon*) (*sensu* Radinsky, 1963, 1965). However, the features including the metaloph connecting the ectoloph at a point fairly anterior to the metacone, the relatively narrower valley between the protoloph and metaloph, and the unreduced posterior part of the ectoloph clearly distinguish the new species from those of helaletids and suggest a lophialetid affinity.

The inclusion of the lower cheek teeth in the same species is with less certainty. The facts that their morphology matches that of the upper molars of the species and not many perissodactyl specimens have been collected from the *Gomphos*-bed in the Huheboerhe area indicate that they are probably referable to the same species of the Lophialetidae.

The Lophialetidae represents an endemic Asian clade of tapiroids in the Early and Middle Eocene. The known genera of lophialetids include *Lophialetes* Matthew & Granger, 1925, *Schlosseria* Matthew & Granger, 1926, *Breviodon* Radinsky, 1965, *Kalakotia* Ranga Rao, 1972, *Eoletes* Biryukov, 1974 (see also Lucas et al., 2001 and Averianov and Godinot, 2005), *Parabreviodon* Reshetov, 1975, *Simplaletes* Qi, 1980a, *Zhongjianoletes* Ye, 1983, and *Ampholophus* Wang & Tong, 1996. In addition, *Aulaxolophus quadrangularis* (Ranga Rao, 1972), *Chasmotherium mckennai* (Sahni and Khare, 1971), and *Schlosseria radinskyi* (Sahni and Khare, 1972) from the Indian Eocene are considered junior synonyms of *Kalakotia simplicidentata* (Russell and Zhai, 1987; Thewissen et al., 1987). *Pataecops* (Radinsky, 1965, 1966) and *Rhodopagus* (Radinsky, 1965), originally classified as lophialetids, were reassigned to the hyracodontid rhinoceratoids (Lucas and Schoch, 1981) and are clearly distinguishable from the lophialetids including *Minchenoletes* here described.

Ampholophus was based on a fragmentary maxilla from the Early Eocene Wutu Formation of Shandong, China, and provisionally referred to Lophialetidae (Wang and Tong, 1996). The M1 of *Ampholophus* has conical paracone and metacone with poorly developed lophs, a relatively labially positioned metacone, a moderately labially protruding parastyle, and prominent paraconule and metaconule on posterior premolars and M1 (unkown for M2-3), which clearly distinguish it from *Minchenoletes* and other lophialetids, and suggest a distant affinity with lophialetids.

Of the genus *Simplaletes*, three species were named, including *Si. sujiensis* and *Si. ulanshirehensis* from the Eocene of Nei Mongol, China (Qi, 1980a), and *Si. xianensis* from the Eocene of Shaanxi (Zhang and Qi, 1981). Lucas et al. (1997) synonymized the first two species with *Schlosseria magister*, and reassigned the last one to the genus *Eoletes* but pending new dental information. *Si. xianensis* was based on an incomplete skull with heavily worn and poorly preserved dentition (Zhang and Qi, 1981). *Minchenoletes* from the upper part of the Nomogen Formation cannot be directly compared with *Si. xianensis* in dental morphology, but its distinctly smaller size and older age may help in distinguishing it from the latter.

Minchenoletes are distinct from other lophialetid genera in having a much smaller size (at least 20% smaller in length of molars, except *Breviodon minutus*), lower crowned cheek teeth, less developed lophs, smaller length/width ratio in M1-2, and proportionally longer M3 compared to M1–2 (Table 1 and 2). These differences clearly diagnose the new taxon, and may indicate a primitive condition in the lophialetid clade, which is consistent with its earlier age (Bumbanian). In addition, the only premolar (a right P4) lacks a complete protoloph-metaloph loop that is previously thought to be the typical lophialetid character. However, our examination of the material of *Schlosseria magister* recently collected from the Arshanto Formation in the Huheboerhe area, Nei Mongol, China, shows that lack of the protoloph-metaloph loop occurs in some of P3s and P4s. This may suggest a possible development of the loop in the lophialetid history.

Table 2　Comparison of the measurements of the lophialetid upper molars　(mm)

		M1			M2			M3		
		L	W	L/W	L	W	L/W	L	W	L/W
Minchenoletes erlianensis	V 14685	7.71	9.36	0.82						
	V 14683	6.95	8.44	0.82	7.46	9.08	0.82			
	V 14684	7.02	8.7	0.81	8.02	9.66	0.83			
	V 14686							8.2	8.67	0.95
	V 14687							7.68	8.26	0.93
*Schlosseria magister*1)		10.6	12	0.88	11.7	13.15	0.89	10.83	12.36	0.88
*Lophialetes expeditus*1)		12.45	13.08	0.95	13.8	14	0.99	13.15	13.47	0.98
*Kalakotia simplicidentata*2)	ONG/K/12 l	9.04	8.03	1.13	9.51	8.28	1.15	9.37	8.63	1.09
	r	7.71	8.24	0.94	9.2	9.01	1.02	9.55	9.51	1.00
*Eoletes gracilis*3)	KAN 5088/69	13.3	12.3	1.08	13.9	13.2	1.05	13.7	12.5	1.10
	KAN 4773/68	12.3	11.6	1.06	12.4	12.5	0.99	14.6	11.7	1.25
*E. tianshanensis*4)	ZIN 32754	9.5	10	0.95	11.1	10.5	1.06			
	ZIN 34023				11.8	10.3	1.15			
	ZIN 35283				11.2	10.7	1.05			
*Ampholophus luensis*5)		9.52	11.2	0.85						

L. length; W. width; l. left; r. right; 1) data (mean) from Radinsky (1965); 2) data measured on the cast hosted in AMNH; 3) data from Lucas et al. (1997); 4) data from Averianov and Godinot (2005); 5) data from Wang and Tong (1996).

