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甘肃灵台文王沟(93002地点)晚中新世—早上新世生物地层[1)]

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摘要 文王沟93002地点剖面从下至上被分成4个生物地层带。Ⅰ带可能属于晚中新世保德期中期,Ⅱ+Ⅲ带属于上新世早期,Ⅳ带属于上新世中期。将各带与93001地点剖面进行了对比。着重探讨了鼠科动物中的 *Huaxiamys* n. sp.向 *H.primitivus* 以及 *Occitanomys* n. sp.向 *Chardinomys* 的演化规律。

关键词 甘肃灵台文王沟,晚新生代,生物地层,鼠类进化

中图法分类号 P534.62

93002地点含小哺乳动物化石地层剖面是本文后一作者在1993年参与黄万波及Hideo Nakaya等组成的中-日野外考察队时发现的。当时从该地点的一个层位采集到小哺乳动物化石,其化石名单已被插入到93001地点的剖面中(郑绍华等,2000)。为了进一步验证该层位的准确位置,弥补93001地点中、下部层位含化石稀少的缺陷,更为了将文王沟剖面和附近小石沟72074(4)地点剖面进行精确的对比,作者等于1999年6～7月又前往该地点逐层筛洗含小哺乳动物化石的砂样。通过室内选样分析,获得了至少35种小哺乳动物化石。

采集方法仍是先开挖出新鲜剖面,然后按旋回地层学方法将同一旋回地层划分为一层,每层再根据岩性变化分为不同的小层,最后逐层挖取岩样(平均每小层取土样约500kg)进行筛洗。共获砂样约400kg。

该地点距93001地点的直线距离约300m,处于93001地点文王沟的下游,其准确位置见郑绍华等(2000,图1)。

由于该剖面未作古地磁年代测定,本文只着重从生物地层学方面进行探讨。

文中剖面分层号为CL,意为本地区的第三个实测剖面。

1 地层划分与剖面描述

文王沟93002地点剖面顶部被坡积黄土覆盖,开挖出的剖面总厚度15.62m,从上往下为:

CL1.上部(CL1-1)为灰绿色泥岩,含大量有机质;下部(CL1-2)为砂砾石层,砂砾石成

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分以钙质结核为主，砾径均一，小于 1cm，泥质胶结　0.65m

CL2. 上部(CL2-1)为灰绿色泥岩，含大量有机质；下部(CL2-2)棕黄色含砾砂质泥岩及砂砾石层，砂砾石成分为钙质结核，砾径均一，小于1cm，泥质胶结　0.73m

CL3. 上部(CL3-1)棕黄色粉砂岩；下部(CL3-2)砂砾石，砾石层厚 90cm，砾石成分仍以钙质结核为主，但含有少量的花岗岩、变质岩成分，分选中等，胶结较坚硬，地形上形成陡坎　1.45m

CL4. 从上至下被分为 5 小层，即棕黄色粉砂质泥岩(CL4-1)；棕黄色泥岩夹少量灰绿色泥岩(CL4-2)；砂岩透镜体(CL4-3)；粗砂层(CL4-4)及下部砾石层(CL4-5)。砾石层厚 50cm，仍以钙质结核为主，含有少量大型花岗岩砾石(砾径大于 5cm)　3.5m

CL5. 上部 (CL5-1)为棕黄色粉砂质泥岩、泥岩；下部(CL5-2)砂石层，厚40cm，以钙质结核为主，含少量花岗岩砾石　1.1m

CL6. 砂砾岩，砂砾石成分以花岗岩、变质岩为主，分选差，砾径从大砾石(> 5cm)到 0.5cm 左右小砾石及桔黄色粗砂混杂，胶结程度不一致，磨圆度好，地形上成陡坎，未取样　0.84m

CL7. 上部(CL7-1)棕黄色粉砂岩，不含化石；中部(CL7-2)为棕褐色泥岩、粉砂质泥岩；底部(CL7-3)为厚约 5cm 的砾石层，主要为泥灰岩角砾及钙质结核，分选与磨圆度差，松散　4.45m

CL8. 灰褐色泥岩、棕黄色粉砂质泥岩，底部为约 10cm 厚的砂岩　1.8m

CL9. 上部棕黄色粉砂质泥岩，下部为砂砾石，砂砾成分以钙质结核与泥灰岩角砾为主，少量为花岗岩砾石，分选与磨圆度差，松散胶结　1.1m

白垩系泥灰岩

2　生物地层分带及其时代对比

93002 地点剖面迄今所发现的小哺乳动物化石计有 35 种，其在地层中的分布见图 1。郑绍华等(2000)曾将 93002 地点含化石层位对应到文王沟剖面砾石层(WL16)之下的 WL17。经过对此地点剖面的详细划分与对比研究后，发现原 93002 地点的化石层位应相当于本剖面的 CL5-2层，位于砾石层(CL6)之上，对应于文王沟剖面的 WL15 下部，而不应与 WL17 对比。

