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山西榆社狐化石一新种

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关键词 山西榆社 上新世 狐

内 容 提 要

本文记述了产自山西榆社上新世地层（麻则沟组下部）的狐化石一新种：*Vulpes beihaiensis*。新种与沙狐最为接近，但以颅部窄、单一的顶嵴较长、门、犬齿更细弱、前臼齿后棱上的附尖较发育、P^4 有较明显的前附尖的残迹等而区别于沙狐。这是欧亚大陆目前所知时代最早、构造最原始的一种狐。

山西东南部的榆社县是中国著名的"龙骨"产地之一。本世纪三十至四十年代德日进（P. Teilhard de Chardin）曾发表了一系列关于榆社哺乳动物化石的专著，证实了这里的化石不但丰富、保存完美，而且其时代从中新世末期一直延续至第四纪初。这使榆社在国外也颇负盛名。近廿多年来，随着科技的进步，国外在新生代晚期地层研究的精确度上有了很大的提高。拿这种水平来衡量，榆社的工作就相形见绌了。这是因为当时研究发表的化石多系收购、无可靠的层位纪录，后来又从未做过细致的地层工作。事实上，八十年代初古脊椎动物与古人类研究所的晚第三纪小组就已意识到了这一点，并逐步开始了对榆社盆地地层及化石的再调查。经过几年的工作，已经取得了一些进展（Qiu Zhanxiang, 1987 a, b）。大约与此同时，本文后一作者也对榆社的进一步工作产生了兴趣。这是因为他在受命负责清理弗里克（Ch. Frick）遗赠给美国自然历史博物馆的化石中发现了一批卅年代采自榆社而至今尚未研究的珍贵标本。共同的兴趣使本文的作者决心组织一次中美双方的合作。这一设想得到了中、美双方自然科学基金会的赞同和支持。经过1987和1988两年秋季进行的野外工作，现已大体完成了对该地区最有代表性的云簇盆地的剖面测制、化石及样品的采集和对现有化石的产地及层位的追索和核实等项工作。野外资料的室内整理、标本鉴定和样品测定等工作正在紧张进行中，成果已初见端倪。由于化石厘定的工作量很大，估计全部工作的完成和发表将需三至五年的时间。为了使这一工作中的某些新知能尽快为需者了解，我们将摘其要者先行报道。本文即其中之一。

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犬科 Canidae Gray, 1821

狐属 *Vulpes* Oken, 1816

白海狐(新种) *Vulpes beihaiensis* sp. nov.

正模 F:AM 97062，头骨，侧向受压变扁；顶骨、右听泡和两侧颧弓破失；左 C^1，P^1 和 P^3 在埋葬前即已脱落；头骨上较突出的部分，包括牙尖，都不同程度地受损(图版 I，1；图版 II，1)。

正模产地 据采集者甘传宝(译音)记录，系采自白海村。标本石化好，骨质部分为棕色，局部夹黑色条纹，牙齿黑色，保存在紫红色中粒长石石英砂岩中。据此判断，它可能产自麻则沟中(见讨论部分)。

副模 F:AM 97068，右下颌水平枝，缺门齿，P_4 稍破损，M_1 下前尖缺失。产自张凹沟(图版 I，2；图版 II，3，4)。

其它标本 1. F:AM 97065，一吻部缺失的残破头骨，保存左 P^4—M^2 和右 M^1，其中只有 P^4 保存较好。产地：白海。2. F:AM 97069，头骨中段，带左 P^4—M^2 和右 P^3—M^1。产地：白海。3. F:AM 97070，左下颌水平枝 M_2 以前的部分，I_1 和 I_2 没有保存。产地：赵庄(图版 I，3，4；图版 II，2)。4. F:AM 97071，下颌中段，仅保留 M_1。产地：赵庄。

上述标本全系弗里克标本，现收藏于美国自然历史博物馆。

地层及时代 麻则沟组下部，距今大约 3—3.3 百万年。

特征 头骨和下颌在大小和形态上都与沙狐最为接近；头基长小于 110 mm，鼻骨短，其后端在上颌骨在面部上最后端之前约 4 mm，头骨在鼻骨后的长度是鼻骨的 1.8 倍，脑颅顶缘后端急剧下降，枕嵴不怎么发育，前臼齿横向薄，M_1 下次尖和下内尖无连接横嵴。与沙狐的不同是：眶后收缩强，脑颅部窄，其最宽处小于 40 mm，额嵴不呈"竖琴状"弯曲，单一的顶嵴长，约 20 mm，门齿更细小，I^3 不特别变粗大，犬齿细长，前臼齿后秣上的附尖较发育，P^4 有较明显的前附尖残迹，M_1 的下内小尖和 M_2 的下内尖及下内小尖较明显，M_2 下原尖和下后尖等大、并列，前外齿带强。