Superfamily Rhinocerotoidea Owen, 1845
Family Hyracodontidae Cope, 1878
Genus *Pataecops* Radinsky, 1966
Pataecops parvus (Radinsky, 1965)

(Figs. 2–4)

Material　IVPP V 14630-1–3, a pair of maxillae with P3–M3 of both sides and a left lower jaw with p4 and roots of p2–3 of the same individual. V 14631-1–3, three maxillary fragments with left DP3–4, right M1–2, and roots of right DP3–4 respectively, probably of the same individual; V 14632, left M3; V 14675-1–2, a pair of maxillae with left P4, M3, and roots of M1–2, and right M1–3 and roots of P4, probably of the same individual; V 14676, a left maxilla with P4–M2; V 14677, a right maxilla with M2 and broken M1; V 14678, a left lower jaw with m1, m3 and roots of p4 and m2; V 14679, a fragmentary left lower jaw with m2; V 14680, a right lower jaw with m2–3 and roots of m1; V 14681, a right lower jaw with m3 and roots of m2; V 14682, fragmentary left lower jaw with m2 and roots of m1.

Horizon and locality　The specimens were collected from the *Gomphos*-bearing bed (NM-3 in Wang et al., 2010) in the upper part of the Nomogen Formation, which is considered to be the Bumbanian in age (Meng et al., 2004, 2007; Wang et al., 2010) and occurs within Chron C24r of Geomagnetic Polarity Timescale (Bowen et al., 2005; Sun et al., 2009). V

