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内蒙古二连盆地冠齿兽科(哺乳纲:全齿目)化石及其生物地层学意义[1)]

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摘要:描述了在内蒙古二连盆地新采集的保存较完好的冠齿兽类化石。基于牙齿特征的比较认为:*Eudinoceras kholobolchiensis* Osborn & Granger, 1931、*E. obailiensis* Gabunia, 1961、*Metacoryphodon luminis* Chow & Qi, 1982 和 *M.* ? *minor* Qi, 1987 的个体大小、上前臼齿前尖 V 形脊角度、原尖前后棱发育程度、上下臼齿脊形化程度和尖脊形状及位置等特征与 *E. mongoliensis* Osborn, 1924 一致,应视为后者的次主观异名;*M. xintaiensis* Chow & Qi, 1982 应归入 *Eudinoceras* 属,变更为 *E. xintaiensis*; *Metacoryphodon* 为无效命名,应予废除。厘定后的 *Eudinoceras* 属共含有 6 个有效种:*E. zhichengensis* Lei et al., 1987、*E. youngi* Xu, 1980、*E. xintaiensis* Chow & Qi, 1982、*E. mongoliensis* Osborn, 1924、*E. crassum* Tong & Tang, 1977 和 *E. sishuiensis* Wang, 1994。修订了 *Eudinoceras* 属和 *E. mongoliensis* 种的齿列特征。将二连盆地冠齿兽类化石的产出层位对应至该盆地重新厘定的地层框架中,*E. mongoliensis* 集中在阿山头组,能确定的最早出现层位为阿山头组底部的 AS – 1 层,最晚出现层位为阿山头组上部的 AS – 5 层,其时代为早始新世中期,约为 53 ~ 49 Ma。

关键词:内蒙古二连盆地,早始新世,阿山头组,伊尔丁曼哈组,冠齿兽科

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冠齿兽科(Coryphodontidae)是一类已灭绝的大型植食性全齿类哺乳动物,在古新世末期至始新世中期广泛分布于欧亚大陆与北美大陆。在北美地区,其特征显著、延续时间较短、分布较广以及数量多等特点使得该类群一度被认为是确定古新世末期至始新世中期不同时段地层的指示化石之一,并被广泛应用于区域性陆相古近系对比之中(Lucas, 1984, 1998; Uhen and Gingerich, 1995)。但在亚洲地区,长期以来由于该类化石比较零散、特征界定不清等原因,在各个属种的分类命名上存在不少争议(周明镇、胡长康,1956; 周明镇、童永生,1965; 周明镇、齐陶,1982; Lucas, 1984; Lucas and Tong, 1987; 童永生、王景文,2006), 使得冠齿兽类在亚洲及洲际陆相古近纪生物地层划分对比和相关问题上并没有显现出它应有的指示作用。

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Eudinoceras 属的模式种 *E. mongoliensis* 最初仅是依据伊尔丁曼哈平台上原定为“伊尔丁曼哈组”中发现的两枚上前臼齿而建立的(Osborn, 1924)。现在看来,该种的建立存在着不少问题。首先,其模式标本仅为两枚 P4, 材料的不足给其他标本的比较和归入带来极大困难。虽陆续有零星材料归入,但直到本文之前,并没有任何 *E. mongoliensis* 可以鉴定的上臼齿材料发表。其次,其模式标本的产地为距二连大布苏东南约 32 km 的伊尔丁曼哈平台(Osborn, 1924)。该剖面上出露的地层最先被全部归入“伊尔丁曼哈组”(Granger and Berkey, 1922), Berkey and Morris(1924)将剖面上富集雷兽的灰色砂岩层以下的红色泥岩分出,临时称为阿山头红层。1927 年才将该红色泥岩层称为阿山头组(Berkey and Morris, 1927)。而 *E. mongoliensis* 的模式标本是 1923 年由 Andrews 和 Osborn 发现的,当时的阿山头组尚未从“伊尔丁曼哈组”中分出,化石发现地点的岩性描述不详,又没有其他伴生动物可以作为参考,因此其具体层位并不确定。

Metacoryphodon 属的模式种 *M. luminis* Chow & Qi, 1982 最初是根据内蒙古呼和勃尔和发现的头骨材料建立的。其具有犬齿异常粗壮,P2 和 P3 原尖前棱明显,原尖后棱趋于消失,M3 具有在原尖前棱上呈稍膨大尖形的前小尖等特征与 *Eudinoceras* 不同(周明镇、齐陶,1982; Qi, 1987)。Qi(1987)又根据在相同地点发现的较小的一枚 P2 和 p2, 因 P2 的后附尖较前附尖更突出、前尖 V 形脊开口处具一小齿带等特征与模式种不同而建立了新种 *M.? minor*。内蒙古 *Metacoryphodon* 的两种并没有任何下臼齿材料,而 *E. mongoliensis* 没有上臼齿材料,一些特征如 M3 上的前小尖并不能作为两者之间的差异来比较讨论。

Lucas(1984, 1998)在比较了 *E. mongoliensis*, *E. kholobolchiensis* 和 *M. luminis* 的部分材料和在哈萨克斯坦斋桑盆地中发现的 *E. obailiensis* 材料后提出,将 *E. kholobolchiensis*, *E. obailiensis* 和 *Metacoryphodon* 的全部标本归入 *E. mongoliensis*。但因 *E. mongoliensis*, *M. luminis* 和 *M.? minor* 之间缺乏相应的比较材料,他并未深入讨论。

近几年来,中国科学院古脊椎动物与古人类研究所考察队在内蒙古二连盆地发现了一些保存较好的冠齿兽类化石,这些发现对解决上述问题有着重要的作用。同时,北美对同一属种冠齿兽类化石集群的发现以及对该类化石种内差异的新认识(Uhen and Gingerich, 1995; Lucas, 1984; McGee, 2001, 2002; McGee and Turnbull, 2010)也对亚洲冠齿兽的分类鉴定提供了理论依据。随着该地区岩石地层学和生物地层学问题的逐步澄清(孟津,1990; Meng et al., 2007; Wang et al., 2010), 结合磁性地层学研究的最新成果(孙勃等,2009), 对该地区已有冠齿兽类化石的生物地层进行厘定,并将其对应到亚洲生物地层序列和哺乳动物年代框架之中是可行及必要的。

1　二连盆地冠齿兽类化石分布

蒙古高原是亚洲最早发现、研究冠齿兽类的地区。在内蒙古二连盆地,化石地点主要分布于二连浩特市东南的伊尔丁曼哈地区、西南的呼和勃尔和地区、巴彦乌兰地区、额尔登敖包地区和沙拉木伦河西岸的乌兰希热地区(图 1)。

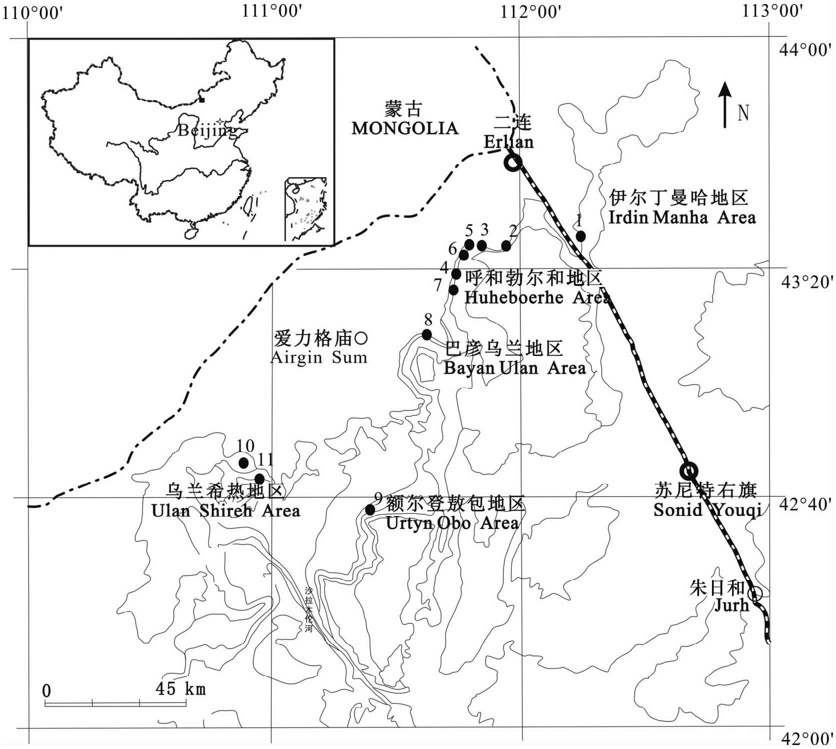

图 1 二连盆地含冠齿兽类化石地点分布

Fig. 1 Sketch showing localities bearing Coryphodontidea fossils in the Erlian Basin (after Meng et al., 1998)
1. 伊尔丁曼哈(Irdin Manha); 2. 都和敏勃尔和(Duheminboerhe); 3. 努和廷勃尔和(Nuhetingboerhe); 4. 呼和勃尔和(Huheboerhe); 5. 乌兰勃尔和北(North of Wulanboerhe); 6. 乌兰勃尔和(Wulanboerhe); 7. 吉布其勒哈沙(Jibuqilehasa); 8. 巴彦乌兰(Bayan Ulan); 9. 额尔登剖面(Urtyn Obo); 10. 乌兰希热(Ulan Shireh); 11. 乌兰陶勒盖(Wulantaolegai)