标 本 描 述

面颊部因受压而变扁，使头骨前半部显得特别细。估计复原后自眶前孔至犬齿间的距离（25 mm）仍远比吻部在犬齿处的宽度要大。门齿区由于门齿很小而很窄，因此吻端应很尖细。前颌骨在犬齿之前有明显的容纳下犬齿的凹槽，这在接近齿槽缘表现得更清楚。这表明下犬齿的尖端是超过上颌齿槽缘的。前颌骨鼻突的后端破损，可能达 P^2 后端上方，但仍与额骨相距甚远。鼻骨相对较粗短。其前端最宽处稍大于 8 mm。其后端距上颌—额缝的最后端还有约 4 mm 的距离。自鼻骨后端至枕嵴的直线长度约为鼻骨长的 1.8 倍 (68.5:37.3)。眶前孔大，位于 P^4 前根之前。眼眶和眶间部都受压变形，但眼眶的高度不会大于眶间宽。额骨不向上隆起，因此自侧面看鼻额部几乎近一直线。眶后突的前外缘近一直线，斜向外后方，边缘呈嵴秣状，秣的内方则为凹陷区。眶后突的后外缘呈弧形，其末端变尖。眶后收缩较强。额嵴在眶后突之后不很清楚，近一直线，至额—顶

缝处左、右额嵴才交会并向后延伸为单一的顶嵴。因此额嵴间之三角形面较大，而顶嵴也较长，达 20 mm。脑颅部不特别加宽，最宽处位于外耳道上方。自侧面看，脑颅区的顶缘在脑颅最宽处之后急剧转向后下方。这和整个枕面相对位置较低也是一致的。腹面听泡仅左侧者保存。其内缘在后破裂孔之前的部分不是相互平行的，而是向前逐渐趋近。这表明左、右两听泡在前端相距较近，而后端相距较远。这种情况在犬科中很少见。外耳道相当高，这使其外开孔接近圆形。

门齿齿冠已全部破失。从保留的部分可看出，门齿特别细小，其前后径相对较短。I^3 只比 I^2 稍大。上犬齿特别细长。上前臼齿之间和 P^1 与 C 之间都有齿隙。牙齿都很侧扁。P^1 单根，前缘短、微凸，后缘长而微凹，主尖位于前半部。舌面凹，颊面凸，前棱在基部稍稍弯向舌侧。牙齿的前缘较薄锐，而不变圆隆。整个看来，与沙狐者相似，只是齿冠稍低些。P^2 主尖已破碎并错位。后缘在主尖之后有一附尖，在基部还有一更大的由齿带变成的尖。P^3 和 P^2 在大小和形态上都接近，但它的附尖更大，大于基部由齿带变成的尖，它的前端也更宽一些。P^4 最特殊的地方是有一分离出来的小前附尖。它的位置稍高于原尖。原尖不特别向前突出，不超过牙齿之前缘，它和前尖基部之间只有一很微弱的凹入。原尖和外脊间以一纵沟相隔。自原尖的顶端向外伸出一嵴，此嵴将原尖的颊侧面分成前小后大两部份，并与自前附尖舌面向下伸出的嵴在沟底相连(图版 II，1)。后尖内面的齿带很发育。M^1 横向较宽，内端较短，后缘凹入不明显，使其轮廓呈长三角形。后小尖锥状，与原尖以沟相隔。次尖，或内齿带，在高度上与原尖相同。有原小尖，但很微弱。外齿带发育完全，在前附尖处膨大。前齿带虽细小，但清楚，在原尖处消失。M^2 的后尖差不多

表 1　狐属几个小型种头骨和下颌的比较(毫米)

Comparison of the skulls and lower jaws of some small-sized *Vulpes* species (in mm)

	Vulpes beihaienris sp. nov.	*Vulpes chikushanensis* (after Young 1930)	*Vulpes praecorsac* (after Odinzow, 1965)	*Vulpes corsac* IVPP c/07; IZ 631
头全长 Max. skull L.	~117.0	104,115		108.7;110.2
头基长 Basilar L.	105.0	109.5×	109.0	93.0—112.0×××
鼻骨最大宽 Max. W. of nasals	~8.0	8.7×		7.3;6.4
鼻骨长 L. of nasals	37.3	~35.5×		36.8;39.2
I^3 后前颌骨宽 W. behind I^3	11.2			12.2;12.0
C 处宽 W. at C	~15.0	~18.5×		18.8;18.2
P^2—P^3 处宽 W. at P^2—P^3	>16.5	~19.3×		19.4;17.8
眶间宽 Interorbital W.	~19.0	~25×		21.1;21.9
眶后宽 Postorbital W.	~20.0	22,28		25.9;23.2
颅最大宽 Max. W. of braincase	34.9	46,50		42.4;41.4
颅长 Postorb. constr. —cranion	51.5	~50×		44.0;48.2
腭长 L. of palate	58.3			54.4;55.5
听泡间宽 Min. dist. between bullae		9		8.4;8.3
下颌全长 Max. L. of lower jaw		81—102(3)		74.6—90.0×××
C—p_3 处高 H. at C—P_3	8.0,7.8	6.8××	8.4—8.9	5.3－8.5×××
M_1 处高 H. at M_1	10.9—11.3(3)	10.8—12.4(3)××	12.6—12.7	9.7—13.2×××

× 根据图版测得；　×× 根据标本测量；　××× 根据 Odinzow, 1965。

表 2 狐类上、下牙齿之比较(毫米)

Comparison of the *Vulpes* upper and lower teeth (in mm)

