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Late Pleistocene human skull from Jingchuan, Gansu Province

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Jingchuan human fossil, found in Gansu Province in 1976, was given a preliminary report in 1984, but questions remained concerning the age and character of the fossil. We conducted field investigation at Jingchuan in May of 2006 to examine the stratum yielding the human fossil and to obtain sediment samples for optically stimulated luminescence (OSL) dating. Three samples collected from different stratigraphic levels at the fossil locality yielded OSL dates of 15, 48 and 7.9 thousand years ago (ka), respectively. Taking stratum study, mammalian fossils and paleoliths into consideration, the OLS date of 15–48 ka appears to be more close to the true age of Jingchuan cranium. There is no distinct difference between the fossil cranium and modern craniums in terms of the traits analyzed, so the relatively modern traits of the Jingchuan cranium do not contradict with its age. Principal components analysis shows that the Jingchuan cranium may be somewhat primitive.

Jingchuan, cranium, human fossil, Late Pleistocene, traits

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A human cranium fossil discussed in the present article was found from Jingchuan County (Figure 1) of Gansu Province, North China in 1976 and given a preliminary report in 1984 [1]. The fossil was unearthed *in situ* from dust-color sandy clay (Figure 2). Based on the associated Paleolithic artifacts and mammalian fossils, the previous report suggested that the age of human fossil belonged to the Late Pleistocene, comparable to the age of Salawusu and Shiyu. However, the further study of Jingchuan cranium remained to do, not only in chronology but in anthropology. In order to push the work forward, we arranged a short field investigation at Jingchuan in May of 2006 to study the stratum yielding the human fossil and to obtain sediment samples for OSL dating in order to better constrain the age of the human fossil.

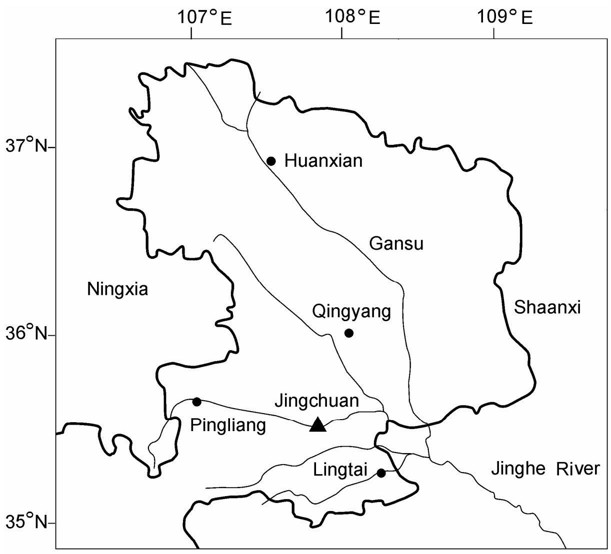

Figure 1 Jingchuan position in China.

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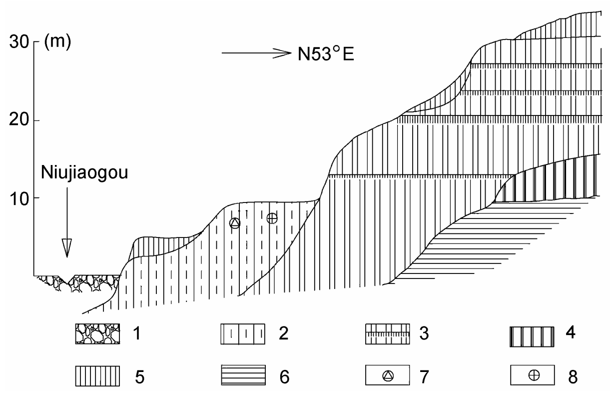

Figure 2 Section of Jingchuan site by Liu et al., 1984 [1]. 1, Artificial deposit; 2, sandy clay with dust-color; 3, reddish clay; 4, red clay; 5, Malan loess; 6, red sandstone; 7, stone artifacts; 8, human fossil.

1 Stratum and dating

1.1 Stratum

Jingchuan County crossed by the Jinghe River is one of the most important cradles of Chinese paleolithic archaeology. The first paleoliths reported were discovered from loess *in situ* here by the Father Emile Licent from France in 1920. Then more paleolithic sites such as Yaotougou, Loufangzi, Jiangjiawan, Niujiaogou, and Dalingshang have been found in this valley since the 1950s [2,3]. The stratum of Niujiaogou site can be divided into two parts: Cretaceous sandstone and Quaternary loess.