根据岩石地层学和哺乳动物化石组合及其进化阶段，可将 93002 地点剖面从下至上划分为 4 个生物地层带。

Ⅰ带：地层层位从 CL9～CL7，相当于 93001 地点剖面的Ⅰ带。该带共有小哺乳动物化石 14 种，其中鼠科 5 种(占 36%)，仓鼠科 3 种(占 21%)，沙鼠科、睡鼠科、松鼠科、鼠兔科、鼩鼱及蝙蝠类各 1 种(分别占 7%)。在该组合中鼠科化石占有显著优势。

该带的动物组合中与 93001 地点下部层位或Ⅰ带共有的种类有：*Huaxiamys* n. sp, *Karnimata hipparionum*, *Occitanomys* n. sp., *Kowalskia*(2 种), *Pseudomeriones abbreviatus*, *Ochotona lagrelii*, Gliridae gen. et sp. indet. 等 9 种，占本带全部种类的 64%；两地点的Ⅰ带均覆盖于白垩系泥岩地层之上和砂砾石层之下，因此，两地点的Ⅰ带

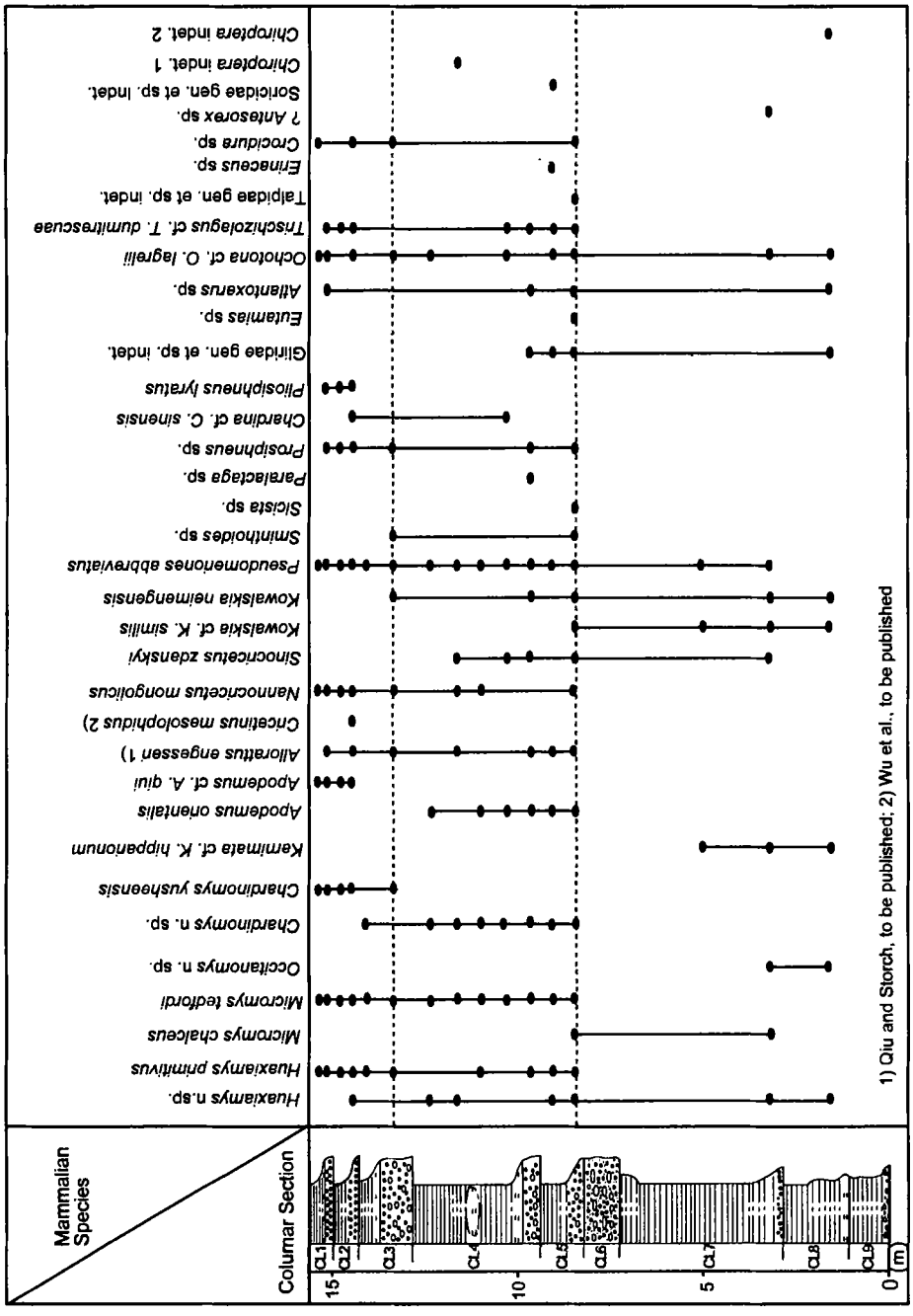

图1 93002地点剖面小哺乳动物化石在地层中的分布

Fig.1 Distribution of the micromammals in the section of Loc. 93002

应是同时的。其差异是93001地点地层厚度(大于8.4m)较大，而93002地点(7.35m)较小，其原因可能是后者更接近于古湖泊的边缘地带。

Ⅰ带中的 *Occitanomys* n. sp. 比内蒙古二登图的 *O. pusillus* (Schaub, 1934)原始，表现为齿尖脊形化程度较低。以M1为例(标本数包括93002地点6件，93001地点12件)，其差别如表1所列。

表1　*Occitanomys* n. sp. 和 *O. pusillus* M1形态特征比较

Table 1　Morphology comparison of M1 between *Occitanomys* n. sp. and *O. pusillus*

	Occitanomys n. sp.	*Occitanomys pusillus*
specimen number	18	190
tlbis(%)	83%	12.6%
relative position of t3 to t2	slightly backwards	far backwards
t3–t5 connection or posterior spur of t3 (%)	61%	93.6%
t4–t8 connection (%)	28.5%	90%
t6–t9 connection(%)	50%	100%