2 术语、测量及缩写

2.1 术语

基于对冠齿兽类颊齿各构造的同源性认识和乳齿的研究(Osborn, 1898; Wood, 1923; Simpson, 1929), 本文所采取的牙齿各构造命名主要根据 Simpson(1929), Lucas(1984), Uhen and Gingerich(1995)和 McGee and Turnbull(2010)的命名方法稍作添加和修改(图 2)。上臼齿唇侧各尖的名称与徐余瑄(1976)和童永生、王景文(2006)采用的名称有些许差异,从前到后依次为(括号内为本文采用的名称):前尖(前附尖)、中附尖(前尖)、无命名(中附尖)和后附尖(后附尖)。在定位中采用 Sisson(1956)(见张鹤宇等译, 1962)所用的定位方法,中文译名主要参考采用《古生物学名词》(全国科学技术名词审定委员会,2009)、周明镇等(1975)和张鹤宇等(1962)的译法。

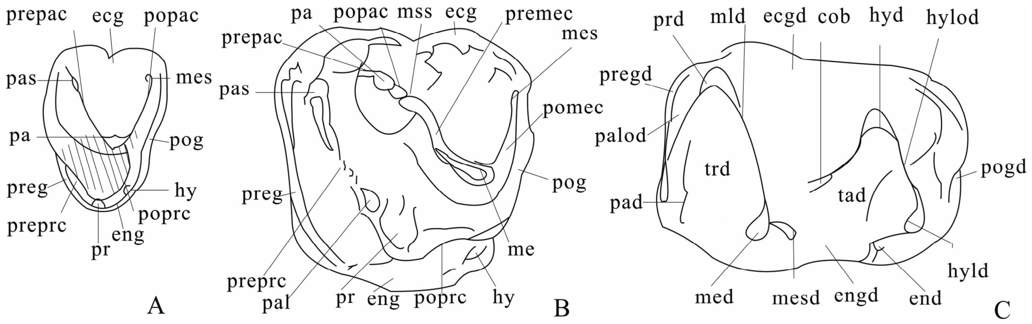

图2　冠齿兽类颊齿各尖结构图

Fig. 2　Cusp homologies of coryphodontid cheek teeth

A. 上前臼齿 upper premolar; B. 上臼齿 upper molar; C. 下臼齿 lower molar

Abbreviations: cob. cristid obliqua 斜脊;ecg. ectocingulum 外齿带;ecgd. ectocingulid 下外齿带;end. entoconid 下内尖;eng. entocingulum 内齿带;engd. entocingulid 下内齿带;hy. hypocone 次尖;hyd. hypoconid 下次尖;hyld. hypoconulid 下次小尖;hylod. hypolophid 下次脊;me. metacone 后尖;med. metaconid 下后尖;mes. metastyle 后附尖;mesd. metastylid 下后附尖;mld. metalophid 下后脊;mss. mesostyle 中附尖;pa. paracone 前尖;pad. paraconid 下前尖;pal. paraconule 前小尖;palod. paralophid 下前脊;pas. parastyle 前附尖;pog. postcingulum 后齿带;pogd. postcingulid 下后齿带;pomec. postmetacrista 后尖后棱;popac. postparacrista 前尖后棱;poprc. postprotocrista 原尖后棱;pr. protocone 原尖;prd. protoconid 下原尖;preg. precingulum 前齿带;pregd. precingulid 下前齿带;premec. premetacrista 后尖前棱;prepac. preparacrista 前尖前棱;preprc. preprotocrista 原尖前棱;tad. talonid 下跟座;trd. trigonid 下三角座

2.2　测量及缩写

牙齿的测量主要参考Lucas(1984)对冠齿兽各牙齿的测量项。V形脊的角度测量方法为脊上三尖连线相交角度。

机构缩写:IVPP, 中国科学院古脊椎动物与古人类研究所,北京;AMNH, American Museum of Natural History, New York 美国纽约自然历史博物馆;CAE, Central Asiatic Expeditions 美国自然历史博物馆中亚考察团。

3　系统描述

全齿目 Order Pantodonta Cope, 1873

冠齿兽科 Family Coryphodontidae Marsh, 1876

真恐角兽属 *Eudinoceras* Osborn, 1924

蒙古真恐角兽 *Eudinoceras mongoliensis* Osborn, 1924

（图3－5）

Eudinoceras mongoliensis Osborn, 1924, p.2, fig.2

Eudinoceras mongoliensis Osborn and Granger, 1931, p.1, figs.1, 9

Eudinoceras mongoliensis Osborn and Granger, 1932, p.1, figs.1, 2, 3, 4

Eudinoceras kholobolchiensis Osborn and Granger, 1931, p.5, figs.2, 3, 6, 7, 10

Eudinoceras obailiensis Gabunia, 1961, p. 711-713, fig. 2

Eudinoceras obailiensis Gabunia, 1962, p. 15-17, figs. 1, 2, 3

Eudinoceras obailiensis Gabunia, 1977, p. 30, pl. I, fig. 1m

Metacoryphodon luminis 周明镇、齐陶,1982, p. 304

Metacoryphodon? minor Qi, 1987, p. 26-27, fig. 14

Metacoryphodon sp. Qi, 1987, p. 27, fig. 15

正模 AMNH 20101, 一左 P4。

副模 AMNH 20102, 一右 P4。

新标本 二连盆地呼和勃尔和,阿山头组 AS-1 层:IVPP V 18046, 缺左侧 I1-2, 右侧 I3, P1 和两侧犬齿的头骨(图 3, 5A); V 18052, 半颗右 M2。努和廷勃尔和,阿山头组 AS-1 层:V 18050, 左 P1; V 18053, 左 M3。吉布齐勒哈沙,阿山头组 AS-1 层:V 18375, 头骨腹侧,带左 I1, P3-M3, 右 I2 和 P2-M3(图 5D); V 18047, 下颌带齿列仅缺两侧 p1

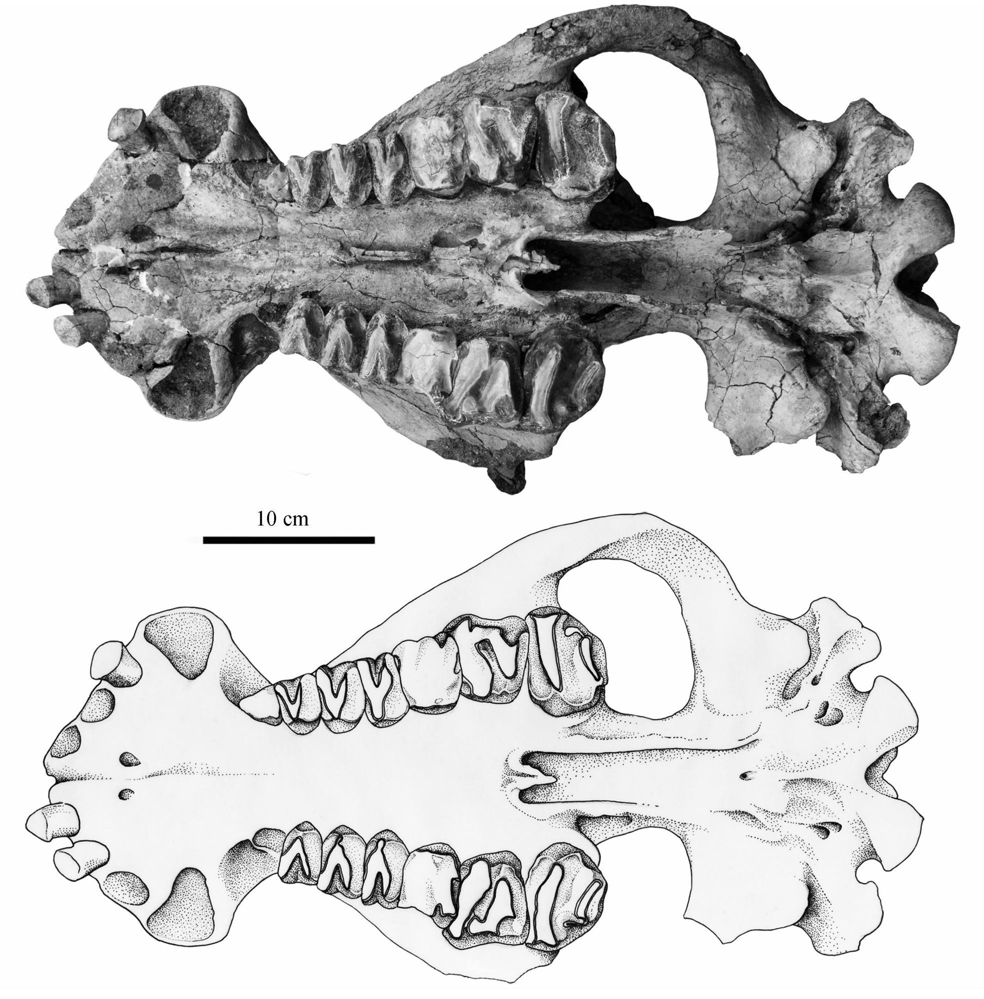

图 3 蒙古真恐角兽头骨(IVPP V 18046)冠面

Fig. 3 Occlusal view of skull of *E. mongoliensis* (IVPP V 18046)

（图 4, 5E）; V 18051, 右 P4。伊尔丁曼哈平台，阿山头组 AS-5 层：V 18377, 左 P4。巴彦乌兰阿山头组底部：V 18054, 右 i1。额尔登敖包剖面底白层（CAE 的层位划分）底部：V 18055, 右 M1? 破碎，左 p2 和 p3。

修订特征　大型冠齿兽类；犬齿较大；P1 单齿根，具中缝；P2-4 原尖弱锥形，具小而明显的次尖，原尖后棱不发育，原尖前棱微弱，前尖 V 形脊平均角度约为 40°, 前后舌三侧齿带发育连续，后齿带尤甚；上臼齿原尖与后尖靠近舌侧，但未及舌侧边缘，前尖为大而孤立的圆钝形，前小尖为原尖前棱上一膨大的尖，后小尖不明显，次尖为小而明显的尖锥形，原尖后棱完全消失，原尖前棱与后尖前棱平行但不等长，与牙齿横轴角度小，后尖 V 形脊平均角度接近 30°; M1-2 后尖后棱短且微弱；M3 为卵形，后尖前棱约为原尖前棱的一半；p1-4 较宽，下原尖 V 形脊角度约为 40°, 下后齿带发育，具小尖；m1-2 下跟座和下三角座接近