The stratum at the Niujiaogou locality consists of sandy clay with dust-color about 10 m in thickness according to the previous report [1] (Figure 2). However, it is not as thick as before because the stratum was partly disturbed for planting about 30 years ago.

Only one terrace can be seen in the Jinghe River valley near the site (Figure 3). It consists of gravels and an overlying sandy layer which is covered with the Malan loess. The first paleosol (S1) with a small single calcareous belt can be seen clearly in the Malan loess. Bedrock lies below the terrace. A small gully named Niujiaogou lies between the terrace and the locality yielding human fossil. Geomorphologically, the fossil locality can be considered as the slope of terrace though the connection of them is cut and eroded out wholly.

1.2 OSL dating

Three samples from the human fossil site were collected for OSL dating. Sample 1 and sample 2 were from north (inner) wall of the site. Sample 3, higher than sample 2, was from a tunnel we dug extending from sample 2. Jingchuan human cranium is unearthed between sample 1 and sample 2 concerning the vertical position. Dating results are as follows.

Sample 1 (NJG-1): 70 cm below the top, 15 ka, OSL.

Sample 2 (NJG-2): 255 cm below the top, the lowest sample, 48 ka, OSL.

Sample 3 (NJG-3): from the tunnel we dug extending from sample 2, 7.9 ka, OSL.

2 Human fossil studies

We conducted a comprehensive study about Jingchuan human fossil, including general morphology, thickness, cranial capacity, endocast, providing more information about this cranium. Jingchuan cranium is from Jingchuan County Museum. We chose some modern and fossil craniums (models) for comparison, including Liujiang, Ziyang, Wushan, Upper Cave 101, Upper Cave 102, Upper Cave 103 and 130 Chinese modern craniums, all these were from Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences.

After analyzing some related papers on human cranium [4–6], we chose 7 nonmetric traits for comparison, and 6 metric traits for principal components analysis. Endocast and capacity of the cranium were also analyzed.

2.1 Surface morphology of Jingchuan cranium

Yellow-brown, Jingchuan human fossil could be conglutinated to an incomplete cranium (Figure 4). Coronal suture, lambdoid suture, sagittal suture and parietotemporal suture are all quite clear except for a small section of sagittal suture between two parietal foramen. This cranium may be older than 20 years according to bone suture study [7–9].

Superior view (Figure 4(b)), Jingchuan cranium is oval and right parietal tuber is obvious. There is a bit sagittal keeling before parietal foramen. Right lateral view (Figure 4(a)): mastoid is quite big, and angular torus does not exist. The upper edge of squama temporalis looks like an arc. Supramastoid crest is obvious. Left lateral view (Figure 4(c)): lateral side of the parietal bone is nearly vertical. Posterior view (Figure 4(d)): superior nucha line, suprema nucha line is obvious. There is occipital torus, but not prominent. External occipital protuberance is obvious. Occipital and nuchale planum joins like arc, not right-angle. The surface of occipital is rough and the external occipital crest is obvious. Inner surface side: there is sigmoid sulcus at the mastoid angle. The branches of middle meningeal artery are all as thin as modern human.

Table 1 shows the comparison of 7 nonmetric traits among Jingchuan cranium, other human fossils in Late Pleistocene and modern craniums. We can come to the conclusion that there is no distinct difference between these fossil craniums and modern ones as to these traits.

2.2 Thickness

Jingchuan cranium is thin. Outer table, inner table, and diploë are all obvious. It is 4.58 mm thick near parietal tuber,

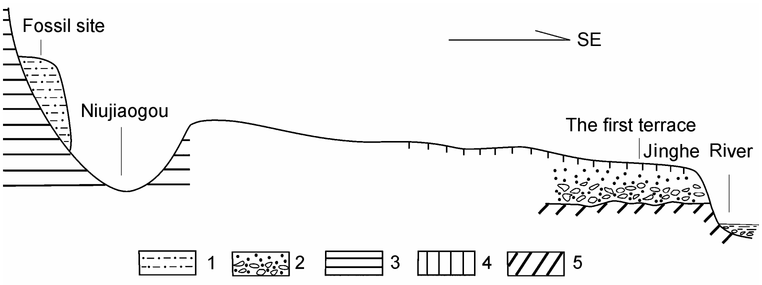

Figure 3 Signal section of Jingchuan site. 1, Sandy clay; 2, gravels; 3, loess-paleosol system; 4, Malan loess; 5, Cretaceous sandstone.