O. pusillus 具有原始性状(如：M1 tlbis缺失，t12清楚，m1 cp清楚)和进步性状(如：高度的皇冠形齿，M1相对很宽)的混合特征，且其皇冠形程度比欧洲早Turolian期的 *O. sondaari* 进步(Storch, 1987)。而文王沟Ⅰ带的 *Occitanomys* n. sp.在M1牙齿形态上更接近于 *O. sondaari*，但后者M1 tlbis存在比例(72%，41件标本)及t3–t5连接比例(0，41件)较小等显得更为原始，而t6–t9连接的比例(74%)则较大(Van de Weerd, 1976)。西班牙中Turolian期的 *O. adroveri* M1 tlbis存在比例(89%～100%)、t6–t9连接比例(98.5%～100%)以及t4–t5连接比例(75%～97%)等方面均比 *Occitanomys* n. sp.显得进步，但t3–t5连接比例(0%～11%)则显得较为原始。因此，仅就 *Occitanomys* n. sp.而言，文王沟Ⅰ带的时代大致可与欧洲中Turolian期相比较。

Ⅰ带的 *Karnimata* cf. *K. hipparionum* 的个体平均虽比二登图标本稍大(二者的M1平均长/宽分别为2.09/1.43和1.99/1.32mm)，但主要形态特征却显得一致。其稍原始的形状表现为：M1齿根数均为3个，而不是3+1；M1 t3后刺存在的比例(15%)较后者(2/3)小；M1 t12发育的比例(67%)较后者(60%)稍大；M2齿根数为4的比例(67%)较后者(89%)为小。

Ⅰ带的 *Karnimata* cf. *K. hipparionum* 更接近西瓦里克早Turolian期的 *K. darwini*，表现在M1 t1后刺不发育(后者仅8%)，t3后刺存在的比例小(后者为19%)。但显然较后者进步，表现在M1平均宽/长比值(0.68)较后者(0.64)大，t12发育的比例(67%)较后者(100%)为小。

产于巴基斯坦Dhok Pathan层(相当于欧洲Ruscinian或Ruscinian/Turolian)的 *K. huxleyi* 与 *K.darwini* 的差别表现在其m3与m2的平均长度之比(95%对83%)、M3与M2的平均长度之比(87%对69%)、M2具4个齿根的比例较高(100%对61.5%)以及m3的齿根数(3对2)等(Jacobs, 1978)。此外，前者M1更圆(M1平均宽/长比为71%对64%)，M1的t12不发育，m3唇侧下前边尖完全退化等。

文王沟Ⅰ带的 *Karnimata* cf. *K. hipparionum* M3与M2平均长度之比(79%)、M2的

齿根数为4的比例(67%)、m3齿根数为3的比例(25%)等方面介于 *K. huxleyi* 与 *K.darwini* 之间，而m3与m2平均长度之比(81%)及m3唇侧下前边尖发育等特征更接近于前者。因此，从 *Karnimata* 判断，文王沟Ⅰ带的时代似也应相当于中 Turolian 期。

由于将93002地点含化石层位对应于文王沟93001地点剖面的WL17层，并将两层位中的化石综合在一起，使得93001地点的Ⅰ带化石组合显得年轻，以致于将其与榆社马会组及高庄组桃阳段动物化石组合以及内蒙二登图动物群相对比(郑绍华等，2000)。排除以上因素，加上上述两种鼠科化石的进化位置，Ⅰ带的时代就显得相对古老。我们倾向于将其置于华北保德期的中期，与欧洲的中 Turolian 期相当(Qiu et al., 1999)。这样93001地点砂砾石层之下的古地磁年龄似应重新解释。