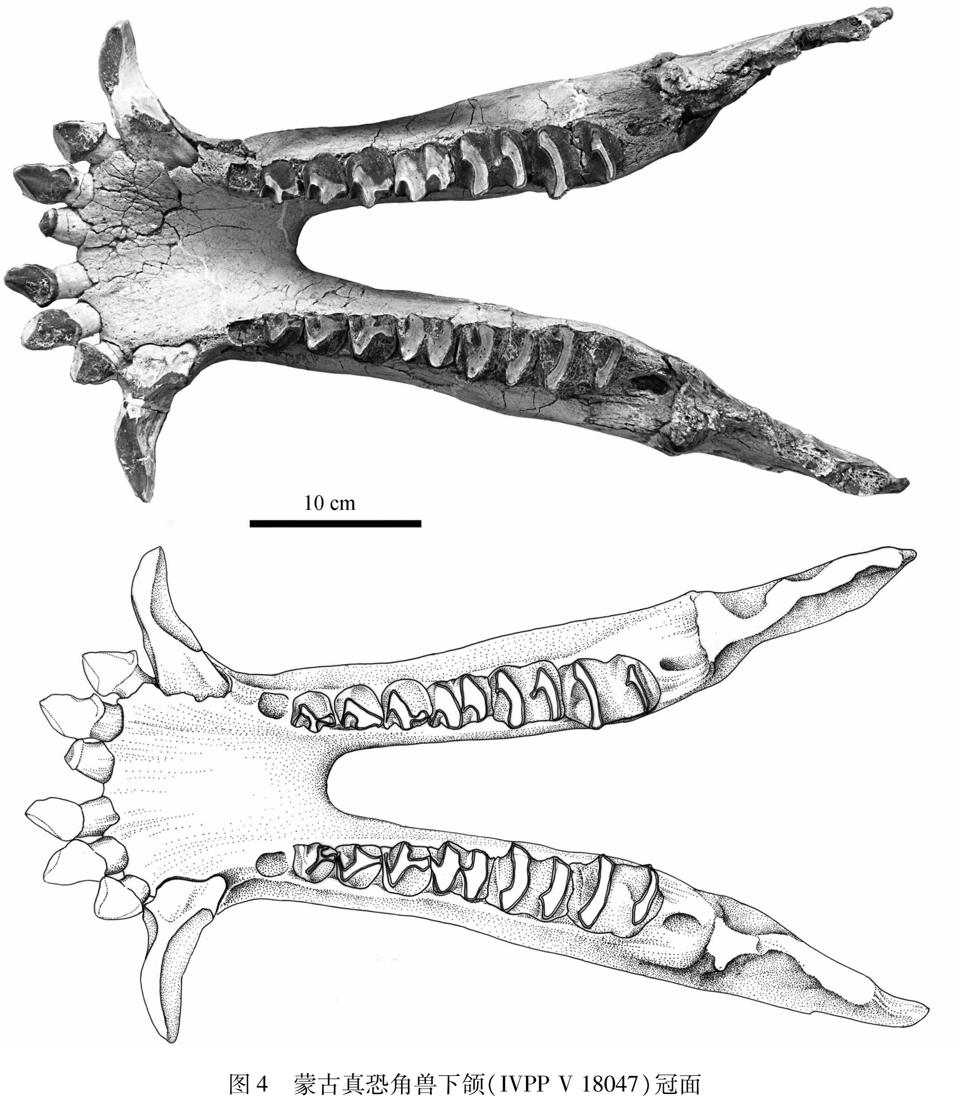

图 4　蒙古真恐角兽下颌（IVPP V 18047）冠面

Fig. 4　Occlusal view of mandible of *E. mongoliensis* (IVPP V 18047)

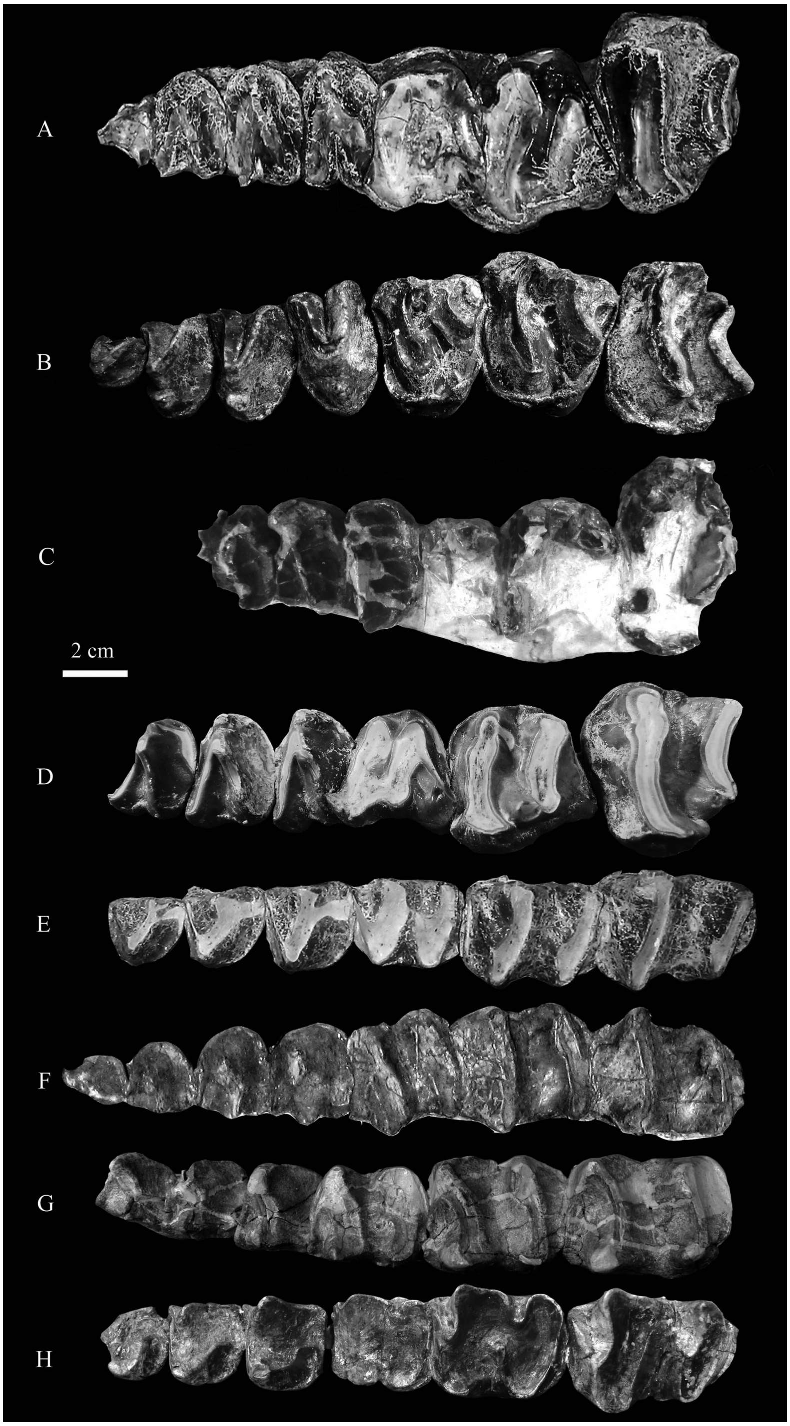

图5　部分蒙古真恐角兽颊齿冠面

Fig. 5　Occlusal views of cheek teeth of *Eudinoceras mongoliensis*

A. left P1-M3 (IVPP V 18046); B. right P1-M3 (Holotype of *M. luminis*, IVPP V 5697); C. left P2-M3 (Holotype of *E. kholobolchiensis*, AMNH 21744); D. right P2-M3 (IVPP V 18375); E. left p2-m3 (IVPP V 18047); F. right p1-m3 (AMNH 26611); G. right p2-m3 (AMNH 26613); H. left p2-m3 (AMNH 26614)

等长,下原尖和下次尖 V 形脊平均夹角约 25°,下前脊和斜脊非常低且弱,斜脊与下后脊的衔接处接近下后脊舌侧的 1/3,不与下后尖相连,前后舌三侧齿带发育连续;m3 下跟座稍大于下三角座。

描述　大型的冠齿兽类,齿式 3.1.4.3/3.1.4.3。

上门齿较为圆钝,下门齿较为扁平。门齿从前往后形状有一定的变化。I1/i1 近中侧的棱非常短,远中侧的棱较长;I2/i2 近中侧棱开始增长,但依然远短于远中侧棱,为不等腰尖锐三角形;I3/i3 近中侧棱与远中侧棱近于相等,近钝角等腰三角形;向后逐渐由竖长变为横阔,厚度递增。门齿均斜向前方伸出,唇舌两侧齿带很发育,形成一个突起的小平台,两侧隆起形成小凹槽。两侧门齿与犬齿之间存在一不宽的齿隙。门齿之间的齿隙和门齿的相对大小不稳定,与个体和年龄差异关系较大。

犬齿较为粗壮,呈獠牙状,牙齿上有纵棱。从 V 18046 的齿槽来看,上犬齿向下外方伸出,且位于颊齿延长线的外侧。舌侧窄,唇侧圆宽,呈水滴状或长圆形。在 V 18047 上,下犬齿齿根向前唇侧向上伸出,从牙侧中部开始即向后唇侧上方翻转,向外伸出的角度大,呈弧形将上犬齿包围,横截面为长椭圆状,上部窄下部浑圆,唇和舌截面均为锐三角形。犬齿与前臼齿之间齿隙较短。

