

## A Case Study of the "erectus" - "sapiens" Transition in Asia: Hominid Remains from Hexian and Chaoxian Counties, Anhui Province, China

Dennis A. Etlar

*Newly discovered fossil hominids from the late middle Pleistocene of China demonstrate that archaic forms of Homo sapiens were either coexistent with or slightly more recent than advanced forms of Homo erectus. This is most clearly seen at sites in Hexian and Chaoxian counties, Anhui province, which date to between 150-200,000 YBP by uranium series tests. The replacement of H. erectus by archaic H. sapiens in China is characterized by the retention of a significant component of heritage features in archaic H. sapiens, overlaid by a mosaic of changes in craniofacial anatomy that trend towards modern humans. This new evidence gives powerful support to the regional continuity theory of human evolution in east Asia. Furthermore, it suggests that the transition from H. erectus to archaic H. sapiens in China was relatively quick and possibly modulated by a heightening of gene flow between western and eastern Asia at approximately 250,000 YBP.*

### INTRODUCTION

The accelerated pace of discovery of late middle Pleistocene - early late Pleistocene human fossil remains in China over the last two decades makes it possible to approach the question of the "erectus" - "sapiens" transition in east Asia from an entirely new empirical basis. Human skeletal remains from this period of time include advanced forms of *Homo erectus* from Zhoukoudian (Skull V) (Qiu *et al.* 1973) and Hexian (Huang *et al.* 1981, 1982; Wu and Dong 1982), and cranial material attributed to archaic *Homo sapiens* from Changyang (Jia 1957), Maba (Wu and Peng 1959), Xujiayao (Jia and Wei 1976; Jia *et al.* 1979; Wu 1980), Dali (Wu 1981), Yingkou (Lu 1985, 1989; Wu, R. 1988) and Chaoxian (Xu *et al.* 1984, 1986a, 1986b) (Figure 1).<sup>1</sup> Of particular note are the hominid remains from Longtandong, Hexian county and Yanshan, Chaoxian county, Anhui province which are taken to represent *H. erectus* and archaic *H. sapiens*, respectively. Not only are these two sites in close spatial proximity (Figure 2), they may also be close in age. The Hexian fauna (Tables 1 and 2) has been correlated with the upper layers at Zhoukoudian (ZKD) and oxygen isotope Stage 8 which would give an age of 240-280,000 years before present (YBP) (Xu and You 1984). The Chaoxian fauna (Table 2) is thought to be somewhat younger due to the absence of archaic species such as *Megantereon* and *Trogontherium* which are encountered at Hexian. Otherwise, the faunas both reflect a similar mixing of northern and southern elements.

Recent uranium series dating of the hominid bearing strata at both sites, however, raises the possibility that they are virtually synchronous and, moreover, somewhat younger than the up-

per layers at ZKD Locality 1 (Chen *et al.* 1987; Chen and Yuan 1988). The uranium series analyses, based on the internal concordance of  $^{230}\text{Th}/^{234}\text{U}$  and  $^{231}\text{Pa}/^{235}\text{U}$  activity ratios of bones and teeth associated with the human remains, date the Hexian site to between 150-190,000 YBP and the Chaoxian site to between 160-200,000 YBP. While uranium series dates are still subject to considerable controversy, the techniques employed to date the organic remains are identical at both sites, and the physical conditions encountered at Longtandong and Yanshan are similar. It is, therefore, reasonable to accept the dates as being broadly comparable. Nonetheless, given the vagaries of uranium series dating these ages should best be taken as minimum ages for both sites. The close spatial and possible temporal proximity of the Hexian and Chaoxian hominids coupled with their morphological differences (*vide infra*) raise obvious questions concerning their relatedness to one another. In addition, the suggested late age of occurrence of *H. erectus* at Hexian raises questions about the temporal span of *H. erectus* in east Asia, and the mode and tempo of its replacement by archaic *H. sapiens*. In order to more fully appreciate the implications of these new finds for an understanding of the course of human evolution in east Asia, this contribution will concentrate on describing and interpreting the human fossil remains from both Hexian and Chaoxian.

While I had the opportunity to view the Hexian calvaria during a recent visit to China, I have not seen the material from Chaoxian, nor have I had the chance to personally study the specimens in question. I have, however, availed myself of the Chinese descriptions of the specimens which are quite detailed in extent and which follow the format and terminology of Wei-

denreich's (1937, 1943) classic descriptions of the hominid remains from Zhoukoudian. Much of the analyses presented in the Chinese accounts has not been previously available in English. I hope that this presentation alleviates, to an extent, this circumstance, thereby facilitating discussion of these important hominid remains by a western audience.

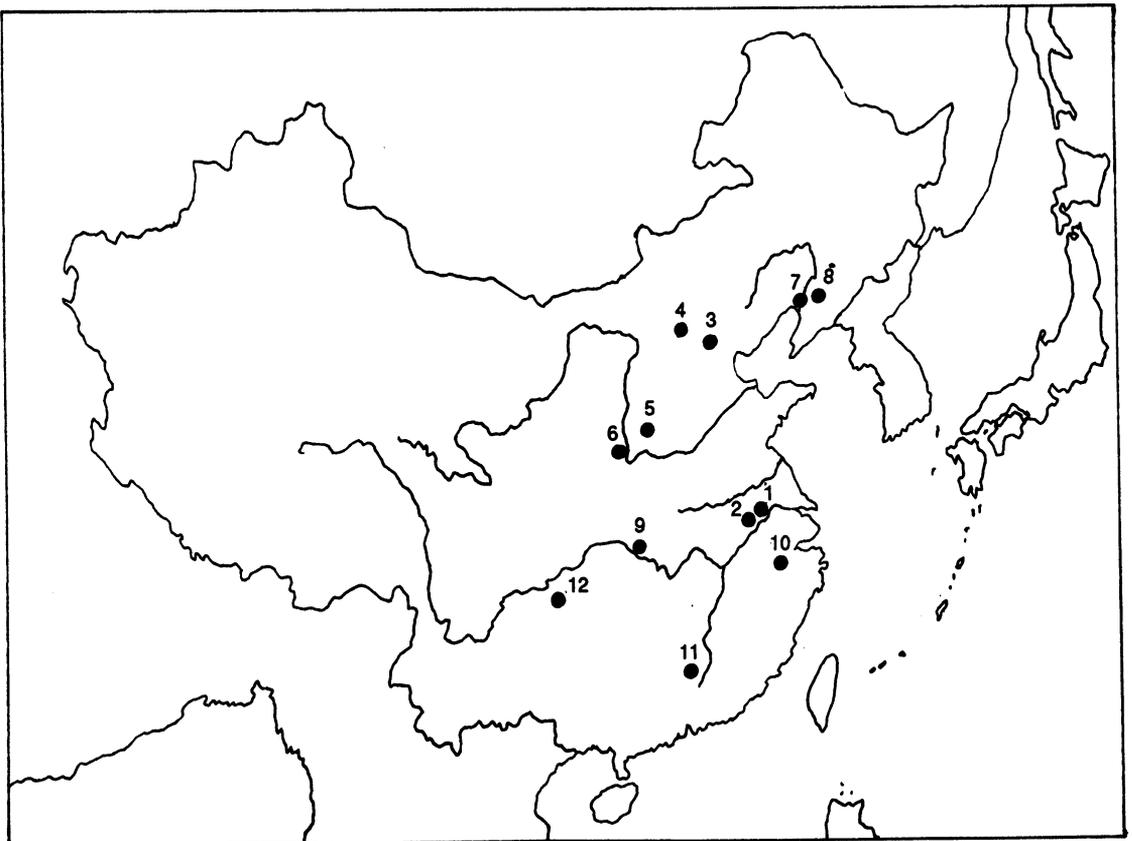
### HEXIAN COUNTY

The Longtandong cave site located on Wangjiashan, a hill near Taodian village, Hexian county, Anhui province (E 118° 20', N 31° 45') (Huang *et al.* 1981, 1982; Wu and Dong 1982; Wu 1983; Zheng 1982; Zheng 1987; Xu and You 1984; Chen *et al.* 1987) has produced the most prolific remains of *H. erectus* unearthed in China since the height of excavations at ZKD in the 1930's. An inventory of recovered specimens includes: a nearly complete calvaria (PA 830), the

supraorbital portion of a frontal (PA 840), a right parietal (PA 841), a fragment of a left mandibular corpus retaining M2 and M3 (PA 831), a right upper P4 (PA 832), a left upper M2 (PA 833), a left lower M1 and M2 of one individual [PA 834 (1-2)], a right upper I1 (PA 835), a left upper M1 (PA 836), a right upper M2 (PA 837), and two left lower M2's (PA 838 and PA 839).