	Vulpes beihaiensis sp. nov. Type	*Vulpes chikushanensis* (after Young, 1930)	*Vulpes praecorsac*		*Vulpes alopecoides* (after Kormos, 1932)	*Vulpes corsac* (after Odinzow, 1965)
			Hungary (after Kormos, 1932)	Odessa (after Odinzow, 1965)		
I^1—M^2	62.0					60.2;61.0×
C—M^2	52.6			58.5		45.4—59.4
p^1—M^2	42.7					43.0;45.1×
p^4—M^2	22.4			22.0		18.8—22.4
M^1—M^2	12.4			11.5—12.4		9.5—12.5
I^1*	1.2×1.4					1.5×2.4;1.7×2.3×
I^2	1.4×1.8					1.7×2.7;1.9×3.2×
I^3	1.9×2.5					2.8×3.5;2.9×4.1×
C	4.0×1.9	5.0×—	5.2—5.3×3.1—3.4			5.2×3.5;5.5×3.0×
p^1	3.3×1.6					3.6×2.3;4.0×2.4×
p^2	6.0×1.9	7.0×3.0		6.9—7.0×2.3—2.4		5.1—8.4×2.0—3.0
p^3	6.3×2.2	7.5×3.0		8.0—8.1×2.8—2.9		6.0—8.2×2.1—3.7
p^4	$\frac{10.7}{11.7}$×5.5	12.0×5.0	11.6—12.6×5.2—5.8	$\frac{11.5}{12.5—12.6}$×6.2	13.3×5.7	$\frac{9.8—11.6}{10.4—12.9}$×4.1—6.5

M^1	7.0×10.0	8.0×9.0—10.0	8.2×9.8	7.6×10.3	7.6×10.3	5.6—7.7×9.0—12.0
M^2	4.1×6.5	4.5×7.0		4.3×7.1	5.0×8.5	3.2—4.7×5.4—7.4
	F:AM 97068 etc.				(after Villalta, 1952)	
$C-M_3$	55.5	59.6[1]				58.0;57.0×
P_1-M_3	47.4					48.9;47.3×
P_3-P_4	27.4;27.3					28.0;27.0×
M_1-M_3	20.4	20.9,21.6[1]				21.7;20.9×
I_3	2.6×2.4					2.9×2.4;3.1×2.6×
C	4.2×3.6;4.7×3.4	5.0×—	5.2—5.9×3.1—3.3			5.6×3.7;5.4×3.6×
P_1	3.3×1.6;3.0×1.6		3.2—3.3×—	3.7—3.9×1.9—2.1		2.5—4.8×1.7—2.8
P_2	6.8×2.2;6.1×2.2	6.7—7.0×2.4—2.5	6.1—6.8×2.5	7.0—7.6×2.4—2.6	6.9×2.4	5.6—7.2×2.1—3.0
P_3	7.2×2.5;7.1×2.5	7.5—8.0×2.4—2.5	6.8—7.7×2.4—2.7	7.9—8.4×2.8—3.0	8.0×2.5	6.3—8.1×2.2—3.2
P_4	8.3×2.9;7.8×3.2	7.5—8.2×3.0—3.3	7.5—7.9×2.9—3.2	8.5×3.0—3.6	8.1×3.2	6.9—8.6×2.6—4.0
M_1	11.8—12.3×4.3—4.8(3)	13.0—13.5×4.2	12.0—12.5×4.7—5.0	12.3—13.4×4.9—5.0	13.6×5.5	11.0—13.1×3.7—5.0
M_2	4.9×4.0	6.0—6.2×4.0—4.1	6.2—6.6×4.9—5.1	6.0—6.6×4.7—4.8	7.2×5.5	4.6—6.2×3.4—4.5
M_3	2.6×2.4	2.5×2.5	3.0×—	2.6—2.9×1.7—2.0	3.8×3.5	1.5—3.1×1.6—2.7

★ 门齿测量为根部之宽×长，但 I_3 为齿冠宽×齿根处之长；
1) 根据标本测量所得；
× 根据 IVPPc/07 和 1Z631 测量。

与前尖等大，后小尖变小，原小尖很难分辨出来，但次尖，或内齿带，仍很宽大。外齿带仍发育，但在前附尖处不膨大，前齿带微弱。在 F:AM97065 标本上 P^4 的前附尖不那么明显地自前尖前缘分离出来，但隆起仍清楚可辨，而且在它之后在颊、舌两侧都有一条窄沟将其和前尖分开。

下颌都很细瘦，没有次角突。在 F:AM97068 上颏孔位于 P_1 与 P_2 之间和 P_3 与 P_4 之间；在 F:AM97070 上颏孔则位于 P_1 和 P_3 的前根之下方。下颌联合的后缘均在 P_2 后端的下方。门齿中唯一保存的一枚是 I_3。它虽然很小，但外侧的附尖已清楚地分离出来。下犬齿和上犬齿一样，也很细长，有前内棱和后棱，后者也稍稍偏向舌侧。在舌侧面基部两棱之间有齿带。牙齿基部的后端隆起使牙齿的弯曲更显著。牙齿的舌侧面平，而颊侧面隆凸。P_1 和 P^1 相似，只是稍小一点。P_{2-3} 和 P^{2-3} 也相近似。但它们的后棱更偏向颊侧，使牙齿自冠面看不完全对称。它们的附尖较小，而基部由齿带扩展成的附尖则较宽大，自冠面看似一棚架将牙齿自后方包围。P_4 的附尖最为发育。M_1 的下前尖较低，其顶缘近于水平；下原尖则很高大；下后尖比例上比沙狐者稍小。跟座相对较长，下内尖总是低于和小于下次尖，并稍稍后于下次尖。两者间无横嵴相连。下次尖以一嵴与下原尖后壁相接，下次小尖分离不明显，下内小尖在 F:AM97070 上为一纵嵴，将跟座自舌面封闭；但在 F:AM97068 上则发育很弱，跟座向舌侧开放。M_2 为不规则梯形，前宽后窄。三角座很高，下原尖和下后尖等高、等大且并列。自下原尖顶端向前内方伸出一嵴，至前缘中部即已达齿冠基部并消失。下次尖远小于前面的两个尖。下内尖更小，并有一弱嵴形之下内小尖将跟座自舌面封闭。前外齿带很膨大。M_3 很小，由两尖组成：较大的下原尖和小些的下后尖。前、后齿带清楚。它们与下后尖的顶端直接相连，但向外侧延伸至下原尖外壁之基部。