P1 单齿根,具中缝,明显小于其他前臼齿,各边角圆滑。原尖前后棱、原尖和内齿带融合于舌侧,原尖向后移动至后附尖的下方且不明显,与前、后附尖组成一个近等边的三角形。前尖 V 形脊角度近于 70°。前尖前棱较前尖后棱短,后齿带较前齿带发育得多(见 V 5697)。P2 长三角形。原尖尖锐突出,位于前尖稍偏后的位置。前尖 V 形脊狭长,角度小,形成的 V 形谷深。后附尖明显高于前附尖,两尖浑圆而膨大,具小而明显的次尖。原尖前后棱不发育,部分未磨蚀的标本中存在原尖前后棱痕迹,其长度不超过该前臼齿总长度的 1/3(见 V 18375)。前尖前棱稍长于前尖后棱,前尖 V 形脊前翼明显低于后翼。外齿带不发育,仅在部分标本的前尖 V 形脊中央有出现。前齿带发育,边缘部有些许褶皱和瘤状隆起,后齿带明显大于前齿带,发育显著,具次尖,前后舌三侧齿带隆起形成条带状的齿缘。P3 和 P4 类似于 P2,只是更大,前尖 V 形脊夹角角度向后变小(部分标本中的 P4 较 P3 稍显宽短,可能因 P4 出齿时与 M1 的挤压所致,见 V 18046 和 V 18375)。

M1 冠面梯形,原尖浑圆而粗大,位置非常靠近舌侧边缘。原尖前棱粗且高,与牙齿横轴交角小,无原尖后棱。原尖前棱的中段存在前小尖的痕迹,为脊上一膨大的钝尖,经磨蚀后消失,如 V 18046。前附尖显著且位置很高,前后向扩展变长,形成一条平行于轴向的短脊,使原尖前棱呈 Y 形。前尖大而孤立,位置高且明显,与前附尖明显不相连,与中附尖在唇侧以一短而弱的前尖后棱相连。次尖为小而明显的尖锥形。后尖前棱粗且高,与原尖前棱平行但不等长。后尖高,在距齿的舌侧边缘 1/3 处。存在不是很明显的后附尖。后尖后棱低矮纤弱,短于后尖前棱,形成一个前长后短的后尖 V 形脊,夹角较小。前后舌三侧齿带较为发育,隆起形成不连续条带,在条带上有丘状或瘤状的突起。外齿带不发育。M2 与 M1 形态相似,只是尺寸更大。

M3 呈卵圆至长卵圆形,长宽比有一定变化。后尖较为膨大,与舌侧边缘仍然有一定距离,较 M1-2 更靠近后侧。不具后尖后棱。后尖前棱较短,约为原尖前棱的 1/2,较原尖前棱更倾斜。前齿带更发育,后齿带较小。其他特征与 M1-2 接近,只是更宽,舌侧更长。

p1 为钝三角形。下前脊和下后脊几乎等长,下后尖处开始有斜脊向后方延伸,直至齿的唇侧最后方。前后唇三侧齿带较为发育,以后齿带为甚,其上具小尖。齿槽为半圆形,单齿根,见 V 18047。

p2 下三角座较短宽,下跟座很发育,尤其是后唇侧膨大,与下三角座一起形成近半圆形。下前尖低矮微弱,下后尖极高,都为尖锐的尖形。下后脊粗壮,下前脊纤弱,下后脊远高且长于下前脊,两脊不对称,高差明显。下三角座的下原尖 V 形脊平均夹角为 45°, 两翼形成谷深。下后脊上舌侧约 1/3 处具一纤弱但明显的斜脊向后延伸到齿的后侧边缘,斜脊平行于齿的纵轴,长度较长。下前齿带发育,下后齿带非常发育。p3 和 p4 与 p2 类似,只是由前向后逐渐增大,下原尖 V 形脊角度逐渐变小,下跟座向后逐渐变大,下原尖和下前尖高度逐渐递减,下后尖高度逐渐增高,斜脊向后越发明显,下后齿带逐渐增大。

m1 较为短宽。下三角座与下跟座的长度接近,稍高于下跟座,下跟座很发育。无下内尖和下后附尖,下后尖和下次小尖高耸尖锐,无前后向的棱。下前脊和斜脊低矮纤弱,明显低且短于下后脊和下次脊。斜脊从下次尖伸出至下后脊舌侧的 1/3 处,明显不与下后尖相连,呈弱棱状。下后脊和下次脊长且突出,长度接近,彼此平行且均微倾斜于牙齿横轴。两 V 形脊角度小,形成锐三角形,平均角度近 30°。前后唇侧齿带发育,下后齿带格外明显。m2 和 m3 类似 m1, 只是由前向后逐渐增大,下前尖向后越发低矮且不明显,下前脊和斜脊往后越加微弱,与下后脊和下次脊的长度比更短,下跟座与下三角座由等宽逐渐变为稍短窄。m3 下后齿带发育成新月形,并凸起形成棱状,不似某些原始类型有第三叶或下次尖后发育有明显的小尖。

测量 见表 1 和 2。

比较 V 18047 和 V 18375 同产自吉布齐勒哈沙地点的阿山头组 AS-1 层,发掘地点距离不超过 10 m。两标本牙齿脊型化程度、大小和咬合相符,应该代表同一种的头骨和下颌。而 V 18046 则采自儿公里外呼和勃尔和地点的阿山头组 AS-1 层,V 18046 和 V 18375 特征完全一致,仅前者稍大,年龄稍老。由此,我们认为这三个材料为同一种。

V 18046 的 P4 与 *Eudinoceras mongoliensis* 正模 AMNH 20101 和副模 AMNH 20102(Osborn, 1924)的原尖前后棱发育程度相似,而 V 18375 的 P4 磨蚀较浅,因而原尖前后棱稍明显。4 件标本 P4 大小类似,前尖 V 形脊角度接近,特征一致,应该为同一种。同时,V 18047 与归入 *E. mongoliensis* 的 AMNH 26611 ~ 26613(Osborn and Granger, 1932)的差别仅在于大小方面,且在正常变化范围之内。V 18047 与这三件下颌材料应属于同一种。据此,新材料 V 18046, V 18047 和 V 18375 应归入 *E. mongoliensis*。

V 18046 和 V 18375 与 *Metacoryphodon luminis* 正模 V 5697 的上臼齿仅在大小方面稍有差异,三件标本臼齿原尖前棱上都有膨大的前小尖,只是 V 18046 磨蚀较深,前小尖较不明显。V 18046 和 V 18375 的犬齿虽未能保存,但存在的齿槽也与 V 5697 的齿槽大小相当。据对 V 5697 的观察,其 P2 和 P3 原尖前棱也都不是很发育,与 V 18375 相当,其明显与否与磨蚀程度有关。同时,V 5697 的上臼齿脊形化程度和尖脊发育状况等特征也与 V 18046 和 V 18375 相当。

由此,V 18046 和 V 18375 与 *E. mongoliensis* 仅有的上前臼齿特征一致,V 18047 与 *E. mongoliensis* 的下颊齿特征一致,V 18046 和 V 18375 与 *M. luminis* 仅有的上颊齿特征一

表1 真恐角兽上齿列测量

Table 1 Measurements of upper dentition of *Eudinoceras* (mm)

Upper teeth	*E. mongoliensis*							*E. xintaiensis*	*E. sishuiensis*	
	V 18046		V 18375		V 5697		AM 21744	V 6380	V 10806	
	left	right	left	right	left	right	Osborn& Granger, 1931	Chow & Qi, 1982	left	right
I1 L		13.9	13.5				15			
I1 W		20.1	33.7				20			
I2 L		16.1		19.3			16.5			
I2 W		21.4		26.2			17			
I3 L	22.6						17.5			
I3 W	20.5						16.5			
C L	45.85*	47.4*		43.9*	40.2*	35.2*	36		56.7	
C W	56.93*	51.1*		49.8*	49.4*	47.4*	47.5		73.7	
P1 L	19.5					19.8	17.5		21.6*	17.5*
P1 W	19.0					18.9	16.5		25.7*	24.9*
P1 A	65°					75°	80°		NA	
P2 L	26.1	25.3		26.8	22.4	25.7	22.5	19.6	28.7	28.1
P2 W	36.6	37.2		35.5	38.7	35.1	32	26.8	46.4	47.7
P2 A	45°	45°		40°	45°	45°	35°	45°	30°	30°
P3 L	25.9	26.4	29.2	29.0	29.3	27.7	23.5	23.1	32.8	33.4
P3 W	40.8	42.6	39.2	40.8	41.4	37.2	35	32.6	49.2	49.4
P3 A	30°	30°	35°	35°	30°	30°	30°	40°	35°	35°
P4 L	25.2	27.2	27.7	26.4	23.4	28.9	22.3	26	39.2	30.7
P4 W	43.7	47.1	43.2	41.9	43.3	43.8	38.5	NA	58.3	59
P4 A	25°	25°	30°	30°	35°	35°	25°	35°	30°	30°
M1 L	39.6	37.2	40.3	40.8	39.9	38.9	26.5	39.7	55.3	53.9
M1 W	46.4	45.7	45.4	41.7	41	44.6	NA	NA	56.0	55.2
M1 A	NA	NA	30°	30°	35°	35°	NA	30°	30°	30°
M2 L	51.1	52.6	50.2	45.2	49.2	51.9	35	42.6	64.0	65.7
M2 W	54.5	52.9	54.3	49.1	53.2	53.9	NA	NA	63.9	63.3
M2 A	40°	40°	30°	30°	30°	30°	30°	30°	30°	30°
M3 L	46.5	49.9	48.8	48.4	44.5	43.2	35		64.5	61.9
M3 W	63.7	61.8	56.5	55.6	58	59.3	50.5		70.2	71.1
P1-4 L	96.7				97.0					
M1-3 L	135.6	128.3		130.2	123.3				190	195
P1-M3 L	232.3				216.6					

注:A. 角度 angle; L. 长 length; W. 宽 width; NA. 不可测量项 measurements not available; * 估测值 estimated.