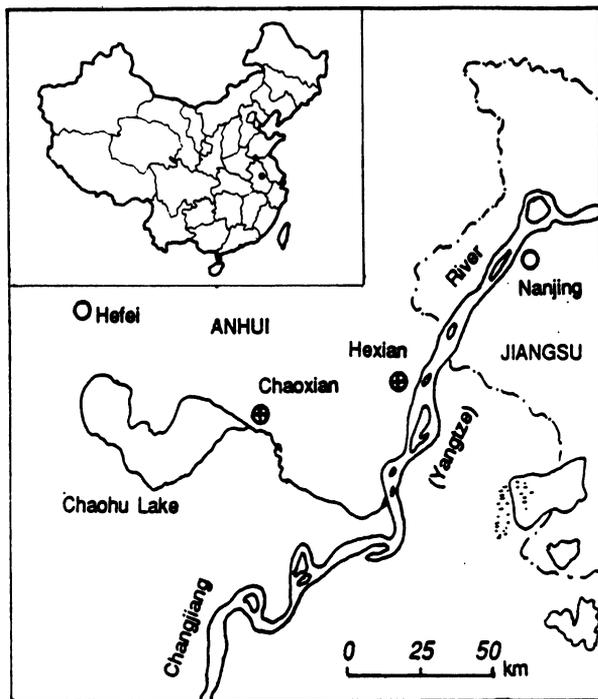
The site has been known since 1973 when it was blasted open during canal construction. The cave was found to be richly fossiliferous and a number of vertebrate specimens were sent to the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), *Academia Sinica* for study. In 1979, at the request of the Anhui Province Water Conservancy Bureau, a team led by Huang Wanpo was dispatched by the IVPP to further investigate the site. More fossil vertebrates were collected along with bone that has been claimed to be artifactual in nature (Huang *et al.* 1982). Excavations were resumed in January 1980. In July the first human fossil, an upper molar, was

Figure 1. Localities in China yielding late middle Pleistocene or early late Pleistocene fossil hominids.



1. Hexian, Anhui
2. Chaoxian, Anhui
3. Zhoukoudian, Beijing
4. Xujiayao, Shanxi
5. Dingcun, Shanxi
6. Dali, Shaanxi
7. Yingkou (Jinniushan), Liaoning
8. Miaohoushan, Liaoning
9. Changyang, Hubei
10. Jiande, Zhejiang
11. Maba, Guangdong
12. Tongzi, Guizhou

Figure 2. Location of the Hexian and Chaoxian sites.



recovered by Qin Wanju of the Anhui Water Conservancy Bureau from previously excavated back dirt within the cave. Later that fall during the third excavation the calvaria and other human fossils were found. Further excavations led to the recovery of additional teeth and cranial remains (Wu 1983).

Longtandong is located on the northern slope of Wangjia Hill, 30 km northwest of the Yangtze River at an elevation of 23 meters above sea level. The deposits within the cave can be divided into four layers. The hominid material comes from the second stratigraphic level which consists of 0.5-1.0 meters of brown to yellow clays (Huang *et al.* 1981, 1982) (Figure 3). The Hexian fauna produced from the cave is biogeographically transitional, containing both paleoartic and subtropical elements (see Tables 1 and 2). The micro-mammalian component shows considerable faunal mixing with northern, southern and "alpine" species seen frequently in the western montane region of China all present (Zheng 1982; Xu and You 1984). Palynological sampling at Longtandong likewise indicates the presence of both northern and southern taxa (Huang and Huang 1985). Since the 1950's it has been anticipated that this area of the North China Plain, situated as it is between the Changjiang (Yangtze) and Huanghe (Yellow) Rivers, would produce a transitional faunal complex containing both northern and southern taxa. Pei

(1957) referred to the area in question as the Huai River Transitional Zone. The mammalian fauna from Sihong in Jiangsu Province, now known to be of Miocene age, was initially thought to be representative of just such a Pleistocene transitional zone. It was later shown, however, that castorid and proboscidean remains at Sihong had been misinterpreted and were not of Pleistocene age (Li and Zhou 1978). The faunal remains from both Hexian and Chaoxian are the first verification of the Huai River Transitional Zone and have contributed greatly to a better understanding of the paleobiogeographic zonation of east Asia during the middle and late Pleistocene (Liu *et al.* 1982; Zheng 1987).

#### HUMAN REMAINS FROM HEXIAN COUNTY

The Hexian calvaria (Figure 4) has been studied in detail by Wu and Dong (1982). The following account of the specimen is based on their analysis.

#### Preservation

The heavily fossilized specimen was originally fragmented into eight pieces. Reconstruction revealed a well-preserved calvaria that retains a substantial part of the cranial base. The restoration consists of: 1) a nearly complete frontal including the supraorbital region, but lacking the inferior portion of the nasal process; 2) a nearly complete left parietal; 3) the right parietal somewhat damaged at pterion, near the parietal eminence and asterion; 4) a left and right temporal, both lacking zygomatic and mastoid processes due to breakage -- the left temporal is relatively complete, the right temporal squama has been lost at the sphenoidal margin and along a portion of the parietal margin; 5) an occiput that preserves the posterior margin of the foramen magnum and much of the nuchal and occipital planes; and 6) the lateral portion of the greater wing of the left sphenoid. The vault between the temporal lines anterior to the vertex and posterior to bregma is flattened. It has been suggested that this may be due to compressive forces during fossilization (Wu and Dong 1982).

The relatively large and robust construction of the calvaria (cranial capacity approximately 1025 cc), the thick and well-developed supraorbital and occipital tori, the well-expressed temporal and nuchal lines and the sloping forehead

Table 1. Taxonomic list of non-mammalian and micro-mammalian vertebrates from Longtandong, Hexian county, Anhui province (after Huang *et al.* 1981, 1982; Zheng 1982; Xu and You 1984; Huang and Huang 1985).

#### REPTILIA

*Ocadia* sp.  
*Amyda* sp.  
*Alligator cf. sinensis*

#### AVES

*Crossoptilon* sp.

#### MAMMALIA

##### Insectivora

*Blarinella quadraticauda* (Milne-Edwards)  
*Chodsigoa youngi* Huang *et al.*  
*Anourosorex squamipes* Milne-Edwards  
 ?*Scaptochirus* sp.

##### Chiroptera

*Rhinolophus cf. ferrum-equinum* Thomas  
 ?*Myotis* sp.  
*Hipposideros* sp.  
*Miniopterus schreberii* Kuhl

##### Rodentia

*Trogontherium cuvieri* Fischer  
*Cricetulus varians* (Zdansky)  
*Apodemus argrarius* Pallas  
*Rattus rattus* (Linnaeus)  
*Rattus norvegicus* Berkenhout  
*Rattus edwardsi* Thomas  
*Microtus brantioides* Young  
*Eothenomys melanogaster* Milne-Edwards  
*Eothenomys inex*  
*Eothenomys eva*  
*Eothenomys proditor*  
*Tamias wimani* Young

combine to suggest a male specimen. Wu and Dong (1982) judge it to be a young adult, as both external and internal sutures (excepting the left sphenoidal suture) are open.

#### Lateral Aspect

Wu and Dong (1982) describe the calvaria as low vaulted with the supraorbital and occipital tori being respectively the most anterior and posterior projecting points on the skull, so that greatest cranial length (g-op) is coincident with the distance between glabella and inion (i.e., inion coincides with opisthocranion). The temporal lines are well-expressed and separated by

77 mm at their closest approximation. The posterior course of the temporal line terminates in a distinct angular torus at the mastoid angle of the parietal. The above features are all characteristic of previously known crania of *H. erectus* from ZKD. The pterionic region, preserved on the left side, is of the sphenoparietal type and assumes an "H" shape. The sphenoparietal suture is 11 mm long (Wu and Dong 1982).

The temporal squama is relatively high and arched superiorly at the parietal margin unlike the condition in Peking man (with the exception of Skull V) in which the squamosal margin is low and straight. The left squamous portion is 70 mm long and 42 mm high, yielding a length/height index of 60, compared to an average of 49.6 in Peking man (Weidenreich 1943), 64.6 in the Dali cranium (Wu 1981) and an average of 65.2 in modern man (Wu and Dong 1982). The Hexian temporal, therefore, approximates that of modern humans in both shape and size. The parietal notch separating the temporal squama from the mastoid region is deeply incised. The root of the zygomatic process of the temporal slants posterosuperiorly, merging with the supramastoid crest which in turn unites with the angular torus. The *sulcus processus zygomatici*, which positions the zygomatic process laterally away from the squama, is wide and shallow rather than narrow and deep as in modern man. The supramastoid and mastoid crests are well-developed as is the supramastoid sulcus. The digastric fossa is broad, shallow and opens up posteriorly, differing from the deeper and more narrow *incisura mastoidea* seen in modern humans. What is preserved of the

mammillary process of the mastoid is relatively small and, as in other specimens of *H. erectus*, lies below the level of the supramastoid crest. It extends further backwards than in modern man. The configuration of the external auditory meatus and the overhanging suprameatal tegmen is as in "*Sinanthropus*" (see Weidenreich 1943:53). The aperture of the meatus is vertically elliptic. The postglenoid process is poorly expressed as a low protuberance.

#### Vertical Aspect

The frontal has a low and sloping squamous portion. The frontal profile (m-g-i) (Martin 1928:

639, No. 32a) measures  $58^\circ$  and the inclination of the frontal squama (b-g-i) [Martin 1928:640, No. 32(2)] measures  $41^\circ$ . These measures are considerably less than in the early *H. sapiens* Dali specimen in which the above angles measure  $72^\circ$  and  $50^\circ$  respectively (Wu 1981), but within the range of variation seen at ZKD (Weidenreich 1943:109) (Table 3).

The supraorbital torus is wide laterally and thick inferosuperiorly. Although the superior margin of the glabellar region is slightly depressed, the left and right supraorbitals unite in a single body. Thickness measures of the supraorbital torus are as follows: left medial 19 mm, left median 16 mm, left lateral 12 mm; right medial 18 mm, right median 17 mm, right lateral 13 mm.

Greatest thickness is medial and least thickness is lateral as in specimens of *H. erectus* from ZKD. The frontal squama above the supraorbitals has a pronounced "bump-like" protuberance as in material from ZKD (Weidenreich 1943:225). This differs from Javanese specimens of *H. erectus*, which show a flat frontal squama. There is a distinct post-toral sulcus in the Hexian calvaria but it is much more weakly expressed than in similar specimens from ZKD. Javanese specimens lack this structure entirely as the flat squamous portion of the frontal merges smoothly with the supraorbital torus.