比 较 与 讨 论

上面的描述已清楚地表明，榆社的这些标本应属犬科中的狐类。这里所说的狐类并不是一个正式的分类单元，它究竟包括那些属也并没有一个明确的界限。通常含义的狐实际上只包括两个属：*Vulpes* 和 *Alopex*。有人也把沙狐单立一属，*Cynalopex*，但目前大多数人仍把它放在 *Vulpes* 中。广义的狐类也还包括非洲及美洲的一些形态上相当特化的一些属，如 *Fennecus*，*Urocyon* 等。榆社标本显然应属通常含义的狐类。它们的尺寸都偏小，吻部尖细而长，眶前孔至犬齿间的距离大于吻端在犬齿处的宽度，眶后突顶面明显凹陷，下颌细弱，无次角突，门齿小，犬齿细长，咬合时下犬齿尖端超过上颌齿槽缘，颊齿薄锐，上裂齿与两臼齿长度相近，上臼齿外齿带发育，具后小尖，下裂齿具下内尖，有 M_3 等。所有这些都是通常含义的狐类所特有的性状而区别于犬科其它各属。

Alopex 和 *Vulpes* 在头骨和牙齿上的区别远不如它们在外形上的区别明显。动物学家和古生物学家曾经提出过两者在头骨和牙齿上的许多差别，例如 T. Kormos 就曾提出过多达 23 项区别，但这些区别特征大多都很细微，而且不很稳定。根据我们的观察，以下几点是比较可信的：1. Alopex 的吻部相对较短宽。它的眶前窝至犬齿间的距离与吻端在犬齿处的宽度大致相等（Kormos, 1932, Hobukob, 1956）；2. 它的门齿和犬齿

的粗壮程度介于 *Vulpes* 和 *Canis* 之间，亦即比狐的粗壮（Miller, 1912, p. 326, fig. 65）；3. 头骨顶缘在鼻额部之间弯曲较明显（Mivart, 1890）；4. 眶后突较粗壮而短，顶面平或仅微凹（Miller, 1912, Stehlin, 1933）。榆社的标本在上述几点上都和 *Alopex* 相反，显然应属 *Vulpes*。

Vulpes 这个属的组成很庞杂，包括了几十个种和亚种。我们在与 *Vulpes* 内各种作了对比后发现，榆社的标本和沙狐（*Vulpes corsac*）最为接近，其次是与赤狐（*Vulpes vulpes*），但同时又有一些自己的特征。赤狐和沙狐的区别可以归纳为以下几项：1. 赤狐个体大，以头基长为例，赤狐大多为 120—150 mm，文献中最小者为 115 mm；沙狐者总是小于此，一般在 90—110 mm 之间；文献中最大者为 113 mm。榆社标本完全落在沙狐的变异范围之内。2. 赤狐的鼻骨长，自鼻骨后端至枕顶间之长为鼻骨本身长的 1.2—1.5 倍；而在沙狐中为 1.6—1.8 倍（Ноьиков, 1956）。榆社标本中为 1.8 倍，亦即与沙狐者一致。3. 沙狐的脑颅顶缘的后端，自侧面看急剧地斜向后下方，而赤狐者倾斜很微弱。榆社标本在这一点上与沙狐者一致。4. 沙狐的矢状嵴发育弱，额一顶嵴互相分开，呈"竖琴状"弯曲，中间所夹之平面很大，顶嵴仅在最后端愈合为单嵴；赤狐之矢状嵴很发育，额嵴在眶后突之后急剧趋近，中间所夹之三角面很小，顶嵴愈合为单嵴，很长。榆社标本在这方面介于两者中间；一方面两额嵴之间所夹之面较宽长，另一方面额嵴不呈"竖琴状"弯曲，而愈合之顶嵴又较长。5. 沙狐的脑颅区相对较宽短，其最大宽只稍小于从眶后突至枕顶的长度，而且眶后收缩也弱，这使脑区显得很粗大。赤狐的脑颅长，其宽远小于自眶后突至枕顶的长，眶后收缩也厉害。榆社标本的脑颅在比例上与赤狐者更接近。6. 沙狐的眼眶大，根据 Ноьиков 的记载，它的高等于或大于眶间宽；在赤狐中，后者大于前者。榆社的标本，虽然在此处受挤压无法准确测量，但眶高显然小于眶间宽。7. 沙狐的前臼齿，都横向较薄。榆社标本也是如此。8. 沙狐的 M_1 的下次尖和下内尖为锥状，它们之间没有横嵴相连；在赤狐中经常有横嵴。榆社标本中也没有发现横嵴，因此与沙狐接近。榆社标本与沙狐和赤狐都不同的是：1. 它的门齿和犬齿比例上更细小。2. 前臼齿后棱上的附尖都较发育。3. p^4 有残存的前附尖。4. M_2 的下原尖和下后尖等高、等大而并列，前外齿带很发育。5. 听泡在前方互相趋近。以上的比较使我们不能把榆社标本归入任何已知现生种中，虽然它和沙狐较为接近。