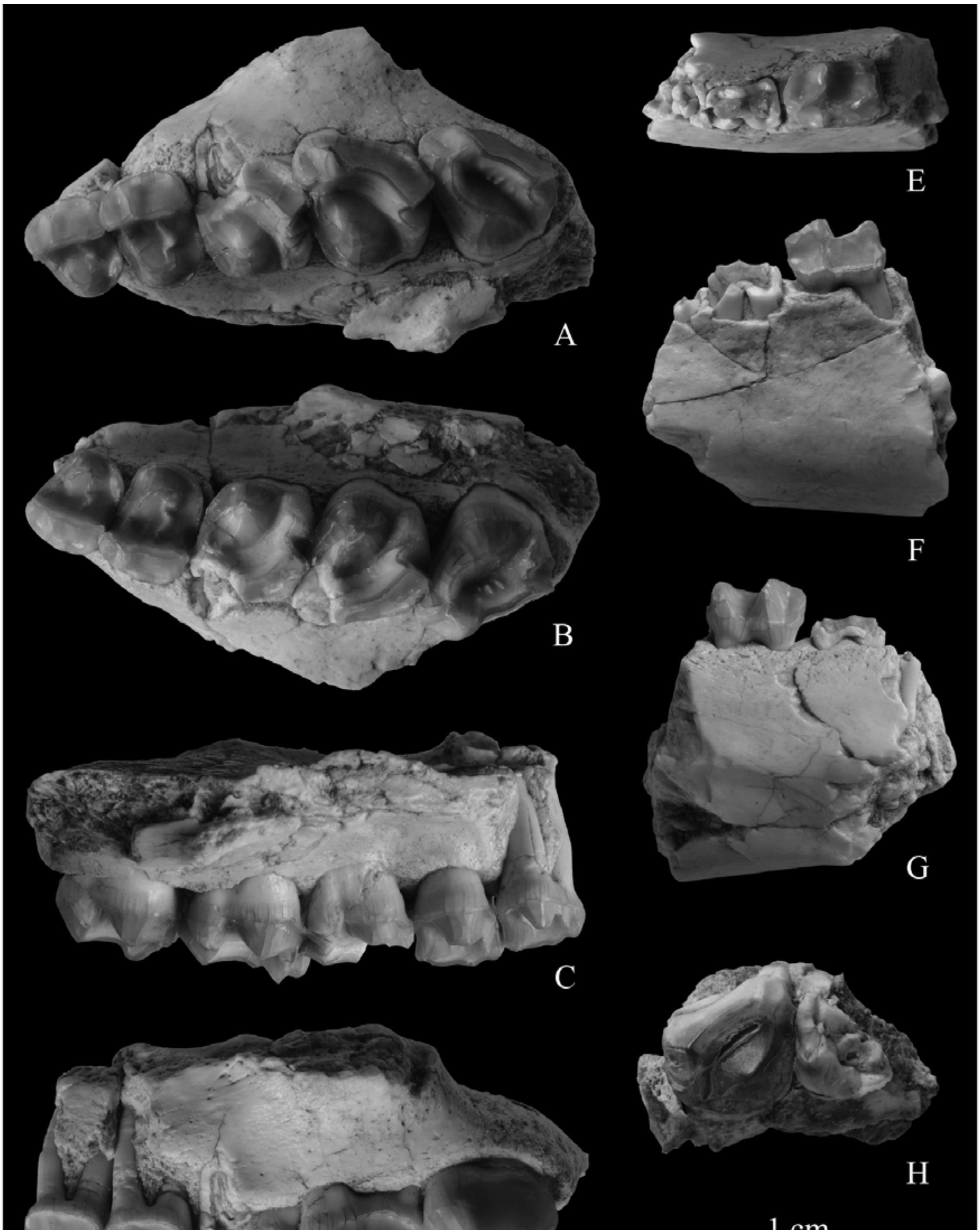

Fig. 2 *Pataecops parvus* (Radinsky, 1965)
A, C, D. Left maxilla with P3–M3(IVPP V 14630-1); B. Right maxilla with P3–M3(V 14630-2); E–G. Left lower jaw fragment with p4 and roots of p2–3(V 14630-3); H. Right maxilla with M2 and broken M1 (V 14677). A, B, E, H. in crown view; C, G. in lingual view; D, F. in labial view

14630–14632 were found at the Wulanboerhe, while the others (V 14675–14682) were collected at the Nuhetingboerhe. Both localities are in the Erlian Basin, Nei Mongol, China.

Description The anterior border of the zygomatic process of the maxilla is at the level above the junction of P4 and M1 and the posterior one is at the anterior part of M3. The anterior end of the palatal process of the palatine is at the level of middle of M1. The anterior border of the internal nares is at the transverse midline of M3(Figs. 2, 3).

The DP3 and DP4 are preserved on V 14631. They are molarized and fairly worn. The ectoloph of DP3 is broken off. The hypocone is located more lingually than the protocone, giving the tooth a trapezoidal outline. The morphology of DP4 is very similar to that of M1 (see description below), but differs from the latter only in being slightly smaller in size and having a metacone deflected less lingually and a proportionally larger hypocone. The well-developed anterior cingulum is continuous with the lingual one that terminating at the lingual base of the hypocone on both DP3 and DP4(Fig. 3H).

Both the P3 and P4(V 14630) are non-molariform and have a subrectangular outline with a rounded lingual side in crown view. On P3, the parastyle is smaller than the paracone. The ectoloph is roughly straight. The protoloph is well developed but discontinuous at the paraconule position though the conule is not clear. The metaloph is a low and short ridge, parallel to the protoloph and well separated from the protocone by a narrow valley. The ectocingulum is well developed. The precingulum terminates at the anterolingual corner, while the lingual cingulum begins at the posterolingual base of the protocone and is continuous with the postcingulum that forms a wide shelf. The morphology of P4 is very similar to that of P3. The P4 differs from P3 in being larger, having a stronger paracone rib on the labial side, a better developed and continuous protoloph, and a slightly stronger metaloph (Fig. 2A, B). Variations are observed on P4. The P4s of both sides of V 14630 have a shelf-like postcingulum and a precingulum continuous with the lingual cingulum, but on V 14675 and 14676, the postcinulum is not shelf-like and the precingulum is discontinuous with the lingual cingulum, which are similar to those on the type specimen.

The upper molars have medium sized parastyles, sharply convex paracones, oblique protolophs and metalophs (Figs. 2, 3). The crown converges from the base to the top in labial view. The paracone with a prominent rib on labial side tilts backwards, especially so on M3. The metacone is increasingly posterolingually deflected from M1 to M3. The labial surface of the ectoloph is steep, and flat posterior to the paracone. The posterior width decreases greatly from M1 to M3, making the outline from subrectangular (M1) through trapodial (M2) to nearly rounded triangular (M3). The protoloph is convex anteriorly. The metaloph is much shorter than the protoloph on M1, and increasingly reduced on M2 and M3. The posterior portion of the ectoloph is very short and extremely reduced on M3. The hypocone is considerably smaller and more compressed anteroposteriorly than the protocone. On M3 the hypocone is closely positioned on the lingual side of the metacone, whereas the dominant protocone is almost the only lingual cusp of the tooth. The precingulum is continuous or discontinuous with the lingual cingulum at the anterolingual corner. The ectocingulum and postcingulum are clearly developed.

The p4 is only preserved on a lower jaw fragment of V 14630. It is submolariform with equally wide trigonid and talonid. The paralophid is relatively high compared to that of the molars. The protolophid is fairly developed with a notch between the protoconid and the metaconid. The metaconid is slightly lower than the protoconid. The fairly high cristid oblique extends along the labial margin of the tooth and reaches the trigonid labially at the base of the protoconid. The hypoconid is nearly as high as the protoconid. The hypolophid does not extend to the small entoconid (Fig. 2E–G).