The frontal eminences are only slightly expressed and thus are similar in degree to male specimens from ZKD. A metopic suture is evi-

Table 2. Taxonomic list of macro-mammalian vertebrates from Longtandong, Hexian county and the upper (hominid bearing) levels at Yanshan, Chaoxian county, Anhui province, China (after Huang *et al.* 1981, 1982; Zheng 1982; Huang and Huang 1985; Xu *et al.* 1984, 1986a, 1986b).

FAUNA	LOCALITIES	
	Hexian	Chaoxian
Primates		
<i>Macaca robustus</i> Young	x	
Carnivora		
<i>Canis</i> sp.	x	
<i>Cuon alpinus</i> Linnaeus	x	sp.
<i>Vulpes</i> sp.	x	
<i>Arctonyx collaris</i> Cuvier	x	sp.
<i>Lutra</i> sp.	x	
<i>Hyaena brevirostris sinensis</i> Owen	x	x
<i>Megantereon</i> sp.	x	
<i>Felis chinensis</i> Gray	x	sp.
<i>Panthera pardus</i> Linnaeus	x	sp.
<i>Ailuropoda</i> sp.	x	
<i>Ursus arctos</i> Linnaeus	x	sp.
<i>Ursus thibetanus kokeni</i> (Zdansky)	x	
Proboscidea		
<i>Stegodon orientalis</i> Owen	x	sp.
Perissodactyla		
<i>Equus</i> sp.	x	x
<i>Tapirus sinensis</i> Owen	x	sp.
<i>Megatapirus</i> sp.	x	
<i>Dicerorhinus</i> sp.	x	x
Artiodactyla		
<i>Sus lydekkeri</i> Zdansky	x	sp.
<i>Sus</i> cf. <i>xiaozhu</i>	x	x
<i>Cervus (Pseudaxis) grayi</i> Zdansky	x	sp.
<i>Megaloceros pachyosteus</i> (Young)	x	x
<i>Hydropotes inermis</i> Swinhoe	x	
<i>Elaphurus davidianus</i> Milne-Edwards	x	
<i>Bison</i> sp.	x	x
Caprinae		x

dent from a point level with the frontal eminences to bregma. An unfused metopic suture is also seen in Skull XI from ZKD (Wu and Dong 1982).

Wu and Dong (1982) note that the breadth of the frontal is expanded over those from ZKD. Least frontal breadth (ft-ft) measures 93 mm, greatest frontal breadth (co-co) 118 mm. Both measurements are nearly 10% greater than the average for ZKD calvariae (Weidenreich 1943: 106). The degree of postorbital constriction can be gauged by an index that measures maximum postorbital constriction (minimum breadth of the frontal behind the orbits) against the distance between the outer edges of the brow ridges (101 mm and 111 mm respectively in the Hexian specimen) (Wu 1981). In the Hexian specimen this index stands at 91 versus a range of 80.7-82.9 in specimens from ZKD and 85.1 for the Dali cranium (Wu 1981). This relatively minor degree of postorbital constriction is considered a distinguishing feature of the Hexian calvaria by Wu and Dong (1982).

A sagittal keel is apparent along the mid-sagittal plane from a position level with the

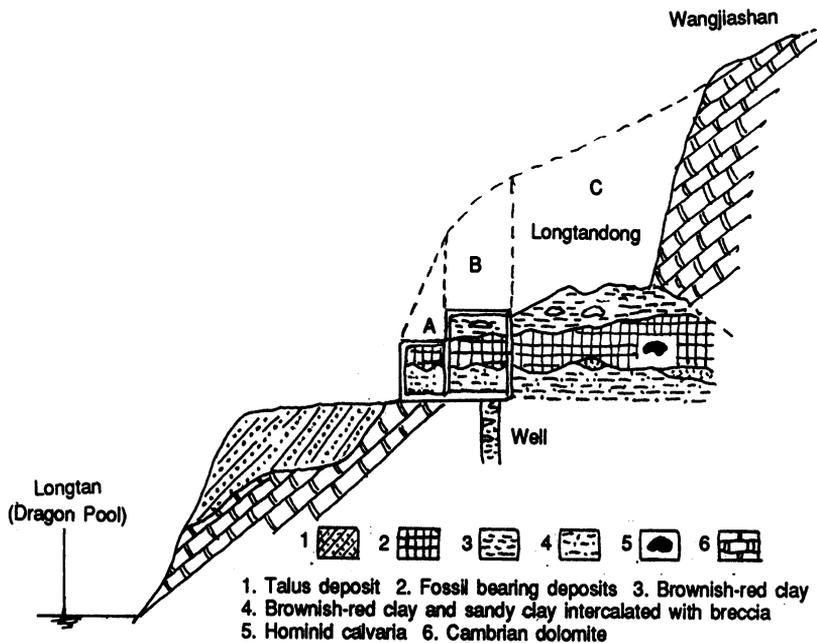
frontal eminences to bregma at which point it gradually disappears. The sagittal keel in Peking man is more prominent extending from a position level with the frontal eminences to the obelion region of the parietals. The robust construction of the vault in Peking man is further reflected by the presence of a cruciate eminence at the junction of the coronal and sagittal sutures. The Hexian specimen lacks this latter structure as well as the parasagittal depressions seen along the sagittal suture in specimens of *H. erectus* from ZKD and Java (Wu and Dong 1982).

Greatest cranial width is low on the skull in line with the supramastoid crests. The outline of the neurocranium at this level is ovoid. The parietal eminences are well-developed which may be an indication of the relative youth of the individual. Parietal foramina are not in evidence.

### Occiput and Cranial Base

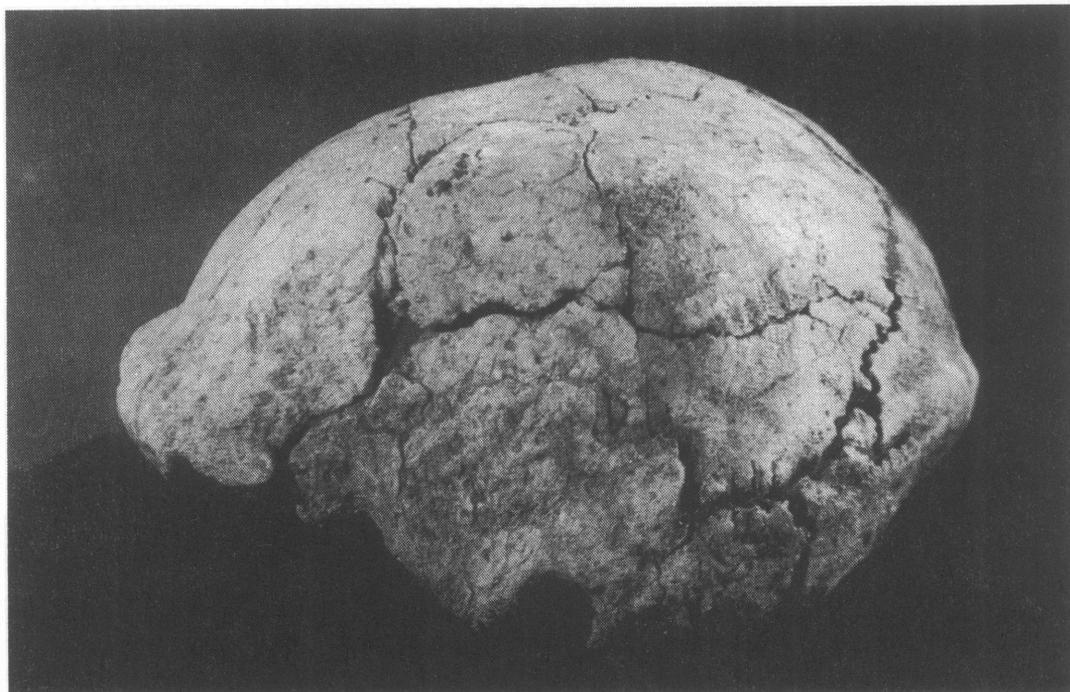
Wu and Dong (1982) state that the occipital torus is well-developed forming a continuous, smooth protuberance. The most projecting point

Figure 3. Stratigraphic profile of Longtandong Cave, Hexian county, Anhui.



A. Trial excavation, Oct. 1979 B. Excavation, Jan. 1980  
C. Excavation, Oct.-Nov. 1980

Figure 4. The Hexian calvaria.



along the torus is at midpoint and the median portion is relatively straight while the lateral portions curve inferiorly, diminishing towards asterion. There is a clear supratoral sulcus. The occipital angle separating the occipital and nuchal planes is acute. The inferior margin of the torus forms a slightly arched line equivalent to the superior nuchal line in modern man. It courses laterally, forming the lateral occipital crest. The external occipital protuberance is indistinct. A large intersutural bone is positioned on the right side at asterion.

In basal aspect a broad and shallow *incisura supraorbitalis* is positioned medially on the lower margin of the left and right supraorbitals. It is bound laterally by a *processus supraorbitalis* in the fashion described by Weidenreich (1943:29). However, these structures are not as distinct as in the ZKD material. Only the anterior surfaces of the orbital roofs are preserved, and they are distinguished by their overall flatness. The frontal sinus is relatively small and is restricted to the upper and lateral portions of the interorbital region in the same manner as the majority of specimens from ZKD (cf. Weidenreich 1943:31) (left anteroposterior length 7.5 mm, right anteroposterior length 11.5 mm, left width 14 mm, right width 11 mm).

