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Lithic artifacts excavated from the Jinshuihekou site in the Hanzhong Basin, Shaanxi Province, China

BIE Jingjing[1, 2], WANG Shejiang[1, 3*], XIA Nan[4], LU Huayu[5], WANG Xianyan[5], YI Shuangwen[5], XIA Wenting[1, 2], ZHANG Gaike[4], Mathew L FOX[6], ZHANG Hongyan[5], ZHUO Haixin[5], ZHANG Wenchao[5]

1. Key Laboratory of Vertebrate Evolution and Human Origins of Chinese Academy of Sciences, Beijing, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, 100044; 2. University of Chinese Academy of Sciences, Beijing, 100049; 3. CAS Center for Excellence in Life and Paleoenvironment, Beijing 100044; 4. Shaanxi Provincial Institute of Archaeology, Xi'an, 710054; 5. School of Geography and Ocean Science, Nanjing University, Nanjing, 210023; 6. School of Anthropology, University of Arizona, Tucson, USA 85716

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Abstract: The Jinshuihekou site, discovered in the 1980s, is located in the southern piedmont of the Qinling Mountains. This site is on the fourth terrace of the Jinshui River, a left tributary of the Hanjiang River in central China. From June 2014 to February 2015, three Paleolithic localities, including the Jinshuihekou site, were excavated near Jinshui town as part of the national key construction project: the Western Route of the South-to-North Water Diversion Project, also known as the "Hanjiang River to Weihe River Water Diversion Project". An area of 370m^2 was excavated yielding 1210 stone artifacts. The early hominins at this site mainly selected cobbles/pebbles from fluvial gravels for tool knapping; predominately made from quartz and quartzite, followed by siliceous limestone, quartzite sandstone and granite. The principal flake knapping method is hard hammer percussion, and considerable components of the artifacts still retain features of its original use without the need for modification. Analyses of the lithic assemblage indicate that the retouched tools are comprised of small tools made on small flakes such as scrapers, notches, awls, and heavy-duty tools such as choppers, picks, and heavy-duty scrapers. The characteristics of the

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作者简介: 别婧婧 (1994-), 女, 江苏盐城人, 中国科学院古脊椎动物与古人类研究所硕士研究生, 主要从事旧石器时代考古学研究。

通讯作者： 王社江， E-mail：wangshejiang@ivpp.ac.cn

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lithic assemblage resemble the Longyadong Middle Pleistocene cave site in the Luonan Basin in the southern Qinling Mountains but with higher proportion of heavy-duty tools. Based on the post-IR elevated temperature IRSL(pIRIR 290°C) dating method, the layer which buried stone artifacts at Jinshuihekou is earlier than 150 ka. The Jinshuihekou site restore the missing part of the Paleolithic cultural sequence in the Hanzhong Basin and provides new materials for studying the behavior and Paleolithic technology of hominins in the catchment of the Jinshui River and the Qinling Mountains region.

Key words: Hanzhong Basin; Jinshui River; Jinshuihekou site; stone artifacts; fourth terrace; late Middle Pleistocene

1. Introduction

The Hanjiang River is the largest tributary of the Changjiang(Yangzte) River, originating in the Qinling Mountains of Ningqiang County, southwest Shaanxi Province. It flows through Shaanxi and Hubei provinces and runs south of the Qinling Mountains and north of the Daba Mountains. The Hanjiang River enters a canyon area at the mouth of the Dalong River in Yangxian County, where the deepest valley was formed. The river source from Xiaoxiakou in Yangxian County to Huanzhu Temple is known as Small Gorge, and the downstream channel from Huanzhu Temple to Weimen, where the Jinshui River flows into, has been named Great Gorge, also known as the Golden Gorge[1, 2]. The Jinshui River, which is the primary tributary of Hanjiang River, is located in the eastern Hanzhong Basin. It originates from the southern slope of the Guangtou Mountain in Foping County[3] and flows through both Yangxian and Foping Counties. It is 87km in length and 35km in Yangxian County, with a drainage area of 730km^2 and is located in the northern temperate zone of southern monsoonal China [3].

In the 1980s, a large number of Paleolithic sites were identified in the Hanzhong Basin, including the Jinshui River catchment [4-13]. Since 2010, a series of important achievements have been made in regards to the excavation and investigation of Paleolithic sites in the Hanzhong Basin[14-18], especially following the successful implementation of the Longgangsi National Archaeological Site Park and the National Key Construction Project. In particular, these achievements made possible the study of hominin behavior in region, and the exchange of Paleolithic technologies between northern and southern China.

From June 2014 to February 2015, our team cooperated with the “Hanjiang River to Weihe River Water Diversion Project”, a national key construction project, were our archaeological team was able to excavate three major Paleolithic sites in Jinshui town, Yangxian County, including the Jinshuihekou site. Our team was comprised of researchers from the Institute of Vertebrate Paleontology and Paleoanthropology of the Chinese Academy of Sciences(IVPP, CAS), Shaanxi Provincial Institute of

Archaeology, and Nanjing University. This paper studies the sedimentology and pedostratigraphy of the Jinshuihekou site and analyzes the lithic artifacts unearthed from the sediments.

2. Site formation and chronology

2.1 Site overview

Jinshuihekou site is located at Yangxian County, Hanzhong City, Shaanxi Province (518m asl, N33°15′ 56.2″, E107°51′50.6″, Fig.1). The excavation area of the Jinshuihekou site consists of two locations: the rear portion of the fourth river terrace, and the southern edge of the terrace facing the Hanjiang River. The excavation area of the sites are 236m^2 and 134m^2 respectively(in total of 370m^2) and, to date, has yielded a total 1210 stone artifacts; including manuports, hammers, cores, flakes, tools, chunks, and debris.

