第 35 卷 第 4 期
1997 年10月

古 脊 椎 动 物 学 报
VERTEBRATA PALASIATICA

pp.250—267
fig.1, pls.I—III

记兰州盆地巨獐犀(奇蹄目,犀科)一新种[1)]

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摘要 本文记述的兰州巨獐犀新种(*Aprotodon lanzhouensis* sp. nov.)是这个属在我国的首次发现。新种以第二下门齿特别粗大、强烈弯曲而区别于哈萨克斯坦的 *A. aralensis*。兰州材料中有与联合部连在一起的下颌支,这使我们第一次确切了解到该属下颌及下颊齿的形态特征。*Aprotodon* 不是 Teleoceratinae 的成员。它和 *Symphysorrachis* 在形态上更为接近。它可能是真犀科中较早分出来的单独一支。

关键词 兰州盆地,早中新世,犀科

中图法分类号 Q915.877

Aprotodon(本文译作巨獐犀)是亚洲第三纪中期一类形态很特殊的犀牛,过去只在巴基斯坦和哈萨克斯坦发现过。由于发现的化石很少,人们对它了解不多。本文前一作者(1990)曾经提到在兰州盆地发现过该属的化石。事实上,首次发现是在 1986 年。这一年本文后一作者在兰州西北约十公里的张家坪,从村民手中收集到该属的一些牙齿;1988 年在张家坪以东约十公里的对亭沟附近,采到一个相当完好的带联合部的左下颌水平支及若干牙齿,此后又不断有所发现。到目前为止,这个属的材料已是兰州盆地大哺乳动物化石中发现最多的一类。这些发现不仅对于确定兰州盆地的地层时代,而且对于全面地了解该属的形态特征和分类地位都很重要。

GL 系甘肃省博物馆野外编号,GVL 系该馆标本编号;V 系古脊椎动物与古人类研究所标本编号。文中测量,除特殊注明外,均以毫米为单位。

一、化 石 描 述

Aprotodon lanzhouensis sp. nov.

(Pl, I; II, 1-3; III; Fig. 1)

正型标本 GVL 8801:基本完整的下颌联合部和左水平支(Pl. I, 1, 2; Pl. II, 1; Fig. 1,

1) 本课题属中国科学院"八五"重点科研项目(Z048)和中国自然科学基金会资助项目(49472083)。

收稿日期: 1997-03-31

B1),1988 年采自对亭沟(GL 8801)第一白砂岩层(咸水河组中段下部,下同)。

其它材料　1. V11059:一残破头骨带右 P1–M2和左 P2–M2(Pl.III,2),产自张家坪南第一白砂岩层(GL 9514)。2. V11060:右下颌水平支,带 p3 和 dp4–m2,m3 尚未萌出(Pl. I,3;Pl.III,1),产自桃湾沟第一白砂岩层中部(GL 9504)。3. V 11061:左下颌水平支,带 dp4–m1,产自黄羊头北第二白砂岩层(GL 9511)。4. V 11378:完整的左 i2(Fig.1,B2),产自黄羊头北第一白砂岩层(GL 9512)。5. GVL 8601:左 p4,左 m1—m2。6. GVL 8602:左 P2。7. GVL 8603:可能属于同一个体的两段左下门齿。以上三件标本均为 1986 年采自张家坪。8. GVL 8701:左 M2(前外角破损)和 M3(Pl.II,3)。9. GVL 8702:右 M2–M3(前外角和原尖破损)(Pl.II,2)。10. GVL 8703:保存完好的左 M3。11. GVL8704:残破老年个体右 M3。12. GVL 8705:左下臼齿。以上五件标本为 1987 年采自张家坪。13. GVL 8706:左下颌水平支残段,带 dp4,m1 和 m2 的前半段。14. GVL 8707:右下颌残段,带 dp3。以上两件标本为 1987 年采自对亭沟。15. GVL 8802:残破左 M1–M3和一右 m1(或 m2)。16. GVL 8803:残破下门齿六段。以上两个编号的标本为 1988 年采自对亭沟第一白砂岩层(GL 8801)。17. V 11379:下门齿一小段,产自黄羊头北西第二白砂岩层(GL 9510)。18. V11380:下门齿齿根一段,1995 年采自桃湾沟白砂岩。19. V 11381:左 m3,产自南坡坪第一白砂岩层底部(GL 9502)。20. V 11382:右 m3(?),产自烟筒沟北第三白砂岩层(GL 9517)。21. V 11383:左 P3 或 P4 内半部,产自严瓦沟黄砂岩层中(GL 9507)。

层位和时代　全部化石均产于咸水河组中。除 V 11383 产自该组下段最底部的黄砂岩层外,其余都产自该组中段的白砂岩层中,且主要在第一层白砂岩中。有两件标本(V 11061 和 V 11379)产自第二白砂岩层,一件(V 11382)产自第三白砂岩层。黄砂岩的时代是早渐新世晚期;白砂岩的时代是早中新世。关于咸水河组的地层划分及地质时代确定,请参考邱占祥等"甘肃兰州盆地咸水河组研究的新进展"(印刷中)。

种的特征　个体比本属已知各种均小。与 *A. aralensis* 相比,下颌联合和下门齿相对较大,下颌联合中央部分很薄,下门齿齿根断面侧向(不是垂向)扁,齿槽以外的部分强烈向上方弯曲,直至垂直向上,磨蚀面面向内方,齿冠断面为三角形,前边较平直。与 *A. smith–woodwardi* 相比,下颌联合向后收缩快,下颌支较细,下门齿齿槽不为横长扁圆形。与 *A. fatehjangensis* 相比,P4 外壁的后半部平,无后尖隆起,内齿带急剧向后上方(离根方向)抬升。

标本描述　正型标本,GVL 8801 下颌骨的冠状突和关节突缺失,后缘稍破损;左门齿末端断失,右门齿齿冠缺失,前臼齿稍破损。虽然如此,就目前所知,它仍是本属保存最好的一个下颌。水平支自侧面看(Pl.I,1)很低,只是臼齿冠高的两倍,下缘呈弧形;齿槽缘也呈弧形,使水平支的高度前后没有什么变化。下颌水平支自上方看(Pl.II,1),呈前后端向外翘的弧形;联合部自 p4 处向前急剧加宽。由于门齿粗大,下颌联合的两侧很粗厚,前臼齿列愈向前愈偏向于水平支的内侧,而不是位于其正中。齿槽嵴很短,长仅 20,始自 dp1 前方,略呈弧形,先稍稍向内,再向外,然后消失。联合部顶面形成一个深陷的向前开放的三角形平面;在前缘中央有一对很小的 i1 的齿槽,宽 5mm 左右,它们之间的距离为 17。这对齿槽在腹面完全看不到。下颌联合的前缘很薄,厚约 10,为钝缘(Pl.I,2)。腹面基本上

为一平面，在前端有三个浅凹：一个中矢凹和在它旁边的一对侧凹。

第二对下门齿，自侧面看，齿槽以外的部分强烈弯曲，其上半部垂直于水平支；自前后看，顶端稍稍向内弯曲(Pl. I, 2)。齿根在齿槽处的断面为椭圆形，长轴为外上至内下方向(见图 1, B1)。齿根已长出齿槽之外。齿冠部分断面为三角形，前内和后内角都很尖锐，前外角圆钝；前面平或稍凹，外后面微微隆凸，内面为磨蚀面，没有珐琅质覆盖，在前和外方覆以很薄的珐琅质，珐琅质层下缘残缺不全，界限不清。左门齿断裂处的前后长和横宽为 41.1 × 23；齿冠基部的前后长和横宽为 43 × 34；齿槽处断面的最大长(内下至外上方向)和宽(垂直于前者)为 41.5 × 34.5。

