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Original article

The onset of Late Paleolithic in North China: An integrative review of the Shuidonggou site complex, China

La fin du Paléolithique au nord de la Chine, une étude complète du complexe de Shuidonggou, Chine

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Abstract

Shuidonggou (SDG) attracts scholars who are interested in Late Paleolithic of China, even east Asia, from generation to generation since 1923 when rich lithic artifacts and animal fossils were discovered at locality 1. During the past almost one century, many excavations have been conducted by different institutes at different localities of SDG. Numerous data has been obtained and tens of thousands of artifacts were yielded. The understanding of nature and context of SDG is increasing gradually with the repeated excavation and in-depth research. The present paper reviewed the formal excavations and achievements in SDG. Especially, a series investigations and excavations since 2002 have been emphasized. After this long-term fieldwork, the geographic range of SDG has extended far beyond the range suggested by previous findings. The presence of discrete cultural horizons at various SDG localities indicate repeated use and

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occupation of the area by early human groups between 50–10 kya with a gap in LGM. During the repeated occupations, diverse and complex behaviors including gathering various plants, heat treatment preparation for knapping, making ornaments, engraving were identified using different kinds of methods and techniques by scholars. Paleoenvironmental reconstruction based on pollen analysis suggests that late Pleistocene/early Holocene human utilization of the SDG area occurred primarily around 32–24 kya and 13–11 kya when climatic conditions were more favorable. Years of excavations and researches make progress with nature of SDG. However, the issues about Initial Upper Paleolithic assemblages in SDG, origin/disappearance of Levallois-like technology in China are still open to debate. Further excavation and research at SDG1 will clarify these issues.

Keywords: Late Paleolithic; China; Blade technology; Levallois; Core-and-flake technology

Résumé

Depuis 1923, date à laquelle un riche assemblage d'artefacts lithiques et d'animaux fossiles ont été découverts dans la localité 1 de Shuidonggou (SDG), ce site attire toutes les générations de chercheurs qui s'intéressent à la fin du Paléolithique en Chine et en Asie orientale. Durant près d'un siècle de nombreuses fouilles ont été réalisées par différentes institutions en différentes localités de SDG. D'abondantes données ont été obtenues et des dizaines de milliers d'artefacts ont été récoltés. La compréhension de la nature et du contexte de SDG s'accroît au fur et à mesure des fouilles successives et de l'approfondissement de la recherche. Cet article présente l'ensemble des fouilles qui ont été réellement organisées à SDG ainsi que leurs résultats. Il met l'accent en particulier sur les recherches et les fouilles qui ont eu lieu depuis 2002. Suite à ces travaux de terrain sur le long terme, l'emprise géographique de SDG s'est avérée beaucoup plus étendue que ne le suggéraient les précédentes découvertes. L'existence d'horizons culturels distincts dans les différentes localités de SDG indique une utilisation et une occupation répétées de ce secteur par les groupes humains entre 50 et 10 ka, avec une interruption lors du dernier maximum glaciaire (LGM). Au cours de ces occupations récurrentes, des comportements diversifiés et complexes ont été mis en œuvre, tels que la récolte de plantes, la chauffe des matériaux destinés à être taillés, la fabrication d'ornements, la gravure ; ceux-ci ont été identifiés par les chercheurs grâce à différents types de méthodes et de techniques. La reconstitution paléoenvironnementale sur la base des analyses polliniques suggère que l'occupation humaine du secteur de SDG à la fin du Pléistocène/début de l'Holocène a eu lieu principalement vers 32–24 ka et 13–11 ka, lorsque les conditions climatiques étaient plus favorables. Toutes ces années de fouilles et de recherches ont permis de progresser sur la question de la nature de SDG. Cependant, les questions concernant les tout premiers assemblages du Paléolithique supérieur à SDG ainsi que l'origine/la disparition de la technologie d'affinité Levallois en Chine restent encore sujet de discussion. Ces questions seront éclairées par la poursuite des fouilles et des recherches à SDG 1.