The lower molars are similar in the morphology, and their sizes increase posteriorly (Fig. 4). The molar is double-rooted and has the talonid being slightly wider but significantly longer than the trigonid. The protolophid and hypolophid are parallel to each other and extend anterolabial-posterolingually, diagonal to the longitudinal axis of the tooth. The paralophid is low and extends first anterolingually from the protoconid and then posterolingually in parallel to the

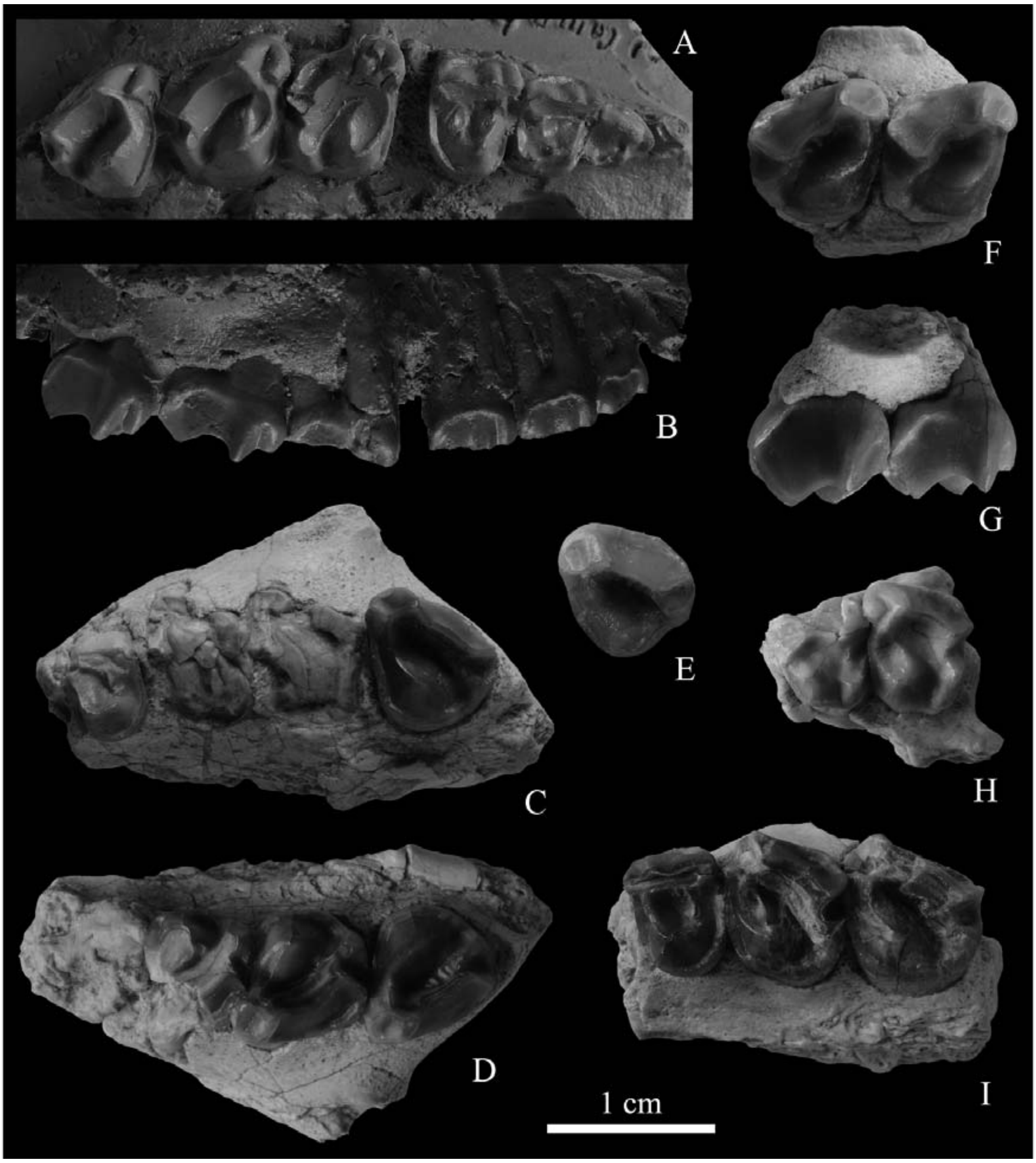

Fig. 3 Upper dentition of *Pataecops parvus* (Radinsky, 1965)
A, B. Right P2–M3 and roots of P1 (AMNH 21747, Holotype, cast); C. Left maxilla with M3, lingual half of P4, and roots of M1–2 (IVPP V 14675-1); D. Right maxilla with M1–3 and roots of P4 (V 14675-2); E. Left M3 (V 14632); F, G. Right maxilla with M1–2 (V 14631-1); H. Left maxilla with DP3–4 (V 14631-2); I. Left maxilla with P4–M2 (V 14676). A, C–F, H, I. in crown view; B, G. in labial view

protolophid. The paraconid is crest-like. The cristid obliqua is relatively unreduced and meets the protolophid posterolabially to the protoconid. It joins the hypolophid as a broad, continuously curved crest. The precingulid, postcingulid and ectocingulid are narrow but clear. The hypolophid is higher than the protolophid. The entoconid is the highest cusp on the lower molars. There is no hypoconulid on m3.

The measurements of upper and lower dentitions of *Pataecops parvus* are listed in Table 3 and 4 respectively.