颊齿齿式全。dp1 很小，单根，未磨蚀，牙齿斜向前上方，齿根裸露在齿槽之外的部分很长，齿冠呈钮扣状，低于其它牙齿；与门齿之间的齿隙长约为 90(Pl. I, 1)。p2 保存不好，双根，牙齿较窄，下原脊前端为尖角状，次脊在长度上和原脊差不多。p3(Pl. II, 1)较 p2 宽大，前窄后宽。下前脊很短小，下原脊的外壁斜向前内方，下后尖粗大，向内后方倾斜；次脊的横脊部分发育完整，但较细。p4 和 p3 很接近。它的下前脊为一很细的嵴，向舌侧逐渐降低。它和下后尖之间的沟很窄。此沟和下前脊都不达齿冠的基部，终止于距齿冠下缘约 10mm 处。外壁的后外角有一明显的褶，是由发育较好的外后齿带形成的。m1 磨蚀最深，外中沟较前臼齿者深，没有外后齿带。m2 下原脊的外壁较平直，其后外角呈直角形，下前脊嵴形，但不象在前臼齿中那样向内下方倾斜。下次脊的前端指向下后脊的中部，向下逐渐移向外方，所以，外中沟自上而下由深变浅。下次脊的外后角也近直角形。前外齿带斜向前上方(Pl. I, 1)，其下端距离齿冠下缘还很远即行消失。后齿带不很发育。m3 和 m2 构造基本一致。p1—p4 长：74.4；p2—p4 长：66；m1—m3 长：109；p1—m3 长：183。其它测量(冠面长 × 最大宽 × 外壁实际高)见表 1。

表1 *Aprotodon lanzhouensis*下颊齿测量

Table 1 Measurements of lower cheek teeth of *Aprotodon lanzhouensis*

标本 / 颊齿	GVL 8801	V 11060	GVL 8706-7
dp1	9.8×9×9		
p2	18.2×14×13		
p3	23.6×21×14	29.3×19×30.3	30.8×14.7×30*
p4	26.2×21.8×14.7		30.4×19*
m1	31.3×24.1×14	35.4×24.2×32	
m2	36.2×24.2×20.7	42.8×22.5×41.5	
m3	39×24.4×25		

* 测量为dp3和dp4

V 11378 是一完整的左下门齿，仅尖端缺失，中部稍破损(见图 1, B2)。这个牙齿比正型标本稍细小，磨蚀较深。齿冠内面磨蚀面长约 160，超过了齿根的长度。它的下端和齿根间形成一个很明显的陡坎。齿根的断面为椭圆形，表面有很多纵向沟；其直径向末端缓慢收缩，因此直至末端仍然相当粗。髓腔细小，不呈开放形。整个门齿的前缘的曲线长约

为 350,其内切直线长大约是 280。齿根最粗处的断面为 40 × 35。此外还有十个下门齿的残段。其中最粗的是 V 11380。它的齿根的最粗处位于齿冠稍下,断面为 50.5 × 44.3。

GVL 8706,8707,V 11060 和 V 11061 都是未成年下颌骨,它们都比正型标本稍大,齿冠也更高。其中 V 11060 保存最好(Pl. I, 3; Pl. III, 1)。下颌的下缘也是弧形的,在 p3 和 dp4 的下方,外壁不向外隆出,在 p3 的下方有一很大的空洞,但很难判断这是病态还是门齿齿槽的残迹。恒齿齿冠都很高,冠高大致与冠长相等。p3 保存好,刚开始磨蚀,冠长向下收缩变短;三角座为 V 形,下前脊斜向前内方,仅在最末端稍稍弯向内方;跟座比三角座稍宽,下次脊形成很高的横脊;自内侧看,前、后两个谷都很深,谷底接近于齿冠基部;没有内齿带,外齿带在前、后两端很发育,方向近陡直。dp4 已磨蚀很深,齿冠形态接近臼齿。m1 三角座接近 U 形,其外壁以近 45°角斜向前内方,所以下前脊较短;外壁和下后脊以近直角的角度相交,但不形成锐嵴,而较圆隆;自内面看,冠长向根部收缩;前、后两谷都为 V 形,前谷浅,后谷深,齿冠下缘呈弧形;外后齿带和 p3 者差不多:近于垂直,至齿冠高的一半则转向内方;前齿带短小,位置很高,接近于齿冠顶部;在外中谷基部有一瘤状突起。m2 构造基本与 m1 同,但齿冠更高;前外齿带较 m1 者更长,陡直地斜向前上方,但不达齿冠顶端,而和 m1 后齿带等高。水平支在 m1 处外高 58,厚 32.5。其它测量见表 1。GVL 8706 的 m2 只保留了三角座部分,还没有磨蚀,其冠高达 46mm。

V 11059 为一残破头骨,眼眶以后部分缺失。头骨受压变扁,一断层将上腭和眼眶以上部分分开。鼻骨及牙齿稍破损。额面平,眶后嵴向后可能形成单一的矢状嵴。额部或眶上都没有隆起或粗糙面。鼻骨很薄,后部厚仅 8mm,其后端宽,两侧缘下垂;鼻中缝在背、腹两侧都很清楚;鼻骨前端比后部略厚,约 12mm,背面在横向上微凸,纵向上平,腹面也平。鼻切迹高,其后端在受压变扁后的高度约为 45;它和眼眶之间的距离很短,仅 58。眶下孔紧靠鼻切迹后缘。如果眼眶按常规位于 M2 或 M1 之上的话,鼻切迹的后缘大概位于 P4 或 P3 之上。前颌骨只保留了右侧约 40mm 长的一段,向前伸展,表明吻端并不急剧向内收缩(Pl. III, 2)。

上颊齿(Pl. III, 2)中,P1 三角形,宽大于长。外壁有一中肋,只有一条后脊,内齿带在前半部发育。P2–P4都处于半臼齿化水平(按 Heissig, 1969 定义)。外壁上有很清楚的前附尖、前附尖褶和前尖肋;后半部分平,无后尖肋。原脊斜向内后方,与外脊连接的部分细,内部变粗,原尖在 P3 和 P4 上有后收缩褶,前收缩褶不明显;后脊总是很细,稍稍弯曲;中谷全都封闭;在中谷的外缘有一隆起;小刺在 P2 上微弱可见;后谷稍经磨蚀即已封闭;由于横脊的壁都很陡直,中谷和后谷既使在磨蚀很深时仍然不消失;前、后、内齿带都很发育:前齿带急剧斜向内下方(向根方向);内齿带在原尖之后急剧斜向后上方(离根方向);后齿带在次尖后方上升较高,稍经磨蚀即和次尖一起形成一个斜向外后方的小刺。后齿带本身很细,但相当高,稍经磨蚀即可形成封闭的后谷。M1 冠面前宽后窄,外长内短;前附尖伸向前外方,至齿冠基部仍然突出于牙齿前缘之前。前附尖褶窄而深。原脊粗壮,内半部斜向内后方,原尖圆,前、后收缩深,反前刺大,末端尖,已和次脊相连而将中谷封闭。次脊比原脊稍细,斜向后内方,前刺处有一微弱的隆起,次尖有一前收缩。前齿带外半部已与原脊愈合,内半部很发育,斜向内下方,至原尖前内角处消失,后齿带由内、外两部分组成,中间为一深的切口,只有当牙齿磨蚀很深时,后谷才能完全封闭,原尖和次尖的内面