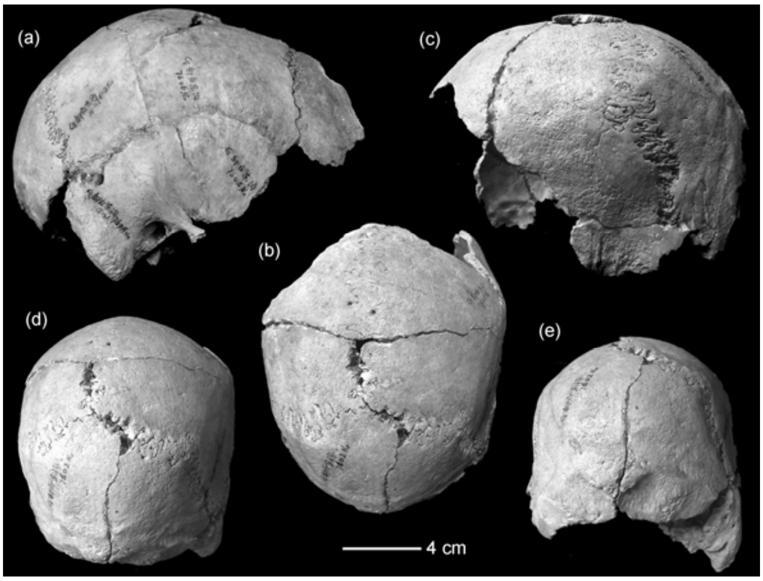

Figure 4 Different views of Jingchuan cranium (a) right lateral view; (b) superior view; (c) left lateral view; (d), (e) posterior view.

with outer table 1.72 mm, diploë 1.29 mm and inner table 1.57 mm, respectively. In modern cranium, it is 2.5–6.3 mm thick here, and outer table is thicker than inner table [10]. Jingchuan cranium is thinner than Wushan cranium (7.0 mm) [11] at parietal tuber, falling within variation of modern cranium.

2.3 Principal components analysis of metric traits

Cranial breadth, auricular height, temporal height, lambda-asterion of Jingchuan is very big among the fossil craniums compared here, and is bigger than the average of modern craniums, but within their variation (Table 2). In order to compare the cranium from a whole scale, we measured 45 modern craniums and made principal components analysis (PCA) on 6 metric-traits (cranial breadth, auricular height, temporal height parietal chord, occipital breadth and lambda-asterion). According to the scatter plot of the first 2 components (Figure 5), we can easily see that modern craniums are centralized in distribution, but fossil craniums are quite dispersive. Though the percent of variance that PC1 and PC2 explain is not high, the PCA does show these differences obviously. Jingchuan cranium is not located in the main distributing area of modern ones.

2.4 Cranial capacity

We calculated cranial capacity using two formulas as follows.

Formula 1 [15]: Cranial capacity = 20.64963 × auricular height–973.261=1504 mL;

Formula 2 [16]: Cranial capacity =31.53 × (lambda-asterion) –1324=1545 mL.

We think the average 1524 mL may represent Jingchuan cranial capacity, which is the biggest among fossil craniums compared here (Table 2).

2.5 Endocast and brain morphology

Endocast reflects the inner surface of a cranium. Though endocast does not represent the true structure of brain, it indeed provides critical information about human brain evolution for it contains surface traits of brain [17]. Figure 6 shows the endocast of Jingchuan cranium. Middle meningeal artery and venous sinus are quite clear. Middle meningeal artery starts from front side of temporal lobe's base,

Table 1 Comparison of 7 nonmetric traits among Jingchuan cranium, other human fossils in Late Pleistocene and modern craniums

	Sagittal keeling	Angular torus	Occipital torus	External occipital crest	External occipital protuberance	Supra-mastoid crest	Mastoid process
Jingchuan	slender	slender	middle	obvious	obvious	middle	big
Wushan	slender	middle	obvious	middle	obvious	–	–
Liujiang	slender	middle	middle	obvious	middle	obvious	small
Ziyang	obvious	middle	middle	middle	middle	obvious	small
Upper Cave 101	middle	middle	obvious	obvious	middle	obvious	big
Upper Cave 102	middle	middle	slender	obvious	slender	slender	big
Upper Cave 103	obvious	slender	middle	obvious	middle	obvious	small
Modern, *N*=130							
Slender	24.7%	39.4%	8.9%	0.1%	2.3%	0.1%	small 14.9% big 88.1%
Middle	45.7%	50.8%	38.8%	16.0%	20.1%	16.0%	
Obvious	29.6%	9.8%	52.3%	83.9%	77.6%	83.9%	

"–" shows parts cannot be seen for bad preservation.

