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## Early to Late Pleistocene human settlements and the evolution of lithic technology in the Nihewan Basin, North China: A macroscopic perspective

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#### ABSTRACT

The Paleolithic of the Nihewan Basin is characterized by large numbers of sites, a long-term scale, definite strata and rich cultural remains. Recently obtained evidence of human activities and dates indicate that the Early to Late Pleistocene Paleolithic sites in the Nihewan Basin form a concentrated time and cultural sequence. Lithic technology developed according to a "continuous evolution" model. The development of the small tool industry is generalized as the "Donggutuo-Zhiyu (also called Shiyu)" series; and the origin of microlithic technology could be traced back to the Early Pleistocene, which supports the theory of local origin. The complexity of lithic technology development is also discussed. © 2012 Elsevier Ltd and INQUA. All rights reserved.

#### 1. Introduction

The Nihewan Basin is located in the valley formed by the Sanggan River and its tributary, the Huliu River. The Sanggan River crosses the basin from southwest to northeast, which covers an area of about 9000 km<sup>2</sup> with an average elevation of 1000 m. It is found in northwest Hebei province and northern Shanxi province, 50 km west of Beijing. The sediments in the Nihewan Basin are lacustrine with a thickness of more than 1000 m, mainly deposited during the Cenozoic era. In particular, due to strong fluvial erosion, the sediments in Donggutuo Platform have been cut down by 100 metres, making the Pleistocene layers containing abundant Quaternary data concerning fauna and human activities accessible. Therefore, the Nihewan Basin is a key region in which to study Chinese and even global Quaternary geology, paleontology and Paleolithic archaeology (Liu, 2006). As early as 1948, the Nihewan beds were set as reference sequence for the Early Pleistocene by the Chinese geological group (Young, 1950). The Pliocene-Pleistocene boundary has now been placed at 2.6 Ma (Mascarelli, 2009).

The Nihewan Basin has been the focus of much research. Research in the Nihewan Basin can be traced back to the 1920s, when French scholars E. Licent and P. Teilhard de Chardin began studying its stratigraphy and paleontology, although rarely Paleolithic archaeology. However, several discussions were held at that

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time, regarding for instance initial hypotheses about early Pleistocene human activities (Teilhard, 1930) and the significance of the rough "handaxes" found in Xiashagou (Breuil, 1935). It was not until the 1960s (Gai and Wei, 1977) and 1970s (Jia and Wei, 1976) when the Hutouliang and Xujiayao sites were discovered, however, that Paleolithic archaeology became an important part of research here. In 1978, with the discovery of Xiaochanglaing (You et al., 1979), scholars began to study the Lower Paleolithic. This was the first time that Lower Paleolithic archaeology was studied systematically in the area, although the age of Xiaochangliang was controversial. Subsequently, the debate over human activities in the Early Pleistocene was resolved by reliable paleomagnetic dating (Li and Wu, 1985; Schick and Dong, 1993; Wang et al., 2005) at Donggutuo (Wei, 1985). Since then, more discovered Paleolithic sites (Xie et al., 2006a,b) in the Nihewan Basin make it a crucial area for the study of early human evolution and culture in China, or even in East Asia.

The Paleolithic of the Nihewan Basin is characterized by a large number of sites, a long-term scale, well-defined strata, and rich cultural remains. More than 60 Paleolithic sites have been discovered (Fig. 1), most of which are open-air sites located in the eastern part of the Nihewan Basin and contained in lacustrine sediments or alluvial deposits of the Sanggan River terraces. A cultural sequence from the Lower to Upper Paleolithic can be reconstructed from these sites (Table 1), providing evidence of prehistoric human activities. Stone artifacts recovered in the Nihewan Basin form the typical and main lithic industry of North China (Zhang, 1999) which is distinguished by small stone artifacts. It is associated with the other main lithic industry distinguished by cobble and large flake tools in South China, demonstrating the complexity of China's Paleolithic culture. In this paper, human occupations from Early to

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Fig. 1. Location of sites mentioned in the text in the Nihewan Basin (after Wei, 2004).

Late Pleistocene are discussed, as well as the development of lithic technology in a macroscopic perspective.