2.2 Stratigraphy and Chronology

The stratigraphic sections studied in this paper have been labeled as JHK1 and JHK2. The bottom of the JHK1 section – a calcium concretion layer – correlates with the top of the JHK2

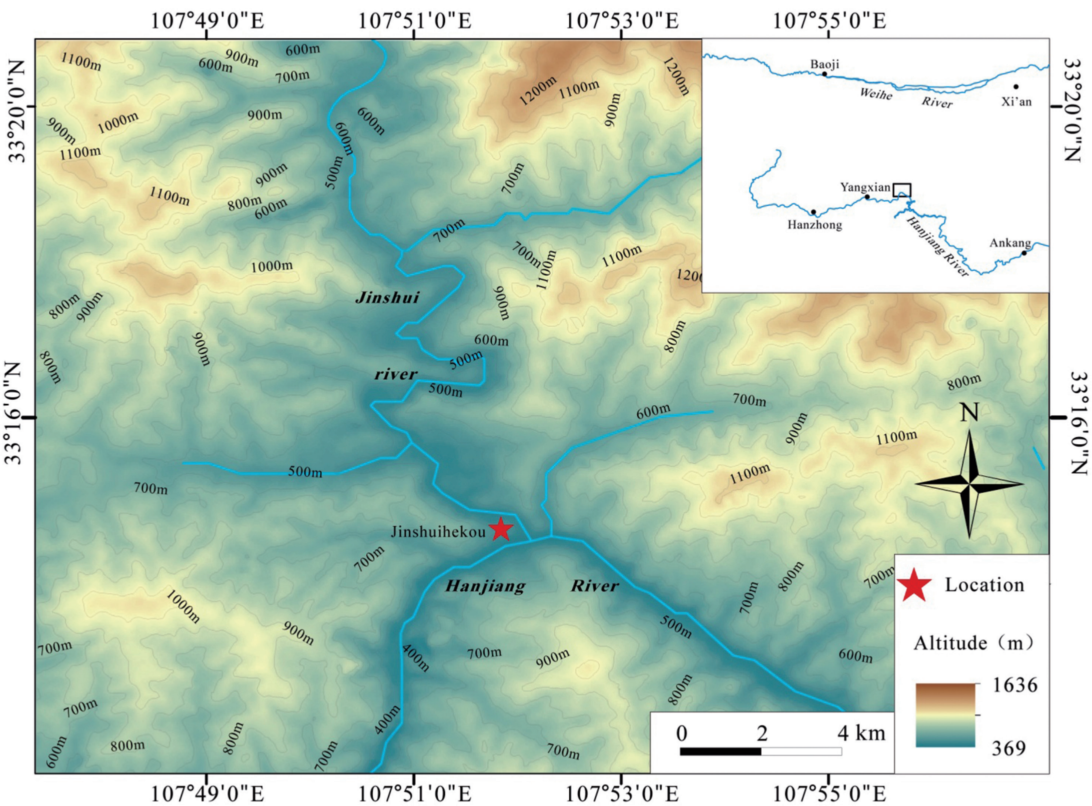

Fig.1 Location of the Jinshuihekou site in Hanzhong, Shaanxi

section, namely, the JHK1 section is located above the JHK2 section. The stratigraphy of the site has been described as follows(Fig.2):

JHK1 section

Our initial field interpretations currently divide JHK1 into 4 discrete stratigraphic units:

Unit 1: Modern soil layer, 0-40cm. This layer contains a small amount of stone artifacts.

Unit 2: Loess sediment, 40-150cm, moist, yellow-brown(10YR 5/6), loose and porous, strong pedogenesis, containing a small amount of calcium concretion smaller than 5cm in diameter, a small amount of plant roots, black iron-manganese nodules with conjunctiva. This layer contains a small amount of stone artifacts.

Unit 3: Calcium concretion layer, 150-190cm, moist, turbid yellow brown(10YR 5/4), with calcium concretion of different sizes. This unit contains a small amount of stone artifacts.

Unit 4: Paleosol, 190-300cm, moist, yellow-brown(10YR 5/6), clay, containing very small amount of calcium concretion with a radius of about 5cm, containing black iron-manganese black spots. The deeper, the darker blue-gray(2.5GY 7/1) mud. This unit contains a small amount of stone artifacts.