表2 真恐角兽下齿列测量

Table 2 Measurements of lower dentition of *Eudinoceras* (mm)

Lower teeth	*E. mongoliensis*			*E. xintaiensis*	*E. youngi*		*E. zhichengensis*
	AMNH 26611	V 18047		V 6381	V 5149		V 25721
	Lucas(1984)	left	right	Chow & Qi, 1982	left	right	Lei et al., 1987
i1 L		19.9	13.6*				
i1 W		26.2	18.6*				
i2 L		24.4	23.7		17.0		
i2 W		30.0	27.4		29.3		
i3 L		17.1	26.2		15.0*		
i3 W		34.0	33.7		18.1*		
c L		30.8	30.5		32.7*	26.8*	
c W		48.1	47.4		21.0*	22.4*	
p1 L	21				18.5	17.8	16.3
p1 W	14.6				12.1	11.8	11.1
trd A	100°				100°	100°	90°
p2 L	21.5	25.2	25.1		17.9	19.7	18.9
p2 W	21.7	24.0	23.7		16.1	17.3	16.8
trd A	45°	45°	45°		40°	40°	66°
p3 L	27	25.9	25.7		21.5	19.7*	19.9
p3 W	22.6	25.4	27.1		20.4	21.1*	19.5
trd A	40°	40°	40°		30°	30°	61°
p4 L	27.8	29.8	27.7	24.2	21.8*		20.9
p4 W	23.4	29.1	28.5	24.5	23.9		20.4
trd A	35°	40°	40°	NA	30°		40°
m1 L	35	39.8	39.0	30.5	31.8		26.5
m1 trd W	31.2	29.8	32.2	26.8	26.1		20.4
m1 tad W	32.5	30.8	30.1		21.4*		20.7
trd A	30°	30°	30°	NA	30°		NA
tad A	30°	30°	30°		25°		NA
m2 L	43.1	47.8	47.6	42	36.2		36.5
m2 trd W	37.4	37.2	38.2	31.7	28.4*		28
m2 tad W	35.9	36.9	37.5		26.4*		25.5
trd A	25°	25°	25°	NA	30°		19°
tad A	25°	25°	25°		25°		NA
m3 L	49.5	56.6	56.0	48.2	42.7	41.8	45.6
m3 trd W	39.2	41.0	42.2	NA	31.6*	28.1*	32.1
m3 tad W	33.6	41.2	39.8		28.3	28.8	28.6
m3 trd A	30°	25°	25°		30°	30°	36°
m3 tad A	35°	35°	35°		25°	25°	NA
p2–4 L		78.1	80.3		77.6		82.0
m1–3 L		140.7	136.2		108.5		100.4
p1–m3 L					182	187	182.4

注：trd. 下三角座 trigonid；tad. 下跟座 talonid；其余注释同表1 for other notes see Table 1；V 25721 标本存放地点不详 holding place unknown.

致。因此，Lucas（1984，1998）认为的 *E. mongoliensis* 与 *M. luminis* 应该归为同一种的观点，有了较充分的化石证据。

Metacoryphodon？*minor* 仅有一枚 P2 和一枚 p2（Qi，1987），从图片来看，P2 的前尖 V 形脊开口处具有的一小齿带可能为外齿带的一个小突起，P2 后附尖较前附尖突出为所有 *E. mongoliensis* 的特性，同时 p2 并没有缺少前、后齿带，因而将以上差别作为将该标本单列一种的证据不充分，应将其归入 *E. mongoliensis*。

Eudinoceras kholobolchiensis Osborn & Granger，1931（图 5C）上颊齿保存完整，但磨损很严重，长宽比例与 *E. mongoliensis* 的相当，前、后齿带差别不大，在正常个体差异范围之内，仅前尖 V 形脊显得稍浅，臼齿特征也符合 *E. mongoliensis* 的典型特征。据此，我们也同意 Lucas（1984）的观点：*E. mongoliensis* 与 *E. kholobolchiensis* 的差异是因后者材料磨损严重所致，*E. kholobolchiensis* 为 *E. mongoliensis* 的次主观异名。

Eudinoceras obailiensis Gabunia，1961 的前臼齿原尖孤立，接近舌侧，前尖前后棱拉长，角度小，前后舌三侧齿带大；M3 原尖和后尖接近舌侧，原尖前棱和后尖前棱与牙齿横轴交角小，前后舌三侧齿带大；下臼齿下后尖与下次尖高耸尖锐，无前后向的棱和下后附尖。两 V 形脊角度极小，呈狭长状，下三角座和跟座长度相近，斜脊不与下后尖接触，交于下后脊舌侧的 1/3 处。这些都是 *E. mongoliensis* 的典型特征，我们认为 Lucas（1984）将其归入 *E. mongoliensis* 是合理的。

除以上形态学证据之外，McGee and Turnbull（2010）对北美 Piceance Creek 盆地灾难型原地埋藏的 12 个 *Coryphodon lobatus* 个体研究后发现，该种的恒门齿、犬齿和前臼齿（= 补换齿 replacement teeth）出齿较早，且补换齿与臼齿交替萌出，符合慢生长和长生命型物种的出齿特征；雄性较雌性发育缓慢，具显著的两性异型，经成年性别比 ASRs（adult sex ratios）证实的一雄多雌等特征都影响了冠齿兽类的形态，使得该类群在居群内和种内都存在着高度变异。性别差异同时影响了成年个体的大小，如其臼齿变异系数（coefficients of variation）范围为 4～12，超出了哺乳动物种内没有性别差异特征的变异系数通常范围 4～10（McGee 2001，2002），可能是因出齿时间不一而受性激素的影响不同而致（Gingerich，1974）。高度的种内变异在一定程度上引导了分种的趋势（Simons，1960），亚洲冠齿兽属种的繁多应部分归因于此。

同时，冠齿兽类平均体重达到 800 kg（Gingerich，1986），可能为当时最大型的哺乳动物之一。据对现生哺乳动物的观察，由于食物和环境的竞争压力，很少能有对生境需求类似的超过一种哺乳动物存在于同一地点的状况（Mayr，1970）；即便有，也是那些体型较小的啮齿类或食肉类等（Hutchinson，1959），由此我们认为 *E. mongoliensis*，*E. kholobolchiensis*，*E. obailiensis*，*M. luminis* 和 *M.*？*minor* 应属于冠齿兽的同一种，后 4 种应视为 *E. mongoliensis* 的次主观异名。因归入的标本，*E. mongoliensis* 已有完整齿列材料。据此，*E. mongoliensis* 的种征被重新厘定（见修订特征）。

讨论　周明镇、齐陶（1982）认为山东新泰官庄组 *M. xintaiensis* 与 *M. luminis* 的差别在于前者个体小，上臼齿不具次尖。从文中的图示及描述可以看出，该种与 *E. mongoliensis* 的差别在于：前者个体较小；前臼齿虽破损但存在原尖前棱痕迹，仅发育至前尖处，前尖 V 形脊的角度接近 *E. mongoliensis*；臼齿呈方形长宽近似，原尖和后尖较 *E. mongoliensis*

的更接近舌侧边缘,前尖圆钝而孤立,次尖极小,具有明显的原尖后棱,原尖前棱较 *E. mongoliensis* 的更垂直,无前尖前后棱,后尖 V 形脊角度略大于 *E. mongoliensis*,唇后舌三侧的齿带不发育;下臼齿下跟座较下三角座小且窄,斜脊较为明显。*M. xintaiensis* 虽具 *Eudinoceras* 的特征,但因上臼齿存在原尖后棱,个体较小,较 *E. mongoliensis* 显得稍微原始,不能直接归入 *E. mongoliensis* 种,建议将 *M. xintaiensis* 归入 *Eudinoceras*,更名为 *E. xintaiensis*。自此,*Metacoryphodon* 属中三个种的全部标本都归入其他属种,*Metacoryphodon* 为无效属名,应予以废除。

Cope(1882)根据一枚左 M2 建立了新属新种 *Manteodon subquadratus*。该标本最显著的特征为 M2 上具次尖,而 Osborn(1898)认为该特征不足以将其另立一属,因此 Lucas(1984)将其归入到 *Coryphodon* 属内,更名为 *Coryphodon subquadratus*。湖北宜昌梅子溪牌楼口组的 *Manteodon youngi* Xu, 1980 仅有一完整的下颌,并不具备该上臼齿特征。且经观察后发现,其具备 *Eudinoceras* 属内下颊齿的特征,可归入 *Eudinoceras* 属。但它个体更小,同时斜脊更靠近唇侧、下后脊和下次脊与牙齿横轴夹角更大而显得比 *E. mongoliensis* 原始,所以我们同意 Lucas(1984, 1998)的建议将其归入 *Eudinoceras*, 并更名为 *E. youngi*。其可能为一较 *E. mongoliensis*, 甚至较 *E. xintaiensis* 更为原始的种。

湖北宜都枝城楼子河洋溪组的 *Coryphodon zhichengensis* Lei et al., 1987 仅有一下颌 V 25721, 其下颊齿两 V 形脊角度小,不具下内尖和下后附尖,不应归入 *Coryphodon* 属。同时,其下后尖、下次小尖和下原尖均呈尖锥状,下前脊和斜脊微弱等均为 *Eudinoceras* 属的典型特征,应归入 *Eudinoceras* 属。据描述,该标本与 *E. mongoliensis* 有如下区别:下前臼齿斜脊不发育,下原尖 V 形脊夹角由前向后急剧变小;下臼齿下三角座略宽短于下跟座,夹角略小于下跟座,斜脊末端在下后脊内侧 2/5 处;m3 特别大,下后脊比较发育,齿带隆起形成米粒状小尖,与下次小尖以弱脊相连。因而 V 25721 显得要比 *E. mongoliensis* 原始得多。建议将其归入 *Eudinoceras*, 并更名为 *E. zhichengensis*。