都没有齿带。M2 构造和 M1 基本一致，只是更长些，前刺很细，随磨蚀加深逐渐消失。自外面看，齿冠的前、后缘都呈弧形，这使牙齿在开始磨蚀和磨蚀深的时候都前后变短，而在中度磨蚀时牙齿最长，M2 外壁中部最大长为 53。M3 没有保存。

表2 *Aprotodon*上颊齿测量(冠面长×最大宽×外壁实际高)

Table 2 Measurements of upper cheek teeth of *Aprotodon* (L×W×H)

种 / 颊齿	*A. lanzhouensis* V 11059	*A. aralensis* (after Borissiak, 1954)	*Aprotodon* sp. V 11062
P1	15.8×16.8×10.5		
P2	24×28×17.5	26–27×35–38×21	
P3	31.3×43.7×23.4	31–32×42–48×28–30	
P4	35.2×49.4×26.2	36×53–54×30	
M1	43×50×25	41–45×58–59×25–26	24.6×35.5×?
M2	51×53×37	50–52×61–63×36–39	34.2×37.7×?

GVL 8701, GVL 8702–4 和 GVL 8802 中有 M3。它们的构造都大同小异。M3，除了外后脊的构造特殊之外，其余的部分都和 M2 很接近。后齿带由两部分组成，只是比 M2 者小。

V 11383 是一个左 P3 或 P4 的内半部。这件标本产于咸水河组的最低部的黄砂岩中，其时代是早渐新世晚期，远早于其它的标本。但是在尺寸大小，中凹封闭，内齿带发育的程度等方面，它和上述的标本都很接近；只是它的原尖从原脊中分出得不那么明显，它的后谷似乎更浅一点。由于材料太少，这一标本真正性质还不很清楚，我们只是暂时把它归入到本种中。

Aprotodon sp.

(Pl. II, 4)

描述与鉴定 V 11062 是一件左上颌，带 P4 后半部，M1–M2和很破碎的 M3 (Pl. II, 4)，产自桃湾沟第一白砂岩层上部(GL 9501)。这件标本在形态上和上述的标本没有什么大的区别，但是尺寸特别小(见表 2)。在长度上它只是 V 11059 的 0.57—0.67，在宽度上只是它的 0.71。如以面积计算，它只有 V 11059 的 0.4—0.48，即不到一半大小。如果把它和上述标本都归入一个种，这一差异将远远超过一般种内个体变异的幅度。V 11062 可能是一个单独的种，但现有的材料太少，目前还不宜建立新种。

二、比较与讨论

1. 兰州种与其它种的比较

Aprotodon 是 Forster–Cooper .(1915)创建的。建属的材料是发现于巴基斯坦俾路支斯坦地区 Bugti 地层中的两个下颌联合部。由于联合部十分宽大，在形态上和河马的相似，Forster–Cooper认为它可能是一类未知的河马，这样就把门齿当成犬齿，而使用 *Aprotodon*

这个词(原意为无门齿)作为属名。1928 年 Vaufrey 根据 Ringström (1924)创建的大唇犀属的材料,指出犀类也有下颌联合部变宽的现象,因而把 *Aprotodon* 和大唇犀视为同物异名。Forster-Cooper (1934)后来同意了这一意见。此后 *Aprotodon* 这个属名就没有人再提及。一直到 1954 年,Beliajeva 在哈萨克斯坦 Agyspe 地点又发现了类似的下颌联合部,才又恢复了这个属。遗憾的是,这两批材料中都没有连在一起的头骨或上、下颊齿。虽然 Beliajeva (1954)曾把一些零散的上牙归到这个属的一个未定种中,但就是她本人对此也不敢肯定。有趣的是,在同一期刊物上 Borissiak 记述了一个采自于同一地点的无角犀的新种: *Aceratherium aralense*。Heissig (1972)把 Borissiak 记述的头骨和 Beliajeva 记述的下颌联合部合并在一起,使用了 *Aprotodon aralense*(应为 *aralensis*)这个种名。在兰州盆地也发现了同样的头骨和下颌,它们在大小上相近。在兰州盆地还首次发现了和大门齿连在一起的下颊齿。它们和上颊齿在特征上也相匹配:都是齿冠较高,齿冠长向根部收缩。这些都有利于 Heissig 的观点。

如果上述的上颊齿都属于 *Aprotodon*,那么 Pilgrim (1912)记述的 *Teleoceras fatehjangense* 也应该归入此属(见下)。Lydekker 在 1884 年定了一个无角犀的新种: *A. blanfordi*。这个种的正型标本与 *Aprotodon* 无关,因为它的 P4 的中谷根本不封闭。但是 Forster-Cooper (1934)归入这个种的一些材料,特别是其中的一个头骨(Pl. 67, Fig. 34)的上牙却非常象是 *Aprotodon* 的。把上述这些材料合并为同一个种的可能性是很大的。如果确实如此,那么种名就应该是 *Aprotodon fatehjangensis* 了。但是目前还没有足够的证据这样作。这样,到目前为止,这个属共有四个种: *A. smith-woodwardi*, *A. fatehjangensis*, *A. aralensis* 和 *A. lanzhouensis*。现分别比较如下:

*A. smith-woodwardi*的正型标本是 Forster-Cooper 1915 年记述的。另一个下颌联合是他于 1934 年记述的。从附图看,这个种的下颌联合后端终止于颊齿齿列之前(兰州种在 p3 前部),联合部的后端不强烈变窄,水平支本身也较横宽(55,兰州种为 45)。它的门齿齿槽横宽大于高,和兰州者不同。Forster-Cooper 没有提供门齿齿槽的测量。根据 Beliajeva 的记载,它的门齿齿槽很宽扁: 52-60 × 24(压扁?)。这和兰州标本的接近圆形的齿槽有很明显的差异。

A. fatehjangensis 的正型标本只包括一个 P4 和一个 M2。P4 相当大,根据我们的测量,长和宽为 43 × 55。在形态上它也不同于兰州的种。它的后尖有外隆起;后谷更宽大,内齿带似乎不那么急剧地向后上方倾斜。它的 M2 的原尖在纵向上变长,内缘平,前刺短而粗。在兰州种中,原尖直至深度磨蚀仍为圆形,前刺很细,稍经磨蚀即行消失。

和 *A. aralensis*(咸海种)相比,主要的差别是在门齿上(见图 1)。根据 Beliajeva 的描述,这个种的门齿比兰州者细小,不那么强烈地弯曲。它的最大长是 237;而兰州种中一个较小的门齿的直线长就是 280,曲线长可达 350。前者最粗的部分是 33 × 35(图 1, A1 是根据 Beliajeva 的图复制的,其齿根断面和联合部的比例显然有误);兰州者为 40-50.5 × 35-44.3。它的冠部没有很突出的前外棱,在兰州种中,前外棱是很明显的。这两个种的联合部也不完全相同:前者在最前缘处顶面并不深凹;在兰州的标本上,在前缘处顶面形成深的凹面,而联合部的底面自前至后都基本上是平的,联合部前端变得很薄(不超过 10,在咸海种中为 18)。此外,在咸海种中,门齿齿槽是横宽的,而在兰州的标本中它的长轴已经

