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Huanglong Cave, a new late Pleistocene hominid site in Hubei Province, China

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Abstract For the past 20 years the modern human origins debate has received a significant amount of attention in paleoanthropological research. Primarily supported by the evidence of earlier dates of anatomically modern human fossils and genetic studies, the “Out of Africa” hypothesis is based on the belief that the ancestor of all modern humans, including modern Chinese, came from Africa. The opposite hypothesis “Mutiregional evolution” proposes that continuous evolution occurred on a regional scale, for which human paleontology offers strong support. However, due to the paucity of hominid fossils in China between 100 and 50 ka, support to the latter hypothesis is currently weak. This is a report here of five human fossil teeth, and associated stone tools and mammal fossils from a newly discovered cave site, Huanglong Cave, located in Yunxi County, Hubei Province, China. Preliminary studies indicate: (1) the morphological features of the human fossils resemble those of late Pleistocene human fossils from China; (2) the stone tools display patterns of both the southern and northern Paleolithic cultures of China; (3) the mammal fossils represent the “Ailuropoda-Stegodon” faunal unit which lived in southern China throughout the Pleistocene. ESR and U-series dating on animal teeth and a stalagmite derived from the same layer as the human teeth indicate two possible ages: 103±1.6 ka and 44±12. 5 ka. In addition to other evidence presented here, it is believed that hominid occupation of the cave was likely around 100 ka. If this age is further substantiated, Huanglong Cave will be the first late Pleistocene hominid fossil site in China where anatomically modern humans lived about 100 ka. The human fossils and other related materials from Huanglong Cave will provide important information for research on the origin of modern Chinese.

Keywords: human fossil, modern human origin, Huanglong Cave, late Pleistocene.

For the past two decades, the modern human origins debate has received significant interest from both the scientific community and the public. The two hypotheses “Out of Africa” and “Mutiregional evolution” are focuses of this debate[1−3]. In particular, the discovery of hominid fossils, artifacts, and paleontological materials in the same context dated ca. 100 ka is important to address the modern human origins debate. For instance, anatomically modern human fossils dated 100 ka or earlier found in Africa have been used as the key evidence to support the “Out of Africa” hypothesis[3−5]. The paleoanthropological record from China and the most part of East Asia is important to this debate[4]. However, human fossil evidence from East Asia that dated around 100 ka is very sparse. The majority of the late Pleistocene human fossils found in China are younger than 50 ka. Even though some fossils are claimed to be older than this age, the ages are not widely accepted or are still being debated[6−8]. We present here new data to support reconstruction of human paleontology and their lifeways from this poorly known time period (100 ka) in China. In May, 2004 while a cultural relic survey was conducted as part of local highway construction, some mammal fossils were discovered in Huanglong Cave, located in Yunxi County, Hubei Province, China. Two small-scale excavations conducted from June to August and November to December 2004, resulted in the discovery of five human teeth, twenty-two stone artifacts, and about 1700 mammal fossils.

1 Geology and stratigraphy

Huanglong Cave is located in Lishi Village, Yunxi County, Hubei Province (110°13′04.3″E， 33°07′62.8″N; altitude 601 m) (Fig. 1). The cave is formed in the Middle Cambrian Yuejiaping Formation limestone. This formation is represented by a black middle to thin layer of bedded muddy limestone and carbonaceous muddy limestone. Huanglong Cave belongs to the east part of the drape of the southern Qinling Mountains area. The landforms of the area are characterized by

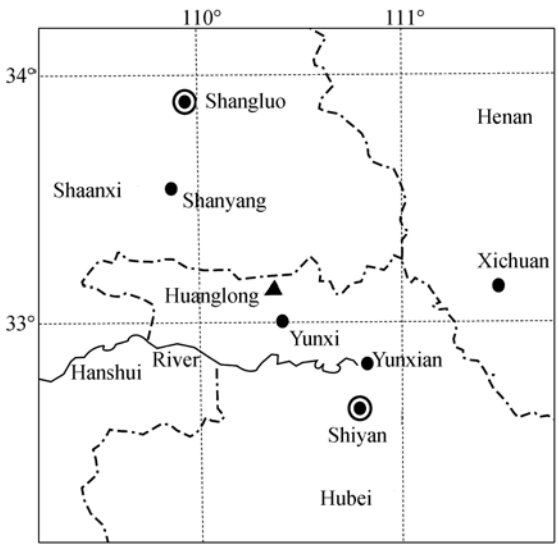


Fig. 1. The location of the Huanglong Cave site.