山东泗水东黄庄东南狼头沟黄庄组的 *E. sishuiensis* (王军,1994), 其正模 V 10806 个体大,P2-4 原尖呈孤立的锥形,前尖 V 形脊平均夹角在 30°左右,臼齿后尖 V 形脊后翼微弱,原尖与后尖在舌侧边缘,原尖前棱与后尖前棱与牙齿纵轴几乎垂直,前后舌三侧齿带发育,具次尖,归入 *Eudinoceras* 应无问题,同时因其高脊型化程度,且上臼齿不具前小尖,与脊形化程度近似的 *E. crassum* 不同,应该代表 *Eudinoceras* 属内另一个不同的种。

广西田东洞均组的 *E. crassum*(童永生、汤英俊,1977)虽破损,但其保存部分的比例则较 *E. mongoliensis* 大得多,尤其是犬齿极大,颊齿的脊形化程度更甚,上臼齿原尖前棱与后尖前棱更直,原尖与后尖更接近舌侧边缘,后尖 V 形脊角度更小,约为 25°, 不具前小尖,前尖较大,与中附尖连接的前尖后棱更为发育,下臼齿的斜脊更偏向舌侧,接近于下后尖。以上特征显得较 *E. mongoliensis* 更为进步,甚至较 *E. sishuiensis* 更显进步。

由此,*Eudinoceras* 一属共含有 6 个有效种:*E. zhichengensis*, *E. youngi*, *E. xintaiensis*, *E. mongoliensis*, *E. crassum* 和 *E. sishuiensis*。根据这 6 个有效种,重新厘定该属齿列特征为:较大型冠齿兽类;犬齿大;上颊齿较宽,V 形脊角度小;P2-4 原尖锥形,位于通过前尖的牙齿中轴稍偏后的位置,前尖位于舌侧 1/3 范围之内,与原尖非常靠近,原尖前后棱不甚发育,与 *Asiocoryphodon* 相当,但明显弱于其他冠齿兽类,前尖后棱明显高于前尖前棱;

上臼齿双脊形化程度较 *Hypercoryphodon* 低,而较其他属高,前尖为大而孤立的圆钝锥形,与前附尖不接触,与中附尖以微弱的前尖后棱相连;下犬齿强烈外弯,下颊齿下跟座宽,V 形脊角度小,V 形脊前翼弱于后翼的特征明显;p2-4 的斜脊长且明显,较 *Coryphodon*, *Asiocoryphodon* 和 *Heterocoryphodon* 更靠近舌侧;m1-3 无下内尖和下后附尖,下后尖与下次小尖呈高耸的锥形,无前后向延长而不同于 *Heterocoryphodon* 和部分 *Coryphodon*, 下后脊和下次脊高耸,与颊齿列纵轴近于垂直,下前脊和斜脊较下后脊和下次脊低且弱得多,斜脊与下后脊的衔接处更接近舌侧,两 V 形脊大小和角度近于相等;m3 无第三叶,下后齿带大,隆起呈新月形。

4　生物地层对比

4.1　二连盆地

如前面提到,不论是 20 世纪 20 ~30 年代还是 80 年代,在二连盆地,所采集的冠齿兽类化石的产出层位大多因当时岩石地层划分及对比等方面的诸多问题并不是很清楚。同时冠齿兽所在动物群的组成混淆等生物地层学方面的问题,也进一步影响了该类群在亚洲古近纪陆相哺乳动物分期和亚洲哺乳动物年代学框架中的作用。基于近年对二连盆地新的地层工作,对该地区新采集的冠齿兽类化石进行整理和对前人在该地区发现的冠齿兽类化石的生物地层进行厘定,根据冠齿兽类在二连地区的出现做如下地层对比:

在呼和勃尔和地区,阿山头组出露得最为完整。通过对该区的详细工作,Meng et al. (2007)将该地区红色泥岩以下的一套具交错层理的河流相砂岩层归入阿山头组,与红色泥岩层组成一个大的沉积旋回,重新定义了阿山头组。近年来该区新采集的 *E. mongoliensis* 标本均出现在这套具交错层理的河流相砂岩中。通过进一步分析对比现今野外工作所获得的资料与美国中亚考察团的野外记录,在这一地区中亚考察团所认为的“伊尔丁曼哈组”实属于阿山头组(Meng et al., 2007; Wang et al., 2010)。因此,推测 CAE 在该地区所采的 *E. mongoliensis* 均出自阿山头组。由于江浩贤(1983)和 Qi(1987)所描述剖面并没有详细的坐标位置,因此这些剖面的精确位置不能确定,但从这些剖面的地点位置图、岩性以及化石组成序列可以看出,江浩贤(1983)的乌兰博尔和剖面即位于现今的乌兰勃尔和,Qi(1987)的 Huhe Bulak 剖面即位于现今的呼和勃尔和地点。虽然 Qi(1987)的阿山头动物群化石来自数个地点,且其组成中明显含有伊尔丁曼哈组的成分(Meng et al., 2007), 但列举的冠齿兽类标本则来自呼和勃尔和和乌兰勃尔和地点的阿山头组靠下部层位,相比而言,这些标本更可能来自阿山头组。江浩贤(1983)的乌兰博尔和剖面已不能与现今的乌兰勃尔和剖面完全对比,但因有 *E. mongoliensis* 产出的第 8 层出现了 *Gobiatherium*? *major* 和 *Schlosseria* 等带有明显阿山头组特性的生物组成,该剖面上的 *E. mongoliensis* 很有可能产自现今的阿山头组。由此,在呼和勃尔和地区,*E. mongoliensis* 仅出现在阿山头组。

在伊尔丁曼哈平台,通过进一步分析对比现今野外工作所获得的资料与 CAE 的野外记录后发现,*E. mongoliensis* 的模式标本,两枚上前臼齿,分别来自距伊尔丁曼哈组营地以南 3.2 和 16 km 的两处缓坡上,后一块标本位于该出露的中部位置(Osborn, 1924)。从该

文图中所示来看,两化石发现地点的地势都非常低,对比现今的野外观察发现,该地区地势如此之低的层位多数为阿山头组,且该图中沉积物保存状况与现今的阿山头组较为接近,这两件标本最大可能均来自现在的阿山头组。同时,我们在该地区厘定后的阿山头组现定为 AS-5 层位 *E. mongoliensis* 新材料的发现,以及在伊尔丁曼哈组中并未发现任何 *E. mongoliensis* 材料,也进一步证实了该地区 *E. mongoliensis* 产自阿山头组。

由此,综合新的地层工作和对前人的生物地层厘定得知,呼和勃尔和地区的 *E. mongoliensis* 集中在阿山头组,将其对应到亚洲生物地层序列和哺乳动物年代框架中后,能确定的最早出现层位为阿山头组底部的 AS-1 层,最晚出现的层位为阿山头组上部的 AS-5 层,其时代为早始新世中期,约为 53 ~ 49 Ma(图 6)。该种出现时间短暂,分布范围广,可以作为阿山头陆相哺乳动物期的指示化石之一。

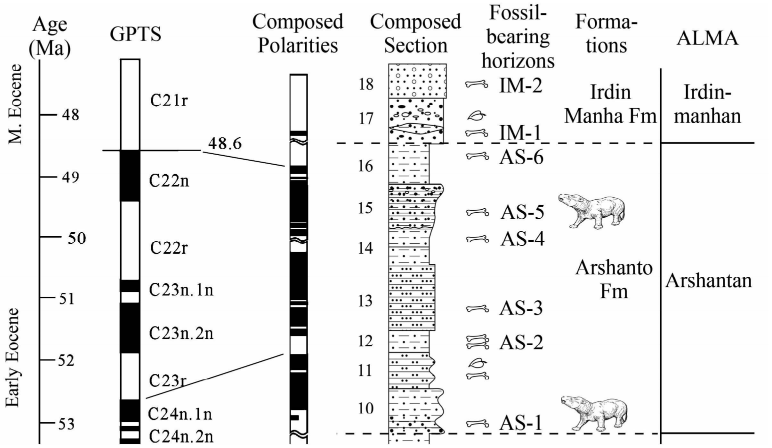

图 6 呼和勃尔和地区蒙古真恐角兽层位综合图

Fig. 6 Correlations of Paleogene stratigraphy, paleomagnetic polarities and horizon of *E. mongoliensis* in the Huheboerhe area (After Sun et al., 2009; Wang et al., 2010)

在额尔登敖包地区阿力乌苏地点底白层底部一套含钙质结核的灰绿色粗砂岩中发现有 *E. mongoliensis*, 但该层的动物组成既含有典型阿山头组的成分,又反映出典型伊尔丁曼哈动物群的特性,因此,底白层可能含有两个组的化石,还需进一步的野外工作对该化石层位细分研究。同时在底白层以下的底红层出现了较 *E. mongoliensis* 原始的 *Asiocoryphodon* sp., 由此,底红层应早于阿山头组,可能与李官桥盆地的玉皇顶组对比。虽然江浩贤(1983)提到额尔登敖包剖面的第 5 层阿力乌苏组产有 *E. mongoliensis*, 但现今化石遗失,无法进一步确认。

在巴彦乌兰地区脑木更平台的阿山头组下部地层发现了 *E. mongoliensis*, 该层位可与阿山头组对比。江浩贤(1983)也提到在巴彦乌兰剖面第 7 层阿力乌苏组底产有 *Eudinoceras* sp., 但同样因为化石遗失和剖面精确位置不定等问题,该 *Eudinceras* 无法进一步确认。