Mots clés : Fin du Paléolithique ; Chine ; Technologie de production laminaire ; Levallois ; Technologie de production d'éclat

1. Introduction

The overall impression of the Chinese Paleolithic sequence is of a technological simplicity, separated between a core-and-flake industry in North China and a cobble-tool industry in South China (Bar-Yosef and Wang, 2012). In fact, the Early Paleolithic of North China is marked by the long monotonous persistence of the basic core-and-flake technology over one million years (Zhang, 1999). Although features associated with the onset of Late Paleolithic in the region is not

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clear, most researchers agree that blade dominated assemblages containing key technological features of the Initial Upper Paleolithic (IUP), which is found in Mongolia, Siberia, and West Asia 50–30 ka (Kuhn and Zwyns, 2014), began to appear in northwestern China about 40–30 ka (Gao, 2013). Following the appearance of these assemblages, the archaeological record began to display an increased range of evidence for symbolic and innovative behavior, suggesting an increased level of human behavioral complexity in North China during terminal Pleistocene. These archaeological occurrences indicate a full-fledged development of the Late Paleolithic of North China.

Explanations for the abrupt transition between the Early and Late Paleolithic remains debated. Does the apparent change in the archaeological record reflect local adaptation towards shifting environmental conditions, or signal the dispersal of hominins from Altai and Central Asia into the region? If it is the latter, what was the relationship between this intrusive IUP phenomenon and the existing local groups? Furthermore, the paleoenvironment of this region is considerably diverse, shaped by the East Asian monsoon cycle and the uplift of the Tibetian plateau. In particular, large areas of northwest China between 40–30 kya were less arid than the region's modern climate, and contained freshwater paleolakes (Zhang et al., 2002; Yang and Scuderi, 2010). As early human groups ventured into this area, how did they interact and adapt to the surrounding landscape?

In order to address these issues holistically, it is essential to conduct in-depth and comprehensive research at late Pleistocene stratified archaeological deposits in this area. Shuidonggou is one of such examples.

The Shuidonggou (SDG) site complex (38°17′55.2″N, 106°30′6.7″E, 1.200 m a.s.l.) is located on the southwestern edge of the Ordos Desert of Northwest China, 28 km southeast of Yinchuan (the capital of the Ningxia Hui autonomous region) and 10 km east of the Yellow River (Fig. 1). A total of 12 localities with late Pleistocene archaeological materials encased in sandy silt deposit were discovered along the bank of the Biangou River, which is a tributary of Yellow River (Pei et al., 2012). Although thousands of Paleolithic sites have been discovered in China, Shuidonggou (SDG) has been regarded as one of the most important Late Paleolithic sites since its initial discovery and excavation in 1923. As the first excavated Paleolithic site in China, SDG has yielded an abundant of artifact and human remains, and generated lively discussions and debates relevant to issues of human cultural origins and evolution in East Asia over the past century.

Since the 2.000s, renewed multidiscipline research was carried out at different SDG localities. This body of research demonstrated that human groups utilized the SDG area over a much greater time range via complex behavioral and technological strategies (Institute of Cultural Relics Archaeology of the Ningxia Hui Autonomous Region et al., 2013). These new studies also clarified the features of the Levallois-like technology at SDG and related its origin to the IUP of Siberia (Peng et al., 2014). More importantly, the systematic and multidisciplinary field research at SDG since 2002 has helped train a generation of young Chinese Paleolithic archaeologists. Here, we present an integrative review of the research that has been carried out at SDG since the early 20th century and discuss major achievements as well as ongoing fieldwork. In addition, we outline key goals for future SDG research that will help clarify the onset of Late Paleolithic in North China.