# 2. Early to Late Pleistocene human occupations: the Paleolithic sequence

#### 2.1. Lower Paleolithic sites

In terms of the Lower Paleolithic sites, the Nihewan Basin is known as one of the richest areas in North China, or even all of China. Over 20 Lower Paleolithic sites have been discovered, including 14 Early Pleistocene ones. They are located in the eastern part of the Nihewan Basin, around Donggutuo village and Cengjiawan Platform (Fig. 1). Many (Table 1) have already been the focus of research, such as Majuangou (Xie and Li, 1998), Xiaochangliang (You et al., 1979; You, 1983; Chen et al., 1999), Donggutuo (Wei, 1985; Hou et al., 1999), Dachangliang (Pei, 2002), Banshan (Wei, 1994), Feiliang (Xie et al., 1998), Huojiadi (Feng and Hou, 1998), Xujiapo (Wei et al., 1999), Cengjiawan (Xie and Cheng, 1990), Maliang (Shen and Wei, 2004), Sankeshu (Hou et al., 2010) and Dongpo (Liu et al., 2010a,b). The first three of these are the most representative Lower Paleolithic sites in the Nihewan Basin.

Goudi (40°13'31"N; 114°39'51"E), also called Majuangou III because it is the third culture layer of the Majuangou site (Figs. 1 and 2(1-4)), is currently the oldest hominid site. Three excavations took place from 2001-2003, and 4286 artifacts were recovered (Wei, 2002, 2003; Gao et al., 2005). The stone artifacts include stone hammers, cores, flakes, chunks, and a small number of tools, represented by scrapers. The main method for producing flakes was direct hard hammering. The site appears to be in situ, given that stone artifacts could be refitted (Xie et al., 2006a,b; Fig. 2(5)). The sediments of Goudi lie between the Jaramillo and Olduvai normal polarity subchrons. Based on the averaged rate of sediment accumulation, the age of Goudi was estimated at 1.66 Ma (Zhu et al., 2004). The latest magnetostratigraphy research shows that the sediments of Goudi are near the onset of the Olduvai positive translation of the sub-period, so the age should be slightly younger than 1.77 Ma (Gao et al., 2005). Considering the mammal assemblage from Majuangou III, including Allophaiomys deucalion, Cromeromys *gansunicus* and *Borsodia chinensis*, the biostratigraphic age estimated by Cai et al. (2008) is suggested to be older than 1.80 Ma.

Since its discovery in 1978 (You et al., 1979), the Xiaochangliang site (40°13'10"N, 114°39'44"E) (Figs. 1 and 3) has been excavated several times, and an area of more than 200 m<sup>2</sup> explored. The 0.5-0.8 m thick culture layer has yielded a large amount of associated fossils and stone artifacts, 1816 of which have been reported (You et al., 1980; You, 1983; Chen et al., 1999). There are two opposite interpretations of the Xiaochangliang lithic industry (Fig. 3(3, 4)). Some researchers consider that it is characterized by random flake knapping, lacking tool retouch and instability of shape (Chen et al., 2002), meaning that the lithic technology is original (Schick et al., 1991). Other researchers (Huang, 1985) recognize many advanced traits, for example, some smaller blades and flake fragments with faceted platforms were observed, and the types of stone tools are diverse, including various scrapers, points, borers, small chopping-tools and burins. Palaeomagnetic studies date Xiaochangliang to 1.36 Ma (Zhu et al., 2001).

The Donggutuo site (40°13′23″N; 114°40′16″E) (Figs. 1 and 4(1)) is one of the most extensively excavated and best studied in the Nihewan Basin. It was discovered in 1981 as part of Pei Wenchong's surveys. Since then, it was excavated in 1983-1984, 1991-1992 (the first Sino-American excavation), 1997 (the second Sino-American excavation). 2001 and 2002. It contains the richest archaeological information of the Early Pleistocene Paleolithic sites in the Nihewan Basin (Schick et al., 1991). More than 10,000 stone artifacts have been found (Wei, 2003), 2145 of which have been published (Wei, 1985; Schick et al., 1991; Schick and Dong, 1993; Hou et al., 1999). The deposits can be divided into five layers, A, B and C–E from top to bottom (Fig. 4 (2)), reaching a total thickness of 5 m. The archaeological material is densely distributed in the upper part of layer C (Fig. 4 (3)), and many retouched tools were found in layer D. Direct hammer percussion and the "bipolar" method were both used for flaking. Tools were chiefly made on small flakes, and most are unifacially retouched. Varied types of scrapers are the most common, with some considerably fine specimens. As a result, Wei (1985) considered that the Donggutuo industry was characterized by advanced stone tools that are generally known in the Late Pleistocene. A prepared wedge-shaped core to produce small