Ⅱ带：地层层位为CL6，相当于93001地点的WL16。岩性为厚度较大的砂砾石层。它代表了一个相当长的侵蚀期，可作为Ⅲ带的底砾岩。

Ⅲ带：地层层位从CL5～CL4，相当于93001地点的WL15。该带鼠科和仓鼠科动物占有优势。动物化石组合中，可与内蒙二登图动物群比较的有：*Micromys chalceus*, *Apodemus orientalis*, *Nannocricetus mongolicus*, *Sinocricetus zdanskyi*, *Kowalskia similis*, *K. neimengensis*, *Pseudomeriones abbreviatus*, *Sminthoides*, *Paralactaga*, *Sicista*, *Eutamias*, *Atlantoxerus*, *Ochotona lagrelii* 等，因而具有浓厚的二登图动物群的特色；和榆社高庄组桃阳段动物化石组合(Tedford et al., 1991; Flynn et al., 1991; Wu and Flynn, 1992)比较，共同种类有：*Huaxiamys primitivus*, *Micromys tedfordi*, *Pseudomeriones abbreviatus*, *Prosiphneus*, *Ochotona lagrelii* 等，因此也具有桃阳段动物组合的特色。

在CL5–2(相当于93001地点的WL15–3和WL15–4)，鼠科动物一个明显的特色是其臼齿开始出现脊形化趋势，例如 *Huaxiamys* n. sp.分化出 *H. primitivus*, *Occitanomys* n. sp.分化出 *Chardinomys* n. sp.等。

通过93002地点剖面，可以看出二登图动物群的时代基本与CL5层相当，如果和93001地点对比，其古地磁年龄大约距今5Ma左右，然而一般将其置于晚中新世(Qiu, 1988;邱占祥等，1990;童永生等，1995;Qiu et al., 1999)。

Ⅳ带：地层层位从CL3～CL1，相当于93001地点的WL14的下部层位，古地磁年龄约在4.7～4.6Ma间。在该带里，*Huaxiamys* n. sp., *Chardinomys* n. sp., *Allorattus engesseni*[1], *Kowalskia neimengensis*, *Sinocricetus zdanskyi*, *Chardina sinensis* 绝灭，而 *Chardinomys yusheensis* 和 *Pliosiphneus lyratus* 开始出现。这个时段的动物化石组合隐约地具有内蒙比例克动物群(Qiu and Storch, 待刊)的特色，例如都有 *Huaxiamys*, *Chardinomys "bilikeensis"*, *Allorattus engesseni*, *Trischizolagus* 等。就 *Chardinomys "bilikeensis"* 的M1具有3～4齿根判断，比例克动物群的层位应相当于CL3，因为这个层位既具有M1为3齿根的 *Chardinomys* n. sp.又具有M1为4齿根的 *C.yusheensis*。

1) Qiu Z D and Storch G, (in press). The early Pliocene Micromammalian Fauna of Bilike, Inner Mongolia, China (Mammalia: Lipotyphla, Rodentia, Lagomorpha)

3 鼠科动物的进化事件

93002 地点Ⅲ～Ⅳ带的小哺乳动物化石虽然种类和数量均相对丰富(见图 1)，对 93001 地点种类相对贫乏的 WL15-14层位是一个补充，但由于剖面较短，还不足以使得文王沟剖面在生物地层方面完全连续起来，这将依靠小石沟剖面加以完善。

该剖面中最能显出生物进化意义的是鼠科化石，其中尤以 *Huaxiamys* n. sp.－*H. primitivus* 及 *Occitanomys* n. sp.－*Chardinomys* n. sp.－*C. yusheensis* 两条线路具有代表性。

3.1 *Huaxiamys* n. sp.向 *H.primitivus* 的转换

Huaxiamys n. sp.在许多方面具有 *Progonomys* 属的特征，如 M1 t1 和 t4 的位置较 t3 和 t6 相对靠后，t1 和 t2 有一高的脊相连，t4 和 t8 有一低的脊相连，缺失 t7，通常具有 t2bis 等，但不同的是 M1 的 3 个齿根之间多一小根，t6 和 t9 大多由一脊相连，t4 和 t5 之间界限不清楚，个体显著较小等。

Huaxiamys n. sp.和吴文裕等(1992)建立该属(属型种 *H. downsi*)时的属征有一定差距，如“M1 的 t2 前壁向前远伸，t3 很后位”在前者还很不明显或更原始，但其余特征均与属同。