Discussion The specimens collected from the Erlian Basin are clearly referable to the genotype, *Pataecops parvus*. The general dental morphology of these specimens is very similar to

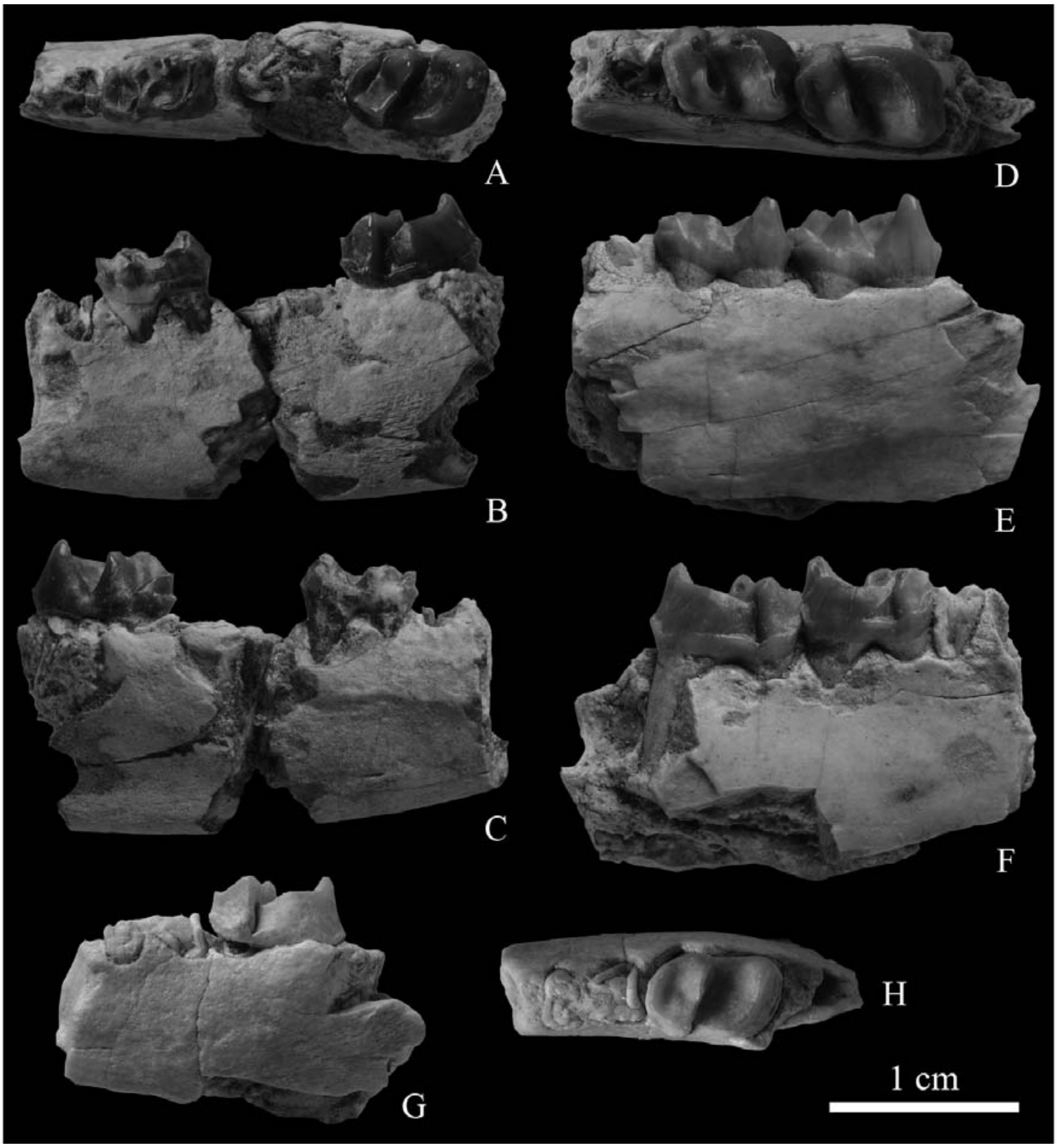

Fig. 4　Lower dentition of *Pataecops parvus* (Radinsky, 1965)
A–C. Left lower jaw with m1, m3, and roots of p4 and m2 (IVPP V 14678); D–F. Right lower jaw with m2–3 and roots of m1 (V 14680); G–H. Left lower jaw with m2 and roots of m1 (V 14682). A, D, H. in crown view; B, F, G. in labial view; C, E. in lingual view

the type (AMNH 21747) and referred (AMNH 21746, AMNH 81861 and PSS 14-1) specimens of *P. parvus* from Mongolia (Radinsky, 1965; Dashzeveg, 1991). On the upper molars, the similar features include the general shape of cheek teeth, long and lingually displaced ectolophs with steep and flat buccal surfaces, very short metalophs and posterior portion of ectolophs, and the paracone ribs tilted backwards. In addition, the lower molars here described do not distinctly differ from previously known specimens. Compared to the specimens of another species, *P. minutissimus*, from the Andarak 2 locality in Kyrgyzstan (Averianov and Godinot, 2005; Reshetov, 1979), the cheek teeth of *P. parvus* are considerably larger. *P. minutissimus* also differs from *P. parvus* in having an ectoloph nearly parallel to the protoloph on M3, a more lingual deflected metacone, a well-developed notch at the lingual margin between the protocone and the hypocone, and less developed cingula.