(ou et al., 1979; You, 1983; Chen et al., 1999; Zhu et al., 2001 Jia and Wei, 1976; Jia et al., 1979; Chen et al., 1984 Liu et al., 2010a,b Hou et al., 2010 Jia et al., 1972; Institute of Archaeology of Chinese Nei, 1985; Hou et al., 1999; Wang et al., 2005 Academy of Social Sciences, 1991; Yuan, 1993 Xie and Cheng, 1990; Wang et al., 2006 Shen and Wei, 2004; Wang et al., 2005 Feng and Hou, 1998; Liu et al., 2010c Xie et al., 1998; Wang et al., 2005 Xie et al., 1998; Zhu et al., 2004 Pei, 1991; Xie et al., 2006a,b Wei, 1994; Zhu et al., 2004 <sup>2</sup>ei, 2002; Ao et al., 2010 Kie et al., 2006a,b Xie and Yu, 1989 Wei et al., 1999 Li et al., 1991 References Lithic industry Microlithic industry Small tool ndustry Middle Paleolithic Upper Paleolithic Lower Paleolithic Stratigraphic correlation Stratigraphic correlation Stratigraphic correlation Stratigraphic correlation Magnetostratigraphic Magnetostratigraphic Magnetostratigraphic Magnetostratigraphic Magnetostratigraphic Magnetostratigraphic Magnetostratigraphic Magnetostratigraphic Magnetostratigraphic Uranium-series Uranium-series Uranium-series Dating method Astronomical 14 C ESR  $11 \pm 0.21$ ;  $11 \pm 0.5$ ;  $18\pm1$  and  $15\pm1$  $28.130 \pm 1.370;$  $28.945 \pm 1.37$ About 1050 <1100 1100 1100 About 1330 1360 1480  $11.6 \pm 0.11$  $321 \pm 15$ 200 - 3007801000100 - 125Age (ka) 74-18 1320 1550 1640 1660 Shanshenmiaozui Kiaochangliang Majuangou III (Yujiagou) Xibaimaying Dachangliang Aajuangou II Xujiapo Feiliang Cengjiawan **Ajuangou I** Donggutuo Hutouliang Xujiayao Dongpo Sankeshu Site name Banjingzi Maliang Huojiadi Xiantai) **3anshan** Goudi) Zhiyu Paleolithic sites chronology in the Nihewan Basin. Fluvolacustrine Fluvial Middle Pleistocene Early Pleistocene Late Pleistocene Stratigraphy

elongated flakes was termed the "Donggutuo core" by Hou (2003, 2008; Fig. 4(4)). It was assumed to have a very close relationship with Upper Paleolithic wedge-shaped microlithic cores in China (Hou, 2003, 2008). However, some researchers considered that there were no advanced traits in the Donggutuo industry (Chen, 2003). Donggutuo is the first palaeomagnetically studied site in the Nihewan Basin (Li and Wu, 1985) and recent research has indicated that the age of Donggutuo site is 1.1 Ma (Wang et al., 2005).

The site of Sankeshu ( $40^{\circ}13'23.43''N$ ;  $114^{\circ}40'48.77''E$ ) (Figs. 1 and 5) was discovered in 2008, and an 8 m<sup>2</sup> test excavated in the same year. A total of 251 stone artifacts and some fragmentary bones and teeth were found in four cultural layers (Hou et al., 2010). Most stone artifacts (Fig. 5(4)) are small and medium-sized, and include cores, flakes, tools, chunks and debris, with tools represented by scrapers, points, endscrapers, notches, denticulates, burins, awls, and borers. Six "Donggutuo cores" (Fig. 5(5)) were discovered, which strengthens the significance of the site for discussing the small tool industry tradition, including the microlithic culture in North China. Based on comparison with the stratigraphic data from the Maliang site, the age of Sankeshu has been estimated to be the late middle period of the Middle Pleistocene (Hou et al., 2010).

#### 2.2. Middle Paleolithic sites

The number of Middle Paleolithic sites (Table 1) is fairly low in the Nihewan Basin. The age of some of these few sites is debated, for example Banjingzi (Li et al., 1991), and only the age of Xujiayao is generally accepted.