H. primitivus 的 M1 材料(包括正型标本)仅 2 件，因此其特征的限定具有一定的局限性，文王沟的标本可作为补充。文王沟的 *Huaxiamys* n. sp.和 *H. primitivus* 特征比较见表 2。

表2　*Huaxiamys* n. sp.和*H. primitivus*的M1特征比较

Table2　Morphology comparison of M1 between *Huaxiamys* n. sp. and *H. primitivus*

	Huaxiamys n. sp.	*H. primitivus*
Similarity		
1　root number	3+1	3+1
2　t7	absent	absent
3　t6 and t9	connected	connected
4　valley between t1 and t2	wide	wide
5　t1bis	present	present
6　t1 and t2	connected	connected
Difference		
1　projecting of t2	slightly forwards	far forwards
2　angle of occlusal surface and anterior slope	33.8°	18.3°
3　t1 and t2	less elongated	elongated
4　t1-t2-t2bis	not connected	connected
5　t1bis	present	absent
6　t3 to t2	slightly backwards	far backwards
7　t12	developed	less developed
8　L(average)(mm)	1.56	1.74
W(average)(mm)	0.98	1.00
W/L (average)	0.63	0.58

表中所列相同点表明它们之间联系密切，可视为同属，不同点表明它们是不同的种且相互间有进化上的关系。*Huaxiamys* n. sp. 比 *H. primitivus* 具有较为原始的性状。在地层层序上，前者从 CL8～CL2-2，后者从 CL5-2～CL1-1，也证明其发生的先后顺序。在 CL5-2～CL2-2期间，两者互相重叠，表明新种的产生并没有立刻替代老种，老种与新种有一段时间共存期，两种间的转换并不是简单的线系进化关系(图 2)。*Huaxiamys primitivus* 的出现，一个最重要的标志是 t1-t2-t2bis的脊形化。从 93002 地点看来，这种脊形化的起始点在 CL5-2，对应于 93001 地点的 WL15 底部，古地磁年代约在 4.9Ma 左右。然而在榆社盆地 *Huaxiamys primitivus* 最早出现在马会组上部(吴文裕等，1992)，因此，推测两种之间的转换时间可能稍早。

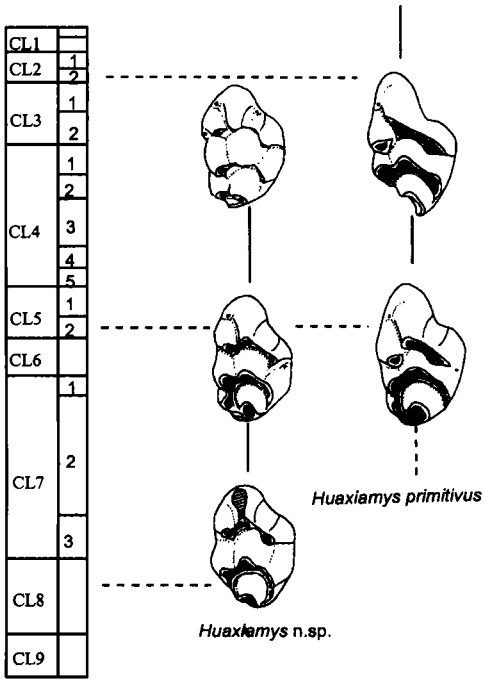

图2 *Huaxiamys* n. sp.和*H. primitivus*的进化关系

Fig.2 Evolution relationship of *Huaxiamys* n. sp and *H. primitivus*

3.2 *Occitanomys* n. sp.－*Chardinomys* n. sp.－*C. yusheensis* 的转换

如上所述，文王沟Ⅰ带(包括 93001 和 93002 地点)的 *Occitanomys* n. sp.具有比二登图的 *O. pusillus* 及欧洲的 *O. adroveri* 原始的特征。*Occitanomys* n. sp. 和 *Chardinomys* M1 的 t1 和 t4 均后位，t7 缺失，t1bis 均不同程度存在等，但在它们之间明显存在着进化上的关系，主要表现为一些形态组合的差异(表 3)。

表3 *Occitanomys* n. sp.、*Chardinomys* n. sp. 和 *C. yusheensis* 的M1特征比较

Table 3 Tooth morphology comparison of M1 among *Occitanomys* n. sp., *Chardinomys*. n. sp. and *C. yusheensis*

	Occitanomys n. sp.	*Chardinomys* n. sp.	*C. yusheensis*
1 specimen number	18	6	6
2 root number	3	3	4
3 t1bis (%)	83%	67%	100%
4 relative position of t1 to t3	far backwards	slightly backwards	slightly backwards
5 relative position of t3 to t2	slightly backwards	far backwards	far backwards
6 t1-t5 connection(%)	33%	67%	50%
7 t3-t5 connection(%)	0	100%	100%
8 t4-t5 connection(%)	39%	33%	100%
9 t6-t9 connection(%)	50%	67%	33%
10 t12(%)	89%	33%	17%
11 W/L ration (average)	0.68	0.68	0.64