接近于垂直了。

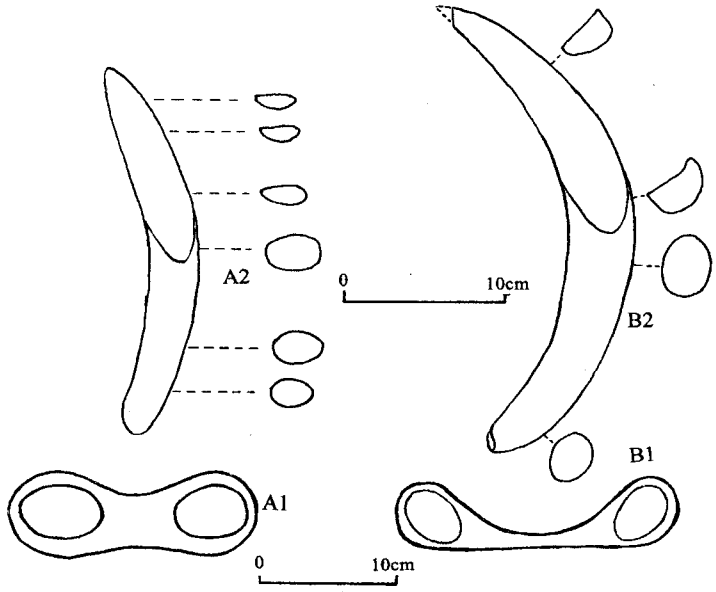

图1 下颌联合部断面(1)及门齿内面(2)示意图

Fig.1 Diagrams showing the anterior view of the symphysis (1) and the inner view of i2 (2)
A:*A. aralensis* (after Beliajeva,1954); B: *A.lanzhouensis* (B1. symphysis: GVL 8801; B2. i2: V 11378)

Borissiak 记述的头骨和兰州种相比,在鼻骨和鼻切迹的构造、眶下孔和眼眶的位置等方面都是一样的。但是兰州种尺寸较小。在兰州种中,从眶前缘至外耳道的距离最多不会超过 220(咸海种为 270),它的额部的最大宽约为 170(咸海种为 233)。兰州标本也没有 Borissiak 所提到的眶上的一对隆起。这两个种在牙齿的构造上几乎没有什么区别,只是兰州者稍小。如果把这两个种的颊齿和门齿放在一起来看,还可以发现,咸海种的个体大,颊齿也大,但下门齿小,而兰州种则是个体小,颊齿也小,但下门齿反而更大。

2. 关于 *Aprotodon* 属的特征

虽然 Beliajeva (1954)和 Heissig (1972)都曾对这个属下过定义,但兰州新材料的发现使我们对这个属有了更清楚的了解。订正和补充后的属的特征如下:头骨无角犀型:较细长,颞嵴向后形成单嵴,鼻骨薄长而平直,鼻切迹高深,后缘达 P3 或 P4,眶下孔紧靠鼻切迹后缘,眼眶前缘距鼻切迹很近。下颌联合呈扇状向前加宽,顶面凹而腹面平,前缘薄;水平支低,下缘弧形。i1 很小或无,i2 很大,根粗壮,断面椭圆至扁圆形,齿冠斜向前上方,直至垂直向上,珐琅质层极薄。颊齿齿式全,半高冠,冠长向根部方向变短。上颊齿前附尖、前附尖褶和前尖肋发育。上前臼齿宽大于长,半臼齿化,横脊壁垂直,后脊细,形成大的封闭中谷和后谷,前、后、内齿带均很发育。上臼齿原尖收缩明显,具大的反前刺,细小前刺。下颊齿原脊斜向前内方,外壁平,其后外角近直角状,前、后外齿带发育,强烈倾斜。下前臼齿相对较短,dp1 钮扣状,p2–p4下前脊发育不全。

3. *Aprotodon* 在真犀科中的分类地位

Aprotodon 也许是犀类中最令人费解的一个属了。长期以来人们不知道它的头骨和牙齿究竟是什么样子。实际上,早在建属之前,Pilgrim (1912)就把这类犀的上牙归入了 *Teleoceras* 属中。在本世纪廿和卅年代,人们多把它和大唇犀联系在一起。在四十年代 Kretzoi (1942, 1943)把 Pilgrim 记述的上牙定了一个新属 *Indotherium*,并把它和板齿犀联系在一起。在五十年代,Borissiak (1954)把这类犀的一个头骨放在了无角犀属,而 Beliajeva 则把它的下颌归入了矮脚犀亚科中。此后 Heissig 虽然正确地把这类犀的头骨和下颌放在了一起,但仍然把它保留在矮脚犀亚科中。这种意见大体上一直保留到今天 (Heissig, 1989, Prothero *et al.*, 1989)。

单就下颌来看,*Aprotodon* 确实和大唇犀最为接近。但是仔细地对比一下就可以看出,两者的差别很大。最重要的有以下几点:1) *Aprotodon* 的下颌联合部在比例上比大唇犀者宽大得多,舌面较宽而平坦;在大唇犀中为一中纵凹槽。2) 下颌下缘弯曲,而且自顶面看其前后端也向外翘。这种情况在整个犀类中很少见。3) 它的第二下门齿不但尺寸很大,且强烈弯曲,齿根粗壮,其断面接近圆形,向末端收缩弱,亦即直至末端仍然相当粗壮,齿冠上的珐琅质层极薄;在大唇犀中弯曲弱,齿根向末端收缩快,珐琅质层厚实。4) 下颊齿齿式全,下原脊的外壁斜向前内方,其外后角呈直角形,外齿带很发育,几近陡直地斜向上方;大唇犀仅在幼年时有 dp1,颊齿的外壁圆隆。*Aprotodon* 和 *Chilotherium* 在头骨和上牙上的区别就更明显了。前者的头骨仍为无角犀型,上前臼齿半臼齿化;而后者的头骨已经高度特化,上前臼齿完全臼齿化。此外,*Aprotodon* 虽然在下颌联合部的特化程度上远远超过了大唇犀,但出现的时代却更早:只发现于渐新世晚期至中新世早期的地层中;而大唇犀则主要发现于晚中新世,亦即前者至少比后者要早出现五百万年。把 *Aprotodon* 归入矮脚犀亚科和这个亚科原来的内涵显得格格不入。矮脚犀亚科中根本没有下颌联合部如此特化的现象。

在下颌和下牙的形态上和 *Aprotodon* 最接近的,很可能是 Beliajeva (1954)所创建的 *Symphysorrachis* 属。内蒙古千里山地区有这个属的材料(研究中)。从这些材料可以看出,这个属的下颌联合已开始变大,顶面在门齿之间凹陷深。它的 i2 也很长大,珐琅质层很薄;下颊齿齿式全,下原脊外壁较平,斜向前内方,后外角较尖锐,外齿带在前、后端都很倾斜等等,这些都是两者相似之处。但两者之间也有明显的差别。后者的联合部不那么宽,腹面有一中嵴,门齿伸向前外方,很少弯曲向上。下颌的下缘和外壁都不象在 *Aprotodon* 中那样弯曲。此外,它的个体也明显地大于后者。*Symphysorrachis* 在上述特征上与 *A. aralensis* 更为接近。兰州种似乎更为特化。

总之,*Aprotodon* 在形态上似乎和亚洲渐新世的 *Symphysorrachis* 更为接近,在某些特征上和欧洲的 *Ronzotherium* 也有相似之处。它不应放在无角犀或矮脚犀亚科中,很可能它是一支早期特化的原始真犀。