middle- to low-altitude mountains and basins, with steep hillsides and gullies. The axis of Huanglong Cave is northeast-southwest with its entrance facing to the northeast. The width of the entrance is 27.8 m and the height is 11 m. The preliminary survey reveals that the cave length is about 400 m (the end is not reached) and the width is 11—117 m. About 50 m in front of the Huanglong Cave is a branch of Hanjiang River named Dashui River. The entrance of Huanglong Cave is about 7.8 m above the current river level. Between the entrance and the Dashui River, there is narrow flat ground. In Huanglong Cave there are thick primary deposits, with a capping flowstone layer. The thickness of the Huanglong Cave deposits increases gradually from the entrance interiorly. From top to bottom, five stratigraphic layers were identified (Fig. 2):

(1) Capping flowstone layer (2—28 cm): Milk-white or brown-yellow layer widely developed in the cave and most of the layer, with pure and dense structure.

(2) Silt clay-sandy gravel layer (1—201 cm): Silty clay and sandy gravel are in the same layer but in different phrase. The deposit of the layer near the entrance mainly comprises gravels bedded in a clay matrix. The gravels decrease in both density and size gradually when moving toward the interior of the cave. In the deeper areas of the cave the deposit becomes silty clay.

(3) Red silt clay layer (58—101 cm): Two thin flowstone layers developed with a break. Below the flowstone layers there are isolated stalagmites which have no direct connection with the flowstone layer.

(4) Mantle limestone layer (41—66 cm): Loose layer mainly composed of mantled limestone breccia and clay matrix residue.

(5) Brown-red silt clay layer (18—26 cm): It has a dense structure without embodied materials.

～～～Erosion surface～～～

Underlying beds: Matrix (Cambrian limestone)

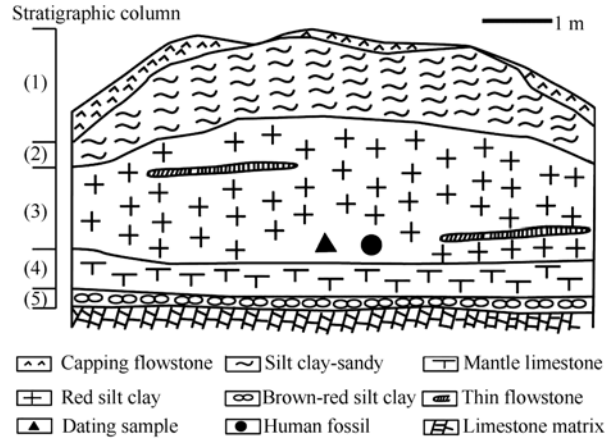


Fig. 2. Stratigraphic context of the Huanglong Cave deposits.

The human teeth, stone artifacts and most of the animal fossils are derived from the red silt clay layer. The human teeth and stone artifacts were found at the bottom of the layer, in association with the stalagmites. No evidence of transportation, sorting or redeposition of the paleontological materials can be identified, suggesting primary deposition.

2 Human fossils

Human fossils from Huanglong Cave are represented by five teeth, which are left M_2 or M_3, right M_2, left upper canine (UC), right I_1 or I_2, and left M^3 (Fig. 3). All the teeth are white or yellow-brown showing varying degrees of fossilization. Except for the left M^3 which displays light occlusal wear, probably representing a young individual, all of the other teeth were heavily worn and likely belonged to middle aged adults. Preliminary observation indicates that the left lower incisor is shovel-shaped, but has no basal tubercle and finger projections, which are usually observed on the *Homo erectus* incisors. When compared with the tooth measurements of Chinese human fossils, the Huanglong Cave human teeth are smaller than those of Zhoukoudian *Homo erectus*, and in the range of modern *Homo sapiens* (Table 1). Accordingly, the Huanglong Cave human fossils should be classified as modern *Homo sapiens*. We propose they are referred as "Yunxi Man".