从表中可以看出 M1 的一些进化趋势，如齿根数目增加，t1 相对 t3 的位置逐渐趋于同一水平，t3 相对于 t2 的位置逐渐后移，t1 和 t5、t3 和 t5 及 t4 和 t5 相连接的比例逐渐增大，t12 存在的比例逐渐减小等，总的趋势是齿尖从较为孤立逐渐向脊形化方向演进(图 3)。

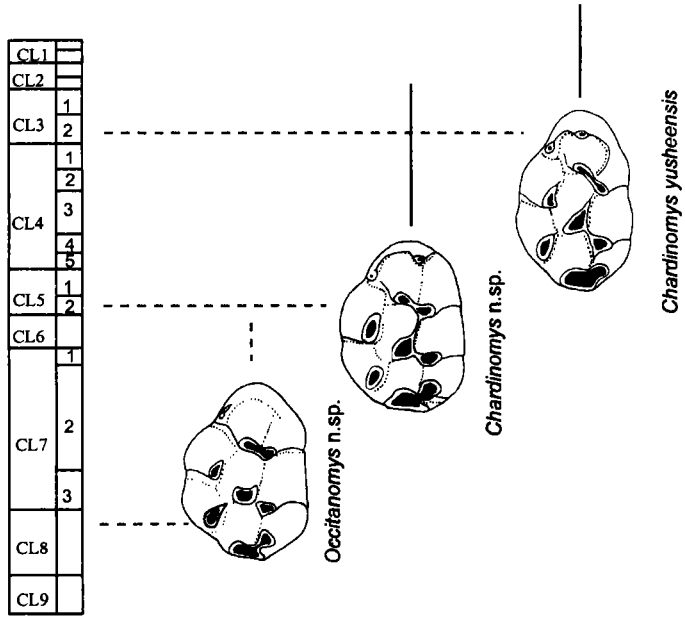

图3　*Occitanomys* n. sp.、*Chardinomys* n. sp.以及*C. yusheensis*的演化关系

Fig.3　Evolution relationships of *Occitanomys* n. sp., *Chardinomys* n. sp., and *C. yusheensis*

在 *Chardinomys* 属中，不同种的 M1 有不同的齿根数目，最原始的种 *Chardinomys* n. sp.具有与其祖先 *Occitanomys* n. sp.相同的数目(3 个)，静乐晚上新世的 *C. louisi* 具有 4～6 个齿根(周晓元，1988)，泥河湾早更新世的 *C. nihewanicus* 具有 6 个齿根(郑绍华，1981)，属型种 *C.yusheensis* 没有记述齿根数目(Jacobs and Li, 1982)，泥河湾晚上新世稍地组的材料(5 个齿根)又被归入到 *C. nihewanicus*(蔡保全等，1993)。从文王沟剖面看，原先的 *C. louisi* 是一个混合种，既包含了 *C. yusheensis*(4 个齿根)，也包含了 *C. nihewanicus*(6 个齿根)；93001 地点晚上新世层位产出的材料均为 5 个齿根，这和静乐组与稍地组的材料一致。因此，仅从 M1 齿根数看似乎有如下的进化趋势：早上新世的 *Chardinomys* n. sp.(3 个齿根)－中上新世的 *C. yusheensis*(4 个齿根)－晚上新世的 *C. louisi* (5 个齿根)－早更新世的 *C. nihewanicus*(6 个齿根)。在地层剖面上，种与种之间存在着不同程度的重叠，其进化模式与 *Huaxiamys* 相同。

4　初步结论

1) *Occitanomys* n. sp.和 *Karnimata* cf. *K. hipparionum* 的相对原始性表明，文王沟Ⅰ带的时代可能为保德期中期或相当于欧洲的中 Turolian 期。

2) 文王沟Ⅱ带的砂砾石层代表了一个相当长的侵蚀期，因此文王沟剖面可能缺失保

德期晚期或晚 Turolian 期的沉积。

3) 93002 地点 CL5–CL4的小哺乳动物化石组合具有明显的早上新世特点，在时代上可与二登图动物群比较，而 CL3–CL1则可与比例克动物群相对比。

4) 鼠科动物在93002地点的化石具有明显的优势，其中最具有进化意义的是 *Huaxiamys* n. sp.向 *H. primitivus* 的转换，*Occitanomys* n. sp.向 *Chardinomys* n. sp.的转换以及后者向 *C. yusheensis* 的转换。

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LATE MIOCENE-EARLY PLIOCENE BIOSTRATIGRAPHY OF LOC. 93002 SECTION, LINGTAI, GANSU

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Summary

The Loc. 93002 was found by the latter author in 1993, which yielded large amounts of small mammal fossils, however, only from one level. Zheng and Zhang (2000) primarily correlated it to the WL17 of Loc. 93001 section. For better understanding its precise stratigraphic position and correlation with the other sections, more detail geological and biostratigraphic work was carried out in 1999. The geographic position of this section was shown in Fig.1 of Zheng and Zhang (2000).