As in specimens of *H. erectus* from ZKD, the mandibular fossa is deep and narrow and the articular eminence is weakly expressed (Weidenreich 1943:47). Of particular note is the presence of a deep groove medially along the anterior margin of the right mandibular fossa. The size of the tympanic plate, its position in relation to the mid-sagittal plane of the cranium and its spatial orientation are all as described for "*Sinanthropus*" (Weidenreich 1943:52-57), i.e., it is very thick, positioned perpendicular to the mid-sagittal plane of the cranium (the plesiomorphic condition for hominoids -- in modern humans the tympanic plate is flexed posteriorly with reference to the mid-sagittal plane) and oriented intermediately between the vertical condition seen in modern humans and the horizontal condition seen in apes. The angle between the tympanic plate and the petrous process, however, is more acute in the Hexian specimen ( $30^\circ$ ) than in specimens known from ZKD ( $50^\circ$  in Skull III). In modern humans the tympanic plate and petrous process are nearly parallel to one another due to the increased obliquity of the former and the more obtuse positioning of the latter in relation to the mid-sagittal plane. In the Hexian specimen the petrous process is positioned less obliquely in relation to the mid-sagittal plane than in material from ZKD ( $60^\circ$

Table 3. Linear measurements, angular measurements and indices of Hexian *H. erectus* and means for *H. erectus pekinensis*, *H. erectus erectus* and Ngandong specimens (after Wu and Dong 1982).

Martin No.	Measurement	Hexian	ZKD	Java	Ngandong
		n	$\bar{x}$	$\bar{x}$	n $\bar{x}$ SD
1(2)	Maximum length: g-op(i)	190	197	184	6 202 9.4
5(1)	Nasion-opisthion line: n-o	131?	145	139	6 154 7.4
8c	Temporo-parietal breadth	145	136	129	4 145 3.6
8	Maximum breadth: eu-eu	160	141	138	6 146 7.0
9	Least frontal breadth: ft-ft	93	87	82	5 103 3.8
11	Biauricular breadth: au-au	144	146	126	5 148 5.0
12	Biauricular breadth: ast-ast	142	114	120	6 126 1.5
20	Auricular-bregmatic height: po-b	95	99	94	6 109 5.1
23	Maximum horizontal circ.: g <sup>h</sup> g(op)	571	564	526	- - -
24	Auriculo-bregmatic arc: po <sup>h</sup> po(b)	291	287	266	6 308 11.5
25	Median sagittal arc II: n <sup>h</sup> o	340?	330	303	6 356 13.3
26	Nasion-bregma arc: n <sup>h</sup> b	120?	123	104	6 130 6.1
27	Bregma-lambda arc: b <sup>h</sup> l	110	102	93	6 108 6.0
28	Lambda-opisthion arc: l <sup>h</sup> o	110	114	105	6 118 6.7
29	Nasion-bregma chord: n-b	99?	110	93	6 117 4.0
30	Bregma-lambda chord: b-l	103	96	90	6 102 5.0
31	Lambda-opisthion chord: l-o	83	84	79	6 86 4.8
32a	Frontal profile: m-g-i (angle)	58	59	51	6 62 4.4
32(2)	Inclination of frontal squama: b-g-i (angle)	41	43	40	6 46 1.3
33(4)	Occipital curvature: l-i-o (angle)	101	103	109	6 99 4.3
8/1(2)	Length-breadth index	84	73	75	6 71 2.9
20/1(2)	Length-height (po-b) index	50	51	51	6 54 2.1
20/8	Breadth-height (po-b) index	59	71	69	6 74 3.4
5(1)/25	Sagittal cranial curvature	39?	44	46	6 43 1.8
11/24	Transverse cranial curvature	50	51	48	6 52 3.4
9/8	Transverse fronto-parietal index	58	62	61	- - -
12/8	Transverse parieto-occipital index	89	81	87	- - -
27/26	Fronto-parietal (arc) index	92?	84	90	6 83 2.7
28/27	Parieto-occipital (arc) index	100	120	110	6 110 8.9
29/26	Frontal curvature	83?	90	92	6 90 1.7
30/27	Parietal curvature	94	94	97	6 95 1.3
31/28	Occipital curvature	76	74	76	6 73 1.8
	Cranial capacity	1025	1059	879	6 1096 86.0

vs. 40°), in this respect falling within the upper range of variation seen in modern human samples (38°-63°) (Tobias 1967). Both a styloid and vaginal process are lacking. The foramen spinosum of the sphenoid is preserved on the right side. The occipitomastoid crest is not as well developed as in Peking man. As described by Weidenreich (1943:63) the *foramen processus styloidei* (which occupies the position of the missing styloid process) and the digastric fossa (*incisura mastoidea*) of "*Sinanthropus*" lie on a straight line while the stylomastoid foramen lies without it. In the Hexian specimen these three structures lie on the same line, concordant with the modern human condition in which the styloid process, stylomastoid foramen and digastric fossa lie in tandem. The foramen magnum is at least 32 mm wide. Its margin is strongly lipped, merging with the external occipital crest posterolaterally.

### Endocranial Construction

The endocranial surface of the Hexian calvaria preserves a low, broad frontal crest. It is divided into two branches separated by a sagittal sulcus along the lower 9 mm of its course. This is similar to the condition in ZKD Skull III as reported by Weidenreich (1943:32). The sagittal sulcus fades out towards the lower third of the frontal squama. There is no *foramen caecum*, consistent with the absence of this feature in "*Sinanthropus*" noted by Weidenreich (1943:34). There are clear cerebral impressions.

Along the sagittal margin of the parietals are small granular depressions, i.e., the *foveolae granulares*. The cerebral impressions and juga are not as distinct as those seen on the frontal. Along the sagittal margin of each parietal is a low crest separated one from the other by a sagittal sulcus. The sphenoidal angle of the left parietal is well-preserved. Internally, a Sylvian crest arises at the border of the sphenoid and slants posterosuperiorly following the anteroposterior diameter of the parietal for half its course. The anterior ramus of the middle meningeal artery cuts across the anterior portion of the Sylvian crest. The presence of a developed Sylvian crest was observed by Weidenreich in his description of the ZKD crania (1943:36).

The internal surface of the occipital shows the typical division of the upper (cerebral) and lower (cerebellar) occipital fossae by a clear cruciate eminence. The central prominence of this latter structure constitutes the internal occipital protuberance. As in other specimens of *H. erectus* the cerebellar fossae are distinctly smaller than

the cerebral fossae, the reverse of the condition in modern man. In Peking man the ratio of the area of the cerebral to cerebellar fossae is more or less 2:1, while in the Hexian specimen it is closer to 4:3, indicating an expansion of the relative area of the cerebellar fossae in relation to the cerebral fossae and a closer approximation to the modern human condition.

There is a 22 mm separation of the internal and external occipital protuberances from each other in the Hexian specimen. This is clearly larger than in the Dali cranium (11 mm) but smaller than in Peking man (27.5-38.0 mm, mean = 32.8 mm). In modern man these structures are coincident.

The sagittal sulcus on the internal surface of the occipital is broad and shallow. It unites with a similarly broad and shallow right transverse sulcus. The left transverse sulcus is broad and deep and positioned slightly higher than the right transverse sulcus. It is not in communication with the sagittal sulcus. This configuration of the occipital sulci conforms to the pattern observed for the ZKD material (Weidenreich 1943:42). The transverse sulci do not extend upward to the mastoid angle of the parietal as in modern man but rather to the mastoid region of the temporal and occipital. The sulcal impressions of the cerebrum and cerebellum are poorly expressed.

The pyramidal process of the temporal is relatively stout. The height of the posterior surface from the base of the superior border of the sigmoid sulcus to the superior petrosal sulcus measures 22 mm in the Hexian specimen. This value does not exceed 18 mm in "*Sinanthropus*" but in modern man it may approach 23 mm (Weidenreich 1943:67). The apertures of both the internal acoustic meatus and the internal vestibular canal are intact. The sigmoid sulcus is broad and deep.

The ramification of the middle meningeal artery follows the pattern seen in "*Sinanthropus*" in which the posterior branch (*ramus temporalis*) is somewhat more robust than the anterior branch (*ramus fronto-parietalis*) and the sub-branches from both are much less abundant than in modern man.

### Cranial Measurements

Cranial measurements of the Hexian calvaria in comparison to relevant samples of *H. erectus* are given in Table 3. A number of these measurements are close to those for *H. erectus* from ZKD and Java. These include cranial length [g-op(i)], cranial height (po-b), inclination of the frontal squama (b-g-i angle), horizontal curvature

of the cranium (biauricular breadth/auriculo-bregmatic arc), fronto-parietal breadth index [minimum frontal breadth (ft-ft)/maximum cranial breadth (eu-eu)], and parietal and occipital curvature. In a number of features the Hexian specimen differs from material from Java and is more similar to material from ZKD, e.g., measures of biauricular breadth (au-au), cranial circumference, transverse arc of the cranium, sagittal arc of the cranium, inferior inclination of the frontal, occipital angle and cranial capacity. The only index of the Hexian specimen that is different from specimens of *H. erectus* from ZKD and more similar to specimens from Java is the parieto-occipital breadth index. This index demonstrates the relatively larger breadth of the occiput in the Hexian cranium when compared to crania from ZKD and the overall spherical shape of the cranium versus the more elliptical shape characteristic of material from ZKD. Relatively progressive metric features of the Hexian cranium include an increase in minimum and maximum frontal breadth, a greater degree of sagittal and frontal curvature, and a relatively low value for the parieto-occipital arc index (indicating that the parietal and occipital arcs are nearly equal to one another versus the greater length of the occipital arc in most *H. erectus* and the greater length of the parietal arc in modern humans). In addition, the Hexian cranium shows a much greater maximum breadth than either the ZKD or Javanese material and its length/breadth index falls within the brachycephalic range rather than the dolichocephalic range of most of the ZKD crania and the mesocephalic range of Javanese specimens from Trinil and Djetis. These latter traits, however, are not thought to possess much phyletic weight (Huang *et al.* 1981).