在欧亚大陆发现的 *Vulpes* 属的化石中，材料较多的有 *V. alopecoides*, *V. praecorsac* 和 *V. chikushanensis* 这三个种。*V. alopecoides* 的上牙只在意大利的 Val d'Arno 和法国的 St. Vallier 发现过。它们比榆社者稍大，特别是 p^4。它的 p^4 没有残存的前附尖，它的 M^1 的后小尖更近嵴形，也不怎么和原尖分离。这个种的下颌只在西班牙的 Villaroya 发现过。尺寸也比榆社者大，其 M_2 更近长方形，而不是梯形。*Vulpes praecorsac* 发现于匈牙利的 Csarnota, Kalkberg, Püspökfürdö 和 Nagyharsanyberg 以及苏联奥德萨的蓬蒂灰岩的洞穴堆积中。匈牙利的材料都很破碎，苏联的材料中还有头骨的腹部，但对比还只能局限在牙齿上。从测量表中可以看出，这个种仍比榆社者稍大。Csarnota 的标本在大小上倒是和榆社者差不多，但可惜材料太少，很难详细对比。不过它的犬齿和 M_2 仍比榆社者大。根据 Kormos 的记述，这个种的 p_4 的齿根在舌侧有一沟将它分成前、后两部分；M_1 的下内小尖在两个标本上完全缺失，而在第三个标本上也很微弱，这表

明下内小尖基本上缺失;臼齿较少退化。这些特征在榆社标本上没有。*Vulpes chikushanensis* 是杨钟健于 1930 年根据周口店第六地点的材料建立的。建种的依据是"竖琴状"弯曲的额一顶嵴,宽大的脑颅部,尖利而小的牙齿及细瘦的下颌。实际上这些都是沙狐的特征。我们把杨钟健的材料和现生沙狐标本对比之后发现它们在主要特征上完全一致。可以看出来的区别都很细微,例如周口店的标本为颅部更宽一点,臼齿上的外齿带发育得更强一些以及 M_2 还有很小的下内尖等。我们觉得它顶多是沙狐的一个亚种,而不应是一个独立的种。造成这种错误的原因是在 1930 年杨钟健建立这个种时,人们对沙狐的头骨及牙齿的特征还不怎么了解。当时可参考的文献主要是 Mivart 1890 年发表的犬科专著中关于沙狐的记述。杨钟健显然误把一件赤狐的标本(其头全长为 140 mm)当做了沙狐的拿来与周口店的化石做比较,这才造成了他把本来属于沙狐的性状当做建立新种的依据的错误。顺便提一下,杨钟健把泥河湾的狐化石也归入了他的鸡骨山种。我们仔细地观察这些标本,觉得它们和周口店第六地点的材料并不完全一样。它们的前臼齿附尖更发育,上臼齿更方一些,M_2 更长,不为梯形而为长方形,M_3 也更长等等。至于它的确切归属需在对我国第四纪狐化石作全面修订后才能解决。

综上所述,榆社标本不同于任何已知的现生和化石种。我们将它订一新种:白海狐,*Vulpes beihaiensis*。新种与沙狐不同的特征中的绝大多数都可以很自然地看作是狐类进化过程中的近祖性状,例如门、犬齿的尺寸之小,脑颅部不特别加宽,具有残存的 p^4 的前附尖等等。如果我们承认新种处于比沙狐更原始的水平上,那么,"竖琴状"弯曲的额一顶嵴和前臼齿后棱上逐渐消失的附尖也应被看作是狐类进化中的近裔性状了。这多少有点令人感到意外,但也并不是不可能的。

上述所有标本都标明产于白海、赵庄和张凹沟三地。前两个地点是村名,并不是化石产地名。后一个地点是无人居住的冲沟,因此应是真实的含化石的地点。根据我们的查访,白海村的居民在解放前主要是在村北的麻则沟内采集化石。赵庄的居民则主要在张凹沟及其附近的一些冲沟,如杏树沟、也西沟等地采集化石,间或也到麻则沟采集。麻则沟内出露的地层,下部是高庄组醋柳沟段的顶部地层,主要由暗色粘土及黄色砂岩组成,所含化石或为白、黄色(砂岩中)或为棕色黑色(粘土中);上部则出露麻则沟组的底部,以紫红色砂岩为主。上述标本中标明采自白海和赵庄的标本都是产自紫红色砂岩中,骨化石为棕、黑色,牙齿为黑色,因此大概是出于麻则沟组底部地层中。张凹沟及其附近的冲沟则只出露麻则沟组的下部和中部地层。岩性和麻则沟组底部的相近,但更杂一些,包括有厚层的黄砂,其中的骨化石为黄褐色。但同时在紫红色砂岩中也含与底部保存状况相似的化石。这样,我们就可得出上述化石主要产于麻则沟组中下部的推断。根据 N. Opdyke 对该段地层古地磁样品的测定和解释,这一段地层大约是从处于吉伯特—高斯界限之上约 30—50 米处开始到高斯期内之猛犸事件之上为止,其时代可判定为大约距今 3—3.3 百万年(详见 Tedford 和邱占祥等,在印刷中)。