2. Pioneer work in the 20th century

In the early 1920s, a quartzite artifact was collected by missionary P. Schotte from a loess-like cliff face at the Hengshanpu village 5 km east of SDG. Subsequently in 1923, French

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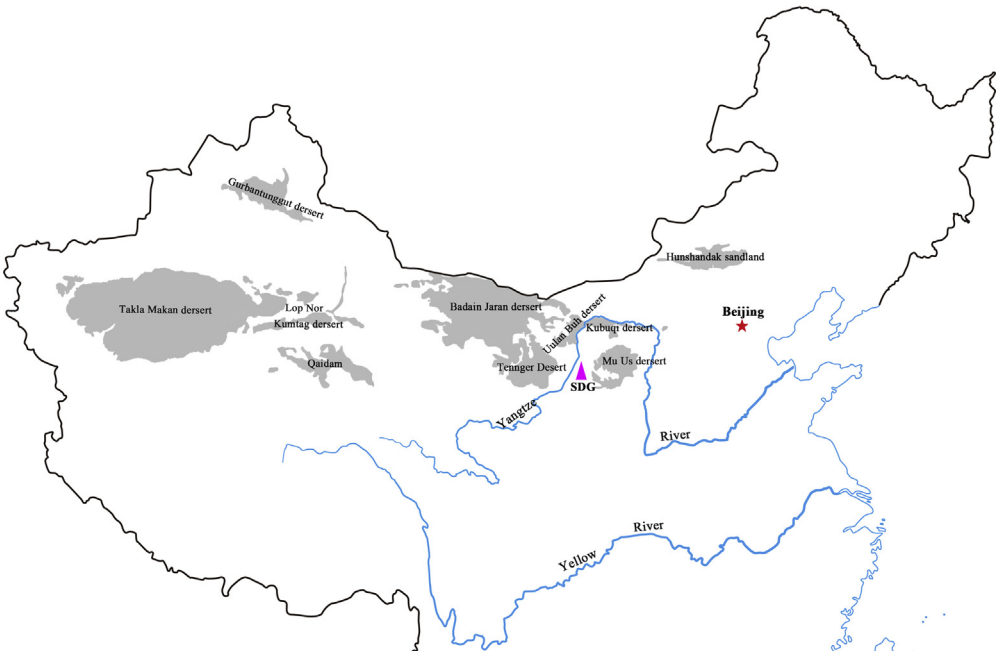

Fig. 1. The location of SDG.
Localisation de SDG.

paleontologists P. Teilhard de Chardin and E. Licent identified five discrete archaeological deposits in SDG; these are referred to as SDG1–5. Teilhard de Chardin and Licent opened an 80 m^2 trench at SDG1 and exposed a 50 cm thick archaeological deposit. The excavation produced more than 300 kg of archaeological finds, including stone artifacts, animal fossils from species such as *Equus przewalskyi*, E. *hemionus*, *Gazella przewalskyi*, *Coelodonata antiquitatis*, *Bos primigenius*, *Hyaena crocuta*, and ostrich eggshell (OES) fragments (Boule et al., 1928).

A preliminary report of the findings was issued in 1925 and a more detailed summary was published in 1928 as part of ''Paléolithique de la Chine'', written by M. Boule, H. Breuil, E. Licent, and P. Teilhard de Chardin. In this book, Breuil suggested that the SDG lithic industry represents a culture seemingly halfway between a very evolved Mousterian and an incipient Aurignacian, or a combination of these two (Boule et al., 1928: 121). After observing the lithic artifacts, F. Bordes also made similar remarks and considered the SDG industry to be a Mousterian with Levallois reduction technique (Bordes, 1968: 130). These conclusions regarding SDG have been widely cited even today due in part to the academic status and reputation of Breuil and Bordes. Many Chinese scholars were attracted to the unique blade dominated assemblage at SDG, which differs substantially from the informal core-and-flake technology that characterize much of the Chinese Paleolithic, and dedicated research to trace its cultural origin to the West [e.g., Li (1993), Zhang (1999)].

Subsequent excavations at SDG1 were carried out in 1960, 1963, and 1980 by Chinese and Russian research teams (Jia et al., 1964). In the 1960 excavation, nearly 2000 lithic artifacts were unearthed from an area of about 36 m^2. Based on the ''*fossiles directeurs*'' concept, the recovery of artifact types such as points and end-scrapers led Jia et al. to consider the SDG Pleistocene

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artifacts as an Upper Paleolithic phenomenon. The researchers also speculated about possible cultural affinities between SDG and the Paleolithic site of Dingcun in Shanxi province to the east (Jia et al., 1964).