4. *Aprotodon* 属的地理分布和时代意义

到目前为止,这个属的化石仅仅发现于巴基斯坦、哈萨克斯坦和我国的兰州盆地。在

巴基斯坦它和巨犀及象共生。在哈萨克斯坦它与巨犀共生，但没有和象类一同发现过。巨犀主要生存于渐新世，少数残存至中新世初，而象类在欧洲是从 Orleanian 期才出现。在兰州盆地，*Aprotodon* 和巨犀及象同时在咸水河组中段的白砂岩层中发现。在欧洲和象类同时首次出现的还有众多的古仓鼠类，例如，*Democricetodon*，*Megacricetodon* 等。在兰州盆地，这类古仓鼠出现于更高的层位中。这可能表明，象类在亚洲的出现要早于欧洲者。在白砂岩层中发现的张家坪动物群(在研究中)和 Bugti 的相比显得更原始些。Downing 等(1993)根据在 Zinda Pir Dome 附近早中新世地层的研究，推断在巴基斯坦"象事件"发生在大约距今 20.5 百万年，亦即比欧洲要早些。兰州盆地的白砂岩层的时代应与欧洲的 Agenian 期相对比，其时代为早中新世早期。

致谢 本文在成文过程中曾就地层时代问题多次与王伴月、邱铸鼎交换意见，受益匪浅。承蒙吴文裕、郑绍华先生审阅文稿，提出宝贵意见；张杰先生为本文拍摄照片。谨此一并致谢。

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A NEW SPECIES OF *APROTODON* (PERISSODACTYLA, RHINOCEROTIDAE) FROM LANZHOU BASIN, GANSU, CHINA

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Summary

Aprotodon, a group of mid-Tertiary rhinoceroses with particularly wide symphyses, was previously known only from Pakistan and Kazakhstan. Its affinity has been little understood because of the paucity of the fossils available for study. The senior author of the present paper first mentioned its occurrence in the Lanzhou basin in 1990. In fact, its first finding was made early in 1986. In that year the junior author of the present paper collected some isolated teeth of this genus from Zhangjiaping, about 10km north of Lanzhou. Later in 1988 a well-preserved lower jaw with characteristic *Aprotodon* huge tusks was unearthed from a layer of thick white sandstone near the village Duitinggou, 10km east of Zhangjiaping. Various specimens, including skull fragments and upper teeth attributable to *Aprotodon*, have been found in the Lanzhou basin since then. Now *Aprotodon* became the best represented genus among the large fossil mammals of the Lanzhou basin, and our knowledge of this genus is considerably augmented owing to these findings. The material to be studied below is important not only for the age determination of the Cenozoic deposits in the Lanzhou basin, but also for a better understanding of the genus *Aprotodon*.

GL is the prefix to the locality number, and GVL to the catalogue number of studied vertebrate fossils of the Gansu Provincial Museum, while V is the prefix to the studied fossils of IVPP. All measurements in the present paper are in millimeters.

Description

Aprotodon lanzhouensis sp. nov.

(Pl. I; II, 1—3; III; Fig. 1)

Holotype GVL 8801, a lower jaw with symphysis and left horizontal ramus well

preserved (Pl. I, 1, 2; Pl. II, 1; Fig. 1, B1), collected from the first white sandstone (base of the middle member of Xianshuihe Formation) near the village Duitinggou.

Referred specimens 1. V 11059, a heavily damaged skull with right P1–M3 and left P2–P3 (Pl. III, 2), collected from the first white sandstone near Zhangjiaping (GL 9514). 2. V 11060, right horizontal ramus with p3, dp4–m2 and erupting m3 (Pl. I, 3, Pl. III, 1), from the same level near Taowangou (GL 9504). 3. V 11061, left horizontal ramus with dp4–m1, from the second white sandstone near Huangyangtou (GL 9511). 4. V 11378, almost complete left i2 (Fig. 1, B2), from the first white sandstone near Huangyantou (GL 9512). 5. GVL 8601, left p4, m1–m2; 6. GVL 8602, left P2; 7. GVL 8603, two fragments of left i2 probably of the same individual. The above three specimens were collected from Zhangjiaping in 1986. 8. GVL 8701, left M2 (broken at the antero–external corner) and M3 (Pl. II, 3); 9. GVL 8702, right m2–m3 (broken at the anteroexternal corner and the protocone); 10. GVL 8703, well–preserved left M3; 11. GVL 8704, heavily worn right M3; 12. GVL 8705, left lower molar. The above 5 specimens were collected from Zhangjiaping in 1987. 13. GVL 8706, fragment of left horizontal ramus, with dp4, m1 and anterior half of m2; 14. GVL 8707, fragment of right horizontal ramus with dp3. The above two specimens were collected from Duitinggou in 1987. 15. GVL 8802, fragmentary left M1–M3 and right m1; 16. GVL 8803, six fragments of i2. The above two specimens were collected from the same site as the holotype in 1988 (GL 8801). 17. V 11379, fragment of i2, from the second white sandstone near Huangyangtou (GL 9510). 18. V 11380, fragment of root of i2, collected from Taowangou in 1995. 19. V 11381, left m3, from the first white sandstone near Nanpoping (GL 9502). 20. V 11382, right m3 (?), from the third white sandstone in Yantonggou (GL 9517). 21. V 11383, inner half of a left P3 or P4, from the yellow sandstone (Lower member of the Xianshuihe Formation, GL 9507).

Locality and age Except for V 11383, all the specimens were found from the basal part (white sandstone) of the middle member of the Xianshuihe Formation. Majority of the specimens were found in the lowest, the first white sandstone, while only a few from the second or third layer of the white sandstone. V 11383 was found in the basal yellow sandstone of the Xianshuihe Formation. The yellow sandstone is dated as latest early Oligocene, while the layers of the white sandstone are dated early Miocene. The readers are referred to the geologic report "New advances in study of the Xianshuihe Formation of Lanzhou basin, Gansu" (Qiu *et al.*, in press) for further information.

Diagnosis The smallest species with proportionally wider symphysis and more robust, strongly curved lower i2 with laterally compressed root. It differs further from *A. aralensis* by having a deeply excavated and thin central part of the symphysis, the

cross section of the crown of i2 being triangular in shape, with anterior border rather flat and worn surface facing lingually. *A. smith-woodwardi* differs further from the new species by having a wider posterior part of the symphysis and stronger horizontally compressed i2. *A. fatehjangensis* differs further from the new species by having metacone rib, but less steeply ascending lingual cingulum on P4, and stronger development of crochet on M2.

Description The type specimen, GVL 8801, although slightly damaged in its ramus ascendens and teeth, is so far the best preserved lower jaw ever found of the genus. Seen from the lateral view, the ramus is low, with its lower and alveolar borders both curved so that its height is about the same under the cheek teeth. It is only about twice the crown height of the molars. Seen from above, the ramus is rather strongly curved with both its extremities deflected laterally. The symphysis starts widening anteriorly from the p4. The enormous size of the i2 renders the lateral border of the symphysis particularly robust. This makes the anterior premolars shifting lingually, instead of being situated centrally, relative to the horizontal ramus. The alveolar crest between dp1 and i2 is very short, only about 20mm long, disappearing soon anteriorly. The symphysis is deeply excavated centrally, bordered by the robust lateral rims containing the enormous i2. The excavated surface is triangular in shape, since the two i2 diverge anteriorly. A pair of tiny alveoli of i1 (most probably di1) can only be seen on the lingual side of the symphysis. The anterior rim of the symphysis is thin, about 10mm thick. On ventral side there are three shallow depressions: a sagittal one and a pair on each side of the sagittal one.