3 Stone artifacts

Twenty-two lithic artifacts were unearthed, including

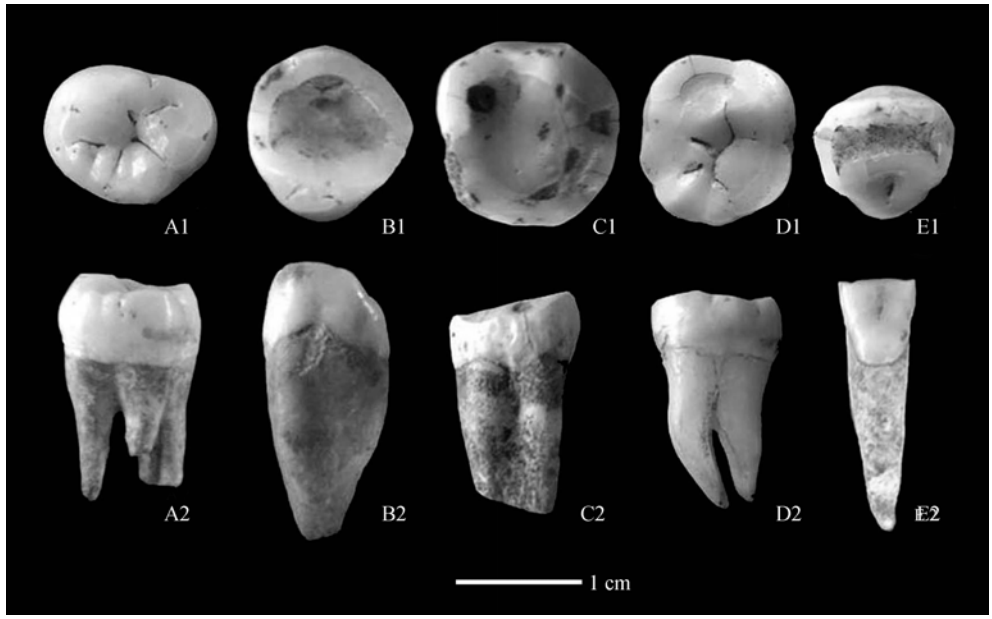


Fig. 3. The human teeth found in Huanglong Cave. The specimen numbers are given in the brackets. A, T29③:62; B, T28③:56; C, T32③S:1; D, T34③:56; E, T29③:59.

Table 1 Measurements of the human teeth found in Huanglong Cave (mm)

Specimen No.	T34③:56	T32③S:1	T28③:56	T29③:59	T29③:62
Tooth type	left M_2 or M_3	right M_2	left UC	right I_1 or I_2	left M^3
BL diameter	10.0	11.0	9.8	7.0	8.5
MD diameter	10.5	11.0	8.2	6.8	11.2

hammerstones, cores, flakes, modified tools, and chunks and debitage. Stone tools with secondary retouch include scrapers, cores, picks, and awls. Five scrapers, made of quartz and flint (Fig. 4 (b)), are identified from the assemblage which represents the greatest percentage of stone tool types. Three picks were identified, which were made of rough siltstone, volcanic rock and metamorphic rock. The blanks for the picks are pebbles. One finished pick has a thick and blunt point at one end, which may have been used for digging. Two of the three picks exhibit deliberate and standardized modification: a pointed end was carefully produced from the original curved surface of the pebble and the other end was purposely blunted, making it comfortable to be held (Fig. 4 (a), (d)). One stone awl, made of vein quartz, was found. It has two sharp edges that meet each other to form a short and blunt point edge (Fig. 4(c)). The one chopper-chopping tool, made of jasper, has retouch and usewear can be identified on several edges. In addition, a stone hammer stone has a depressed region with small pits. We believe the depression developed over time through consistent breaking of nuts. Analysis of the flakes reveals that even though they were not further modified, some of them display evidence of usewear.

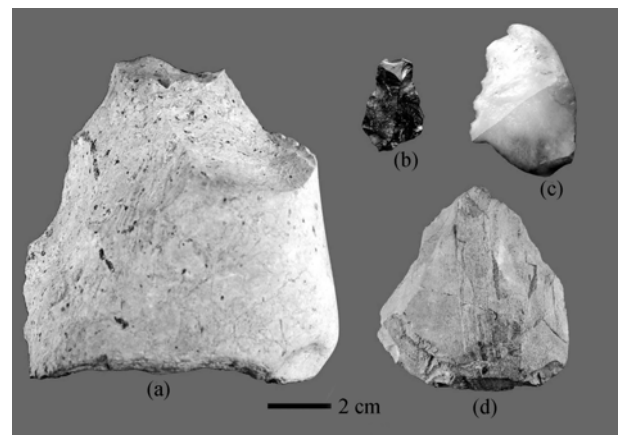


Fig. 4. Some of the stone tools found in Huanglong Cave (the specimen numbers are given in the brackets). (a) Pick (T19③:52); (b) Scraper (T20③:57); (c) Awl (T63③:51); (d) Pick (T36③:51).