The Xujiayao site (Jia and Wei, 1976; Jia et al., 1979; Fig. 6), represented by localities 74093 (40°06'04"N, 113°58'41"E) and 73113 (40°06′53″N, 113°57′31″E) with the majority of material found in the first, is located on the western bank of the Livigou River, 1 km southeast of Xujiayao village, Yanggao County, in the eastern part of the Datong basin. The site was discovered in 1974 during a field investigation and excavated in 1976, 1977, and 1979. The thickness of the deposits was 26–28 m (Jia et al., 1979; Fig. 6(1, 2)), with the culture layer 8-12 m below the present-day surface. Abundant remains (Fig. 6(3, 4, 5)) were recovered from Xujiayao, including more than 20,000 stone artifacts (Wei, 2004), at least 5000 faunal remains (based on Norton and Gao, 2008) and 20 fragments of archaic Homo sapiens fossils (Jia et al., 1979). According to the published 14039 stone artifacts (Jia and Wei, 1976; Jia et al., 1979), the lithic assemblage is made up of flakes (60.2%), cores (18.4%), tools (13.8%) and spheroids (7.6%); 65% of the lithics were produced using locally available vein quartz. The abundant spheroids (n = 1073) were regarded as the most exceptional feature of the Xujiayao industry. Twenty fragments of human fossils, including twelve parietals (two of which can be refitted), one temporal, two occipitals, one juvenile maxilla, one mandible, two isolated left upper molars and one lower molar, have been analyzed by many researchers (Jia et al., 1979; Wu, 1980, 1986, 1990), but a general consensus has not been achieved. Based on the analysis of the mammals, Jia and Wei have suggested Xujiayao would not be earlier than the Late Pleistocene (Jia and Wei, 1976), but over 100,000 years old (Jia et al., 1979). Uranium-series dating on Equus (horse) teeth indicate an age bracket between 100–125 ka (Chen et al., 1984), which is universally accepted by archaeologists.

#### 2.3. Upper Paleolithic sites

At least 20 Upper Paleolithic sites have been found in the Nihewan Basin (Table 1), with the Zhiyu (also called Shiyu) site and the Hutouliang sites representing the small tool industry and microlithic industry respectively.

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1. The landscape of Majuangou site



5. Refitted stone artifacts (after Gao et al., 2005)



Fig. 2. Majuangou site.



2. A bird's eye view of Majuangou site (photo Q. Wei)



3. The excavation at Goudi in 2001 (photo Q. Wei)

The Zhiyu site (39°24'11"N; 112°21'05"E) is located on the second terrace of Zhiyu River, in the southwest Nihewan Basin (Figs. 1 and 7(3)). It was discovered in 1963. The remains recovered include 15,000 stone artifacts, 39 bone tools and one occipital fragment of late Homo sapiens (Jia et al., 1972). The lithic assemblage (Fig. 7(4)) includes cores, flakes and tools, typically small. Hard and soft hammer percussion, bipolar technique and indirect percussion were used for flake knapping. The tools vary widely in shape. The finely produced ax-shaped knives may be a type of composite tool. According to lithic technology and typology, primitive types of microlithic technology are very important for exploring the origin of the microlithic cultural tradition in North China; for example, the fanshaped core could be the archetype of the wedge-shaped microlithic core (Jia et al., 1972). The Zhiyu fauna reflect late Pleistocene mammalian fauna, and the <sup>14</sup>C dating indicates that the age of Zhiyu is  $28,130 \pm 1370$  BP,  $28,945 \pm 1370$  BP (Institute of Archaeology of Chinese Academy of Social Sciences, 1991) and  $33,155 \pm 64$  BP (Yuan, 1993).