The i2, seen from lateral side, is strongly curved, turning upright in its upper part. Seen from the front, the tip of the crown turns even slightly inward (Pl. I, 2). The cross section is oval in shape at the alveolar border, with its major axis extending in externo-upper to inner-lower direction. The root grows beyond the limit of its alveolus. The cross section of the crown is triangular in shape, with sharp antero-inner and postero-inner angles, but flat, or even slightly concave anterior border. The inner surface lacks any trace of enamel covering, while the other two surfaces are covered by extremely thin layer of enamel. The enamel becomes thinner toward the root and subjects damage easily. This blurs its lower border.

The cheek tooth formula is complete. The dp1 is tiny, single-rooted, situated lower than the other cheek teeth. The exposed part of its root is very long, slanting anteriorly upward. The crown is button-shaped, unworn. The p2 is damaged. What can be seen is the following. It is double-rooted, with narrow crown. The anterior end of the protolophid is pointed. The talonid is about as long as the trigonid. The p3 is wider than the p2 in general, but narrow anteriorly. The paralophid is tiny, and the protolophid stretches antero-lingually. The metaconid is robust, slanting posterolingually.

The transverse part of the hypolophid is complete, but still very thin. The p4 is similar to p3. Its paralophid sends a thin ridge downward and posteriorly. The trigonid basin is shallower than the talonid basin. There is a fold at the postero-external corner of the tooth. It is the remnant of the posterior cingulum when the tooth is worn. The m1 is the most worn among the teeth. The mid-valley on the external wall is deep, but the posterior cingulum can not be seen. The trigonid of the m2 is U-shaped, with its external wall approximately straight and its posterior end rather right-angled. The antero-external cingulum is well developed, strongly slanting and situated comparatively high. The postero-external cingulum is less developed than the former.

V 11378 is the best preserved isolated i2 (Fig. 1, B2). Its maximum straight length is about 280, and the curved length measured from its outer margin is 350. The cross section at the most robust part measures 40 × 35. The most robust one among the i2 specimens measures 50.5 × 44.3.

The lower jaws, GVL 8706, V 11060 (Pl. I, 3, Pl. III, 1), V 11061, are similar to the holotype in general morphology, but larger and higher crowned.

V 11059 is a badly damaged skull. It was found separated by a small fault along the level between the palate and the orbit. The frontal is flat, with strongly converging postorbital ridges, suggesting the presence of a long single-crested portion of the sagittal crest. No protuberance or particularly roughened areas exist on frontal or supraorbital region. The nasal bone is very thin, only 8mm at its posterior end, about 12mm at its anterior tip. The nasal bones are not coalesced, leaving clear suture between them. The sagittal part of the nasal bone is thicker than its lateral border, which slightly droops. The nasal notch is long and high. Its estimated height is about 45mm. The preorbital bar is short, only 58mm. The infraorbital foramen is close to the posterior border of the nasal notch, which may lie above the P4 or P3. A portion of the premaxillary bone is preserved, which indicates they are not particularly reduced.

The P1 (or DP1) is triangular in crown view, wider than long. A rib is seen at the middle of the external wall. Only metaloph is well developed. The inner cingulum is developed in the anterior half of the inner side. The P2-P4 are semi-molariform (according to Heissig, 1969). The parastyle, paracone rib and the fold between them are all clearly seen on the external wall. The posterior half of the external wall is flat, without metacone rib. The protoloph slants posteriorly inward. It connects the ectoloph by a thin band, while its internal end becomes much thicker. The posterior protocone constriction is more clearly shown than its anterior counterpart in P3 and P4. The metaloph is always very thin and curved. The middle valley is always closed. A closed postfossette is formed when the tooth is only slightly worn. The anterior, inner

and posterior cingula are well developed an form an almost continuous ridge. Both the anterior and posterior cingula ascend labially, while the inner one slants strongly upward posteriorly. The upper molar has strongly anteriorly extending parastyle and deep parastyle fold. Both the anterior and posterior protocone constrictions are clearly shown. The antecrochet is large, pointed slightly at its end. In M1 the antecrochet connects the metaloph and blocks the middle valley lingually. The hypocone is provided with an anterior constriction only. The crochet is not very well developed. The cingula on the anterior, posterior and lingual sides are well developed, interrupted only at the inner side of the protocone and hypocone. For measurements see tables in the Chinese text.

The referral of the specimen V 11383, an incomplete P3 or P4, to the present species is based on its general size, the presence of a closed middle valley and development of cingulum. However, there are some minor differences between V 11383 and the corresponding tooth of the present species. Its protocone constriction seems less clearly shown, and the postfossette seems shallower. It should be noted here that V 11383 was found in the yellow sandstone, the lowest level of the Xianshuihe Formation. If the present determination proves trus, the geologic age of *A. lanzhouensis* would be considerably extended, from early Miocene to the latest early Oligocene. The material is too poor to make any conclusive determination. The above referral is strongly tentative in nature.

***Aprotodon* sp.**

V 11062 is a left maxillary bone with posterior part of P4, M1–M2 and heavily damaged M3. Morphologically it is almost the same as the other specimens described above. However, it is only about half the size of the latter (Table 2). It is too small to be included in the above species, and the material is too poor to establish a new species for it.

Comparison and discussion

1. Comparison of *A. lanzhouensis* with the other species of the genus

Forster–Cooper erected the genus *Aprotodon* in 1915, based on two edentulous symphyses from Bugti beds of Baluchistan, Pakistan. The symphysis was so broad and similar to that of a hippopotamus that Forster–Cooper thought it might be an unknown kind of hippopotamus with big canine–tusks, but without incisors. Hence he coined the name *Aprotodon*. Vaufrey corrected this error in 1928, having pointed out that similar widening of symphysis occurred in *Chilotherium* erected by Ringström in 1924. Thus he synonymized it with *Chilotherium*. The genus *Aprotodon* was

rehabilitated in 1954, when Beliajeva found similar specimens from Kazakhstan. Unfortunately, up to then no associated skull, nor lower jaw had been found together with the odd-looking symphysis. Interesting enough, in the same volume Borissiak assigned a skull from the same locality as the symphysis described by Beliajeva to the genus *Aceratherium*. Heissig (1972) combined the skull and the symphysis together and assigned them to *Aprotodon*, using Borissiak's specific name: thus *Aprotodon aralensis*. In Lanzhou basin similar phenomenon occurred. We have found both skull and lower jaw of the same general morphology together, although not in direct association. This seems to support Heissig's point of view strongly.

If the above association holds true, the skull fragment described by Pilgrim in 1912 as *Teleoceras fatehjangense* should also be relocated in *Aprotodon* (*vide infra*). The type specimen of *Aceratherium blanfordi* erected by Lydekker in 1884 has nothing to do with the present genus. The middle valley of its P4 is not closed as in *Aprotodon*. However, some specimens referred by Forster-Cooper (1934) to *A. blanfordi*, especially the teeth of a skull (Pl. 67, fig. 34), are very similar to those of *Aprotodon*. It is not impossible that all the above discussed specimens from Pakistan belong to one and the same species of *Aprotodon*. Nevertheless, it is premature to do so based on the available material. Thus the genus is now considered to contain four species: *A. smith-woodwardi*, *A. fatehjangensis*, *A. aralensis* and *A. lanzhouensis*.