乌兰希热地区,在乌兰希热组中部发现了冠齿兽类化石,虽发现化石不多且保存状况不佳,但根据其犬齿大小、头骨长宽比以及吻部粗隆等形态,可与 *Hypercoryphodon* 比较,其

时代可能晚于阿山头组。同时，根据 Osborn and Granger（1931）和叶捷（1983）在该地区乌兰希热组中采集的已确定的 *E. mongoliensis* 材料可判定，该地区乌兰希热组中部以下存在可能与阿山头组对比的地层，乌兰希热组中部地层则可能与产出了 *Hypercoryphodon* 的伊尔丁曼哈组对比。但精确对比仍需进一步的化石采集和野外工作。

4.2　亚洲其他地区

如前所述，*E. kholobolchiensis* 和 *E. obailiensis* 为 *E. mongoliensis* 的次主观异名。包含 *E. kholobolchiensis* 的正模和副模的蒙古 Kholobolchi Nor 盆地 Kholobolchi 组，和包含 *E. obailiensis* 的哈萨克斯坦斋桑盆地的 Obayla Subsvita 中部的哺乳动物群年代可能与阿山头期相当，包含了 cf. *Eudinoceras* sp. 的蒙古 Bugin-Tsav 盆地 Khaychin-Ula 地区 Khaychin 组的哺乳动物群年代可能与阿山头期相近。

新疆准噶尔盆地三个泉化石沟的依希白拉组（童永生，1989）A 层发现的一颗不完整的左上臼齿 V 7927，破损较为严重，仅能看出其原尖前棱较为拉长，不与牙齿轴向垂直，前齿带较为发育，大小接近于 *Heterocoryphodon* 或 *Eudinoceras*，但标本过于破碎，未能归入具体属种。在其上的依希白拉组 B 层发现带右 m3，2 颗左 p1 和半颗上门齿的 V 7928，原定为 *Eudinoceras* sp.。该 m3 保存完好，下原尖 V 形脊夹角约为 45°，下后尖和下次尖高耸，下后尖非尖锥形，有往前的膨大，无下内尖，下前脊低矮，斜脊微弱，与下后脊的衔接处接近下后脊的舌侧 1/3 处，下后脊和下次脊与轴向角度小，具前后唇三侧齿带，前、后齿带较为发育。两颗左 p1 的下原尖 V 形脊夹角接近 90°，斜脊明显，位于下后尖后，下后齿带大，形成跟座雏形。V 7928 的这些特征与 *Heterocoryphodon xuae* 较为相符，但有如下区别：前者更大，下 m3 的两 V 形脊角度更小，下前尖、下前脊和斜脊更微弱，显得更为进步，建议将其定为 *Heterocoryphodon* sp.，依希白拉组 B 层的年代可能稍晚于产出 *H. xuae* 的李官桥盆地玉皇顶组底部哺乳动物群的年代。

新疆准噶尔盆地蜥蜴梁，索索泉岩系红砾山组发现了含一枚右 P4 的 V 814（周明镇、胡长康，1956），其大小与 *E. mongoliensis* 近似，前尖 V 形脊角度稍大，约为 35°，原尖前后棱发育不完全，具微弱的次尖。将其定为 *Eudinoceras* cf. *E. mongoliensis* 比较合适。如果该化石层位可靠，那么该组的哺乳动物群年代可能与阿山头期大致相当。

河南卢氏盆地孟家坡卢氏组中层（周明镇等，1973）发现的冠齿兽标本有左 I1-3，右 P2-4，左 P2，左 i1-2 和右 i3。这些标本个体大于 *E. mongoliensis*，但小于 *E. crassum*，其上前臼齿前尖 V 形脊角度小，前尖靠近舌侧，原尖前后棱不发育，前、后齿带发育，次尖明显。这些特征与 *Eudinoceras* 相符，同时因个体较大，前尖 V 形脊更为收缩，显现出较 *E. mongoliensis* 更为进步的特征，但无臼齿材料进一步确认，只能将其定为 *Eudinoceras* sp.。同时，1957 年在卢氏县供销社收购的龙骨化石 V 5782 具左 I3，右 I1-2，右 P4 和右 m2，其中的左 I3，右 I1-2 和右 P4 与上述卢氏组中层的化石特征一致，大小相符，应为同一种。但其中的右 m2 却明显较其他化石小得多，甚至小于 *E. mongoliensis*，其下前尖依然为尖形，明显原始于 *E. mongoliensis*。虽然特征原始，但其两 V 形脊角度小，下后尖不膨大，无下后附尖，依然与 *Eudinoceras* 属的特征相符。因此，该盆地内孟家坡卢氏组中层哺乳动物群的年代应晚于阿山头期，V 5782 中的右 m2 产出层位的年代可能早于阿山头期。

湖北宜昌梅子溪牌楼口组的 *E. youngi*（徐余瑄，1980）因个体更小，同时斜脊更靠近唇侧、下后脊和下次脊与牙齿横轴夹角更大而显得比 *E. mongoliensis* 原始。湖北宜昌洋溪西部上红层东湖组发现的破头骨带犬齿和破 M2?，I1，右 P1，下犬齿和 i2（Teilhard and Young，1936），根据其图版可以看出，该 P1 的前尖 V 形脊角度较大，M2 的原尖前棱近于轴面垂直，类似于 *E. youngi*；同时由于产出层位与 *E. youngi* 一致，大小近似，因而该化石很可能与 *E. youngi* 为同一种。因此，湖北宜昌梅子溪牌楼口组和洋溪西部上红层东湖组的哺乳动物群年代应该稍早于阿山头期，但不会早于玉皇顶组底部的哺乳动物群年代。

湖北宜都枝城楼子河洋溪组的 *E. zhichengensis* 因下臼齿下三角座略宽短于下跟座，夹角略小于下跟座，斜脊末端在下后脊内侧 2/5 处；m3 特别大，下三角座下原尖 V 形脊前翼比较发育，齿带隆起形成米粒状小尖，与下次小尖以弱脊相连等特征显得要比 *E. mongoliensis*，甚至比 *E. youngi* 原始得多，因此该哺乳动物群的年代要早于阿山头期，甚至早于牌楼口组的年代。

山东曲阜泗水东黄庄东南狼头沟黄庄组 *E. sishuiensis*（王军，1994）的脊形化程度非常高，其年代应该晚于阿山头期，同时，黄庄动物群中的其他属种在其他地区的伊尔丁曼哈动物群和沙拉木伦动物群中有所发现，因此其时代不会早于中始新世早期。石荣琳（1989）的 SDM-84003.1-3 标本与 *E. sishuiensis* 的产出层位一致，鉴于其大小一致，但过于破碎，建议命名为 *Eudinoceras* cf. *E. sishuiensis*。

广西田东洞均组发现的 *E. crassum* 个体极大，上臼齿的脊形化程度高，不具前小尖，下臼齿的斜脊更偏向于舌侧，接近于下后尖（丁素因等，1977；童永生、汤俊英，1977；徐钦琦，1982），因而显得较 *E. mongoliensis* 甚至较 *E. sishuiensis* 更为进步，推测洞均组的哺乳动物群年代可能晚于阿山头期，甚至晚于黄庄组的年代。

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CORYPHODONTIDS（MAMMALIA：PANTODONTA）FROM THE ERLIAN BASIN OF NEI MONGOL，CHINA，AND THEIR BIOSTRATIGRAPHIC IMPLICATIONS

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Summary

Coryphodontids (Mammalia: Pantodonta), as the most geographically widespread major group of extinct large herbivorous mammals, are among the most useful mammalian index fossils for drawing stratigraphic correlations in North America (Lucas, 1984, 1998; Uhen and Gingerich, 1995). In Asia, however, confusion regarding their taxonomy and misinterpretations of the lithostratigraphy of the fossil-bearing units have made it difficult to use coryphodontids for this purpose. Given improved understanding of intraspecific variation and sexual dimorphism within this highly variable taxon (Uhen and Gingerich, 1995; McGee, 2001, 2002; McGee and Turnbull, 2010), and the availability of newly clarified lithostratigraphic correlations (Meng, 1990; Meng et al., 2007; Wang et al., 2010) and a recently established framework for Asian mammalian biochronology (Sun et al., 2009), it is an opportune time to restudy Asian coryphodontids. Specifically, Erlian Basin, Nei Mongol, China is one of the most important regions in the world for research in Paleogene vertebrate paleontology and stratigraphy, and has yielded some well-preserved coryphodontid material that can provide plenty of detailed information and clarify some taxonomic problems. Based on this material, *Eudinoceras* has been revised as follows.

1 Systematic paleontology

Order Pantodonta Cope, 1873

Family Coryphodontidae Marsh, 1876

Genus *Eudinoceras* Osborn, 1924

***Eudinoceras mongoliensis* Osborn, 1924**

(Figs. 3 – 5)

Holotype AMNH 20101, a left P4.

Paratype AMNH 20102, a right P4.

New materials From the horizon AS-5 of the Arshanto Formation at Irdin Manha: IVPP V 18377, left P4. From the horizon AS-1 of the Arshanto Formation at Huheboerhe: V 18046, skull (Fig. 3, 5A); V 18052, incomplete right M2. From the horizon AS-1 of the Arshanto Formation at Nuhetingboerhe: V 18050, left P1; V 18053, left M3. From the horizon AS-1 of the Arshanto Formation at Jibuqilehasha: V 18375, skull (Fig. 5D); V 18047, mandible (Fig. 4, 5E); V 18051, right P4. From the Arshanto Formation in the Bayan Ulan area: V 18054, right i1. From the bottom of the "basal white" layer (Central Asiatic Expeditions, CAE) at the Urtyn Obo section: V 18055, incomplete right M1?, left p2, p3.