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A PLIOCENE SPECIES OF *VULPES* FROM YUSHE, SHANXI

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The Yushe County in Shanxi Province is one of the most famous "dragon bone" localities in China. Teilhard de Chardin's monographs on the fossil mammals from Yushe made it well known internationally as well. However, the work so far done there is far from completion, especially when compared with the recent achievements in stratigraphic work on late Cenozoic deposits in Western countries. This is partly due to the lack of reliable stratigraphic records for the purchased "dragon bones", and partly to lack of modern field work there. At the beginning of the 80s the Neogene group of the Institute of Vertebrate Paleontology became aware of this and started to re-investigate the Yushe Basin. Since then some progress has been made (Qiu Zhanxiang, 1987 a, b). At about the same time the second author of the present paper became interested in carrying out further work in Yushe Basin after he had found the valuable unstudied specimens from Yushe in the famous Frick Collection. The common interest made the authors of the present paper determined to try to organize a cooperation between American and Chinese colleagues. The idea has gained full support from the Foundations of Natural Sciences of both countries. After two fall seasons work in 1987 and 1988, the section measuring in Yuncu subbasin, the most representative subbasin of the Yushe Basin, was largely completed, while paleomagnetic sampling, fossil collecting, including wet-washing technique for micromammals, and inquiry of the local residents about the provenance of the fossils purchased by Licent's and Frick's men during the 30's were extensively carried out. Now the data processing and other lab work are in full swing. Since, as we estimate, it would take another 3 to 5 years to finally publish all of the work, we would like to publish some new findings in short papers in order to let them be known as early as possible. The present paper is one such contribution.

Canidae Gray, 1821

Vulpes Oken, 1816

Vulpes beihaiensis sp. nov.

Holotype F: AM 97062, skull, laterally compressed, parietals, zygomatic arches and the right tympanic bulla lacking; left upper canine, P^1 and P^3 had apparently dropped out before burial. Other parts of the skull, the tops of the tooth cusps included, are variously damaged.

Type locality Probably Mazegou (vide infra).

Paratype F: AM 97068, right ramus horizontalis, lacking incisors, with P_4 and M_1

partly damaged. Locality: Zhangwagou.

Referred specimens 1. F: AM 97065, a broken skull without muzzle, left P^4—M^2 and right M^1 are preserved, but only P^4 is more or less intact. Provenance: Beihai. 2. F: AM 97069, a *middle part of skull, with left* P^4—M^2 *and right* P^3—M^1. *Provenance: Beihai.* 3. F: AM 97070, left ramus horizontalis anterior to M_2, without I_{1-2}. Provenance: Zhaozhuang. 4. F: AM 97071, middle part of lower jaw, with only M_1. Provenance: Zhaozhuang.

All the above listed specimens are kept in the American Museum of Natural History.

Level and geological age The lower part of Mazegou Formation, approximately 3—3.3 Ma.

Diagnosis *Skull and lower jaw approximate those of Vulpes corsac: Skull basilar length* less than 110 mm; nasals short, posterior end situated 4 mm anterior to the posteriormost part of maxilla-frontal suture; skull length posterior to nasals 1.8 times length of nasal; viewed from side posterior half of brain case slopes down and backward sharply; occipital ridge weakly developed; premolars very slender; no transverse ridge linking the hypoconid with entoconid in M_1. Differ from *Vulpes corsac* in stronger postorbital constriction, narrower brain case, less 40 mm in width, "lyrated" frontal and parietal crests lacking, parietal crests unified as long as 20 mm, smaller size of incisors, including I^3, slenderer canines, stronger posterior accessory cusps on premolars, presence of parastyle rudiment in P^4, presence of entoconulids on M_{1-2}; M_2 with equal sized and connated protoconid and metaconid and well developed anteroexternal cingulum.

Description

The facial part of the skull is unusually narrow because of the strong postmortem lateral compression. However, the distance from the infraorbital foramen to the posterior border of the canine is certainly longer than the restored width of the muzzle at the canines. The anterior end of the muzzle is conspicuously narrow and pointed because of the small size of the incisors. A groove on the facial wall of the premaxilla anterior to the canine to accommodate the lower canine is present, which indicates that the lower canine surpasses the alveolar border of the upper teeth when the jaws are occluded. The nasals are comparatively robust and short, their widest part measures 8 mm. Their posterior end lies 4 mm short of the posteriormost part of the maxilla-frontal suture. The length from the posterior end of the nasals to the acrocranion is about 1.8 times the length of the nasals. The large infraorbital foramen lies anterior to the anterior root of the P^4. Though deformed, the height of the orbit should not be greater than the interorbital breadth when restored. The frontal area is flattened so that the upper profile of the anterior half of the skull is almost straight. The postorbital process is not very pointed, but its frontal surface is strongly excavated, which makes the lateral rim conspicuously ridge-like. The postorbital constriction is rather strong. The frontal crest is weakly shown and almost straight. The two frontal crests converge and finally unite with each other at about the frontalparietal suture. The united parietal crest is about 20 mm long. The brain case is not particularly wide. The widest part lies at the level of the external meatus, and is less than 40 mm. The posterior part of the upper profile of the brain case turns sharply downward. In accordance with this, the occiput is quite low in position. Only the left tympanic bulla is preserved, its inner border anterior to the foramen lacerum posterius is not parallel to the sagittal line of the basicranium, but converges with it anteriorly. The

external meatus is rather large, almost rounded in form viewed laterally.