Of *A. smith-woodwardi* only two symphyses were described. One is the type described by Forster-Cooper in 1915, when he erected the genus; the other was described in 1934. Differing from that of *A. lanzhouensis*, its posterior border seems to be situated anterior to the tooth battery (at the anterior border of the p3 in *A. lanzhouensis*). The symphysis of *A. smith-woodwardi* is not rapidly narrowed posteriorly, and the horizontal ramus is robust, 55mm thick (45 in *A. lanzhouensis*). Forster-Cooper did not provide us with any measurements of the incisors. According to Beliajeva, the alveolus of i2 is rather vertically compressed: 52-60 (horizontal) × 24 (vertical). In all these features the two forms are quite different. Of the described material of *A. fatehjangensis*, practically only a P4 and a M2 are of value for comparison. The P4 is rather large, 43 × 55, thus larger than that in the Lanzhou species. Morphologically it is also different. It has a prominent metacone rib on the external wall, its postfossette is wide and large and the inner cingulum does not slant so strongly. The protocone of the M2 is flattened on its lingual side, and the crochet is thick. In *A. lanzhouensis* the protocone is always rounded in form, even when heavily worn, and the crochet is tiny, easily obliterated by slight wearing.

In comparison with *A. aralensis*, the differences lie mainly in the symphysis and incisors. According to Beliajeva's description, the i2 in the Aral species is generally smaller (length and robustness) and weaker in curvature (Fig. 1). The symphysis in

the Aral species is apparently less deeply excavated on its dorsal surface and its anterior rim is not as thin (18mm thick) as in the Lanzhou species (10mm thick). In addition, the i2 alveolus in the Aral species is wider than high, while in the Lanzhou species it is higher than wide. The general morphology of the skull found in Lanzhou basin conforms the skull described by Borissiak very well, with only a few minor differences. The Lanzhou skull is definitely smaller, and there is no protuberances above the orbit observed in the Aral species.

2. Diagnosis of *Aprotodon*

The new material from Lanzhou renders it possible to amend the diagnoses of the genus given by Beliajeva (1954) and Heissig (1972) as follows: Skull is acerathere in form: slender, with Y-shaped sagittal crest and long, straight and thin nasals; nasal notch high, preorbital bar short. Symphysis widens anteriorly, deeply excavated above, but flat below; horizontal ramus low, with curved lower border. The i1 is present or lost; i2 enormous in size, root robust, oval in cross section, crown strongly curved, covered by very thin layer of enamel. Cheek tooth formula complete, comparatively high-crowned. The uppers with prominent parastyle fold and constricted protocone; upper premolar wider than long, semi-molariform, with closed middle and posterior valleys and strong lingual cingulum; upper molar with large antecrochet, but fine crochet. The lowers with oblique protolophid, right-angled protoconid, prominent and steeply ascending anterior and posterior cingula on labial side. The dp1 is button-shaped; paralophid very short in p2-p4.

3. Systematic position of *Aprotodon* in Rhinocerotidae

Aprotodon belongs probably one of the most perplexing groups in Rinocerotidae. So far no complete lower jaw has ever been described, not to speak of associated skull. Even now we are not certain of what its skull, jaw, and cheek teeth look like. In fact, prior to the establishment of the genus *Aprotodon*, the specimens referable to it was assigned by Pilgrim (1912) to the genus *Teleoceras*. In 1920s and 1930s *Aprotodon* was generally considered synonymous with *Chilotherium*. Kretzoi (1942, 1943) created a new genus for it, *Indotherium*, and thought it might be an elasmothere. As noted above, Borissiak attributed its skull to *Aceratherium*, while Beliajeva put its lower jaw into the subfamily Teleoceratinae. Heissig was right when he associated Borissiak's skull with Beliajeva's symphysis together, but again he thought it a member of Teleoceratinae. This point of view is generally held nowadays (Heissig, 1989, Prothero *et al.*, 1989). However, no serious justification has ever been made. In fact no member of this subfamily has ever been found with so aberrant symphysis, so enlarged i2 in combination of precociously specialized cheek teeth.

Superficially, *Aprotodon* and *Chilotherium* are very similar in the structure of their symphyses. However, a closer observation discloses the essential differences between them. 1) *Aprotodon* has a proportionally larger and wider symphysis than *Chilotherium*. 2) The horizontal ramus of the first genus is curved not only in side view (lower border curved), but also in dorsal view (both extremities deflect outward). This is seldom seen in rhinoceros in general. 3) The i2 in the former is enormously large, strongly curved, with very robust and weakly constricted root, with its crown covered by extremely thin enamel. 4) *Aprotodon* has a complete cheek tooth formula, with U-shaped angular trigonid and strongly slanting external cingulum in the lower cheek teeth. In *Chilotherium* the dp1 drops early in life, the external wall is always rounded in lower cheek tooth. There is no doubt that the two genera differ widely in their skull structure. *Chilotherium* has a highly specialized skull with fully molariform premolars, while that of *Aprotodon* remains primitive acerathere in character with semi-molariform premolars. Furthermore, there is a big gap between the occurrences of the two genera. The first genus is so far known only from the deposits earlier than the early Miocene, while the latter later than middle Miocene and became flourishing only from the late Miocene.

It seems that the genus *Symphysorrachis* created by Beliajeva in 1954 is more similar to *Aprotodon*, as far as the morphology of the lower jaw and teeth is concerned. Among the late Eocene-early Oligocene rhinoceroses *Symphysorrachis* is the only one with similarly widened symphysis and enlarged i2. It is highly probable that these two forms, together with *Ronzontherium* from Europe, belong to a particular lineage split early from the first true rhinoceroses.

4. Distribution of *Aprotodon* and its significance

The discovery of *Aprotodon* from Pakistan, Kazakhstan, and the Lanzhou basin, tends to indicate that the Tibet plateau did not play a role of physical barrier for large mammals between the areas north and south to it until the end of the early Miocene. The co-occurrence of proboscidean and giant rhinoceros fossils with *Aprotodon*, but without *Democricetodon* and *Megacricetodon*, in the lower part of the middle member of the Xianshuihe Formation in Lanzhou basin shows that the geologic age of the fossil-bearing white sandstone beds could be earlier than MN3b in European geochronology. Therefore, the immigration of the proboscideans into Asia probably took place earlier than into Europe.

图版说明 (Explanations of plates)

图版 I (plate I)

Aprotodon lanzhouensis sp. n. 下颌骨(Lower jaw), GVL 8801, × 1 / 2

1. 唇面 (Labial view)
2. 前面 (Anterior view)
3. V 11060, 右下颌骨 (Right lower jaw), 冠面 (Crown view), × 1 / 2

图版 II (plate II)

Aprotodon lanzhouensis sp. n.

1. GVL 8801, 下颌骨 (Lower jaw), 冠面 (Crown view), × 1 / 2
2. GVL 8702, 右 (Right) M2–3, × 1
3. GVL 8701, 左 (Left) M2–3, × 1

Aprotodon sp.

4. V 11062, 左 (Left) P4–M3, × 1

图版 III (plate III)

Aprotodon lanzhouensis sp. n.