Differential diagnosis Large coryphodontid; canines tusk-like; P1 with a single root that is divided by a midline fissure; P2-4 with undeveloped preprotocristas and postprotocristas, preparacristas and postparacristas long and shallow, narrow paracone angles (about 40°), well-developed and distinct postcingulums, and well-developed precingulums and ectocingulums; M1-3 with inflated paraconules on preprotocristas, no metaconules, protocones and metacones closely approaching but not reaching lingual edges of teeth, blunt and prominent paracones, mesostyles that are connected only to the postparacristas, small, conical and distinct hypocones, premetacristas parallelling but not as long as preprotocristas, both being nearly perpendicular to long axes of cheek teeth; M1-2 with postmetacristas that are much shorter and more slender than premetacristas, relatively small metacone angles (about 40°); M3 oval, with premetacrista nearly half as long as preprotocrista; p2-4 broad, with trigonid angles of about 40° and well-developed postcingulums; m1-2 with trigonids nearly equal in size to talonids, trigonid and talonid angles about 25°, inconspicuous paralophids, inconspicuous cristid obliques that contact metalophids about 1/3 of distance from lingual edge to labial one, and well-developed precingulids and postcingulids; m3 with trigonids narrower than talonids.

Comparisons V 18047 and V 18375 were unearthed from the horizon AS-1 of the Arshanto Formation at Jibuqilehasha. They fit together well when placed in occlusion, are proportional to one another in size, and show about the same degree of bilophodonty. V 18046, from the horizon AS-1 of the Arshanto Formation at Huheboerhe close to Jibuqilehasha, is also similar to V 18375 in general morphology. All of these considerations indicate that these specimens all belong to the single species.

V 18046 and V 18375 share the following characters of P4 with the holotype and paratype of *E. mongoliensis* (AMNH 20101 and 20102): protocone isolated and prominent, postparacristas and postprotocristas poorly developed, preparacrista and postparacirsta meet at narrow angle, precingulum, postcingulum and ectocingulum all distinct, and postcingulum prominent. Meanwhile, V 18047 resembles *E. mongoliensis* in general morphology, despite a slight size difference that is within the expected range of intraspecific variation. All of these characters indicate that the new specimens are referable to *E. mongoliensis*.

In the most recent review of Asian coryphodontids, Lucas (1984) concluded that *Metacoryphodon luminis*, *M. xintaiensis*, *Eudinoceras kholobolchiensis* and *E. obailiensis* should be regarded as synonyms of *E. mongoliensis*. Considering, however, that no upper molars were known at the time for *E. mongoliensis* whereas no lower teeth were known for *M. luminis*, a satisfactory comparison between these species was not possible. The new specimens provide nearly complete information about the dentition of *E. mongoliensis*, in contrast to the incomplete material previously available.

V 18046 and V 18375 resemble the holotype of *M. luminis* in having an equivalent degree of bilophodonty in M1-3 and similarly poorly developed postparacristas and postprotocristas on P2-4, and the only important putative difference is the relative degree of development of preparacristas on P2-3. In the holotype of *M. luminis* (IVPP V 5697), however, the preparacristas on P2-3 are so poorly developed that their presence does not constitute a major difference between P2-3 in this specimen and the equivalent teeth in V 18046 and V 18375 (Fig. 5). The similarities between V 18046, V 18375 and V 5697 and previously known specimens of both *E. mongoliensis* and *M. luminis* imply that the latter species is a synonym of the former (Lucas, 1984, 1998).

McGee (2001, 2002) and McGee and Turnbull (2010) developed a better understanding of individual, sexual and intraspecific variation in Coryphodontidae through the recovery of a large sample from a single locality, presumably from a single population. Coryphodontids appear to have had a polygynous social structure in which males and females reached sexual maturity at different ages, along with the slow-growing, long-lived characteristics, make this taxon to have a highly range of variation that the molars have coefficients of variation ranging from 4 to 11. Under this hypothesis, the small morphological differences among *Metacoryphodon*? *minor*, *E. kholobolchiensis* and *E. obailiensis* are considered to be the result of intraspecific variation.

E. mongoliensis is a large species, with a typical individual weighing as much as 800 kg (Gingerich, 1986), and was perhaps even the largest mammal in the Arshanto fauna. Examples among living mammals show that two species cannot coexist indefinitely in the same locality if they have identical ecological requirements. In general, two species of the same genus will be very similar morphologically and presumably ecologically, making them unlikely to be sympatric or to be preserved in the same fossil sample (Mayr, 1970). When morphologically and ecologically similar species of living mammals do exist sympatrically, they are most likely to be small mammals such as rodents or carnivores (Hutchinson, 1959). We therefore believe that *E. mongoliensis*, *E. kholobolchiensis*, *E. obailiensis*, *M. luminis* and *M.* ? *minor* all represent a single coryphodontid species. The list of dental characters in the diagnosis of *E. mongoliensis* given above takes this taxonomic perspective into account.

Chow and Qi(1982) established *M. xintaiensis* for specimens IVPP V 6380 and V 6381, which they considered to differ from *M. luminis* in that the upper molars lacked hypocones. However, V 6380 and V 6381 cannot presently be located in the IVPP collections, so that we cannot confirm the existence of this morphological difference. However, the description and figures given by Chow and Qi(1982: fig. 1. 1-2) show that *M. xintaiensis* is smaller than *E. mongoliensis* and also differs from the latter species in the following morphological features: M1-2 are as long as their width, the postprotocristas are short but distinct, the preprotocristas lying parallel to the premetacrista are more nearly perpendicular to the axis of the cheek tooth and approach the lingual edge, no hypocone or postmetacrista is present, the talonid is bigger, the metaconid and hypoconulid are more cuspidal and elevated, the V-shaped trigonid and talonid are slightly broader, and the postcingulid on the m3 is well developed. These differences show that V 6380 and V 6381 are more primitive than *E. mongoliensis*. According to size, degree of bilophodonty and the relatively small angles, we suggest that *M. xintaiensis* should be referred to *Eudinoceras*, as *E. xintaiensis*. The reassignment of all three species of *Metacoryphodon* to *Eudinoceras* implies that the former genus name is no longer valid. At present, *Eudinoceras* contains six valid species: *E. mongoliensis*, *E. xintaiensis*, *E. zhichengensis*, *E. crassum*, *E. sishuiensis* and *E. youngi*.

2 Comments on biostratigraphic correlation

E. mongoliensis is known to occur within the Arshanto Formation in the Huheboerhe area in both horizon AS-1, at the bottom of the Formation, and horizon AS-5 near the top (Fig. 6). The ages of these horizons are about 53 and 49 Ma, respectively. The morphological distinctiveness, short and well-established stratigraphic range, and widespread geographic distribution of *E. mongoliensis* make this species an index fossil for the Arshantan Asian Land Mammal Age (ALMA). Accordingly, discoveries of *E. mongoliensis* at localities outside the Huheboerhe area can provide a basis for biostratigraphic correlations.

In the Urtyn Obo area, *E. mongoliensis* has been found near the bottom of the “basal white” layer(CAE), which contains other Arshanto mammals but also some fossils that are otherwise only known from the Irdin Manha Formation. The basal white layer may contain two separate faunas, in which case it could be subdivided on the basis of additional fieldwork. The “basal red” layer, which underlies the basal white, contains a single P1 referred to *Asiocoryphodon* sp., implying that the basal red may correlate with the Yuhuangding Formation in the Liguanqiao Basin.

In the Bayan Ulan area, *E. mongoliensis* has been found near the bottom of local exposures of the Arshanto Formation, confirming that they correlate with the Arshanto Formation in the Huheboerhe area.

In the Ulan Shireh area, a few fossils have been found in the middle of the Ulan Shireh Formation. Although this material is not abundant or well preserved, the size of the canine and the rough surface of nasal tuberosity allow the specimens to be referred to *Hypercoryphodon*, which is otherwise known only from the Irdin Manha Formation. Based on verified fossils reported by Osborn and Granger(1931) and Ye(1983), and referred to *E. mongoliensis*, the lower part of the Ulan Shireh Formation may contain strata that correlate with the Arshanto Formation.

At the Irdin Manha escarpment, all the deposits exposed at the section were originally referred to the Irdin Manha Formation (Granger and Berkey, 1922), until 1924, Berkey and Morris recognized Arshanto red beds beneath the titanothere-rich sandstone of the Irdin Manha Formation. At a later date they tentatively referred the lower red beds, which had previously been considered part of the Irdin Manha Formation, to the Ar-shanto Formation (Berkey and

Morris, 1927). The holotype of *E. mongoliensis* was found in the "Irdin Manha Formation" in 1923. Examination of both the new data collected these years and the field notes of the CAE indicates that the lower red beds of the "Irdin Manha Formation", which yielded the holotype of *E. mongoliensis*, should be assigned to the Arshanto Formation (Meng et al., 2007). The presence of *E. mongoliensis* in the Arshanto Formation is confirmed by our fieldwork.

Regarding other areas, the Kholobolchi Formation in the Kholobolchi Nor Basin of Mongolia and the Middle Obayla Subsvita in the Zaysan Basin of Kazakhstan appear to date to the Arshantan Land Mammal Age. The middle part of the Lushi Formation in the Lushi Basin of Henan, the Huanzhuang Formation in the Sishui area, Shandong and the Dongjun Formation of the Bose Basin of Guangxi, China are younger than the Arshantan Land Mammal Age. The Khaychin Formation of the Khaychin-Ula area in Bugin-Tsav, Mongolia and the Holishan Formation in the Junggar Basin of Xinjiang, China date roughly to the Arshantan Land Mammal Age. The Pailoukou Formation in the Meizixi area, the Yangxi Formation in the Zhicheng area, Hubei, and the Yixibaila Formation in the Junggar Basin of Xinjiang, China are older than the Arshantan Land Mammal Age.

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