The 1963 excavation at SDG1 was directed by Pei Wenzhong. Having been trained in France, Pei was known for his outstanding work at Zhoukoudian. At SDG1, the excavation recovered polished stone artifacts, such as grindstone, from a fluvial-lacustrine silt deposit in the upper stratigraphic layer; the lower layer produced large quantities of chipped stone artifacts. Based on this observation, Pei and Li (1964) suggested that the SDG1 stratigraphic sequence has two major components, with the upper layer corresponding to the Holocene Neolithic period. This hypothesis was later supported by C^{14} dates in 1980 excavation.

The last excavation at SDG1 in the last century was carried out in 1980 by the Ningxia Museum and the Ningxia Geology Bureau. From the 4th of September to the 11th of October, a total of 6700 lithic artifacts and 63 mammalian fossils representing 15 species were unearthed from the 52 m^2 trench. The excavators also encountered rich distributions of ash and charcoals in the archaeological deposit (Institute of Cultural Relics Archaeology of the Ningxia Hui Autonomous Region et al., 2013). The two teams, that is, the Ningxia Museum and the Ningxia Geology Bureau, divided the stratigraphic sequence, which is over 10 m deep, into either 8 or 16 geological strata. Two dating methods were applied as part of this project, although only a few results were reported. Radiocarbon samples place the Pleistocene strata 5 and 6 at 17.250 ± 210 BP and 26.230 ± 800 BP. On the other hand, uranium-series indicate older ages in the range of 38.000 ± 200 BP and 34.000 ± 2.000 BP for the Pleistocene strata. Pollen analysis suggests that the environment was cold and dry when ancient humans occupied this region in terminal Pleistocene (Zhou and Hu, 1988).

After analyzing $\sim$ 3000 lithic artifacts from the Pleistocene culture layers, the researchers again identified the unique SDG technological characteristics in comparison to the Chinese Paleolithic, and placed the SDG industry in the Early Late Paleolithic period due to low proportions of microlithic production (Institute of Cultural Relics Archaeology of the Ningxia Hui Autonomous Region et al., 2013). On the other hand, Brantingham and colleagues (Brantingham et al., 2001) observed that the assemblage is rich in side scrapers, and thus "*regardless of the counting procedure*, *Shuidonggou has a strong Middle Paleolithic typological signature*." (2001: 744). By further comparing the SDG1 lithic collection to IUP assemblages from Kara Bom (Siberian Altai) and Chikhen Agui (Mongolia), Brantingham et al. (2001) argued that there is a strong cultural relationship among these assemblages and a technological continuity between the earlier local Middle Paleolithic variants and the later Initial Upper Paleolithic tradition.

In summary, research at SDG during the 20th century helped clarify important issues including the Levallois blade characteristic of the lithic assemblage and its similarity with the IUP in West and Central Asia. Some Chinese researchers, on the other hand, have suggested relationships between SDG and other Middle Paleolithic sites in North and Central China (Gai and Huang, 1982; Li, 1993). To some extent, the different viewpoints concerning the cultural nature and affinity of the SDG industry can be attributed to the limited investigation of SDG1. Due to limited dates, some of the finds, including a bead, bone tools, and hearths, were reported but not analyzed in detail. The debate over the SDG1 chronology was also fueled a lack of clear provenience of the dated samples. It is also worth noting that, despite having been identified in 1923, SDG Localities 2–5 received minimal attention from researchers over the last century.

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3. New progress and achievement

3.1. 2002–2007 excavation and achievement

Between 2002 and 2007, a series of investigations was conducted at SDG by a multidisciplinary team directed by Xing Gao. This research included field survey of the surrounding region, the identification of seven additional SDG localities (SDG6–12), the excavation of Localities 2–9 and 12, geological analysis and chronometric dating of the stratigraphic sequence, and the systematic analysis of archaeological materials, including those recovered previously from SDG1. These research efforts resulted in a wealth of new information regarding past human activities at SDG and were published as several site reports and research papers (Liu et al., 2008; Liu et al., 2009; Guan et al., 2011; Lui et al., 2012; Guan et al., 2012; Pei et al., 2012; Peng et al., 2012; Li et al., 2013a; Li et al., 2013b; Zhou et al., 2013; Guan et al., 2014; Pei et al., 2014; Peng et al., 2014; Guan et al., 2015; Wei et al., 2016). We summarize these research achievements below.