Table 2 Comparison of metric traits among Jingchuan cranium, other human fossils in Late Pleistocene and modern craniums (mm)

	Cranial breadth	Auricular height	Parietal chord	Temporal height R	Occipital breadth	Lambda-asterion R	Cranial capacity (mL)
Jingchuan	143.0	120.0	115.5	52.5	107.0	91.0	1524
Liujiang	143.0	115.0	118.8	45.5	109.0	86.5	1480 [12]
Ziyang	131.0	112.0	108.0	33.5	100.0	84.5	1156 [13]
Upper Cave 101	145.0	115.0	122.5	49.0	123.0	76.0	1500 [14]
Upper Cave 102	136.0	121.0	122.1	42.0	107.5	91.0	1380 [14]
Upper Cave 103	132.2	119.0	122.0	–	106.4	79.5 L	1300 [14]
Modern a), Mean	138	111.8	111.3	47.3	105.9	83.8	1360
Range (*N*=45)	129–147	105–119	102–121.2	36.5–55.8	94.5–116.5	66.5–94	1135–1595

a) *N*=39. "L"and "R" represent left and right respectively.

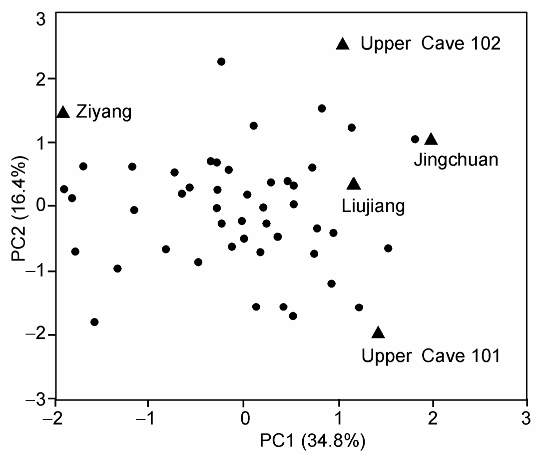

Figure 5 Six-variable PCA of Jingchuan, Late Pleistocene fossils and modern craniums (male). ● Modern craniums.

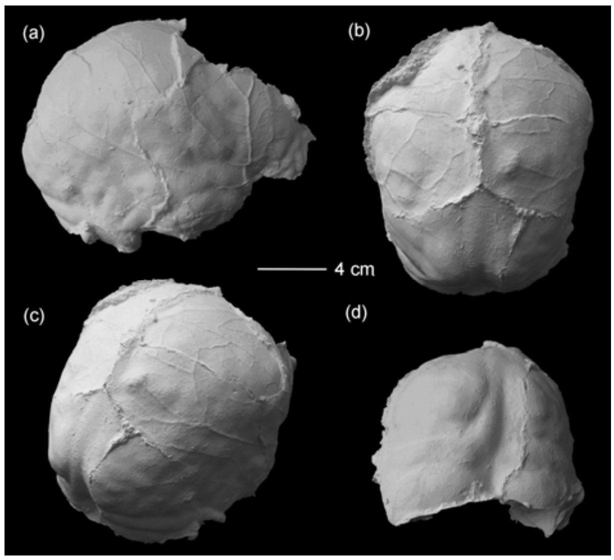

Figure 6 Endocast of Jingchuan cranium.

stretching along inner side of temporal lobe, and divides into 2 branches. The front branch covers anterior 2/3 parts of parietal bone and the back branch extends to a smaller area, posterior 1/3 parts of parietal bone (Figure 6(a)). The brain of Jingchuan cranium is oval (Figure 6(b)) and its parietal lobe is plump (Figure 6(c)). Left and right occipital lobe is not asymmetric, and the right occipital lobe projects back more remarkably than the left (Figure 6(b), (c)). Superior view: venous sinus leans to left side (Figure 6(d)). All these show that Jingchuan brain is similar to modern ones [17,18].

The endocast is 126.1 mm wide, and ast-ast is 98.2 mm. The vertex of endocast to the lowest point of temporal lobe is 132.1 mm. All these three metric traits are within variation of modern human, which are 117.0–137.3 mm, 91.5 –107.5 mm and 110.9–133.8 mm, respectively.

3 Discussion

3.1 The age of Jingchuan human cranium

The accumulation layer yielded Jingchuan cranium is made up of dust-color clay, with mammal fossils and paleolith in the same layer according to the previous study. The mammal fossils include *Equus* sp., *Cervus* sp., *Coelodonta antiquitatis* (?), Bovidae and *Myospalax fontanieri*. These mammals belong to Pleistocene fossil fauna in North China. Paleoliths unearthed include cores (12), flakes (39) and retouched tools (37), and some of these paleoliths are from Hezhigou site, not far from Niujiaogou. These paleoliths are mainly made of quartzite and vein quartz. Core reduction includes percussion with hard hammer and bipolar flaking. The stone tools include sidescraper, points, spheroid and chopper [1].