The basic fieldwork method is the same as that was adopted in the work on Loc. 93001 section (Zheng and Zhang, 2000).

Since no paleomagnetic data can be used, this paper mainly focused on the biostratigraphic classification and correlation, and also on the bioevents in the evolution of Muridae.

CL in this paper represents the stratigraphic level of this section.

1 Stratigraphic classification and correlation

The total thickness of the section is 15.62m, which was divided into 9 major levels and different layers in each level as shown in Fig.1.

In this section, the CL6(conglomerate level), can be lithologically correlated to the WL16 of Loc. 93001 section. The source materials are mainly composed of granite and metamorphic rocks with large sized pebbles and reflecting long distance high-energy transportation.

2 Biostratigraphic classification and comparison

From this section, large amounts of fossils belonging to 35 species were discovered by screen washing. The distribution of fossil taxa in the section was shown in Fig. 1.

According to the lithostratigraphic division and fossil contents, especially the phylogenetic position of some dominant elements, four biostratigraphic zones were recognized in this section.

Zone I: Represented by CL9–7. It can be correlated to the Zone I of Loc. 93001 section. There totally discovered 14 species of micromammals. Among them murids are the dominant elements (36%). With the Zone I of Loc. 93001 section, this zone shares 9 species that take about 64% of total species. The difference between them exists mainly on the thickness of the strata. Since the conglomerate level is relatively horizontal in this area, the reasonable explanation for the difference may be on the different topographic height of the base rocks, or on the different erosion extent.

Compared to the *Occitanomys pusillus* from Ertemte (Schaub, 1934), the *Occitanomys* n. sp. from this zone is characterized by its less lophodonty upper molars. The detail morphologic differences of M1 were listed in Table 1. Compared with the European *Occitanomys sondaari* of Early Turolian (Van de Weerd, 1976), the present new species has the M1 with higher percentage of having t1bis, t3–t5 connected, but lower percentage of t6–t9 connection. With the Middle Turolian *O. adroveri* of Spain, it has lower percentage of having t1bis, t6–t9 and t4–t5 connection, and higher percentage of t3–t5 connection. Evidently, the new species is not in the phylogenetic lineage of European species. However, by the evolution stage, the present species shows primarily that the Zone I can be correlated to Middle Turolian stage.

Though the average size of *Karnimata* cf. *K. hipparionum* is slightly larger, it has almost the same morphology with those from Ertemte (Storch, 1987), except the statistic data show its primitiveness. The root number of M1 is 3, not 3 + 1, the percentage of existing posterior spur of t3 is 15% rather than 2 / 3, the percentage of developed t12 is about 67% than 60%, and the percentage of M2 having 4 roots is 67% than 89% in the latter.

Compared with the Early Turolian *K. darwini* and *K. huxleyi* found from Dhok Pathan (Ruscinian or Ruscinian / Turolian boundary), the present species has some characters statistically in between them. The average length ratio of M3 / M2 is 79% (83% in *K. darwini* – 95% in *K. huxleyi*); the percentage of M2 with 4 roots is 67% (61.5% in *K. darwini* – 100% in *K. huxleyi*); m3 with 3 roots is 25%, while the average length ratio of m3 / m2 (81%) and the development of lingual anteroconid on m3 are more close to the *K. darwini*. So, from the evolutionary stage of this species, this zone can also be correlated to Middle Turolian.

Zheng and Zhang (2000) correlated the Loc. 93002 to the WL17 of Loc. 93001

section, and combined its fossil contents into the Zone I of the 93001 section, which was thought younger than it should be by comparing with the fauna of Ertemte and the assemblage of Mahui and Lower Gaozhuang Fm. After detail correlation, the original Loc. 93002 should be the same as the CL5 in the section. Exclusive of the old collections, the assemblages of both Zone I of Loc. 93001 and Zone I of Loc. 93002 sections should be of the same age, and can be correlated to Middle Turolian stage.

Zone II: Represented by CL6. As explained above, this level can be correlated to the WL16 of 93001 section, from which no fossil was discovered. Strictly this is not a biozone, but only represents a big gap between Zone I and Zone II.