Table 3　Measurements of the *Pataecops parvus* upper cheek teeth (mm)

		DP3		DP4		P2		P3		P4		M1		M2		M3	
		L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W
IVPP V 14631	l	5.68*	6.58	6.81	7.68												
	r											7.55	8.05	8.20	8.34		
AMNH 21747						4.17	4.35	4.83	6.34	5.42	7.71	6.86	8.68	8.11	8.93	7.86	8.09
V 14630	l							4.65	6.22	5.09	7.16	6.99*	7.40*	8.23	8.34	8.10	8.23
	r							4.73	6.20	5.17	7.24	6.90*	7.60*	8.11*	8.28*	8.13	8.26
AMNH 21746	l							5.22	5.85	5.84	7.30	7.39	8.73	8.55	8.89	7.91	8.08
	r									5.70	7.27	7.14*	8.67*	8.08	8.66	7.86	7.95
V 14632																7.82	7.99
V 14675	l									5.29*	6.38*					7.86	7.98
	r											6.84*	7.86*	7.85	8.19	7.88	8.04
V 14676										5.60	7.52	7.60*	8.43*	8.46*	8.83*		
V 14677														8.27	8.26		

L. length; W. width; l. left; r. right; * estimated.

Table 4　Measurements of the *Pataecops parvus* lower cheek teeth (mm)

	p4		m1		m2		m3	
	L	W	L	W	L	W	L	W
V 14630	5.74	3.94						
AMNH 81861			6.23	3.59	6.84	4.18		
V 14678			6.41	3.55			7.46	4.63
V 14679					7.04	4.68		
V 14682					7.16	4.51		
V 14680					7.15	4.79	7.80	5.16
V 14681							7.94	5.15

L. length; W. width.

The systematic position of *Pataecops parvus* remains uncertain. It was originally placed in the Lophialetidae by Radinsky (1965), and together with *Rhodopagus* was distinguished as the subfamily Rhodopaginae within the Lophialetidae by Reshetov (1975). Lucas and Schoch (1981) placed it with *Rhodopagus* in the rhinocerotoid family Hyracodontidae. Hooker (1989) raised the subfamily Rhodopaginae to family rank and considered it as the sister group of the Deperetellidae, instead of being closely related to either the Rhinocerotoidea or Tapiroidea. Gabunia and Kukhaleishvili (1991) restored *Rhodopagus* and *Pataecops* to the stem ceratomorph family Lophialetidae, when they described *Rhodopagus radinskyi*. The differences of *Rhodopagus* and *Pataecops* from the lophialetids, including straight and steep ectoloph, greatly reduced metaloph and posterior portion of ectoloph, obliquely oriented protolophid and hypolophid, and no hypoconulid on m3, do not seem to support their lophialetid affinity. But the systematic position of both genera at the familial level is still unresolved. Dashzeveg and Hooker (1997) reemphasized that the Rhodopagidae is a separate family of Rhinocerotoidea, while McKenna and Bell (1997) placed both *Rhodopagus* and *Pataecops* in the Hyracodontidae. Averianov and Godinot (2005) doubtfully included *Pataecops* in the family Rhodopagidae. However, it is clear that *Pataecops* is a primitive rhinocerotoid. The occurrence of *P. parvus* in the deposits of Bumbanian age in the Erlian Basin clarifies the earliest record of the Rhinocerotoidea as the earliest Eocene, which indicates that the early history of the Rhinocerotoidea should be reconsidered pending on better preserved specimens with sufficient morphological information.

3 Biostratigraphy

Perissodactyla are highly diverse in the Eocene Epoch. Their fossils are most commonly found in Eocene deposits globally and thus bear importantly on biostratigraphy and biochronology. The Asian endemic lophialetids, such as *Lophialetes* and *Schlosseria*, are often used as index fossils in biostratigraphic correlation and age determination of the fossil-bearing deposits. Because of its rich faunas, the Mongolian Plateau has been a major data source for Asian Paleogene mammalian biostratigraphy and biochronology. Most of the Paleogene ALMAs were proposed based on the mammalian faunas found in this region (Li and Ting, 1983; Romer, 1966; Russell and Zhai, 1987; Tong et al., 1995; Wang et al., 2007). The mammalian faunas therefrom serve as the primary means for biostratigraphic correlation in eastern Asia. However, it has been recognized that premature and erroneous stratigraphic correlations between different localities in previous work have resulted in compositional mixture of some classic faunas (Meng et al., 2007). For example, both *Lophialetes expeditus* and *Schlosseria magister* were reported from the Arshanto and Irdin Manha formations in the Erlian Basin (Qi, 1980b, 1987; Radinsky, 1965), while the former was even reported from the "Houldjin beds" (Radinsky, 1965). This problem has been noticed for a long time, but has never been resolved because it requires not only a systematic fossil collecting in the field to prove the faunal mixture but also a thorough review of the specimens that have been published in early studies (Meng, 1990; Qi, 1987; Radinsky, 1964; Wang et al., 2010).