At present, the number of stone artifacts found in Huanglong Cave is insufficient to reconstruct the whole picture of Chinese human manufacturing utilization. A preliminary synopsis can be drawn however. The

Huanglong Cave humans used both direct hammer stone percussion and bipolar flaking to produce flakes and other stone tools. The former technique was widely used throughout the Paleolithic period of China, and the latter one was mainly found in Paleolithic sites from North China. Most of the stone tools found in Huanglong Cave were made expediently on locally available pebbles, clearly exhibiting characteristics of the Paleolithic pebble industry of South China. However, the presence of delicately modified scrapers made of small flakes and the application of the bipolar technique suggests the assemblage displays cultural features of North China as well. This mixed character suggests a transitional development between southern and northern China during the Upper Pleistocene. The existence of hammer stone, cores, flakes and debiage further suggests that stone knapping activities occurred inside the cave. Cut marks identified on some associated animal fossils indicate humans used the stone tools to process animal carcasses. All these findings prove that the Huanglong Cave is a place for prehistory humans to live and conduct some related activities. It is a cave home for humans.

4 Mammal fossils

About 1700 mammal fossils have been found in Huanglong Cave. Our preliminary identifications place these fossils into 11 orders and 50 species:

(1) Primates Linnaeus, 1758
Homo sapiens
Macaca robustus Young
Macaca mulatta Zimmermann
Trachypithecus phayrei

(2) Decapoda
Somanniathelphusa zhongshiensis Dai

(3) Anura
Rana sp.

(4) Insectivora Bowdich, 1821
Anourosorex squamipes
Erinaceus sp.

(5) Chiroptera lumenbach, 1979
Hipposideros pratti
Hipposideros armiger
Rhinolophus ferrumequinum
Rhinolophus pearsoni Horsfield
Rhinolophus macrotis
Megaderm lyra Geoffroy
Myotis sp.
Murina leucogaster

(6) Lagomorpha Brandt, 1855
Ochotona sp.

(7) Rodentia Bowdich, 1821
Caryomys ineg
Cricetinus varians
Petaurista xanthotis
Petaurista alborufus
Callosciurus eryfhraeus
Sciurotamias forresti
Belomys pearsoni
Hystrix subcristata
Rhizomys sinensis

(8) Carnivora Bowdich, 1821
Neofelis nebulosa
Crocuta ultima
Cuon alpinus
Canis lupus
Arctonyx collaris
Paguma larvata
Ailuropoda melanoleuca baconi
Ursus thibetanus
Ursus thibetanus kokeni
Panthera tigris
Felis sp.

(9) Proboscidea Illiger, 1811
Stegodon orientalis

(10) Perissodactyla Owen,1848
Rhinoceros sinensis
Dicerorhinus kirchbergensis
Megatapirus augustus

(11) Artiodactyla Owen, 1848
Sus scrofa
Moschus moschiferus
Muntiacus muntjak
Hydropotes inermis
Rusa unicolor
Cervus nippon
Naemorhedus goral
Gazella sp.
Capricornis sumatraensis
Bubalus bubalus

The Huanglong Cave faunae are a mixed assemblage comprising extinct (e.g., *Macaca robustus*, *Cricetinus varians*, *Crocuta ultima*, *Ailuropoda melanoleuca baconi*, *Ursus thibetanus kokeni*, *Stegodon orientalis*, *Rhinoceros sinensis*, *Megatapirus augustus*), and extant species (e. g., *Neofelis nebulosa*, *Cuon alpinus*, *Canis lupus*, *Arctonyx collaris*, *Paguma larvata*, *Sus scrofa*, *Rusa unicolor* and *Cervus nippon*). Some

mammal fossils discovered from Huanglong Cave are displayed in Fig. 5. The Huanglong Cave assemblage is representative of the oriental fauna typical of the middle and late Pleistocene of South China. The faunal composition indicates both tropical and sub-tropical forest environments. For example, *Neofelis nebulosa* is the representative of tree-living animals in sub-tropical forests[9], and *Belomys pearsoni* lives in the ever-green broad-leaved forest[10]. There are also many fossils of *Rhinolophus*, a typical forest animal living in broad forest environments[11]. The Huanglong Cave faunae also include animals that typically exist in the Qinling Mountains region. These animals include *Capricornis sumatraensis*, *Naemorhedus goral*[12], and *Caryomys ineg*. The faunal composition reflects its geographic location in the southern part of the Qinling Mountains, and its border position separating the South and North China biazones.