Zone III: Represented by CL5–CL4, which can lithologically be correlated to the WL15 of Loc. 93001 section. The faunal assemblage of this zone shows high similarity with the Ertemte fauna by sharing *Micromys chalceus*, *Apodemus orientalis*, *Nannocricetus mongolicus*, *Sinocricetus zdanskyi*, *Kowalskia similis*, *K. neimengensis*, *Pseudomeriones abbreviatus*, *Sminthoides*, *Paralactaga*, *Sicista*, *Eutamias*, *Atlantoxerus*, and *Ochotona lagrelii*. It can also be compared with the assemblage of Taoyang member in Yushe basin by sharing *Huaxiamys primitivus*, *Micromys tedfordi*, *Pseudomeriones abbreviatus*, *Prosiphneus*, and *Ochotona lagrelii*. According to the paleomagnetic dating of WL15 of Loc. 93001 section, this level should be about 5Ma in age, of early Pliocene, while the Ertemte fauna was generally thought as Latest Miocene (Qiu, 1988; Qiu and Qiu, 1990; Tong et al., 1995; Qiu et al., 1999).

Zone IV: Represented by CL3-CL1, which can be correlated lithologically to the lower part of WL14 of Loc. 93001 section. In this zone, the *Huaxiamys* n. sp., *Chardinomys* n. sp., *Allorattus engesseni*[1)], *Kowalskia neimengensis*, *Sinocricetus zdanskyi*, and *Chardina sinensis* died out gradually, while *Chardinomys yusheensis* and *Pliosiphneus lyratus* first occurred. To some extent, this assemblage has basic characteristics with the Bilike fauna (Qiu et al., to be published). Both the faunas have *Huaxiamys*, *Chardinomys "bilikeensis"*, *Allorattus engesseni*, and *Trischizolagus*. The *Chardinomys "bilikeensis"* from Bilike have 3～4 roots on M1, while from CL3, there produced both *Chardinomys* n. sp. with 3 roots on M1 and *C. yusheensis* with 4 roots on M1.

3 Bioevents in the evolution of Muridae

From this section, there are at least two phylogenetic lineages of Muridae that can be recognized: *Huaxiamys* n. sp. - *H. primitivus*, and *Occitanomys* n. sp. - *Chardinomys* n. sp. - *C. yusheensis*. At the same time of the turnover, the bioevents occurred which may suggest environmental changes.

1) Qiu Z D and Storch G, in press. The early Pliocene Micromammalian Fauna of Bilike, Inner Mongolia, China (Mammalia: Lipotyphla, Rodentia, Lagomorpha).

3.1 The evolution from *Huaxiamys* n. sp. to *H. primitivus*

The *Huaxiamys* n. sp. fits well with the diagnosis of this genus except some primitive characters: the t2 not projecting so forward and t3 not posterior shifted. The *H. primitivus* described by Wu and Flynn (1992) was represented by two M1s, which could not give enough character variations. The materials from Wenwanggou can be good complement. Detail descriptions of these two species will be given in later papers. The morphologic character comparison of the M1 between these two species was given is table 2 for discussion.

By the comparison as Table 2 shows, the two species have same characters as: root number on M1(3 + 1), lacking of t7, t6–t9 connected, t1bis present, wide valley between t1 and t2 etc. The differences between them show the primitiveness of the new species and their evolutionary relationships. One of the most important changes is the connection of t1–t2–t2bis in the latter species. The *Huaxiamys* n. sp. is first recorded from CL8, and *H. primitivus* from CL5–2. They are coexisted in the section from CL5–2 to CL2–2. The distribution of the species in the strata (Fig. 2) shows that the new species did not replace the ancestor species right after its occurrence, while they coexisted during a time period.

3.2 *Occitanomys* n. sp.-*Chardinomys* n. sp.-*C. yusheensis* lineage

As discussed above, the *Occitanomys* n. sp. could not be in the European *Occitanomys* lineage. However, it shows close relationships with *Chardinomys*, which is autochthonous in China. The comparison of the three species is shown in Table 3.

The concept of *Chardinomys* is becoming much clear by studying on the materials from Lingtai. There are different root numbers of M1 in different species. There are 3 roots on M1 of *Chardinomys* n. sp., the same as its ancestor species *Occitanomys* n. sp.; 4 roots in *C. yusheensis*; 5 roots in *C. louisi* which was thought with 4～6 roots (Zhou, 1988); and 6 roots in *C. nihewanicus*. The same as the *Huaxiamys* lineage, the distributions of these species in strata are also overlapped to different extent. The evolutionary process should be the same as the *Huaxiamys*.

4 Primary conclusion

1) The relative primitiveness of *Occitanomys* n. sp. and *Karnimata* cf. *K. hipparionum* suggested that the Zone I of Wenwangou can be correlated to the Middle Baodean or Middle Turolian of Europe.

2) The conglomerates of Zone II and great different fossil components between Zone I and Zone III show that the sections of Wenwanggou lack of sediments of Late Baodean stage by erosion.

3) The micromammalian assemblage of Zone III shows evidently of Early Pliocene, and can be correlated with the Ertemte fauna. Zone IV can be tentatively correlated to the Bilike fauna.

4) Murids are the dominant elements in the 93002 section. Among them two

important evolutionary lineages can be recognized.

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