The thickness of the cranial vault bones at various points along the cranium is as follows: at the median point of the frontal squama 7 mm; at the left parietal eminence 13.5 mm; at the mastoid angle of left parietal 18 mm; at the midpoint of the occipital torus 18 mm; at the cerebellar fossa of occipital 6 mm; and at the median point of the temporal squama 10 mm. These values demonstrate that cranial vault thickness is overall less than in Peking man and much less than in Lantian man.

### Additional Remains

The supraorbital fragment (PA 840) described by Wu (1983) preserves much of the right torus and a small portion of the frontal squama immediately superior to it. Medially it is broken at glabella. The nasal process of the frontal is

preserved as is a small portion of the roof of the ethmoidal sinus. The external surface of the bone is exfoliated in places. Wu (1983) observes that while the supraorbital torus is strongly developed, it is not quite as robust as in the calvarial specimen PA 830. It differs from PA 830 and homologous ZKD material in that the thickest part of the torus is situated along the supraorbital midline rather than further medially. Although most of the frontal squama is lost, Wu (1983) notes that, as in PA 830, postorbital constriction is not as great as in crania from ZKD. In like manner the post-toral sulcus is reduced in both PA 830 and PA 840, differing in this respect from the ZKD crania. In all other respects the PA 840 specimen is said to be similar to both PA 830 and material from ZKD.

The right parietal fragment (PA 841) described by Wu (1983) is 40 mm long and 60 mm wide. It preserves the area around the parietal eminence and a small portion posterior to the parieto-temporal suture. The bone surface is smooth without evidence of exfoliation. It is darker in color than either PA 830 or PA 840, coming as it does from darker sediments towards the eastern part of the cave. The other cranial specimens come from lighter colored sediments towards the western part of the cave. All the material, however, was excavated from the same stratigraphic level. The wall of PA 841 is relatively thick -- 11 mm in the vicinity of the parietal eminence, well within the range of Peking man (5-16 mm). The temporal margin is robust but the bone thins out posteriorly.

The left mandibular corpus fragment (PA 831) (Wu and Dong 1982) retains M2 and M3 *in situ* although the mesial margin of the M2 crown is damaged. The teeth are relatively well worn indicating that the specimen belonged to a mature individual. The corpus is said to be extremely robust and particularly thick and is most likely that of a male. There are three mental foramina positioned between P4 and M1. Corpus height between M1 and M2 is 32 mm, corpus thickness at the same position is 20.7 mm, yielding a robusticity index of 64.7 (Wu and Dong 1982). This is greater than in all ZKD and Javanese specimens (both male and female), as well as the Chenjiawo mandible from Lantian. The teeth retained by the specimen will be discussed below along with other dental specimens from the site.

### Dental Remains

The dental remains from Hexian (Table 4) are remarkable for their overall robustness and large size. In nearly all instances (except M3) the

Table 4. Measurements of the Hexian dentition.

	Crown	
	Length	Breadth
Right I <sup>1</sup> (PA 835)	11.7	9.4
Right P <sup>4</sup> (PA 832)	9.0	13.4
Left M <sup>1</sup> (PA 836)	12.3	13.7
Right M <sup>2</sup> (PA 837)	12.5	15.5
Left M <sup>2</sup> (PA 833)	12.0	14.0
Left M <sub>1</sub> (PA 834-1)	12.5	13.1
Left M <sub>2</sub> (PA 834-2)	13.3	13.6
Left M <sub>2</sub> (PA 838)	13.6	13.9
Left M <sub>2</sub> (PA 839)	14.3	13.4
Left M <sub>3</sub> (PA 831)	11.3	10.7

In millimeters (After Wu and Dong 1982; Wu 1983.)

teeth from Longtandong approach or exceed the upper limit of the range of metric variation for previously known dental specimens of *H. erectus* from Asia. This is all the more significant given the relatively progressive nature of the Hexian remains and their purportedly young geologic age. Coupled with the large size of dental remains and the extreme thickness of cranial vault bones from the upper Pleistocene site of Xujiayao in Shanxi Province, it is apparent that mere measures of overall size and robusticity do not serve as good phylogenetic indicators among east Asian Pleistocene hominids.

Teeth recovered from Longtandong include the socketed left lower M2 and M3 from the PA 831 mandible, a right upper P4 (PA 832), a left upper M2 (PA 833) and left lower M1-M2 [PA 834 (1-2)] from the 1980 excavation, as well as a right upper I1 (PA 835), a left upper M1 (PA 836), a right upper M2 (PA 837) and two left lower M2's (PA 838 and PA 839) recovered during the 1981 excavation.

The central incisor (Wu 1983) is particularly large, exceeding even the Yuanmou incisors in mesiodistal (md) length and labiolingual (ll) breadth. Its overall size is most comparable to the Krapina neandertals. The crown is well-preserved except for a small piece of enamel lost at the distal corner of the incisive margin which is otherwise only slightly worn. The specimen is said to be clearly shovel-shaped with a broad incisive edge and thickened lateral margins which turn inward towards the lingual surface of the tooth. The labial face of the crown projects both longitudinally and horizontally and has three prominent longitudinal swellings. Lingually there is a pronounced basal tubercle which is confluent with the lateral margins. There is a central lingual

fossa but it is not as well-expressed as in the Yuanmou specimens. Four finger-like projections of various lengths emanate from the basal tubercle and terminate in the central fossa. The root is extremely robust and conical. There are distinct broad and shallow mesial and distal vertical grooves (Wu 1983).

The upper P4 (Wu and Dong 1982) is again very large and robust, well exceeding the means for mesiodistal length and buccolingual breadth seen for this tooth in previous samples of *H. erectus* from Asia. The upper and lower molars, besides their large size, are morphologically consistent with other samples of *H. erectus* from China (Wu and Dong 1982; Wu 1983).

#### SUMMARY OF HUMAN REMAINS FROM HEXIAN COUNTY

It is clear from the above review that the Hexian cranial and dental remains follow the morphological pattern of *H. erectus* in China as meticulously outlined by Weidenreich (1937, 1943). There can be no doubt as to their attribution to the taxon *H. erectus* if that taxon is to have any validity. The calvaria nevertheless does show certain progressive features that can best be described as advanced over the condition seen at ZKD, hence the appellation "advanced *H. erectus*" used in this article to describe the material.

#### CHAOXIAN COUNTY

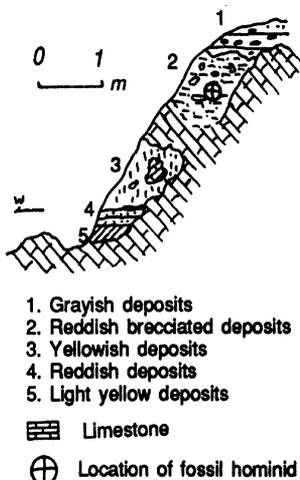
The hominid bearing site in Chaoxian county is located on Yanshan Hill outside of Yanshan Village, Daishan Township, Chaoxian county,

Anhui province (E 117° 52', N 31° 33') (Xu *et al.* 1984, 1986a, 1986b; Chen *et al.* 1987).

In April 1982, following reports of the discovery of Quaternary mammalian remains at Yanshan Hill, a joint work-team of the IVPP and the Anhui Archeological Institute was formed to excavate the site. After one month's work a large quantity of mammalian fossils were recovered, including an incomplete human occipital bone. Further excavations during the winter of 1983 led to the recovery of additional faunal remains as well as a fragmentary human maxilla.

Yanshan Hill is part of a belt of low lying hills, averaging 500 meters above sea level, which continue to its west and south. To the east and north is the broad flood plain of the Yuxi River which flows southeast towards the Changjiang (Yangtze) and drains Chaohu Lake. Terraces in the vicinity of Yanshan are poorly defined but are clearly in evidence on either bank of the Yuxi. Yanshan Hill is an isolated karstic outcrop that is riddled with a series of N/S trending fissures, some of which have been widened into caverns. The fossil bearing locality is the remnant of one such cavern which has collapsed and been subsequently exposed on the western slope of the hill. Five strata have been identified. The upper strata (1 and 2) are not in direct communication with the lower strata (3-5) (Figure 5). Their contained faunas also differ from the lower strata, yielding an assemblage with a definite early Pleistocene aspect and bearing a less diagnostic but demonstrably younger fauna than the lower strata (Table 2). The human occipital comes from stratum 2 which has been correlated faunally with the upper layers at ZKD, although

Figure 5. Stratigraphic profile of Yanshan Hill, Chaoxian county, Anhui.



there is no reason to reject a potentially younger age (see discussion in Introduction above).