All the crowns of the incisors are broken. The preserved roots show that they are very small, not very long anteroposteriorly. I^3 is only a little larger than I^2. The upper canine is particularly slender but long. Diastemata exist between the premolars and between P^1 and the canine. All the upper premolars are thin laterally. The P^1 is single-rooted. Its anterior border is short and convex, while its posterior one is longer and concave. It is convex labially and concave lingually. The P^2 has an accessory cusp on its posterior ridge. P^3 is similar to P^2. What is remarkable for the P^4 is the appearance of the tiny, but clearly separated parastyle. On the specimen F: AM 97065 the parastyle of the P^4 is not as clearly separated from the paracone as in the type specimen, but it is still present. Its protocone does not extend beyond the anterior border of the tooth, which is only weakly concave. A clear cingulum is deveioped on the inner wall of the metacone-metastyle blade. The M^1 is triangular in form, with a small conical metaconule, well separated from the protocone. The protoconule is also present, but not very clearly shown. The hypocone, or the inner cingulum, is as high as the protocone, when viewed from the lingual side. The external cingulum is well developed, while the anterior cingulum is weak, interrupted only at the protocone. The metacone is about equal to the paracone in size in the M^2. However, its metaconule is tiny and its protoconule is hardly discernible. The hypocone remains very large.

All the lower jaws are very slender, without any indication of the subangular lobe. The mental foramina lie below P_{1-2} and P_{3-4} respectively on F: AM 97068, while below the P_4 and the anterior root of the P_3 on F: AM 97070. The symphysis ends at the level of the posterior border of the P_2. There is only one I_3 preserved among the lower incisors. A large lateral cusp is formed beside the main cusp in I_3. Like the upper canine, the lower canine is also slender, with two prominent crests: an antero-internal and a posterior one, which curves slightly internally. There is a lingual cingulum between the two above described crests. The P_1 is similar to the P^1, but smaller in size. the P_{2-3} are also similar to the P^{2-3}, with the only distinctions that their posterior ridges turn a little lingually and their basal cingula are a little larger. The accessory cusps of the P_4 are the best developed among the premolars. The paraconid of the M_1 is low, with its upper border stretching almost horizontally. The protoconid is robust. The talonid is comparatively long, with its entoconid always smaller than the hypoconid. These two cusps are both conical in form, without linking ridges between them. The hypoconulid is not very well differentiated. The entoconulid is well formed and ridge-shaped on F: AM 97070, blocking the talonid valley lingually, while that on F: AM 97068 is less developed, leaving the talonid almost open lingually. The M_2 is irregularly trapezoidal in shape. Its trigonid is very high, with equally high and connate protoconid and metaconid. A ridge extends from the top of the protoconid to the middle of the base of the anterior border. The hypoconid is much smaller than the trigonid cusps, while the entoconid is even smaller. The antero-external cingulum is well developed, making the tooth wide across the trigonid. The M_3 is composed of two cusps: the protoconid and metaconid. The anterior and the posterior cingula seem to originate from the top of the metaconid and extend to the base of the labial wall of the protoconid.

Comparison and discussion

Vulpes is a rather complex genus and contains dozens of species and subspecies. Our

comparisons led us to the conclusion that the Yushe specimens approximate *Vulpes corsac* the most, and the smaller individuals of *Vulpes vulpes* the next. *Vulpes vulpes* differs from *Vulpes corsac* in the following characters. 1. It is generally larger than *Vulpes corsac* in size. Its basilar length is usually around 120—150 mm, the smallest recorded in literature is 115 mm (Novikow, 1956). *Vulpes corsac* is certainly smaller, it varies within 90—110 mm, the largest seen in the literature is 113 mm. The basilar length of the Yushe specimen falls within the range of variation of *Vulpes corsac*. 2. *Vulpes vulpes* has longer nasal bones. Its skull length posterior to the nasals is only 1.2 to 1.5 times as long as the nasal bones. The same figure for *Vulpes corsac* is 1.6—1.8 (Novikow, 1956). The Yushe skull conforms with the latter species in this respect. 3. The posterior part of the upper profile of the brain case turns sharply downward in *Vulpes corsac*, while it is either almost flat or slightly curved in *Vulpes vulpes*. The Yushe skull has the same strongly curved brain case as in *Vulpes corsac*. 4. *Vulpes corsac* has typically "lyrated" frontal-parietal crests and a large flat surface exists between the paired crests, while in *Vulpes vulpes* the two crests unite quickly into a single sagittal crest. In this respect the Yushe skull is intermediate between the two extremes. 5. *Vulpes corsac* has a comparatively broad brain case. its breadth is only slightly smaller than the distance between the postorbital process and the acrocranion, while in *Vulpes vulpes* the latter is much longer than the brain case width. The Yushe skull has a comparatively narrow brain case, thus is similar to *Vulpes vulpes*. 6. *Vulpes corsac* has a large orbit. Its height is equal to or even larger than its interorbital breadth, while in *Vulpes vulpes* and the Yushe skull the contrary is the case. 7. The premolars are generally very thin in *Vulpes corsac*, as well as in the Yushe specimen, while in *Vulpes vulpes* they are thicker laterally and 8. There is no ridge connecting the hypoconid and entoconid on M_1 in *Vulpes corsac*. The same is true for the Yushe specimens, while in *Vulpes vulpes* such a transverse ridge usually exists. At the same time the Yushe specimen differs from both of the above discussed species. 1. Its incisors and canines are even smaller than those of *Vulpes corsac*. 2. The posterior accessary cusps are more developed in the Yushe specimen. 3. There is a clearly separated parastyle on P^4. 4. The protoconid and the metaconid in M_2 are about equal in size and connate in position and finally. 5. The tympanic bullae seem to converge strongly anteriorly. Therefore, we can not assign the Yushe specimen to any of the two living species, although it is apparently closer to *Vulpes corsac*.