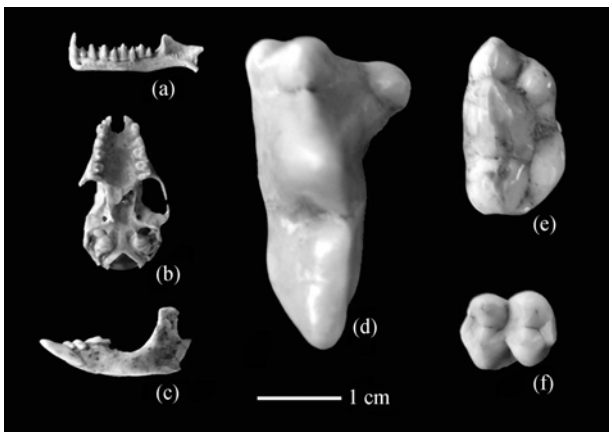


Fig. 5. Some mammal fossils from Huanglong Cave. The specimen numbers are given in the brackets. (a) Mandible of *Hipposideros pratt* (T19③:63); (b) skull of *Murina leucogaster* (T20③:3); (c) mandible of *Anourosorex squamipes*(T20③:4); (d) premolar of *Panthera tigris* (T59③:5); (e) premolar of *Ailuropoda melanoleuca baconi*(T58③:15); (f) left second deciduous molar of *Macaca robustus* (T25③:52).

5 Dating

Dating for the layer yielding the hominid fossils in Huanglong Cave was carried out in three different laboratories.

(1) Uranium-series dating-rhinoceros tooth. Specimen derived from the same layer as the human fossils was analyzed by U-series at the Laboratory of the Institute of Karst Geology, Chinese Academy of Geological Sciences. The result indicated an age of 94 ka (Table 2), which correlated well with the fauna and stratigraphic reconstructions.

(2) Uranium-series dating-stalagmite. At approximately the same horizontal level with the layer yielding the human fossils we collected a pure and dense stalagmite sample. At the TIMS Laboratory of the Department of Geology and Geophysics, University of Minnesota, the stalagmite sample was analyzed by Dr. Cheng Hai. Dr. Cheng took two small pieces from the stalagmite sample and tested them separately. The results gave an age of 103 ka (Table 3), which is close to that obtained from the U-series rhinoceros tooth.

(3) ESR dating - rhinoceros tooth. At the State Key Laboratory of Earthquake Dynamics，Institute of Geology, China Earthquake Administration, we analyzed a second rhinoceros tooth with electron spine resonance，indicating an age of 44 ka (Table 4), which is younger than the dates from the U-series studies.

The U-series dates correlate well with each other, but the ESR date was much younger. We believe that ESR dating on just one animal tooth may have some uncertainties or biases. For instance, the animal teeth may have experienced complicated absorption and leaching during the burial period which would cause uncertainties for the ESR date. Due to this situation, we believe ESR ages for teeth are usually young. Since the uranium and thorium in a stalagmite are from a closed environment, U-series ages from stalagmites are usually more reliable. Accordingly, we are inclined to accept the age from the stalagmite samples.

We need to verify the exact provenience of the stalagmite sample and its relationship with the human fossils. From our initial examinations, we believe the sta-

Table 2 U-series analysis and age result for the Huanglong Cave rhinoceros tooth

Test No.	Sample No.	Sample site	U (ppm)	$^{234}U/^{238}U$	$^{230}Th/^{234}U$	Age (ka)	Corrected age (ka)
021	HC1	Huanglong Cave	1.583	1. 469	0.595	92. 4±12.1	94.7±12.5

Table 3 U-series analysis and age results for the Huanglong Cave stalagmite

Sample No.	^{238}U (ppb)	^{232}Th (ppt)	$^{230}Th/^{232}Th$ (atomic × 10^{-6})	^{234}U* (measured)	$^{230}Th/^{238}U$ (activity)	^{230}Th age (a) (uncorrected)	^{230}Th age (a) (corrected)	$^{234}U_{Initial}$** (corrected)
HL-1	146.0±0.2	18922±58	113±1	379±2	0.8903±0.0051	106267±1009	103739±1616	508±4
HL-2	141.8±0.2	14132±38	147±1	384±2	0.8880±0.0048	105049±949	103119±1348	514±4