3.1.1. Increased geographic range of late Pleistocene human presence

As mentioned earlier, Shuidonggou is a large-scale Paleolithic site complex consisted of multiple open-air localities. Renewed investigation since 2002 demonstrated that human activity in this general region extended far beyond the range suggested by previous findings. Specifically, blade productions were found not only in SDG, which is situated at the edge of the desert, but also in Liupanshan Mountain, which is located on the loess plateau and west of Helan Mountain. This distribution pattern provides clues for tracing the footprint of early humans in this area and exploring past human adaptation to different landscapes (Gao et al., 2013a,b).

3.1.2. Establishing chronological sequence

The presences of discrete cultural horizons at various SDG localities indicate repeated use and occupation of the area by early human groups between 50–10 kya. New dates have pushed the age of the blade dominated assemblages at SDG 1, 2, and 9 to 40 or even 50 kya (Li et al., 2013a,b; Morgan et al., 2014; Nian et al., 2014). These blade elements ceased to appear in the stratigraphic sequence around 30 kya and were replaced by core-and-flake assemblages at SDG 7 and 8 (Wang et al., 2015; Niu et al., 2016). No archaeological remains were found in this region during the Late Glacial Maximum (LGM) until the appearance of typical microblade assemblages at SDG12 12–11 kya (Yi et al., 2014). These results suggest a continuous sequence of human behavioral development at SDG from 50 to 10 kya with a gap during in LGM.

This chronological sequence is based mainly on dated samples from SDG2 and SDG12, both of which contain more complete stratigraphic sequences and diagnostic lithic assemblages. However, the minimal occurrence of blade production artifacts at SDG2 stands in sharp contrast to the high proportion of Levallois blade elements at SDG1 (Keates and Kuzmin, 2015). This technological discrepancy between the two localities, which are in close proximity to each other, means that the established cultural sequence remains open to debate (Peng et al., 2014). Future research focusing on an in-depth and systematic assessment of chronology, stratigraphy, and technology at SDG can help clear up these issues.

3.1.3. Paleoenvironmental reconstruction

Archaeological evidence suggests that humans began utilizing the SDG area during Martine Isotope Stage (MIS) 3. According to geological data from ice core, lake sediment, and loess-paleosol,

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Northwest China during MIS3 witnessed the expansion of paleolakes (Zhang et al., 2002). Pollen analysis at SDG2 suggests a temperate grassland environment with some deciduous broadleaf trees during 38–29 kya. The abundance of aquatic and hydric species represented in the pollen record also indicates the presence of wetland in the area at this time. Between 29 and 20 kya, the region's environment likely transitioned into a temperate desert steppe setting, with some presence of *Betula sp*. and *Ulmus sp*. During this time, there are only a few known archaeological sites in this part of North China; the cold and dry condition of the LGM may have limited the extent of human activities in this area. At SDG2, there is minimal pollen record for this period, which reflects the temperate desert steppe environment of the broader region; small amounts of *Picea sp*. and *Abies sp*. were present in the surrounding hills (Liu et al., 2012). Traces of human occupation at SDG reappeared at the onset of the Holocene. The archaeological deposit at SDG12, which has been dated to 13–11 kya, formed when the climate was relatively warmer and more humid (Liu et al., 2008). These findings suggest that late Pleistocene/early Holocene human utilization of the SDG area occurred primarily around 32–24 kya and 13–11 kya when climatic conditions were more favorable.