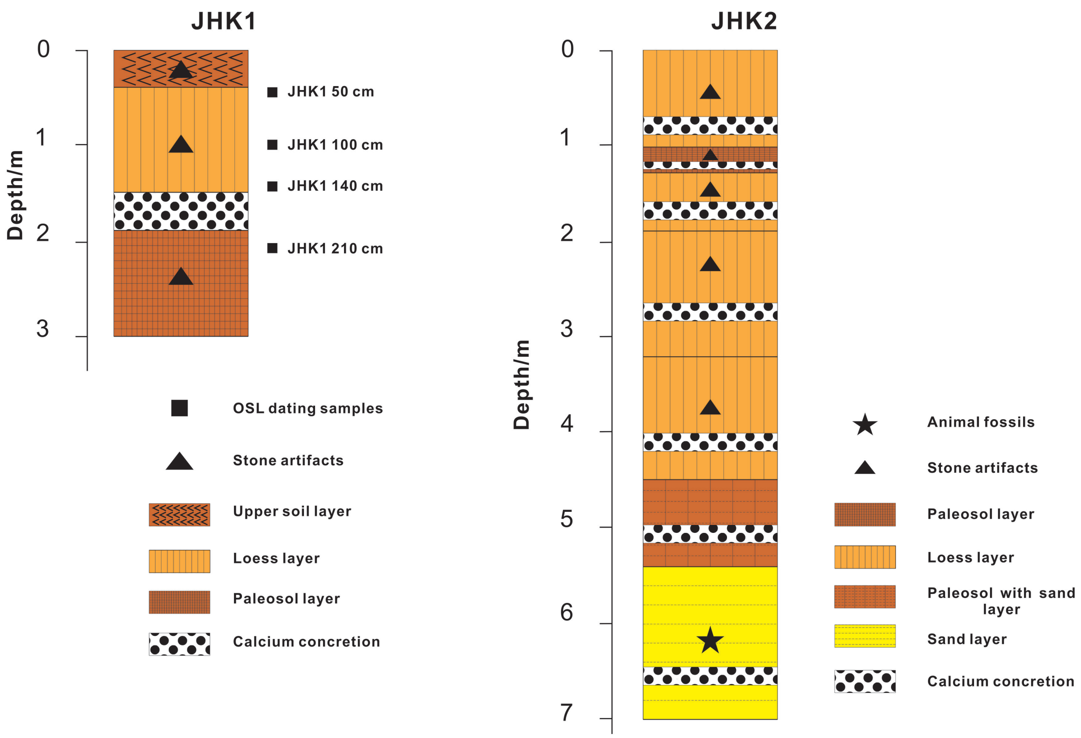

Fig.2 Pedostratigraphy of the Jinshuihekou site

JHK2 section

To date, our field interpretations currently divide JHK2 into 7 discrete stratigraphic units, which is largely based on color and the relative concentration of calcium carbonate nodules. Furthermore, the presence of these calcium carbonate nodules throughout the entire section is a unique feature of the JHK2 Section. Black iron-manganese plaques are covered in soil layers and a small amount of iron-manganese nodules with a size of 0.5cm are distributed. The blue-gray mud is irregularly distributed in the soil(or in a blocky distribution, or distributed along an irregular inclined surface), and small calcareous particles are observed on the surface of some cyan mud.

Unit 1: 0-100cm, moist, orange(7.5YR 6/6), containing a lot calcium concretion with a diameter of 3-8cm. This unit contains a small amount of stone artifacts.

Unit 2: 100-130cm, moist, bright brown(7.5YR 5/6), and has less calcium concretion distribution compared to the upper unit. This unit contains stone artifacts.

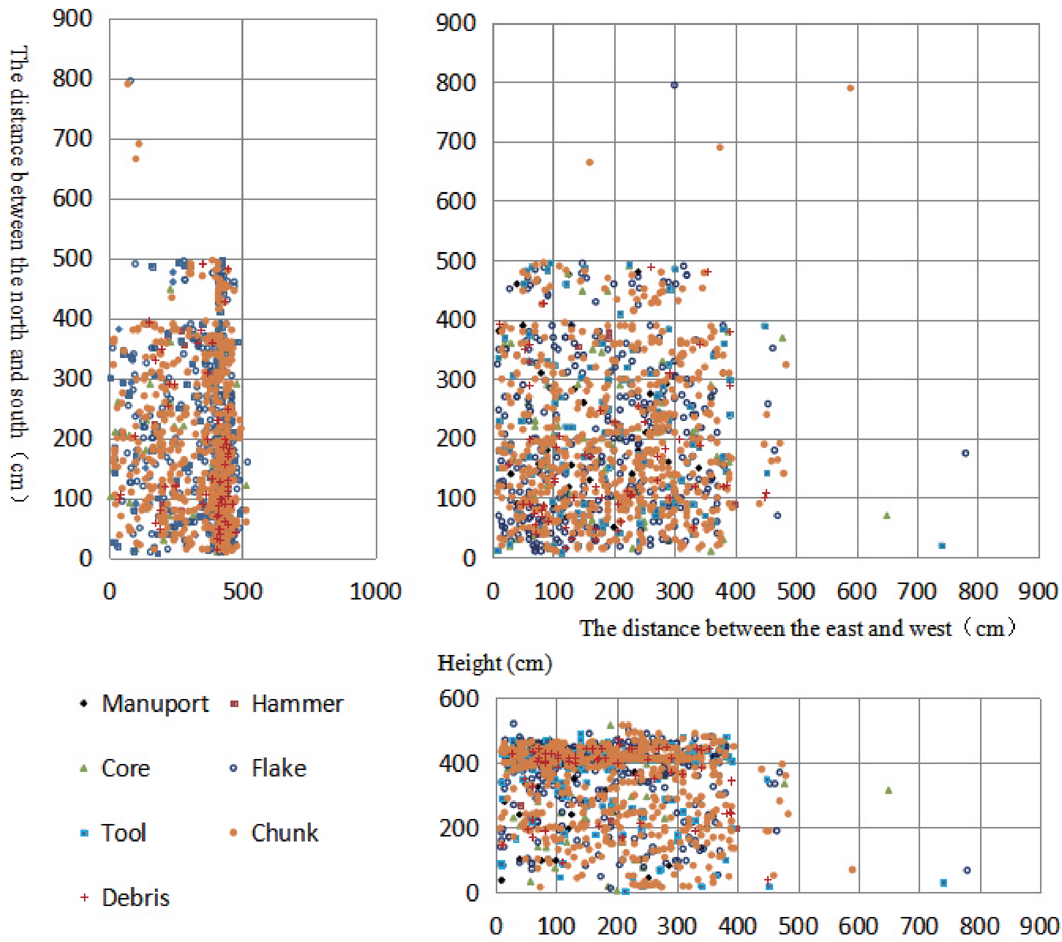

Fig.3 Plan and vertical distribution of lithic artifacts

Unit 3: 130-190cm, moist, bright brown(7.5YR 5/6). There is a high density of calcium concretion distributed within this layer, and shows the process of calcium concretion developed from grey clay. This unit contains stone artifacts.

Unit 4: 190-320cm, moist, bright brown(7.5YR 5/6). Calcium concretion with a diameter of 1-10cm is scattered. This unit contains stone artifacts.

Unit 5: 320-450cm, moist, bright brown(7.5YR 5/6). Calcium concretion is densely distributed, and a small amount of large irregular massive calcium nodules and localized calcium harden distribute separately. This unit contains a small amount of stone artifacts.

Unit 6: 450-540cm, moist, bright brown(7.5YR 5/8). The general trend observed shows increased depth correlates to increased sand content. This layer contains irregularly large amounts of calcium concretion. The number of calcium concretion decreases with increasing depth. Calcium concretion is developed where red soil is present in the sand. There are no stone artifacts in this layer.

Unit 7: 540-700cm, moist, bright yellow-brown(10YR 6/6), pure fine sand. This unit contains fine mica particles and a big calcium concretion with a diameter of 50cm at 650-700cm. There are no stone artifacts but animal fossils.