## HUMAN REMAINS FROM CHAOXIAN COUNTY

### Occiput

The occipital fragment recovered at Yanshan described by Xu *et al.* (1984) preserves much of the squama except for a small portion near lambda which is damaged. The nuchal surface below the inferior nuchal line is lost. The damaged area near lambda reveals that the inner plate, outer plate and diploe are all of equal thickness. The denticulated lambdoidal margin is well-preserved as is approximately 8 mm of the right occipitomastoid margin, allowing for the determination of asterion on the right side. The occipital torus does not extend directly towards asterion but is arched superiorly on either side with the lateral portions curving downwards. The torus does not project strongly and is restricted to the median portion of the occiput where it is of uniform thickness (ca. 15 mm). It fades out laterally towards the asterionic region. The external occipital protuberance is indistinct. Although a supratoral sulcus is undeveloped, a supratoral fossa can be seen above the median portion of the torus. The superior nuchal line is indistinct as the surface of the occipital torus merges smoothly with the surface of the nuchal plane. The inferior nuchal line is somewhat more distinct. What is preserved of the nuchal plane is relatively smooth.

Internally, the cruciate eminence, sagittal and transverse sulci, and internal occipital protuberance can clearly be made out. The distance separating the external and internal occipital protuberances is 22 mm, the same as in the Hexian calvaria. Due to the incompleteness of the specimen the relative proportions of the cerebral and cerebellar fossae cannot be made out.

In terms of overall dimensions the Chaoxian occipital falls within the range of variation of Chinese *H. erectus*. Biasterionic breadth is reconstructed to be approximately 122.4 mm. This value is close to that of ZKD Skull V (124 mm), somewhat more than in other specimens from ZKD (111-117 mm), and considerably less than in the Hexian specimen (141.8 mm). The length of the occipital chord from lambda to inion is 50.2 mm, in keeping with specimens from ZKD which range between 47 mm and 52.5 mm.

Although the incompleteness of the specimen does not allow for the direct calculation of the occipital angle, its profile in mid-sagittal section

suggests that it was less sharply flexed than in typical specimens of *H. erectus*, approximating more closely the condition seen in archaic *H. sapiens*. Thickness at the midpoint of the occipital torus is 7 mm. This is considerably less than in specimens of *H. erectus* from China which range from 12 mm to 20.4 mm.

In sum, the Chaoxian occipital specimen is metrically similar to specimens of *H. erectus* previously known from China in that the occiput is relatively broad and the squamous portion is relatively short. However, a number of features differ from *H. erectus* and tend towards the condition seen in archaic forms of *H. sapiens*. These include: 1) the morphology of the occipital torus; 2) the perceived greater degree of occipital curvature; and 3) the relative thinness of the bone.

Based on the preservation of the denticulate structure of the lambdoidal margin, Xu *et al.* (1984) conclude that the lambdoidal suture had not closed. However, the relatively large breadth of the occiput suggests that the individual was fully grown. Therefore, they infer that the specimen belonged to a young adult. Given the relative gracility of the specimen and the undeveloped nature of the occipital torus and other ectocranial buttresses, they further conclude that it belonged to a female.

In assessing the phylogenetic affinities of the Chaoxian occiput Xu *et al.* (1984) caution that its relatively progressive features may be a function of both its age and sex. They conclude, however, that the degree of occipital curvature, thinness of the cortical bone and abbreviation of the occipital torus exceed the range of variability observed for male and female specimens, both adolescent and fully mature, previously attributed to *H. erectus* in China. They therefore consider the specimen to represent an anatomically primitive form of *H. sapiens*.

## Maxilla

The maxillary fragment discovered in 1983, also from stratum 2, consists of the right maxilla containing P3-M1 and the alveoli for I1-C, as well as a portion of the left maxilla which retains the alveoli for I1-2 and the mesial wall of the canine alveolus. The external surface of the right alveolar process is lost posterior to P4, exposing the whole root of M1. Both lateral incisors are broken off at the cervix. An isolated left P4, M1 and M2 are also associated with the maxilla, yielding a total of 8 whole or partial teeth.

The maxillary specimen is well-preserved subnasally and a moderate degree of alveolar prognathism can be observed in lateral aspect.

Xu *et al.* (1986a, 1986b) observe that the profile contour of the nasoalveolar clivus is not straight nor slightly concave as in modern humans exhibiting subnasal prognathism, but more convex as in Maxilla 5 of "*Sinanthropus*" (Weidenreich 1943:76) or the Lantian maxilla. These latter specimens, however, are said to be considerably more prognathic than the Chaoxian specimen. Although the anterior nasal spine is broken away, Xu *et al.* (1986a, 1986b) infer it to have been strongly developed as reflected by the caliber of its preserved base. Alveolar height (nasospinale-prosthion) is 27.8 mm, longer than in either Peking man (*H. erectus*) or Changyang man (archaic *H. sapiens*). The inferior margin of the right half of the piriform aperture is intact, as is two-thirds of the left inferior margin. There is a rather steep but short incline separating the nasoalveolar clivus from the inner floor of the nasal aperture, differing from the condition seen in "*Sinanthropus*" in which the clivus is separated from the nasal floor only by a simple "*margo limitans*" (Weidenreich 1943:76). In this respect the Chaoxian specimen approximates the condition seen in modern man. From the state of preservation of the right inferior nasal margin it can be estimated that the nasal aperture was relatively broad, much as in "*Sinanthropus*".

The anterior portion of the base of the nasal cavity is preserved. The elliptically shaped nasal orifice of the incisive canal is positioned near the front of the nasal cavity. The floor of the cavity is slightly concave posteriad versus a flat configuration in the ZKD and Changyang remains.

The condition of the maxillary sinus can be observed on the right side where it is exposed. It extends anteriorly to a position in line with P3 and medially to the palatine process. The maxillary sinus in "*Sinanthropus*" is not as extensive.

The anterior part of the hard palate as well as a small portion near M1 is preserved. As in specimens of "*Sinanthropus*" and modern man, it is rugose. The incisive foramen is complete and positioned near the alveolar margin (i.e., behind orale) and the incisive canal can be seen to ascend nearly vertically. Both these traits are fully modern and differ from the condition in *H. erectus* in which the incisive foramen is positioned more posteriorly and the canal is inclined at an angle of approximately 40° to the alveolar plane.

## Dental Remains

A total of eight whole or partial teeth have been recovered at Yanshan. They are all preserved *in situ* in the maxilla or clearly associated with it. The alveoli of the two central incisors

and the right canine are preserved intact, while the lateral incisors are broken off at their roots. The superior extremity of the canine jugum is fairly well removed from the nasal floor, unlike the condition in "*Sinanthropus*" in which the canine jugum reaches the level of the inferior margin of the nasal aperture. Xu *et al.* (1986a, 1986b) note that this discrepancy may be due to either an overall reduction in the length of the canine root or to the increased height of the alveolar face in the Chaoxian specimen.

In addition to the three teeth preserved intact in the right maxilla (P3-M1), three isolated left upper cheek teeth were also recovered. These consist of a P4, M1 and M2. Only P4 preserves a complete root. The crowns of all six teeth show varying degrees of wear but are nonetheless in good condition. Metrically all six teeth fall within the mid to upper range of variation of Chinese *H. erectus* (Xu *et al.* 1986a, 1986b). They are more robust than the two teeth (P3 and M1) associated with the Changyang maxilla but less robust than material from Xujiayao (Table 5).

Morphologically, the teeth are virtually indistinguishable from those of *H. erectus* in China (Zhang 1986). Although both upper central incisors are lost, their alveoli are completely intact and a labiolingual diameter of no less than 8.3 mm has been estimated (Zhang 1986). This is considerably greater than the mean for the labiolingual diameter of upper I1's from ZKD. The upper lateral incisors are broken off at the cervix. Small portions of the crowns of both teeth are, however, preserved mesially and a labiolingual diameter of between 8 mm and 8.5 mm has been estimated (Zhang 1986). This is near the mean for Chinese *H. erectus*.

Although the Chaoxian upper right P3 is worn occlusally, its structure is still evident. As in *H. erectus* from ZKD the buccal and lingual cusps are separated by a deep longitudinal furrow, the inner slopes of the two cusps have

developed horizontal ridges, and there is a well-defined "*tuberculum molare*" on the buccal surface (see Weidenreich 1937:37). The arrangement of ridges and wrinkles on the upper P4's is also said to be highly reminiscent of Chinese *H. erectus* (Zhang 1986).

The two upper M1's, being antimeres, are morphologically identical. The crown is rhomboidal in occlusal outline and broader anteriorly than posteriorly. The cusps are differentially worn but still identifiable. The protocone and paracone are nearly equal in size, the metacone slightly smaller. The boundary between the protocone and paracone is along the central axis of the occlusal surface of the tooth. The basal swelling of the buccal surface and a Carabelli's trait on the mesiolingual surface of the protocone observed in the Chaoxian specimens are common characteristics of *H. erectus* upper M1's from China (Zhang 1986). The upper M2 is also noted to be morphologically indistinguishable from *H. erectus*. The "*erectus*"-like character of the teeth of archaic *H. sapiens* in China is a unique feature of the continuum of human evolution in east Asia (Zhang 1986) and has been noted for specimens from Xujiayao (Jia *et al.* 1979) and Tongzi (Wu 1984).

#### SUMMARY OF HUMAN REMAINS FROM CHAOXIAN COUNTY

The relatively modern morphology of the Chaoxian maxilla is consistent with the attribution of the Chaoxian occiput to anatomically archaic *H. sapiens*. Features reminiscent of "*Sinanthropus*", such as the relatively pronounced alveolar prognathism, broad nasal aperture and robust "*erectus*"-like dentition, are balanced by such progressive features as a strong anterior nasal spine, the anterior position of the incisive foramen and vertical orientation of the incisive canal, the greater extent of the maxillary sinus develop-

Table 5. Robustness of teeth crowns (length x breadth) recovered from Yanshan, Chaoxian compared to other Chinese specimens.