3.1.4. Levallois-like blade technology and its origin and disappearance

A re-assessment of the SDG1 lithic assemblage recovered from the 1980 excavations identified two distinct reduction sequences geared towards the production of blades and bladelets (Peng et al., 2012; Peng et al., 2014) (Fig. 2). The main reduction sequence produced standard blades, elongated flakes and bladelets from broad-faced cores, and mostly from bidirectional

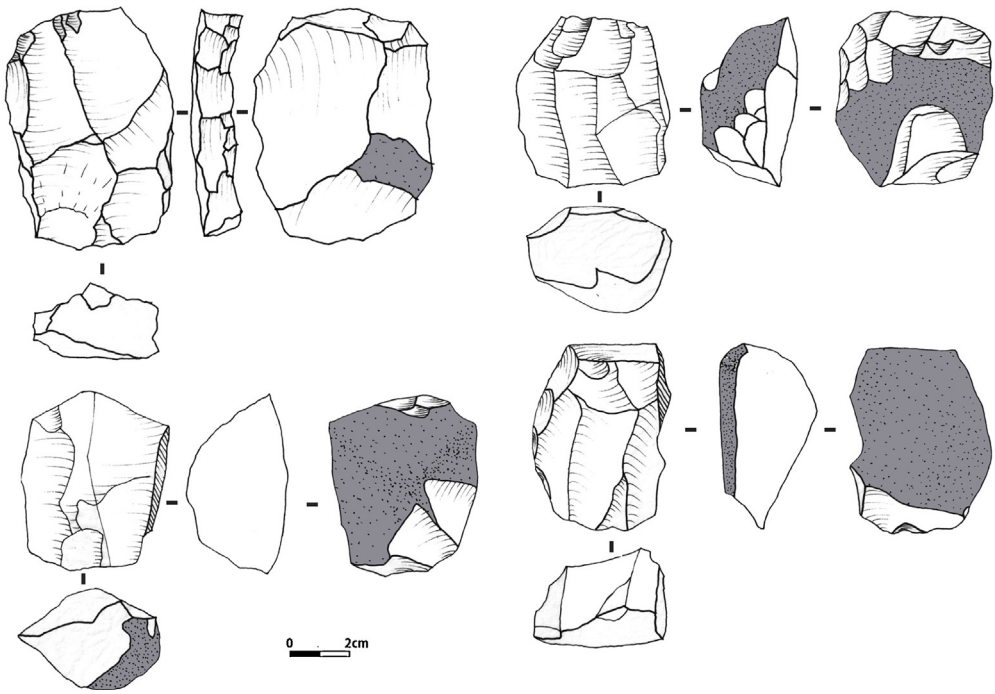

Fig. 2. Broad-faced cores of SDG1 IUP assemblages.
Éclats de SDG1 IUP.

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knapping via direct percussion. The other less common reduction system produced blades and bladelets from prismatic and narrow-faced cores.

Comparing to other Initial Upper Paleolithic and Early Upper Paleolithic (EUP) assemblages in Northeast Asia (Kuhn and Zwyns, 2014), the SDG1 assemblage is typologically and technologically similar to the IUP found in the Altai region of Siberia and Mongolia. However, given the wide chronological range represented in the SDG1 Pleistocene sequence and the fact that the SDG1 assemblage does contain some EUP technological features, such as the prismatic and narrow-faced core reduction sequence, we cannot exclude the possibility of incursion of EUP technology at SDG1. It is also important to note that, the thousands of lithic artifacts unearthed from the more than 5 m thick Pleistocene deposit were as all assigned to a single one culture layer. Therefore, a more detailed diachronic assessment of the SDG1 lithic sequence would require further systematic excavation at SDG1.