The stone artifacts of the site are mainly distributed in the upper yellowish-brown and tawny loess-paleosol layer, which contain calcium concretions at depth of 5.0m. An abundance of stone artifacts was unearthed at the depth of 4.3-4.8m[19](Fig.3). A chronology is developed for the section using post-IR elevated temperature IRSL($pIRIR_{290°C}$) dating method[20, 21]. The results indicate that the youngest age of the site is >150ka and the general age of the site is older than the upper limit of the dating technique.

3. Lithic assemblages

To date, lithic artifacts excavated from the Jinshuihekou site total 1210 including manuports(n=38), hammers(n=6), cores(n=67), flakes(n=327), retouched tools(n=122), chunks(n=590), debris(n=60). Among the retouched tools are choppers(n=17), picks(n=1), heavy-duty scrapers(n=8), scrapers(n=92), notches(n=2) and awls(n=2). The raw material of all artifacts consist of either quartzite, siliceous limestone, quartz and, in a small amount of cases, granite and quartzite sandstone(Table 1). At the site, a majority of lithic artifacts are small with a size of <50mm(Fig.4), however, we do observe a series of heavy-duty tools(common in the Hanzhong Basin), such as choppers, pick and heavy-duty scrapers. A considerable number of the artifacts, especially flakes, show signs of usage without retouching.

3.1 Manuport

38 manuports are gravels from channel deposits. The lithology is dominated by quartzite(*n*=28; 73.68%), followed by quartz(*n*=9; 23.68%), and quartzite sandstone(*n*=1; 2.63%).

3.2 Hammer

Raw material of our six hammers are quartz(*n*=3; 50%) and quartzite(*n*=3; 50%). The average weight of hammers is 551.93g and the standard deviation is 189.47g. The hammers are easy to hold, and scars on the surface are concentrated or scattered.

Tab.1 Category and raw material(RM) of the stone artifacts

R Materials / Type	Quartz	Quartzite		Siliceous limestone	Quartzite sandstone	Granite	Total	%
		Dark	Light					
Manuport	9	26	2	1	0	0	38	3.14
Hammer	3	3	0	0	0	0	6	0.5
Core	36	8	13	6	3	1	67	5.54
Flake	121	78	23	104	1	0	327	27.02
Chunk	244	260	36	43	6	1	590	48.76
Debris	32	28	0	0	0	0	60	4.96
Tool	42	49	7	22	2	0	122	10.08
Scraper	37	36	6	21	0	0		
Notch	1	1	0	0	0	0		
Awl	2	0	0	0	0	0		
Chopper	2	11	1	1	2	0		
Pick	0	1	0	0	0	0		
Total	487	452	81	176	12	2	1210	100
%	40.25	37.35	6.69	14.55	0.99	0.17		100

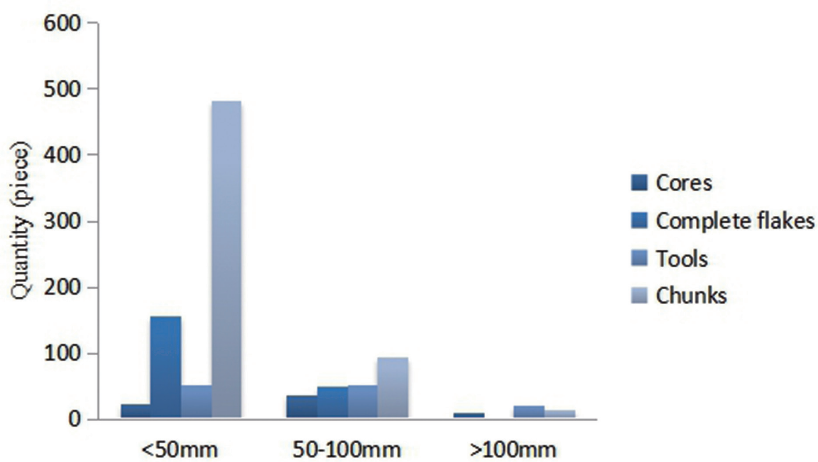

Fig.4 Distribution of the size (length) of lithic artifacts

3.3 Core

The raw material of the 67 cores are quartzite(*n*=36; 53.73%), quartz(*n*=21; 31.34%), siliceous limestone(*n*=6; 8.96%), quartzite sandstone(*n*=3; 4.48%) and granite(*n*=1; 1.49%). Currently, our analysis show that core size exhibits a large range with lengths ranging from 20.64mm to 243.87mm. The average value of core length is 66.76mm with a standard deviation of 38.52mm. The width range of the cores is 21.21-238.96mm, with the average value of 71.28mm and the standard deviation of 43.74mm. The range of thickness is 5.61-158.59mm, with the average value of 51.22mm and the standard deviation of 39.4mm. The range of weight is 4.70-4050.13g, with the average value of 672.02g and the standard deviation of 1062.76g. The maximum flake scars platform angles range between 60°and 145°, with an average angle of 109° and the minimum angles range from 45° to 113° and an average angle of 79° respectively.

Most of the cores have natural platforms(*n*=42; 62.68%), however, there are 42(20.9%) cores with plain platforms and 14(16.42%) cores with natural and plain platforms. There are 32(47.76%) cores with single striking platform, 27(40.3%) cores with double striking platforms, and eight(11.94%) cores with multiple striking platforms.

Hard hammer percussion is the main manufacturing technique at the site. Flaking patterns on cores with single striking platform is unidirectional and unifacial, while cores with double striking platforms or multiple striking platforms is multidirectional.

The knapping facet on most cores is one(*n*=33; 49.25%), and only three(4.48%) cores have four(the largest number) knapping facets. Scar numbers on cores are variable: most cores(*n*=49; 73.13%) have three or less scars, and small number of cores(*n*=18; 26.87%) have more than three scars. This shows the low utilization efficiency of cores in the site.