The Hutouliang sites (Fig. 1) are located on the northern bank of the Sanggan River, around Hutouliang village, which is about 30 km east of Yangyuan County, Hebei province. Since discovery in 1965, nine localities have been discovered in the third terrace of the Sanggan River. The Yujiagou site (locality 65039; 40°09/41″N; 114°28′50″E, Fig. 7(1)) is one of the most important. Five excavations to date have recovered more than 40,000 stone artifacts (Xie et al., 2006a,b). Direct hammer percussion is the main method of flake knapping, accompanied by indirect percussion and the bipolar method. Tool types vary and include scrapers, points, burins, arrowheads, etc. The pressure technique was used to retouch tools. The lithic assemblage (Fig. 7(2)) is typical of the microlithic technology during the Upper Paleolithic in North China. The number of microcores and microblades is very large, and wedge-shaped cores are the most abundant and account for 85% of the microcores. The <sup>14</sup>C dating of bone fossils indicates that the age of Yujiagou is 11,000 ± 210 BP, 11,000 ± 500 BP or 11,600 ± 110 BP (Gai, 1991).

#### 3. Paleolithic sites chronology

Researchers focused on biostratigraphy since the discovery of Nihewan in the 1920s rather than the Paleolithic, until the 1970s after the discovery of Xiaochangliang. Wei (1991) established a geological sequence for the archaeological sites in the Nihewan Basin based on the materials available at that time. Recently, with the increase in archaeological discoveries and advances in dating techniques, it is necessary to adjust the chronological sequence.

Reliable chronology and dating is essential to construct a credible time sequence of Paleolithic sites. Quaternary dating methods, such as stratigraphy, isotope chronology and paleomagnetism can be applied to date Paleolithic sites (Huang, 2000). Among these methods, stratigraphy is the basic method (Bordes, 1968) and provides the basic information for the relative chronology of the Nihewan Basin, associated with biostratigraphy. Barbour et al. (1927) named the lacustrine sediments between the Pliocene red clay and the Late Pleistocene loess the "Nihewan Beds", in which Teilhard (1930) and Breuil (1935) discovered fauna and so-called hominid remains. Paleolithic sites are mainly located on platforms

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Fig. 3. Xiaochangliang site.

formed by lacustrine sediments in the eastern part of the Nihewan Basin and on terraces of the Sanggan River formed by fluvial sediments. Different facies represent different ages and cultural contents. Lacustrine facies include Lower and Middle Paleolithic layers, and fluvial and flood deposits include Upper Paleolithic layers. In biostratigraphy, the Nihewan fauna are typical Early Pleistocene mammalian fauna of North China (Tang, 1991), and the Xujiayao and Zhiyu fauna are typical Late Pleistocene mammalian fauna (Huang, 1991). It is thus feasible to establish a general chronology of Paleolithic sites in the Nihewan Basin (Table 1).

It is not easy to find suitable samples for isotopic dating in the Late Cenozoic stratigraphic units in the Nihewan Basin. Palaeogeomagnetism is the major method used to determine the age of Early Pleistocene sites in the Nihewan Basin. It was first applied by Cheng et al. (1978) in Nihewan, and subsequently the age of Donggutuo was determined (Li and Wu, 1985). It was accepted as a reliable method for dating Paleolithic sites in the works of Zhu Rixiang (Zhu et al., 2001, 2004). Currently, there are quite a number of credible age data for the Paleolithic sites in the Nihewan Basin. These data, which are associated with the stratigraphic relations between different sites, make the chronological framework for Nihewan Paleolithic sites clear. The Goudi site, also known as Majuangou III, is the lowest artifact layer in Nihewan, 8 m below Majuangou I. Majuangou II lies near Majuangou III. The Banshan site, in the same geological section of Majuangou, is 24 m higher than Majuangou I. The ages of Majuangou I, II, III and Banshan have been estimated at 1.66 Ma, 1.64 Ma, 1.55 Ma and 1.32 Ma (Zhu et al., 2004) respectively, based on paleomagnetic dating. Paleomagnetic studies situate the Xiaochangliang site at 1.36 Ma, according to Zhu et al. (2001). The Dachangliang site, opposite to Xiaochangliang on the other side of the gully, was considered to be in the same stratum and therefore the same age as Xiaochangliang (Pei, 2002). The latest astronomical dating shows that the estimated age for Dachangliang is 1.48 Ma (Ao et al., 2010), slightly older than Xiaochangliang. Based on stratigraphic data and comparison with Xiaochangliang, the age of Shanshenmiaozhui, 2.27 m higher than Xiaochangliang, has been estimated at 30-40 ka younger than Xiaochangliang (Wei, 2003). The artifact layer of Donggutuo is thick and can be divided into five layers A, B, C, D, and E. The latest dating result for Donggutuo is 1.1 Ma (Wang et al., 2005). Feiliang corresponds to the A and B layers at Donggutuo. Huojiadi and Xujiapo are 0.5 m and 1.69 m higher than Donggutuo, respectively. So, Feiliang, Huojiadi and Xujiapo are younger than Donggutuo. The latest dating of Huojiadi is 1.00 Ma (Liu et al., 2010a,b). Cengjiawan dates to 1.1 Ma, the same as Donggutuo (Wang et al., 2006). Maliang is 18 m higher than Dongguotuo with a dating of 0.78 Ma (Wang et al., 2005). Sankeshu, located somewhere higher than Maliang, is estimated to be more than 300 ka (personal communication by approval of Dr. Zhou Liping). ESR results indicate