Sample 3 (NJG-3), belonging to Holocene, does not accord with the characteristic of mammal fossils, paleolith and physiognomy of stratum. Sample 3 may represent Niujiaogou's age only if we find some evidence that the accumulation layer containing fossils is not natural, but from Neolithic site. The accumulation layer, however, is pure, and mammal fossils and stone tools show traits of Pleistocene, different from that of Holocene, the stratum of which often contains polished stone tools, pottery sherds and modern mammal bones. Taking the above into consideration, we believe sample 3 does not represent Jingchuan cranium's age.

Sample 1 and sample 2 are within the age of Malan loess, and consistent with the characteristics of the mammalian fossils and stone tools found at the site. Meanwhile, the fossil site probably belongs to the first terrace as analyzed before, giving more evidence to our opinion of Jingchuan cranium's age here. Therefore, we may regard 15–48 ka as the cranium's age at present. In order to make sure the age, we hold the opinion that stratum study is of importance, and searching for proper material in the future at this site for dating using radio-carbon isotope makes far-reaching sense.

3.2 Comparison among Jingchuan cranium, modern craniums and fossil craniums in Pleistocene

Seven nonmetric traits of Jingchuan are similar to modern craniums, and metric traits are within the variation of modern ones, though bigger than the average. The thickness, cranial capacity and endocast of Jingchuan are all similar to modern craniums or within their variation. On average, cranial capacity is 1450 mL in male, and 1300 mL in female [7]. Jingchuan capacity is calculated to 1524 mL according to the formula, suggesting it is possibly male [19].

The metric traits of Jingchuan are within the variation of fossil craniums in Pleistocene except for external occipital protuberance, which is obvious in Jingchuan, different from other fossils. As to metric traits comparison, the auricular height, temporal height and lambda-asterion of Jingchuan are quite big, though parietal chord is relatively small. Cranial capacity of Jingchuan is bigger than any other fossil craniums. But meanwhile, the figure may not reflect Jingchuan cranial capacity exactly, for it is calculated according to several traits.

PCA shows that modern craniums are centralized in distribution, but fossil craniums are quite dispersive. Jingchuan cranium is not located in the main distributing area of modern ones. These may mean that human craniums in Pleistocene have a larger variation, and Jingchuan cranium is somewhat primitive.

3.3 Peculiarity of Jingchuan morphology

The morphology of Late Pleistocene craniums attracts much attention of paleoanthropologists. It was assumed that their morphology was quite similar to modern human beings, and particular race traits may form in this period or earlier [20–22]. In East Asia, Upper Cave and Liujiang cranium represents Archaic Mongoloids or called primitive Mongoloids, fossil craniums in Late Pleistocene represent mosaic of primitive and modern traits [20,23–25]. In recent years, some scholars put forward the idea that human have been evolving since Late Pleistocene [26–29], and craniums in Late Pleistocene are bigger than in Holocene [26]. Some traits of Neolithic craniums are intervenient of fossil craniums and modern ones [30]. Traits of races may form in Late Pleistocene or in Holocene [28,29].

Many traits of Jingchuan cranium, such as sagittal keeling, angular torus, occipital torus, external occipital crest, external occipital protuberance, mastoid process, and supramastoid crest are similar to modern human. In our opinion, this does not contradict with its early age, because there is no distinct difference between craniums in Late Pleistocene and modern ones as to these traits. Those traits of Liujiang are also similar to modern ones, but it is older than 67 ka. Liu et al. [31] found that most traits of Liujiang are within the variation of modern Chinese, leaving few traits such as low orbit relatively primitive. Whether Jingchuan's face is primitive or not remains unknown because of bad preservation.

4 Conclusion

Taking stratum study, mammal fossils and paleolith into consideration, we believe that 15–48 ka may reflect the true age of Jingchuan cranium. There is no distinct difference between the Jingchuan fossil cranium and modern human craniums in the traits we analyzed, so the relative modern traits of Jingchuan cranium do not contradict with its age. PCA shows that Jingchuan cranium is not located in the main distributing area of modern ones, which may indicate that it is somewhat primitive. Jingchuan human fossil provides new evidence for the study of human origin and migration in China and East Asia.

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