Recent investigations in the Erlian Basin have clarified some stratigraphic problems (Meng et al., 2007; Wang et al., 2010). Based on the new stratigraphic data and fossils systematically collected, *Schlosseria magister* and *Lophialetes expeditus* are proved to occur in the Arshanto and the Irdin Manha formations, respectively, while *Minchenoletes erlianensis* is from the upper part of the Nomogen Formation (Fig. 5). The faunas from the Arshanto and Irdin Manha formations are unambiguously of the Arshantan and Irdinmanhan age (ALMA), *Schlosseria magister* should thus be counted as a member of the Arshantan fauna, whereas *Lophialetes expeditus* as a member of the Irdinmanhan fauna. The fossil mammals associated with *Minchenoletes erlianensis* from the *Gomphos*-bearing bed in the Huheboerhe area clearly suggest a Bumbanian age (Meng et al., 2004; Wang et al., 2010). The occurrence of *Minchenoletes erlianensis* in the Bumbanian age not only provides new data for biostratigraphic study, but also extends the earliest record of Lophialetidae into the earliest Eocene. Morphologically, *Minchenoletes*, *Schlosseria* and *Lophialetes* are more similar to each other than to any other lophialetid. The morphological changes from *Minchenoletes* via *Schlosseria* to *Lophialetes* include the size being larger, the tooth crown being higher, the lophs (crests) being better developed, and the upper molars being more quadrate in crown outline, which probably reflect the evolutionary trends of certain lophialetid lineages and are consistent with the stratigraphic records.

Pataecops parvus is a troublesome taxon because the information related to its locality and horizon remains unclear. It was reported to be collected at about 9 km (5 miles) north of Orok Nor, Mongolia (Radinsky, 1965:212). When Dashzeveg (1991) reported some new specimens of *P. parvus*, he included the type specimen in the materials from the locality called Menkhen Teg, 38 km northwest of the Tsagan Khutel locality (p. 35), although he pointed out that the specimens described by Radinsky in 1965 were from the Tsagan Khutel locality (p. 9).

According to the fieldnote of Granger, the Central Asiatic Expeditions (CAE) used their

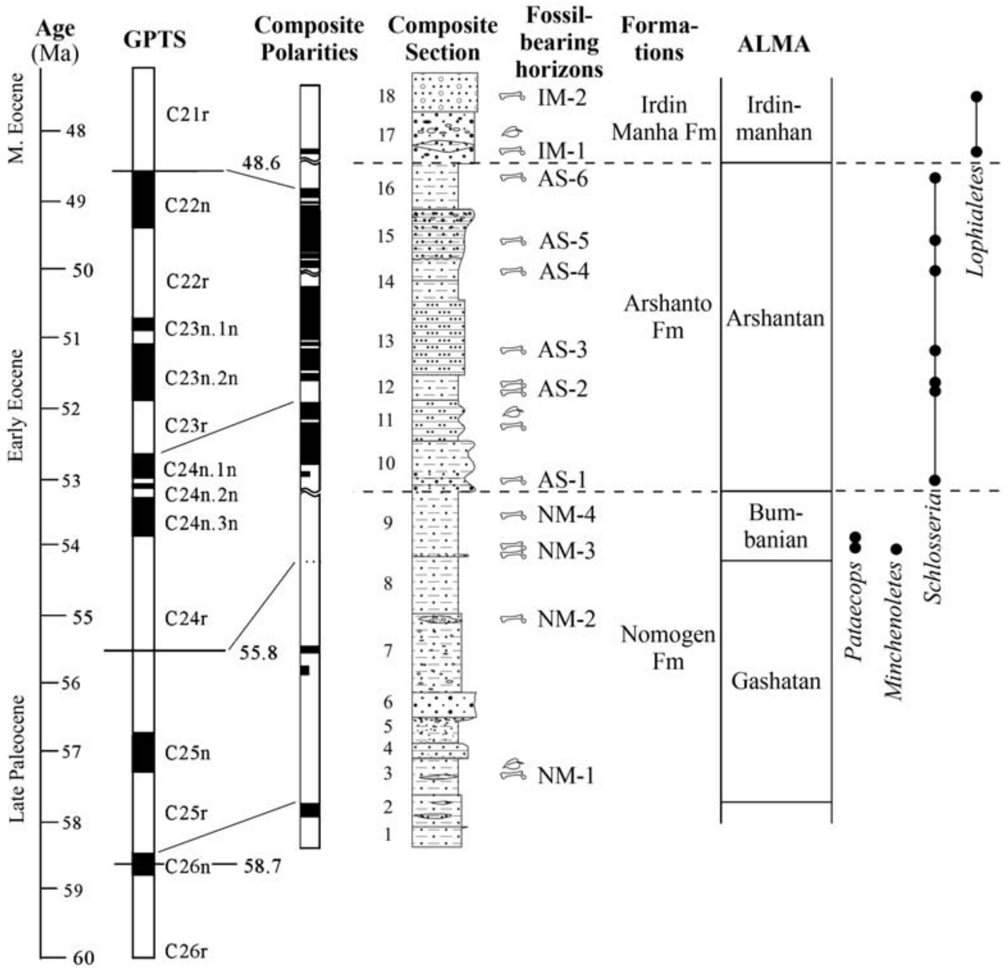

Fig. 5 Stratigraphic distribution of *Pataecops parvus* and certain lophialetids in the Huheboerhe area, Erlian Basin Paleomagnetic data is from Sun et al. (2009) and the section is modified from Meng et al. (2007); for details of stratigraphic sequence and mammal-bearing horizons, refer to Wang et al. (2010)