3.4 Flake

There are 327 flakes recovered from the site, which include 205 complete flakes and 122 broken flakes. Quartz(*n*=121; 37%), siliceous limestone(*n*=104; 31.8%), quartzite(*n*=101; 30.89%) and quartzite sandstone(*n*=1; 0.31%) are the most common materials of flakes at the site.

3.4.1 Complete flake

205 complete flakes account for 62.69% of flakes. The length of flakes range from 11.16-97.56mm, with average value of 40.78mm and standard deviation of 16.11mm. The range of width is between 10.54-87.13mm, with average value of 36.6mm and standard deviation of 15.2mm. The range of thickness is from 3.83mm to 60.2mm with average value of 14.89mm and standard deviation of 7.64mm. The range of weight is between 1.1-560.5g, with the average value of 38.42g and the standard deviation of 70.92g. There are largest number of small-sized flakes(L<50mm; 75.61%), and a certain number of medium-sized flakes(50<L<100mm; 23.9%),

with no large flakes(L>100mm).

Complete flakes can be divided into six types based on the characteristics of butt and dorsal patterns. There are 11 pieces of flake type I(natural butt, natural dorsal pattern), 48 pieces of flake type II(natural butt, part-artificial dorsal pattern), 69 pieces of flake type III(natural butt, artificial dorsal pattern), four pieces of flake type IV(artificial butt, natural dorsal pattern), 29 pieces of flake type V(artificial butt, part-artificial dorsal pattern), 44 pieces of flake type VI(artificial butt, artificial dorsal pattern).

The thickness of the flake platform ranges from 0 to 60.98mm, with the average value of 11.77mm, and the standard deviation of 7.19mm. The range of width is 0-78.58mm, with the average value of 24.88mm, and the standard deviation of 14.13mm. The range of flaking angle is 0°-143°(98°on average), and the range of exterior platform angle is 0° to 127°(82°on average). The dorsal surface of 12 flakes(5.85%) have their entire dorsal scars covered by cortex ,while 184 flakes(89.76%) have less than three dorsal scars and nine flakes(4.39%) have four to five dorsal scars.

The distal ends of flake morphological features are dominated by stepped terminations(n=96; 46.83%), while 73(35.61%) are feathered, nine(4.39%) are hinge and 18(8.78%) are plunge. The shape of flakes is various, dominated by trapezoidal(n=121; 59.02%) and irregular patterns(n=42; 20.49%), followed by inverted triangle(n=25; 12.2%), tongue(n=10; 4.88%), triangle(n=4; 1.95%) and square(n=3; 1.46%).

3.4.2 Broken flakes

122 broken flakes account for 37.31% of total flakes recovered, which include 13 left half, 14 right half, 26 distal snap, seven middle snap, 32 proximal snap, and 30 fragments. The results reveal that the lengths of the broken flakes range between 14.8mm and 96.09mm with an average value of 32.55mm and the standard deviation of 14.88mm. The width varies between 10.85mm and 105.97mm, and the average width is 32.9mm, and standard deviation is 15.59mm. The thicknesses range from 5.04mm to 36.06mm, with an average thickness of 12.96mm the standard deviation of 5.89mm. The weight range from 1g to 208.6g with an average value of 21.92mm the standard deviation of 30.66g.

3.5 Tools

In total, we recovered 122 tools, which include 92 scrapers(75.41%), two notches(1.64%), two awls(1.64%), 17 choppers(13.93%), eight heavy-duty scrapers(6.56%), and one pick(0.82%). Quartzite(n=56; 45.9%), quartz(n=42; 34.43%), siliceous limestone(n=22; 18.03%), quartzite sandstone(n=2; 1.64%) are main raw materials of tools in the site. The blank of tools are dominated by flakes(n=64; 52.46%), followed by cores(n=22; 18.03%), chunks(n=21; 17.21%) and cobbles(n=15; 12.3%). The tool edge retouch occurs as interior(n=46; 37.7%) and bifacial(n=41; 33.61%). Most of the tools were retouched simply. 27 and 46 tools retain 50-99% and 1-49% cortical surface respectively, only 49 tools have no cortical surface. Tools in the

Jinshuihekou site are dominated by small tools, but also contain a proportion of heavy-duty tools.

3.5.1 Scrapers

A total of 100 scrapers were unearthed, of which eight are heavy-duty scrapers. Quartzite(*n*=42; 38%), quartz(*n*=37; 37%) and siliceous limestone(*n*=21; 20%) are the common raw materials of scrapers in the site. Flakes(*n*=63; 63%) are the prime blanks of scrapers, followed by chunks(*n*=18; 18%), cores(*n*=16; 16%) and cobbles(*n*=3; 3%). The length of scrapers ranges from 19.65mm to 194.45mm, with the average value of 58.82mm and standard deviation of 29.39mm. The range of width is 18.31-114.01mm, with the average value of 49.41mm and standard deviation of 22.46mm. The range of thickness is 5.89-86.02mm, with the average value of 20.25mm and standard deviation of 12.98mm. The weight of scrapers ranges from 5.1g to 1804.6g, with the average value of 120.64g and standard deviation of 255.75g. Most scrapers at Jinshuihkou are single-sided edge(*n*=73; 73%), followed by double-sided edges(*n*=15; 15%), and end scrapers(*n*=12; 12%).

2014JS: 0880(Fig 5: 5) is a single-side scraper. The raw material is quartz. The length, width and thickness are 72.59mm, 71.38mm and 39.56mm, respectively. The weight of the scraper is 260g. The scraper is made of chunk with 20% cortical surface. The edge appears wavy when viewed horizontally and s-shaped when viewed vertically and a single-sided edge was retouched. The length of retouched part is 31.83mm and the angle of scraper edge is 70°. The retouched scars on the edge are continuously distributed and the retouched scars are relatively small.