Among the fossil *Vulpes* species only three species are more or less adequately represented. They are *Vulpes alopecoides*, *Vulpes precorsac* and *Vulpes chikushanensis*. The upper dentition of the first species has been found in Val d'Arno, Italy, and St. Vallier, France. They are larger than our Yushe specimens in size, especially the P^4, on which no parastyle is observable. The metaconule on the M^1 in this species is hardly separated from the protocone and more ridge-like than conical in form. The lower jaw of this species has only been found in Villaroya, Spain. It is large in size as well. Its M_2 is more rectangular than trapezoidal in shape. The second species, *Vulpes praecorsac*, has been found in a number of sites in Hungary and in cave and fissure fillings in Odessa, USSR. Again, it is larger than the Yushe material in size. According to Kormos, the root of the P_1 is grooved, and the entoconulid is absent on two of the three M_2. *Vulpes chikushanensis* was erected by C. C. Young in 1930 based on good material from Locality 6 of Zhoukoudian. The diagnostic features of that species were the "lyrated" frontal-parietal crests, the particularly broadened brain case, the small and sharp dentition and the slender lower jaw. As we can see from the above discussion, all these

characters are nothing but the distinguishing features of *Vulpes corsac*. The Zhoukoutian material may slightly differ from the living species by minor characters, such as a slightly widened brain case, somewhat better developed external cingula on the molars and the presence of a tiny entoconid on M_2 etc. However, it seems to us, these minor differences do not warrant Young's erection of a new species. In our opinion, it could be no more than a subspecies of *Vulpes corsac* at the most. Young's failure to recognize the *corsac* affinity of the Zhoukoudian material could, perhaps, be explained by the fact that *Vulpes corsac* was very poorly known at that time. In fact, no useful morphological description of skull and jaw was availabe prior to 1930, except for Mivart's monograph on the Canidae. Young also included the vulpine material from Nihewan in his new species. We would like to point out that the material from Nihewan is morphologically slightly different from that of Zhoukoutian. The posterior accessory cusps on the premolars are more developed, the upper molars and the M_1 are more rectangular in shape and the M_2 is more elongated etc. The final assignment of this material would be possible only after a thorough revision of all the Quaternary vulpines of China, which is beyond the scope of the present paper.

Since the Yushe specimens can neither be attributed to any of the living species of *Vulpes*, nor to any of the known fossil ones, we erect for them a new species, *Vulpes beihaiensis*. Morphologically it is closest to the living *Vulpes corsac*. It is interesting to note that most of the features by which the new species differs from *Vulpes corsac* is to be considered as plesiomorphic in vulpine evolution, such as the small size of the incisors and canines, the presence of a rudiment of parastyle on P^4 etc. The absence of a "lyrated" sagittal crest in the structurally more primitive *Vulpes beihaiensis* is rather unexpected. Usually the "lyrated" sagittal crest has been considered as a plesiomorphic feature, since it has been found in many otherwise quite primitive forms in the Canidae.

As indicated by the original labels, the above described specimens came from Beihai, Zhaozhuang and Zhangwagou. The first two are, in fact, village names, thus can not be real localities. They are only places where specimens were purchased. The last is an unpeopled valley, that is, it is the most likely to be a real fossil locality. From inquiry we know that the villagers of Beihai used to collect fossils in Mazegou valley, several km north to the village, before founding of the People's Republic, while those of Zhaozhuang collected mostly in Zhangwagou and its adjacent valleys, such as Xingshugou, Yexigou etc., but sometimes also in Mazegou. Therefore, all the specimens of *Vulpes beihaiensis* seem to have come either from Mazegou, or the Zhangwagou area. Stratigraphically Mazegou contains the top of the Gaozhuang Formation and the base of the overlying Mazegou Formation. The base of the Mazegou Formation is characterized by the frequent occurrence of hard violet fossil-bearing sandstones. The fossils from these sandstones are often grey, brown (bones) and black (teeth) in colour. The top of the Gaozhuang Formation is characterized by alternation of dark-coloured clay and yellow sands yielding fossils of different colour and state of preservation. If some of the above described fossils were really from the Mazegou valley, the most probable layers producing such fossils fall within the base of the Mazegou Formation. The deposits of the Zhangwagou and its adjacent valleys all belong to the lower and middle parts of the Mazegou Formation. The preservation and the colour of the fossils support this assumption. The preliminary results of the paleomagnetic sampling show that this part of section corresponds to the interval from a little higher than the Gilbert-Gauss boundary to the upper limit of the Mammoth Event in the Gauss Chron, that is, about 3—3.3 Ma.

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