camp on Kholobolchi Nor as a landmark to coordinate their fossil localities in this area. For the horizon and locality of *Pataecops* specimens (field no. 547, catalogue no. AMNH 21746, 21747 and 81861), Granger (1925:33) wrote (they were) "presumably from the same horizon as no. 544–546 but the locality is some 15 miles (24 km) further up (N. E.) the same draw; in the vicinity of the high red bluffs from which the Hsanda Gol fossils (548) were obtained." He further recorded the locality of fossils numbered 548 as "from exposures 15 miles (24 km) N. E. of camp on Kholobolchi Nor" (Granger, 1925:34), while the skulls of coryphodontid *Eudinoceras kholobolchiensis* (field no. 544 and 545, catalogue no. AMNH 21744 and 21745) (Osborn and Granger, 1931) were recorded "from a small set of exposures 7.8 miles (12.5 km) south of camp on Kholobolchi Nor" (Granger, 1925:32). After comparison of the field record of Granger in 1925 with the map in Dashzeveg (1991:9), it is evident that the type locality of *P. parvus* is very close to or even the same as the Menkhen Teg where the specimens described by Dashzeveg (1991) were collected.

Radinsky (1965:212) reported that *Pataecops parvus* was found in the Late Eocene Kholobolchi Formation (= Kholboldji suite in Dashzeveg, 1991; Kholoboldzhi-Nur Svita in Russell and Zhai, 1987). The species was later included in the Kholobolchi fauna (Russell and Zhai, 1987; Dashzeveg, 1991; Dashzeveg and Hooker, 1997). The age of the fauna was considered to be Middle Eocene (Russell and Zhai, 1987; Dashzeveg, 1991) and more recently correlated to the Arshantan (Dashzeveg and Hooker, 1997; Lucas, 2001). Dashzeveg and Hooker (1997:136) suggested that the Arshantan "predates the Irdinmanhan and belongs to the earliest middle or latest early Eocene", whereas Lucas (2001) considered the Arshantan land mammal age to be older than the North American middle Bridgerian. Lucas and Emry (2001) regarded the Irdinmanhan and Arshantan ages as collectively correlative with the Bridgerian, but Luterbacher et al. (2004) correlated the Arshantan with the entire Bridgerian and the Irdinmanhan with the Uintan. Our recent work suggests an Early Eocene age for most of the Arshanto Formation, hence most of the Arshantan ALMA, in the Huheboerhe area of the Erlian Basin (Sun et al., 2009; Wang et al., 2010). The Arshantan ALMA is correlative to the middle-late Wasatchian and most of the Bridgerian of the North American Land Mammal Ages and also the middle Ypresian through earliest Lutetian (Wang et al., 2010).

However, the Kholobolchi Formation ranges from 60 to 91 m (200 ~ 300 feet) in thickness (Berkey et al., 1929). All fossils from this formation were included in one fauna. From our field experience in Nei Mongol and the literatures concerning the Kholobolchi, the fossils lumped in the Kholobolchi fauna are very likely from different horizons. J. Hooker (pers. comm.) also thought the fossils of the Kholobolchi fauna were not from one single level. In addition, none of those fossils was reported unambiguously associated with *Pataecops parvus*. On a sketch of the Kholobolchi section, the horizon of *P. parvus* (field no. 547) was shown at a fairly lower level (Lower Eocene) (Granger, 1925:36). Since the new materials were collected with certainty from the upper part of the Nomogen Formation and associated with the Bumbanian fauna, it is reasonable to consider that *P. parvus* was from a lower stratigraphic level, possibly a Bumbanian equivalent in Kholobolchi or its vicinity. Confirmation of this argument requires further detailed biostratigraphic work in the type locality of the species. This may also imply that the mixture of the Arshantan and Irdinmanhan faunas in the Erlian Basin is not an isolated incident. The composition of some classic Paleogene mammalian faunas of the Mongolian Plateau that serve as the foundation of the Asian Land Mammal Ages need to be clarified.

4 Conclusions

(1) Newly found specimens of perissodactyls from the upper part of the Nomogen Formation represent two species: the lophialetid tapiroid *Minchenoletes erlianensis* gen. et sp. nov. and the hyracodontid rhinocerotoid *Pataecops parvus*. They extend the fossil record of both the Lophialetidae and the Rhinocerotoidea to the earliest Eocene.

(2) Recent stratigraphic data show the distribution of three lophialetid genera, *Minchenoletes*, *Schlosseria*, and *Lophialetes*, in the eastern part of the Erlian Basin, Nei Mongol, China. *Minchenoletes* is only found from the upper part of the Nomogen Formation, correlative to the Bumbanian ALMA. *Schlosseria* and *Lophialetes* occurred respectively in the Arshanto Formation and the Irdin Manha Formation, in contrast to some previous report that both genera coexisted in the two formations. This result will enhance their significance in biostratigraphic correlations.

(3) Discovery of *Pataecops parvus* in the Bumbanian deposits seems conflict in age to the previous report related to the species. But review of the fieldnote of the CAE reveals the possibility that the Mongolian specimens of this species came from a lower stratigraphic level than most taxa previously included in the Kholobolchi fauna, in terms of the Bumbanian equivalent deposits.

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