2014JS: 1106(Fig 5: 8) is a heavy-duty scraper made of dark quartzite. The length, width and thickness are 194.45mm, 100.27mm and 86.02mm, respectively. The weight of the scraper is 1377.8g. The blank of the heavy-duty scraper is core with 10% cortical surface. Two side edges all appear wavy when viewed horizontally and s-shaped when viewed vertically, with a double-side edge retouched. The length of left retouched edge is 113.8mm and the angle of surfaces is 70°. The length of right retouched edge is 122.37mm and the angle of surfaces is 85°. The retouched scars on the edge are continuously distributed. The length of biggest scar on edges is 33.77mm and width is 62.12mm. The length of biggest scar on edges is 7.62mm and width is 19.03mm.

3.5.2 Notches

The raw materials of two notches are quartzite and quartz, respectively.

2014JS:1021(Fig.5: 6) is made of dark quartzite. The length, width and thickness are 91.82mm, 62.77mm and 8.73mm, respectively. The weight of the scraper is 89.9g. The blank of the notch is chunk with 40% cortical surface. About ten percent of the surface is wrapped with calcium concretion. The edge of the notch is concave by unifacially retouching. The length of retouched part is 44.89mm and the angle of retouching edge is 62°. The retouched scars on the edge are continuously distributed and the retouched scars are relatively small.

3.5.3 Awls

The raw materials of two awls are quartz.

2014JS:1089(Fig.5: 3) is made of flake without cortex. The length, width and thickness are 39.6mm, 33.68mm and 11.95mm, respectively. The weight of the scraper is 18.4g. The left side of the awl has an inclined surface, and the right side is unifacially retouched to form a sharp corner with an edge angle of 68°.

3.5.4 Pick

The raw material of the pick is dark quartzite.

2014JS:1053(Fig.5: 4) is a trihedral pick. The length, width and thickness are 132.42mm, 79.35mm and 55.42mm respectively. The weight of the scraper is 485.6 g. The blank of the pick is cobble or core with 30% cortical surface. The cortical surface forms a triangular cross-section with the two retouched surfaces. The base surface preserves the original cortical surface, and its two side edges modified by flake removals and formed an endpoint at the distal end. The edge angle is 65°, and the gravel surface and the ridge edge are at an angle of 56°. Two side edges appear convex when viewed horizontally. The length of retouched part is 131.7mm and 68mm,

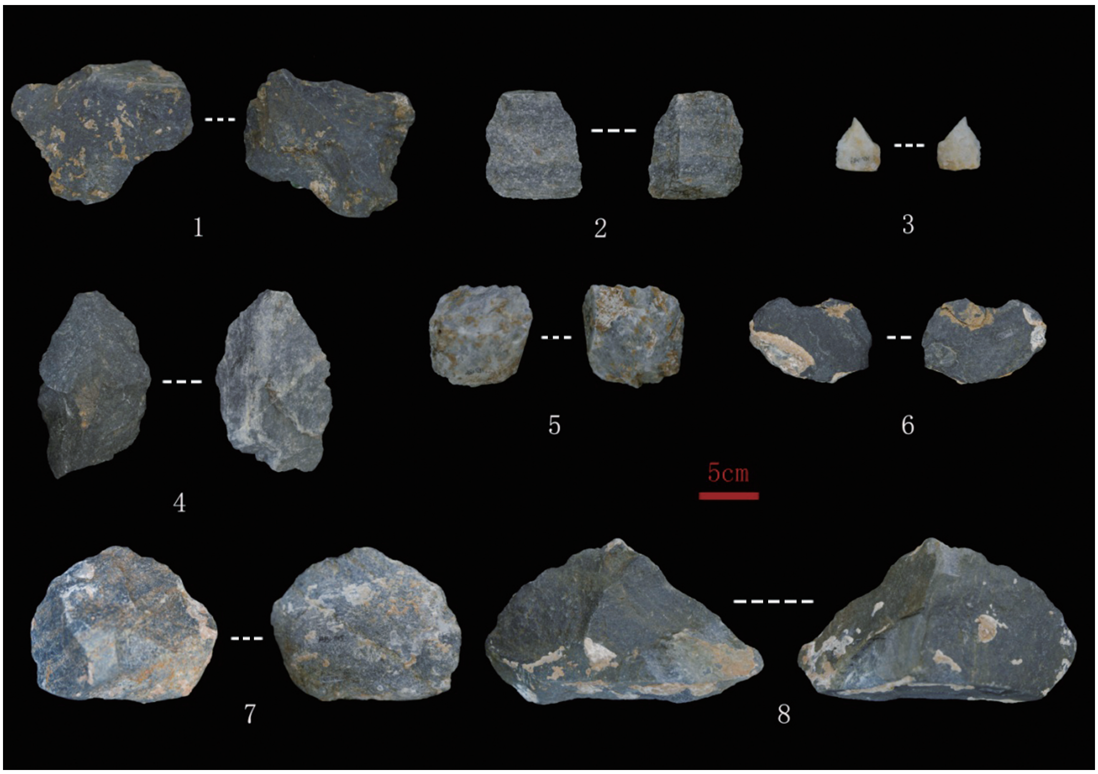

Fig.5 Lithic artifacts from the Jinshuihkou site

1. 2014JS.1093: core; 2. 2014JS.0508: flake; 3. 2014JS.1089: awl; 4. 2014JS.1053: pick; 5. 2014JS.0880: scraper; 6. 2014JS.1021: notch; 7. 2014JS.1105: chopper; 8. 2014JS.1106: heavy-duty scraper

respectively. The retouched scars on edges are continuously distributed with sharp side edges.

3.5.5 Choppers

The raw material of the 17 choppers are quartzite(*n*=12; 70.59%), quartz(*n*=2; 11.76%), quartzite sandstone(*n*=2; 11.76%), siliceous limestone(*n*=1; 5.89%). The blanks of choppers are dominated by pebbles(*n*=12; 70.59%), followed by cores(*n*=5; 29.41%). The length of choppers range from 71.32mm to 172.19mm, with average value of 115.63mm, and standard deviation of 28.68mm. The range of width is 86.2-147.17mm, with average value of 114.09mm and standard deviation of 19.66mm. The range of thickness is between 48.45mm and 231.61mm, with average value of 90.89mm and standard deviation of 43.28mm. The range of weight is 386.9~3760.13g, with average value of 1715.31 g and standard deviation of 913.57g. Most choppers are retouched in end-edge(*n*=12; 70.59%). 12 choppers have one to four scars on the edge(70.59%), while five choppers have between four and eight scars on the edge. The retouch of chopper edge occurs as interior(*n*=15; 88.24%) and bifacial retouching on edges is uncommon(*n*=2; 11.76%).