1. V 11060, 右下颌骨 (Right lower jaw), 唇侧 (Labial view), × 1 / 2
2. V 11059, 上齿列 (Upper dentition), 冠面 (Crown view), × 2 / 3


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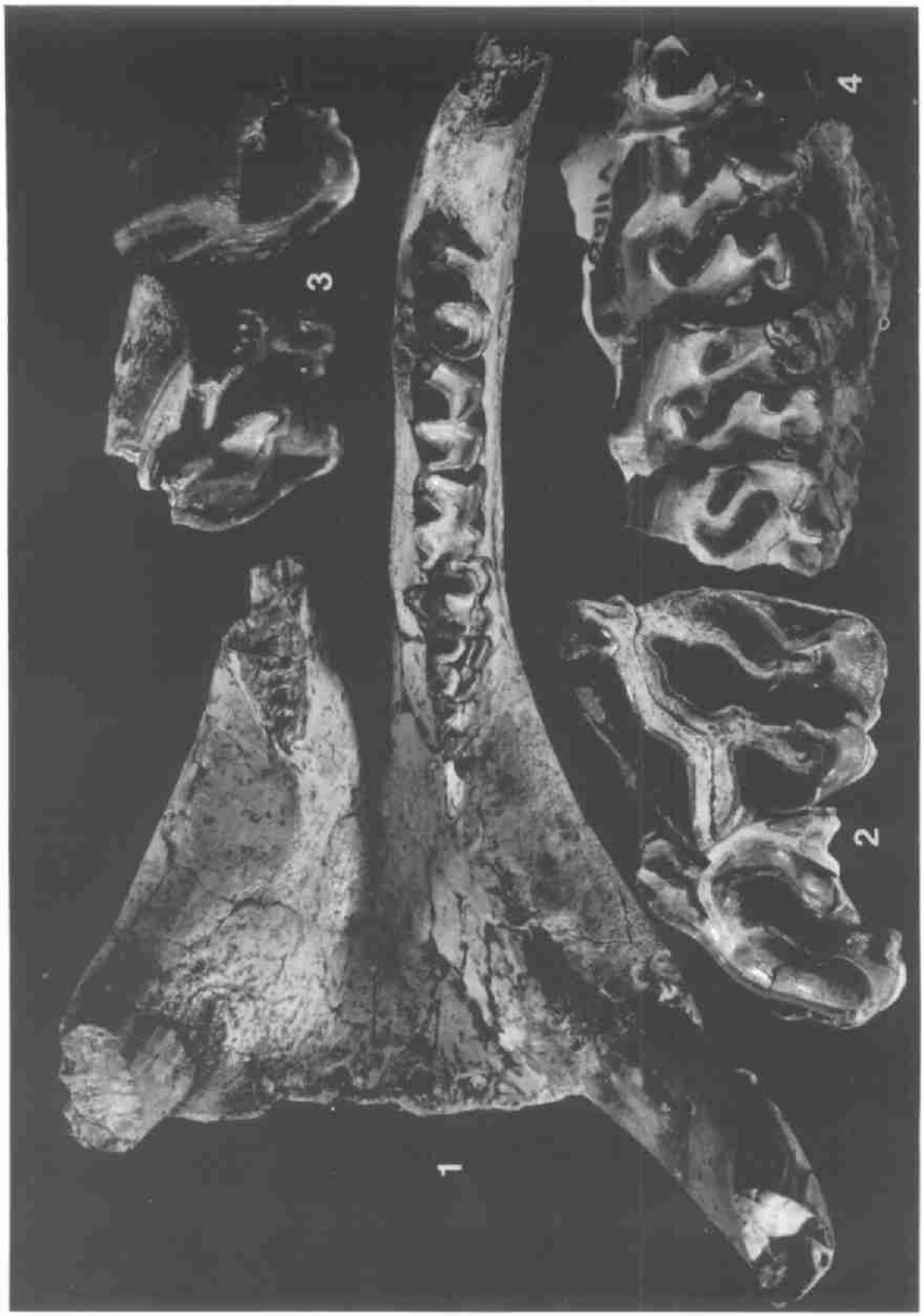
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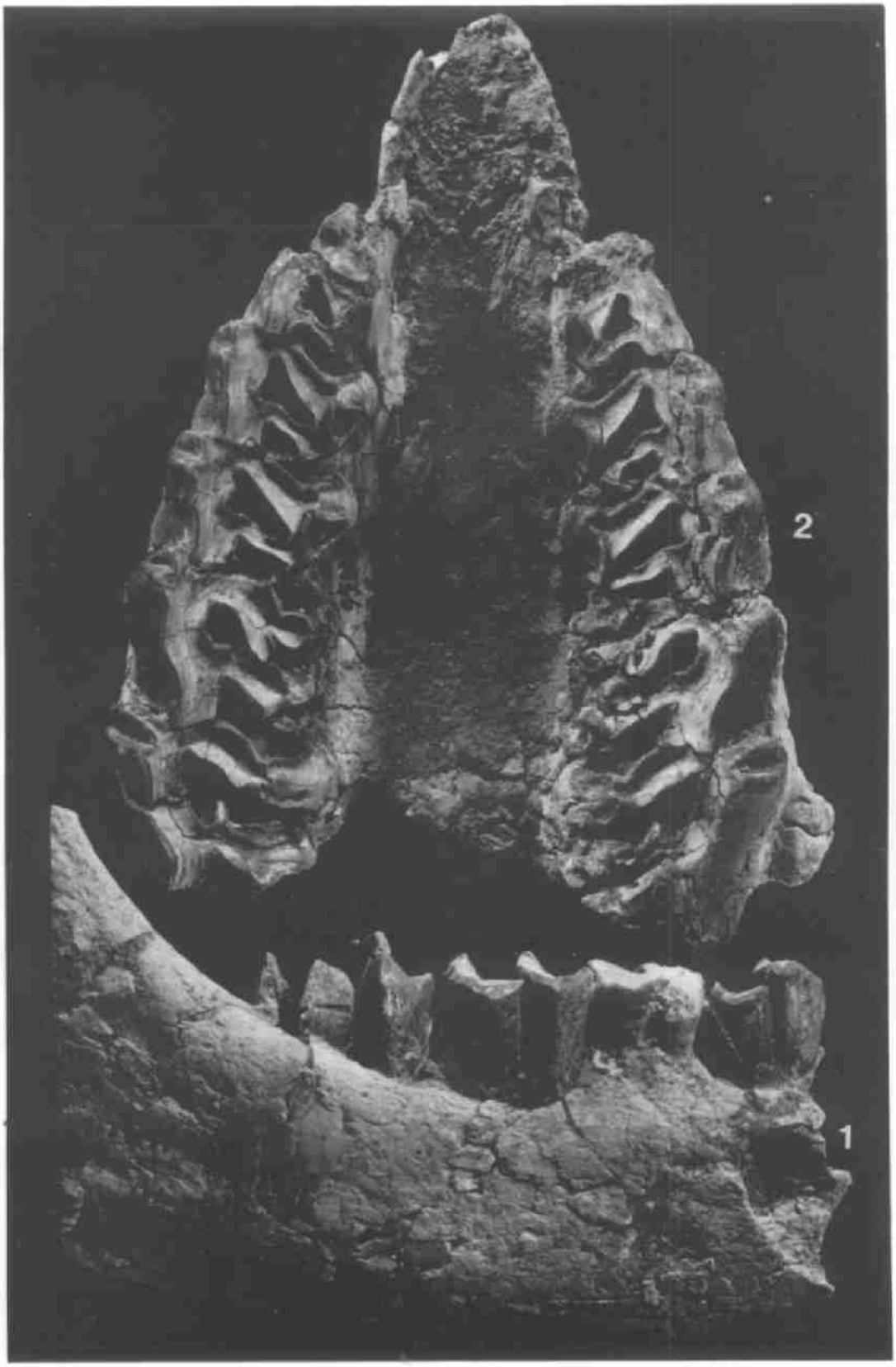
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