1. the landscape of Donggutuo



3. Remains at Donggutuo (photo Q. Wei)



2. Stratigraphic profiles



4. The "Donggutuo core" (after Hou, 2003)

Fig. 4. Donggutuo site.

that the age of the Dongpo cultural layer ranges between  $304\pm12$  ka and  $333\pm23$  ka, with an average of approximately  $321\pm15$  ka (Liu et al., 2010c).

Middle Paleolithic sites found in lacustrine sediments are rare, of which Xujiayao is an example. Others are found in fluvial sediments, such as Banjinzi. According to U-series dating, Xujiayao dates to 100 ka–125 ka (Chen et al., 1984). The age of Banjinzi, located on the second terrace of the Sanggan River, more disputed than Xujiayao, is 74–18 ka (Li et al., 1991; Wei, 2004).

Late Paleolithic sites are mainly found in Malan loess and fluvial sediments of terraces, for example, the Hutouliang sites are in terraces and Malan loess; Xibaimayin and Zhiyu are in terraces. Xibaimaying dates to  $18 \pm 1$  ka and  $15 \pm 1$  ka based on U-series dating on taurodont (Xie and Yu, 1989). Zhiyu dates to  $28,130 \pm 1370$  BP,  $28,945 \pm 1370$  BP (Institute of Archaeology of Chinese Academy of Social Sciences, 1991) and  $33,155 \pm 645$  BP (Yuan, 1993) based on  $^{14}$ C dating. According to  $^{14}$ C dating of bone fossils, Yujiagou dates to  $11,000 \pm 210$  BP,  $11,000 \pm 500$  BP or  $11,600 \pm 110$  BP (Pei, 1991).

From the data shown above, there are no sites known during the periods 0.7–0.3 Ma and 0.2–0.1 Ma. More work is required to explain the lack of sites.

# 4. The development of lithic technology: in brief and macroscopic

4.1. Continuous development from the Lower to Upper Paleolithic and Upper Paleolithic innovation

The road map for the development of lithic technology in the Nihewan Basin can be generalized as follows: continuous development of small tool technology from the Lower to Upper Paleolithic (L-UP) and innovation of microlithic technology in the Upper Paleolithic (UP). In a macroscopic view, the dominant feature of stone artifacts of the Paleolithic sites in the Nihewan Basin is their small size, However, except for microlithic tools, the Paleolithic period cannot be distinguished by transformation of Paleolithic industries from early to late periods without the help of stratigraphy and chronology.

The common characteristics of Lower Paleolithic culture in the Nihewan Basin are: 1) raw materials are low quality flints acquired near the site; 2) direct hammer percussion is the major method for flake knapping, and the bipolar method appears rarely; 3) tools are generally small with simple retouch, and more extensively modified

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1. The landscape of Sankeshu site



2. Stratigraphic profiles



5. The "DGT core" from Sankeshu site

Fig. 5. Sankeshu site

tools are fairly uncommon; 4) tool assemblages contain primarily scrapers, while choppers/chopping tools are absent. It belongs to the early small tool industry in Nihewan. In particular, the "Donggutuo cores" named by Hou (2003, 2008), which were first found at Donggutuo, typologically share basic similarities with the wedge-shaped cores that emerged in the Upper Palaeolithic. This might be the original form of the microlithic technique in North China in the Late Paleolithic.