2014JS:1105(Fig.5: 7) is end-edged chopper made of dark quartzite. The length, width and thickness of the chopper are 133.3mm, 114.47mm, 85.82mm, respectively. The weight is 1605.7g. The end edge of the chopper is unifacially shaped and edge pattern is convex when viewed horizontally and arc-shaped when viewed vertically. The length of retouched edge is 138.23mm and the angle of retouched surfaces is 75°. The retouched scars on the edge are continuously distributed. The length of biggest scar on edges is 55.93mm and width is 43.3mm. The length of smallest scar on edges is 13.91mm and width is 21.28mm.

3.6 Chunks and debris

590 chunks account for 48.76% of the number of stone artifacts. The length of chunks ranges from 12.98mm to 173.76mm. The range of width is 6.65-152.76mm. The thickness of chunks ranges between 2.45mm and 104.95mm. The weight ranges between 0.5g and 2888.1g. Quartzite(*n*=296; 50.16%) and quartz(*n*=244; 41.36%) are the dominating raw materials of chunks, followed by siliceous limestone(*n*=43; 7.29%), quartzite sandstone(*n*=6; 1.02%) and granite(*n*=1; 0.17%).

There are 60 pieces of debris in the site which have been defined as artifacts with maximum diameter of 10mm including insignificant features. These account for 4.96% of all artifacts.

4. Discussion and conclusion

The attributes of the unearthed stone artifacts at Jinshuihekou site can be summarized as follows:

i) The lithic assemblage consists of manuports, cores, flakes, tools, chunks and debris;

ii) Cortex preserved on the stone artifacts indicates most raw materials in the site are fluvial gravels, dominated by quartz and quartzite; followed by siliceous limestone, quartzite sandstone and granite;

iii) Hard hammer percussion is the main technique for knapping. Platforms of cores are predominantly natural and plain, and scars on cores are mostly less than four. The proportion of cores with cortex is high. In comparison to similar sites in the region, these features suggest a low utilization efficiency of cores.

iv) There are more complete flakes than broken flakes. The average size for complete flakes is small(length, width, and thickness of 40.78mm, 36.6mm, and 14.89mm respectively). Platform of flakes are predominantly natural and plain. Dorsal surfaces are predominantly unnatural with scars less than four. It indicates that hominins usually discarded cores in the early percussion stage.

v) The size of artifacts are predominantly less than 50mm, however, there are some artifacts of medium-sized($50<L<100$mm) and large-sized($L>100$mm). Blanks of tools are dominated by flakes, followed by chunks, cores and pebbles.

vi) There are small hard-hammer percussion flake tools, dominated by scrapers, awls, notches, and pebble / cobble tools dominated by choppers, heavy-duty scrapers and one pick in the site.

Analyses of the lithic assemblage demonstrate that the retouched tools consist of both heavy-duty and small tools. The heavy-duty tools are mainly manufactured from local pebbles or cobbles, and contain a variety of forms such as choppers, heavy-duty scrapers, and picks. The small tools appear to be made of small flakes and chunks, and contain forms such as scrapers, awls and notches.

Similar to other sites in the region, our excavations have revealed that local quartz is the most widely utilized raw material at Jinshuihekou. The texture of quartz is brittle and joints appear well developed, which should produce a large amount of debris during flaking and shaping. However, we observe a very small amount of debris, which indicates either(a) the site has been modified through time(post-depositional alteration) or(b) hominins did not utilize the site for artifact processing. Currently, we observe that raw materials used in artifact manufacture are largely comprised of fluvial gravels from riverbank alluvial deposits. More than half of the excavated artifacts appear to be partly covered in calcite crusts. We also observe that the amount of debris is relatively small, thus, we suggest the site may have been hydrodynamically disturbed. However, further excavations and analysis are needed to verify the effects of site formation processes and potential site function.

Most importantly, we argue that the excavation and analysis of materials from Jinshuihekou not only represents an important contribution in establishing a more complete Paleolithic cultural sequence in the Hanzhong Basin, but also contributes to understanding the Chinese Paleolithic at large. More specifically, since the Hanzhong Basin contains a wide variety of unique features, such as rich Paleolithic localities containing a large number of stone artifacts and animal fossils, well-preserved and deeply stratified sites, and has a long history of detailed archaeological research, understanding Hanzhong is critical to Paleolithic research in the region. Our research may also help clarify long term cultural trends and the relationship between Northern and Southern Paleolithic traditions.

The Paleolithic industry in this area was traditionally recognized as part of the pebbles/cobbles-tools tradition in Southern China, which was dominated by choppers, hand-axes, picks, spheroids and heavy-duty scrapers[4-13, 15, 18, 22]. However, this may be an oversimplification as recent archaeological research carried out in the Hanzhong Basin after 2009, shows that stone artifacts from the Longgangsi site, dating to the late of Early Pleistocene to early Middle Pleistocene, are mainly retouched flake tools including scrapers, points and burins in small and medium in size[14, 16, 17, 23]. Meanwhile, collected lithic artifacts from the Yaochangwan(early Middle Pleistocene to late Middle Pleistocene) and Hejialiang(Late Pleistocene) mainly embrace heavy-duty tools, such as spheroids, hand-axes, picks and heavy-duty scrapers. The noted loss of small flake tools was thought to possibly be a result of human disturbance[15, 22]. This new picture likely paints a more complex cultural sequence than the simple pebbles/cobbles-tools tradition, and that post-depositional processes may affect our understanding of Paleolithic trends.