	P <sup>3</sup>	P <sup>4</sup>	M <sup>1</sup>	M <sup>2</sup>
Chaoxian specimens	107.0	104.6-106.7	154.1-159.6	166.4
ZKD specimens (ave.)	102.0	105.9	141.1	138.4
Hexian specimens	-	120.6	168.5	168.0-193.8
Changyang specimens	78.4	-	138.2	-
Xujiayao specimens	-	-	187.6	157.3

(After Xu *et al.* 1986a, b; Wu and Wu 1985.)

ment and the diminution of the canine jugum. The differences between the Chaoxian and Changyang specimens, in terms of greater alveolar height and more robust dentition in the former and a flatter nasal floor in the latter, may be due to sexual dimorphism, with the Chaoxian specimen representing a male individual and the Changyang specimen representing a female (Xu *et al.* 1986a, 1986b).

### CONCLUSION

The Hexian and Chaoxian remains are powerful evidence for the regional continuity theory of human evolution in China. There can be no doubt that a significant transformation

affecting the human lineage in east Asia took place during the terminal period of the middle Pleistocene. The nature of this transformation must still be elucidated.

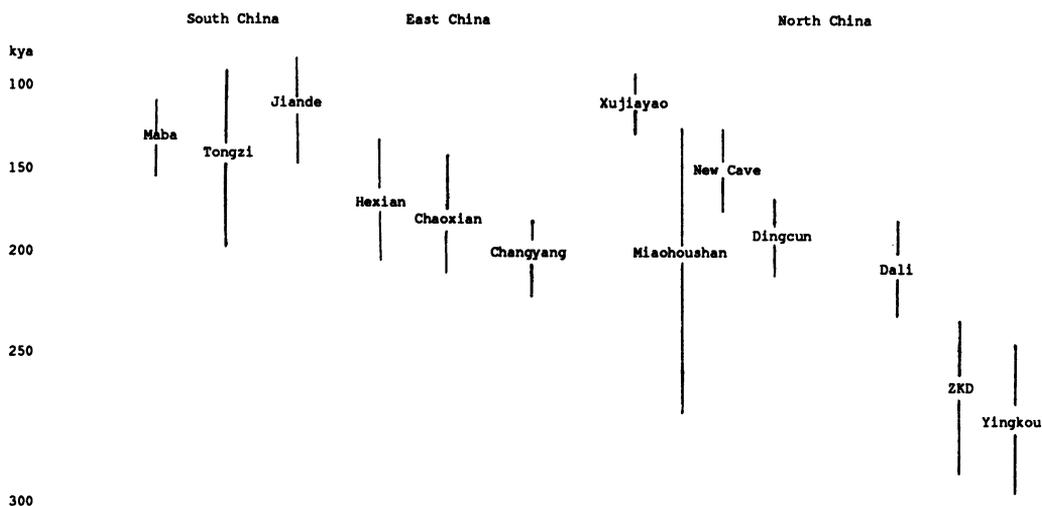
It appears that there is a considerable degree of continuity in the transition from "advanced *H. erectus*" to "archaic *H. sapiens*" in China. Individuals with more or less of the former or latter morphologies seem to have lived in close spatial and temporal proximity. Recent discoveries of material of an archaic "*sapiens*"-like morphology in China and the dating of these and previously known specimens tend to reinforce this interpretation (Table 6, Figure 6). Archaic material from Dali, Yingkou (Jinniushan) and Changyang has all been dated within a period of time during which advanced forms of *H. erectus* still appar-

Table 6. Late middle Pleistocene - early late Pleistocene hominid sites in China serialized by uranium series age determinations (after Chen and Yuan 1988).

Site name, province	Fossils	Age range (KYA)
Yingkou, Liaoning	Cranium and partial skeleton	230-300
*Zhoukoudian Locality 1 (Layers 1-3)	Calvaria (Skull 5)	220-290
Dali, Shaanxi	Cranium	180-230
Changyang, Hubei	Maxillary fragment and teeth	170-220
Dingcun, Shanxi	Teeth and juvenile parietal	160-210
Chaoxian, Anhui	Occipital, maxillary fragment and teeth	160-200
*Hexian, Anhui	Calvaria, cranial fragments, mandible fragment and teeth	150-190
Zhoukoudian New Cave	Tooth	135-175
Miaohoushan, Liaoning	Teeth, juvenile femoral diaphysis	130-290
Maba, Guangdong	Calvaria	119-140
Tongzi, Guizhou	Teeth	102-191
Xujiayao, Shanxi	Cranial bones, cranial fragments, mandible fragment and teeth	100-125
Jiande, Zhejiang	Teeth	90-117

\* advanced *H. erectus*, all others attributed to archaic *H. sapiens*.

Figure 6. Approximate ages of late middle Pleistocene - early late Pleistocene hominid bearing sites in China based on uranium series age determinations.



ently persisted. A picture is, therefore, emerging of a swift yet mosaic replacement of "*erectus*"-like morphologies by "archaic"-like morphologies commencing approximately 250,000 years ago in east Asia (cf. Zhang 1988). Whether "advanced-*erectus*" and "archaic-*sapiens*" individuals represent successive populations or merely polymorphs within a single evolving lineage is a question which will be resolved only through the recovery and analysis of more fossil material.

In another context it is clear that there was considerable evolutionary change within the *H. erectus* lineage in Asia even prior to the appearance of archaic *H. sapiens*. These changes include an increase in average cranial capacity, associated expansion and change in the proportions of the various cranial vault elements and a gracilization of the ectocranial buttressing system. With the advent of archaic *H. sapiens* in China a new set of derived "*sapiens*"-like craniofacial morphologies are laid over the earlier "*erectus*" pattern (Tables 7 and 8).

What were the factors mediating this change? One explanation may be the emplacement of exogenous characters into the indigenous population by gene flow from without (an admixture model) (cf. Wolpoff 1985, 1989; Wolpoff *et al.* 1984). Comparison of archaic *H. sapiens* specimens from China and elsewhere in the Old World (cf. Wu and Wu 1982; Wu, X. 1988) may help elucidate the extent of this postulated gene flow between Asia, Europe and Africa during the late middle Pleistocene. An increase in population movements during this period may well explain the impetus for the transformation, along more

modern lines, of regional populations in east Asia at approximately 250,000 YBP. This transformation is a major yet unheralded event in the annals of human evolution, predating the transition to fully modern *H. sapiens* in east Asia by perhaps 200,000 years. How the advent of "archaic *Homo sapiens*" in east Asia relates to the later occurrence of anatomically modern humans in this region of the world is another question that must now be addressed as we begin to unravel the evolutionary biology of east Asian hominids. It is more and more clear, however, that the argument for regional continuity throughout a considerable portion of the human career in east Asia has been reinforced by the discovery of the new hominid remains discussed above.

In conclusion, it is incontrovertible that the increasingly complete record of human evolution in east Asia during the late middle Pleistocene - early late Pleistocene transition will play a steadily more important role in attempts to understand the dynamics of human evolution in a regional context.

#### ACKNOWLEDGMENTS

I would like to express my respect and admiration for the community of paleoanthropologists and Paleolithic archeologists in China today who, under at times difficult circumstances, have persevered in their important work of documenting the physical and cultural legacy of human development in China. They deserve great credit for their important contributions to the study of

Table 7. Distribution of cranial features of the Hexian calvaria between "*erectus*"-like and "*sapiens*"-like morphologies.

Features	" <i>erectus</i> "-like	" <i>sapiens</i> "-like
1. Supraorbital construction	x	
2. Inion coincident with opisthocranium	x	
3. Well-expressed angular torus	x	
4. Temporal squamous margin arched		x
5. Sulcus of zygomatic process shallow and wide	x	
6. Broad digastric fossa (incisura mastoidea)	x	
7. Mammillary process of mastoid small and positioned below supramastoid crest	x	
8. Construction of external auditory meatus	x	
9. Construction of mandibular fossa and accessory structures	x	
10. Frontal profile and inclination	x	
11. Well-expressed frontal tubercle	x	
12. Supratoral sulcus reduced		x
13. Increased frontal breadth		x
14. Reduced post-orbital constriction		x
15. Reduced sagittal keeling (also lack of cruciate eminence at bregma and parasagittal depressions)		x
16. Greatest cranial breadth low	x	
17. Acute angle between nuchal and occipital planes of occiput	x	
18. Construction of occipital torus	x	
19. Orientation of tympanic plate to mid-sagittal plane	x	
20. Orientation of tympanic plate to petrous portion		x
21. Configuration of styloid region	x	
22. Absence of foramen caecum	x	
23. Ramification of middle meningeal artery	x	
24. Expansion of cerebellar fossae in relation to cerebral fossae		x
25. Distance between external occipital protuberance and internal occipital protuberance reduced		x
26. Stout pyramidal process		x
27. Horizontal curvature	x	
28. Parietal curvature	x	
29. Occipital curvature	x	
30. Sagittal curvature		x
31. Frontal curvature		x
32. Cranial capacity	x	

Table 8. Distribution of cranial features of Chaoxian specimens between "*erectus*"-like and "*sapiens*"-like morphologies.