3. Remains at Sankeshu site

The Middle Paleolithic culture follows the Lower Paleolithic culture with similar features so that it is hard to distinguish them simply by lithic technology. However, there are differences between sites, for example, Banjinzi and Xujiayao. The lithic assemblages of Banjinzi have obvious inheritance traits and Xujiayao forms a connecting link between the preceding and the following lithic technologies (Jia et al., 1979). The characteristics of the Xujiayuao industry are: 1) the bipolar method is used for flake knapping, which appeared in the Lower Paleolithic, but here is closer to that found at Zhoukoudian; 2) flakes with prepared platforms are rare; 3) blades

typically found in Upper Paleolithic sites appear at Xujiayao; 4) points, scrapers and burins are similar to those found at Zhoukoudian and Zhiyu; 5) funnel-shaped and primitive prismatic cores and thumb-shaped scrapers probably developed into corresponding types in the Upper Paleolithic; 6) spheroids are abundant and regarded as the most exceptional feature (Jia, 1978).

The Xibaimaying and Zhiyu Upper Paleolithic sites carried on the small tool industry, especially at Xibaimaying, which is characterized as pure small tool technology (Xie and Yu, 1989). Zhiyu shows transitional traits from the small tool culture to the microlithic culture (Jia et al., 1972), which is demonstrated by the use of the bipolar technique, the presence of fan-shaped cores (the embryonic stage of wedge-shaped cores) and a variety of tools, such as points and scrapers, the dominant types.

Jia et al. (1972) made the first attempts at describing assemblage variation in North China and concluded that there are at least two major Paleolithic traditions in China. One is the Zhoukoudian Locality 1-Zhiyu series of small, irregular flake tools

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#### 8

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1. The landscape of Xujiayao site (photo Q. Wei)



2. Stratigraphic profiles



Fig. 6. Xujiayao site.

associated with scrapers and burins, and the other is the Kehe-Dingcun series, characterized by chopper/chopping tools made on large flakes and heavy triangular pointed tools. The former shows a continuity and improvement over time in the technique of flake manufacture from the Early Pleistocene into the Late

Pleistocene, and the latter continues into the Emaokou Neolithic site in Shanxi province (Jia and You, 1973). Jia's arguments are still sound today. The small tool industry can be traced back to the Donggutuo Early Pleistocene site. Once "DGT cores" were formally defined, they have been recognized not only from Donggutuo, but

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1. The landscape of Yujiagou site



3. The landscape of Zhiyu site (photo Q. Wei)



2. The stone artifacts of Yujiagou site

4. The landscape of Zhiyu site

Fig. 7. Zhiyu and Yujiagou Upper Paleolithic sites.

also at Zhoukoudian locality 1 and locality 15 (Gai, 1991, after reanalysis), Xujiayao, Shuidonggou (Hou, 2008) and at least five cores at the recent newly excavated Sankeshu site (Hou et al., 2010). According to current research, the developmental route of the small tool industry in North China should be modified as the Donggutuo-Zhiyu series, which includes Zhoukoudian locality 1 (Teilhard and Pei, 1932), Sankeshu (Hou et al., 2010), Xujiayao (Jia et al., 1979), Zhiyu (Jia et al., 1972) and develops into the micro-lithic culture.

Microlithic technology is very advanced when it appears in the Upper Paleolithic, like an innovation in lithic technology. It is represented by the site of Hutouliang in which microcores and microblades are very common. It is characterized by the wedge-shaped microcore, being marked by the presence of the Hetao technique. Indirect percussion and pressure methods were widely used for flake knapping and tool modification. As described earlier, the microlithic tradition can be traced back to Donggutuo, as early as 1.1 Ma, and may be found the shadows in the small tool technology development of the "Donggutuo- Zhiyu" series. This is strong evidence for the theory of a local origin (An, 1978) for the microlithic culture tradition.

#### 4.2. The complexity of lithic technology development

In the West, the division of cultural sequences and stages are arranged by lithic technological and typological similarity and variability within the system, such as the classification of the Mousterian industry by Bordes (1953) and the five models technology tradition by Clark (1969). However, in China there is no standard technology except for microlithic technology to divide the Paleolithic into culture stages. The solution taken by Chinese scholars has been to compare the Chinese Paleolithic remains with the European cultures based solely on a chronological basis and then to assign the site to a certain period accordingly. This situation has caused controversy for the "Chinese Middle Paleolithic" (Gao, 1999; Huang, 2000; Gao and Norton, 2002). As mentioned above, Nihewan Paleolithic culture develops according to a "continuous evolution" model with the small tool industry from the Early Pleistocene into the Upper Pleistocene. Although the lithic assemblage at Xujiayao shows distinguishing features, it is still difficult to find a standard lithic technology for division into Paleolithic stages. The reason for this developmental model has been previously discussed (Pope, 1989; Zhang, 1990; Reynolds, 1991).