From a chronological perspective, the Jinshuihekou site also helps to restore the missing link between early and late Middle Pleistocene Paleolithic sequences in this region. That is, for decades researchers working in the region only examined Early Pleistocene, early Middle Pleistocene and Late Pleistocene sites that existed in the basin, however, these new results fill in the critical late Middle Pleistocene Paleolithic gap. Finally, our analysis demonstrates that this late Middle Pleistocene sequence is unique as heavy-duty tools exist, but the small(20-50mm) and middle-sized(50<L<100mm) flake tools dominate the sequence.

Interestingly, most of the Middle Pleistocene open air sites [4-19, 22-58] discovered in the Qinling Mountains region, are dominated by heavy-duty tools[4-6, 10, 11, 13, 15, 17, 18, 38, 54, 59]. The Acheulian tools were common in the open air sites of the Qinling Mountains region in late Middle Pleistocene[7-9, 17, 39, 40, 44, 45, 49, 50, 55-58]. Compared with these sites in the Qinling Mountains region, the lithic assemblage in Jinshuihekou with retouched flake tools and a small amount of heavy-duty tools displayed similarities to the Longyadong site in the middle to late Middle Pleistocene[46, 50], however, the proportion of heavy-duty tools is higher in the Jinshuihekou site.

Outside of a unique cultural sequence that demonstrate Paleolithic trends in the region may be oversimplified, our results also challenge traditional age models based on biostratigraphic markers. In the 1980s, Tang *et al.* discovered several Paleolithic sites with similar types of stone artifacts in the Hanzhong Basin, including the Jinshuihekou site. They argued that stone artifacts and animal fossils at the site, which were all members of the *Ailuropoda-Stegodon* fauna that date from the Middle to Late Pleistocene in southern China, were directly correlated and located at the third terrace of Hanjiang River in the Paleolithic site near Dabagou Village. Moreover, they discovered animal fossils thought to date to the Early Pleistocene such as *Ailuropoda microta* and *Rhinoceros sinensis* at Jinshuihekou site. Consequently, based on correlations between cultural layers, fossil remains, and biostratigraphic markers they determined the age of these sites to be the Middle Pleistocene[6].

However, according to more recent excavations carried out in 2014, the animal fossils, Tang et al discovered, were not in the same stratigraphic layer as the stone artifacts. More specially, it was discovered that all animal fossils are located in lower fluvial layers, while stone artifacts are contained in the upper loess-paleosol sequences at the site. It was also argued that Jinshuihekou was located on the third or fourth terrace of the Hanjiang River, however, we are able to demonstrate that the site is, in fact, located on the fourth terrace of the Jinshui River which is the tributary of Hanjiang River. This difference is critical as sequences related to the Jinshui are unique from the geological, geomorphic structures and deposits of the terraces of Hanjiang River in the Hanzhong Basin. Therefore, based on the mammalian fossils found at Jinshuihekou site at the terrace of Jinshui River, we argue that it is impossible to determine the age of Paleolithic sites found at the terraces of Hanjiang River in the Hanzhong Basin.

In total, we argue that the discovery and excavation of Jinshuihekou site enriches Paleolithic research in the region as these results help clarify the development of Pleistocene culture in the catchment of Jinshui River and the Qinling Mountains region. Furthermore, these results also provide new evidence in understanding technological exchange and cultural communication between the northern and southern regions of central China. Since the Qinling Mountains are widely regarded as the major natural barrier that separates northern and southern climate zones, we believe this region is also an important area for the exchange of Paleolithic culture between the north and south of China.

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陕西汉中洋县金水河口旧石器遗址出土石制品研究

别婧婧[1,2]，王社江[1,3]*，夏楠[4]，鹿化煜[5]，王先彦[5]，弋双文[5]，夏文婷[1,2]，张改课[4]，Mathew L. FOX[6]，张红艳[5]，卓海昕[5]，张文超[5]

1. 中国科学院古脊椎动物与古人类研究所，中国科学院脊椎动物演化与人类起源重点实验室，北京 100044；2. 中国科学院大学，北京 100049；3. 中国科学院生物演化与环境卓越创新中心，北京 100044；4. 陕西省考古研究院，西安 710054；5. 南京大学地理与海洋科学学院，南京 210023；6. 亚利桑那大学人类学系，图森 85710

摘要：位于汉水左岸一级支流金水河第四级阶地的金水河口遗址是汉水流域发现较早的一处旧石器遗址。2014 年 6 月 ~2015 年 2 月，为了配合国家重点建设工程——南水北调西线“引汉济渭”项目的实施，我们对金水流域金水镇附近的 3 个旧石器遗址进行了正式发掘，金水河口遗址即为其中之一。该遗址发掘面积 370m^2，出土不同类型石制品 1210 件。研究显示在金水河口遗址生活的古人类主要选取附近河滩砾石为原料进行剥片及工具加工。石制品的岩性以石英和石英岩为主，硅质灰岩次之，并少量使用了石英砂岩和花岗岩原料。古人类主要使用锤击法剥片。遗址中石核的利用效率较低，近半数石片有直接使用的痕迹。加工工具的毛坯以石片为主。工具类型除了刮削器、凹缺器、石锥等小型工具之外，还有砍砸器、手镐、重型刮削器等重型工具。遗址中碎屑数量很少。石制品组合以刮削器等小型工具为主，也包含少量重型工具。相较于汉中盆地已发现的遗址，金水河口遗址的文化面貌与洛南盆地中更新世的龙牙洞遗址更相似，但是重型工具的比例更高。由于遗址堆积物已超出了钾长石红外后释光测年法（post-IR IRSL）的测年范畴，目前只能给出遗址的埋藏时间下限，即埋藏石制品地层的年代不晚于 150 ka。作为汉中盆地有明确测年的中更新世晚期遗址，金水河口遗址为我们系统了解汉江支流金水河流域和秦岭地区的石器工业特点、遗址地层堆积及年代等提供了新的、丰富的材料。

关键词：汉中盆地；金水河；金水河口遗址；石制品；第四级阶地；中更新世晚期

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