Features	" <i>erectus</i> "-like	" <i>sapiens</i> "-like
1. Construction of occipital torus		x
2. Presence of supratoral fossa on occiput		x
3. Distance between internal occipital protuberance and external occipital protuberance reduced		x
4. Overall dimensions of occipital	x	
5. Occipital thickness		x
6. Nasoalveolar clivus convex	x	
7. Nasoalveolar clivus separated from floor of nasal aperture by short incline rather than "margo limitans"		x
8. Anterior nasal spine present		x
9. Incisive canal ascends vertically		x

human origins and evolution. I would also like to thank Prof. T.D. White, Mr. Monte McCrossin, Mr. Gary Richards and the editor for useful comments which helped improve the character of this manuscript.

## NOTES

<sup>1</sup> The term "advanced *Homo erectus*" is used to designate hominid specimens which evince to a considerable extent the total morphological pattern of *H. erectus* as defined by Weidenreich (1943) for the ZKD remains while at the same time possessing a limited number of characters trending in the direction of later *H. sapiens*. The term "archaic *Homo sapiens*" refers to specimens clearly derived in the direction of modern humans but whose total morphological pattern cannot be accommodated by inclusion within "anatomically modern *Homo sapiens*".

## REFERENCES CITED

- Chen, Tiemei, Sixun Yuan, Shijun Gao and Yanqiu Hu (1987) Uranium series dating of fossil bones from Hexian and Chaoxian fossil human sites. *Acta Anthropologica Sinica* 6(3): 249-254.
- Chen, Tiemei and Sixun Yuan (1988) Uranium series dating of bones and teeth from Chinese Palaeolithic sites. *Archaeometry* 30(1):59-76.
- Huang, Wanpo, Dusheng Fang and Yongxiang Ye (1981) Observations on the *Homo erectus* calvarium discovered at Longtandong, Hexian, Anhui. *Science Bulletin (Kexue Tongbao)* 26(24):1508-1510.
- Huang, Wanpo, Dusheng Fang and Yongxiang Ye (1982) Preliminary study on the fossil hominid skull and fauna from Hexian, Anhui. *Vertebrata Palasiatica* 20(3):248-256.
- Huang, Wanpo and Cixuan Huang (1985) Mammal fossils and sporo-pollen compositions at Hexian Man locality and their significance. In *Symposium of National Conference on Quaternary Glacier and Periglacial (Selection)*. Beijing: Kexue Chubanshe. Pp. 180-183.
- Jia, Lanpo (Chia, Lan-po) (1957) Notes on the human and some other mammalian remains from Changyang, Hupei. *Vertebrata Palasiatica* 1(3):247-258.
- Jia, Lanpo (Chia, Lan-po) and Qi Wei (1976) A Palaeolithic site at Hsu-chia-yao in Yangkao county, Shanxi province. *Acta Archaeologica Sinica* 2:97-114.
- Jia, Lanpo (Chia, Lan-po), Qi Wei and Chao-rong Li (1979) Report on the excavation of Hsuchiayao Man site in 1976. *Vertebrata Palasiatica* 17(4):277-293.
- Li, Chuankuai and Minzhen Zhou (1978) A correction of the age of the Xiaocaowan Formation and its mammalian fauna. *Acta Stratigraphica Sinica* 2(2):122-130.
- Liu, Jialong, Shuoan Zhen and Fupuan Jin (1982) Some new species of mammals in the middle Pleistocene from Chaoxian, Anhui, with a discussion of the transitional district of Huai River. *Memoirs of Beijing Natural History Museum* 19:1-26.
- Lu, Zun'e (1985) *The Excavation and Significance of the Jinniushan Site*. Peking University Archaeological Department Publication.
- Lu, Zun'e (1989) On the time of Jinniushan (Gold Ox Mount) man and the position of its evolution. *Liaohai Cultural Relics Journal* 1:44-55.
- Martin, Rudolf (1928) *Lehrbuch der Anthropologie*, 2nd edition. Jena: Gustav Fischer.
- Pei, Wenzhong (1957) The zoogeographical divisions of Quaternary mammalian faunas in China. *Vertebrata Palasiatica* 1(1):9-23.
- Qiu, Zhonglang, Yumin Gu, Yinyun Zhang and Senshui Zhang (1973) Newly discovered *Sinanthropus* remains and stone artifacts at Choukoutien. *Vertebrata Palasiatica* 11(2): 109-131.
- Tobias, Philip V. (1967) *Olduvai Gorge*, volume 2. Cambridge: Cambridge University Press.
- Weidenreich, Franz (1937) The dentition of *Sinanthropus pekinensis*: A comparative odontography of the hominids. *Palaeontologica Sinica*, New Series D 1:1-180.
- Weidenreich, Franz (1943) The skull of *Sinanthropus pekinensis*: A comparative study on a primitive hominid skull. *Palaeontologica Sinica*, New Series D 10:1-484.
- Wolpoff, M.H. (1985) Human evolution at the peripheries: The pattern at the eastern edge. In Philip V. Tobias (ed.), *Hominid Evolution Past, Present and Future*. New York: Alan R. Liss. Pp.355-366.
- Wolpoff, M.H. (1989) Multiregional evolution: The fossil alternative to Eden. In Paul Mellars and Chris Stringer (eds.), *The Human Revolution*. Princeton: Princeton University Press. Pp.62-108.
- Wolpoff, M.H., Xinzhi Wu and A.G. Thorne (1984) Modern *Homo sapiens* origins: A general theory of hominid evolution involving the fossil evidence from east Asia. In Fred H. Smith and Frank Spencer (eds.), *The Origins of Modern Humans: A World Survey of the*

- Fossil Evidence*. New York: Alan R. Liss. Pp.411-484.
- Wu, Maolin (1980) Human fossils discovered at Xujiayao site in 1977. *Vertebrata Palasiatica* 18(3):229-238.
- Wu, Maolin (1983) *Homo erectus* from Hexian, Anhui found in 1981. *Acta Anthropologica Sinica* 2(2):109-115.
- Wu, Maolin (1984) New discoveries of human fossils in Tongzi, Guizhou. *Acta Anthropologica Sinica* 3(3):195-201.
- Wu, Rukang (Woo, Ju-kang) (1988) The reconstruction of the fossil human skull from Jinniushan, Yingkou, Liaoning province and its main features. *Acta Anthropologica Sinica* 7(2):97-101.
- Wu, Rukang (Woo, Ju-kang) and Xingren Dong (1982) Preliminary study of *Homo erectus* remains from Hexian, Anhui. *Acta Anthropologica Sinica* 1(1):2-13.
- Wu, Rukang (Woo, Ju-kang) and Xingren Dong (1985) *Homo erectus* in China. In Rukang Wu and John W. Olsen (eds.), *Palaeoanthropology and Palaeolithic Archaeology in the People's Republic of China*. Orlando: Academic Press. Pp.79-89.
- Wu, Rukang (Woo, Ju-kang) and Ruce Peng (1959) Fossil human skull of early Paleolithic stage found at Mapa, Shaokuan, Kwangtung province. *Palaeovertebrata et Palaeoanthropologica* 4(4):159-164.
- Wu, Rukang (Woo, Ju-kang) and Xinzhi Wu (1982) Comparison of Tautavel man with *Homo erectus* and early *Homo sapiens* in China. In *L'Homme erectus et la Place de l'Homme de Tautavel Parmi les Hominides Fossiles*. Congres International de Paleontologie Humaine 1er Congres, Colloque International du Centre National de Recherche Scientifique. Pp.605-616.
- Wu, Xinzhi (1981) The well-preserved cranium of an early *Homo sapiens* from Dali, Shaanxi. *Scientia Sinica* 2:200-206.
- Wu, Xinzhi (1988) Comparative study of early *Homo sapiens* from China and Europe. *Acta Anthropologica Sinica* 7(4):287-293.
- Wu, Xinzhi and Maolin Wu (1985) Early *Homo sapiens* in China. In Rukang Wu and John W. Olsen (eds.), *Palaeoanthropology and Palaeolithic Archaeology in the People's Republic of China*. Orlando: Academic Press. Pp.91-106.
- Xu, Chunhua, Yinyun Zhang, Caidi Chen and Dusheng Fang (1984) Human occipital bone and mammalian fossils from Chaoxian, Anhui. *Acta Anthropologica Sinica* 3(3):202-209.
- Xu, Chunhua, Yinyun Zhang and Dusheng Fang (1986a) Human fossil newly discovered at Chaoxian, Anhui. *Acta Anthropologica Sinica* 5(4):305-310.
- Xu, Chunhua, Yinyun Zhang and Dusheng Fang (1986b) New finds from the human fossil localities at Chaoxian, Anhui. *Prehistory (Shiqian Yanjiu)* 3-4:41-45.
- Xu, Qinqi and Yuzhu You (1984) Hexian fauna: Correlation with deep-sea sediments. *Acta Anthropologica Sinica* 3(1):62-66.
- Zhang, Yinyun (1986) The dental remains of early *Homo sapiens* found in China. *Acta Anthropologica Sinica* 5(2):103-113.
- Zhang, Yinyun (1988) The problems caused by dating on the *Homo erectus* and early *Homo sapiens* in China. In The Guangdong Provincial Museum and the Museum of Qujiang County (eds.), *Treatises in Commemoration of the 30th Anniversary of the Discovery of Maba Human Cranium*. Beijing: Cultural Relics Publishing House. Pp.127-132.
- Zheng, Longting (1987) Inquiry into the paleoanthropology and paleoecology of Anhui. *Prehistory (Shiqian Yanjiu)* 2:9-14.
- Zheng, Shaohua (1982) Character and significance of Hexian man micro-mammalian fauna. *Science Bulletin (Kexue Tongbao)* 11:683-685.