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However, the Paleolithic culture in the Nihewan Basin is not simple, and can even be said to be quite complex. There are some lithic technologies beyond period, for example, the "Donggutuo core" technology. The "Donggutuo core" is prepared core discovered at Donggutuo in the Lower Pleistocene as early as 1.1 Ma, which was wedge-prepared to produce small elongated flakes. The chaîne opératoire of selection and design of the entire body of the "DGT Core", such as platform trimming, sides and knapping initiated on the ends, indicates a very close relationship with the Upper Paleolithic wedge-shaped microcore (Hou, 2003, 2008). Arguments that the smaller blades found in the earlier Xiaochangliang site (You, 1983) are archetypes of Upper Paleolithic microblades would be stronger based on the discovery of the "Donggutuo core". The complexity of beyond-period lithic technologies could be called the "Chinese phenomenon" of lithic development in the global perspective of Paleolithic technology development. This phenomenon was noted when researchers first studied the Zhoukoudian industry (Teilhard and Pei, 1932). Geologically, the Zhoukoudian industry is old, but small elongated flakes produced by the bipolar method are Upper Paleolithic products in the West.

Microlithic culture became the main lithic technology during the Upper Paleolithic after its emergence. Nevertheless, the small tool culture still existed at some sites, such as Xibaimaying and Zhiyu. The microlithic culture and the small tool culture developed simultaneously, but without mutual influence, which also demonstrates the complexity of Nihewan culture. An explanation of the phenomenon probably needs to take social culture into consideration.

#### 5. Conclusion

Abundant sites are found in clear stratigraphic context, facilitating exploration of the Paleolithic culture sequence in the Nihewan Basin. Especially with the advancement of dating methods, the chronology of Nihewan Paleolithic sites is increasingly clear. The Early to Late Pleistocene Paleolithic sites in the Nihewan Basin compose a concentrated sequence in time and culture. The lithic technology develops according to a "continuous evolution" model. The small tool technology improves continually from the Early Pleistocene to the Upper Pleistocene, and its developmental route can be generalized as the "Donggutuo-Zhiyu" series. The origin of microlithic technology can be traced back to the Early Pleistocene. Moreover, there are some complexities in the development of lithic technology, for example, some advanced technologies first emerged in the early period, traditional technology unaffected by new technology. There are many subjects worth exploring in depth in the Nihewan Paleolithic.

Renzidong (Zhang et al., 2000), Longgudong cave (Zheng, 2004), Longgupo (Huang et al., 1995) are the earliest Chinese sites, around 2.0 Ma and found in South China (Hou and Zhao, 2010). In North China, the Early Pleistocene sites are mainly located in the Nihewan Basin, and Goudi (Majuangou III) is the earliest site with a date of 1.66 Ma (Zhu et al., 2004). Other sites with earlier date results are controversial in regard to both stratigraphy and archaeological material (Tang et al., 1999). Finding proof of human activity earlier than 2.0 Ma in older strata is very important in future research. Whether the emergence of mammals, which have been dated to 2.0 Ma in the Nihewan (Cai et al., 2008), could be evidence of human activity, is still under discussion (O'Regan et al., 2011). It now seems likely that investigations and excavations in older strata are the key ways to find the earliest human activities in the Nihewan Basin.

The current evidence supports the Out of Africa theory (Carbonell et al., 1999, 2010) of human origins, but the time of the early hominid dispersal out of Africa and the oldest human expansion in different regions are still very hot topics in paleoanthropology and Paleolithic research. Outside of China, the earliest human fossils are found at Dmanisi (Gabounia et al., 2002) in Georgia as early as 1.85 Ma (Reid et al., 2011), and in western Europe, the oldest evidence of hominids are from Atapuerca in Spain with a date of 1.1–1.2 Ma (Aguirre and Carbonell, 2001). Templeton's research (Templeton, 2002, 2005) suggests that there have been three expansions in human evolution, and the first is around 1.9 Ma. Therefore, Nihewan could play an important role in research of human origins if evidence of human activity around 2.0 Ma could be found.

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