Table 4 ESR analysis and age result for the Huanglong Cave rhinoceros tooth

Lab No.	5103
Sample No.	N1W2③:59
Enamel thickness (mm)	2.1
Thickness of removed enamel (mm)	0.1
Dose（Gy）	56.16±2.38
U-enamel (ppm)	2.81
U-dentine (ppm)	5.05
U-sediment (ppm)	2.10±0.10
Th-sediment (ppm)	7.05±0.35
K-sediment (%)	1.52
EU (Gy/ka）	1.673±0.142
LU (Gy/ka)	1.316±0.124
EU age (ka)	34.78±3.28
LU age (ka)	44.18±4.54

lagmite may be from the same layer as the human fossils. However, two other possibilities still exist. One is that the stalagmite covers the human fossil layer. If so, the age of the human fossils will be older than 103 ka. The other is that the stalagmite is under the human fossil layer indicating that the cave formed before 103 ka, and the human activities occurred after 103 ka.

6 Discussion and conclusions

Huanglong Cave is a huge cave extending backing depth 400 m with many branches, and its deposits are well preserved with clear stratigraphic context. All the human fossils and associated materials were found in primary deposits. Our stratigraphic and faunal analyses, as well as the U-series and ESR dating indicate that the living period of humans in this cave was between 100 and 44 ka, more probably around 100 ka.

The morphology and size of the five human teeth from Huanglong Cave resemble those of modern humans. The stone tools were primarily produced with vein quartz, sandstone, and flint. The main stone tools are scrapers and picks, which were made with hard hammer direct percussion. The stone of big and small sizes are represented in the tool assemblages. The Huanglong Cave stone tools are of the characteristics of both gravel stone tools from southern China along the Yangtze River, and flake stone tools from northern China. In Huanglong Cave many fragmentary mammalian bones were found. We believe that these fragmentary bones may be derived from carcasses processed by humans. Among the faunae associated with the human fossils in Huanglong Cave, there are three primate species, and also many forest and tropical species. For instance, *Somanniathelphusa zhongshiensis*, is a typical tropical animal, with its extant species only living in the mountain regions of Guangdong Province. Most of the mammals found in Huanglong Cave are grass-eating species. Many of the animal bones are fragmentary, which may be caused by human activities. The taxonomic composition is representative of the "Ailuropoda-Stegodon" fauna that lived in south China during the middle and late Pleistocene periods. The faunal diversity also indicates a climate with diversified ecological environments suitable for humans.

Our preliminary analyses of the archaeology, paleontology and chronometric dating suggest that Huanglong Cave was likely a human home base utilized for 100 ka. Since very few Chinese fossils are dated 100 ka, the paucity of reliable data has seriously reduced the reliability of the local origin of modern Chinese hypothesis. The ages of some important late Pleistocene human fossils found in China (e.g., Zhoukoudian Upper Cave, Ziyang, Chuandong, Salawusu) are all within 50 ka. Although the age of Liujiang was said to be 67 ka, its age has been debated because the exact layer yielding the human fossils is not clear. In recent years, there have been some reports[8] claiming the discovery of human fossils in China around 100 ka[6]. However, these claims have not widely been accepted by other scientists engaged in this field. The discovery of the Huanglong Cave site offers new human fossil evidence for exploring these problems. According to our current findings and preliminary studies, we believe that at least 100 ka anatomically modern humans lived in the west Hubei and Three Gorges area. The climate and ecological conditions during the Pleistocene maybe were suitable for humans. In the past several decades, in the west Hubei and Three Gorge region, where Huanglong Cave is located, a series of human fossils ranging from early to late Pleistocene were found. These include the Yunxian *Homo erectus* crania, Meipu *Homo* sp. teeth in Yunxian, *Homo erectus* teeth from Bailong Cave in Yunxi, early *Homo* sp. teeth from Jianshi, early *Homo sapiens* teeth from Xinglong Cave in Fengjie, and the mandible from Longgupo in Wushan[13−17]. According to the Huanglong Cave deposits, including stratigraphic reconstructions, fossils, and chronological dating, we believe the age of the layer yielding the human fossils is between 100−44 ka, but more likely around 100 ka. The human fossils and other related materials from Huanglong Cave offer valuable information for research on the origin, evolution, and cultural development of humans in the west Hubei and

Three Gorges area. In the coming years, we will conduct further surveys and analyses of the stratigraphic context of Huanglong Cave. In addition to more dating tests on the large mammal teeth, we are going to clarify the relationship between the human fossils and stalagmites. Further survey, excavations, and detailed studies on the Huanglong Cave site will play an important role in clarifying the picture of late Pleistocene human evolution and modern human origins in China.

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