Considering the various site localities at SDG, a variety of Late Chinese Paleolithic technology is represented. In particular, the Levalloisian-blade assemblage and the simple core-and-flake technologies appear to alternate over time, suggesting a dynamic yet complex picture of early human adaptation, migration, and interaction in Northeast Asia during the Last Glaciation. There is currently no evidence showing any direct connection between the Levallois-like techno-complex and the local core-and-flake industry of North China; the former likely relate to the dispersal of early human groups from farther west and northwest. The Levallois-like technology appeared in SDG earlier than the dates suggested by previous research. Interestingly, the Levallois blade technology did not have any obvious technological influence on the local industries. Assuming that the intrusive IUP-like technology represents a coherent cultural package, the SDG sequence suggests that groups of early modern human possessing the distinctive blade technology dispersed to this area from farther west/northwest during the late Pleistocene. However, these groups abandoned this region at some point while local populations continued to utilize the region. These local groups retained their technological tradition in stone tool manufacture (i.e., simple core-and-flake technology), meanwhile adopted some modern behaviors reflected by the curation of stone tools and the use ornamentation and heat treatment technologies.

3.1.5. Behavioral diversity and complexity

In contrast to the emphasis on determining the cultural affinity of the SDG industry during the last century, a major aspect of the 2002–2007 projects focused on the behavioral and adaptive strategies of early human group (Gao et al., 2013a,b). Archaeological materials such as stone artifacts, bone tools, ornaments, combustion features, and animal and plant remains were collected and analyzed in-depth to infer about past behavioral patterns, including stone heat treatment, complex utilization and organization of living space, and the use of plant resources.

Use-wear analysis of 48 lithic artifacts from SDG2 revealed that four of the artifacts were used for scarping/whittling, while another four were used for cutting/slicing, and one artifact was hated. On the other hand, no sign of drilling, graving, or penetrating was detected among the studied sample (Gao et al., 2013a,b). Residue analysis of lithic artifacts showed that early human groups at SDG2 gathered and processes a variety of plant resources (Guan et al., 2014). The intra-site spatial distribution of archaeological materials at SDG2 suggests a living organization centered around hearths, indicating a base camp site function (Guan et al., 2011). Heat treatment practices were applied at SDG2 to enhance the fracture property and knappability of stone raw materials (Zhou et al., 2013; Zhou et al., 2014; Guan et al., 2015). Experimental and micro-CT analysis of OES beads from surface collection have clarified the manufacture process of these

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ornaments and highlighted the potential cognitive and technological complexity of SDG hominins (Wang et al., 2009; Yang et al., 2016). Several incision lines on a core recovered during the 1980 excavation at SDG1 were confirmed to be an outcome of intentional behavior and probably of a non-utilitarian character (Peng et al., 2012).A *C. fluminea* recovered from CL3 of SDG2 were identified as the earliest instances of personal ornamentation and the earliest example of a shell bead from China (Wei et al., 2016). Experimental and ethnographic evidence suggests the possibility that the thousands of burned and fire-cracked stones from SDG12 were used as heat retainers for cooking food or boiling water. If true, the indirect manipulation of heat energy illustrates an advanced ability of past groups to control and apply heat as a means of adapting to the local environment (Gao et al., 2014).

These diverse and complex behaviors represented at different SDG localities display a wealth of information about ancient human Northwest China during the late Pleistocene. Importantly, some of the symbolic artifacts, which are seen as a hallmark of behavioral modernity (McBrearty and Brooks, 2000; Henshilwood and Marean, 2003; Norton and Jin, 2009; Nowell, 2010), were found in association with basic, informal core-and-flake assemblages rather than blade assemblages. This finding has important implication for rethinking the implicit role that blade technology often holds in the so-called modern human behavior package.

3.2. New excavation since 2014

In terms of lithic technology, however, despite the identification of blade production elements at various culture layers from SDG2, 7 and 9 (Pei et al., 2012; Li et al., 2013a,b; Niu et al., 2016), the emergence of blade technology at SDG is still debated (Li et al., 2013a,b; Keates and Kuzmin, 2015) largely because the overall proportions of blade elements in the assemblages of SDG2 are low, the current chronological ages at SDG2 do not align with their respective stratigraphic positions and the distribution of the dated samples to date is extremely uneven among different culture layers, and the stratigraphic and chronological affiliation of the blade assemblage at SDG1 remains unclear. In addition, it remains uncertain how the distribution of blade technology, in its various forms, relates to the often co-occurring core-and-flake technology across the various SDG Localities (Gao et al., 2013a,b). To clarify these questions, a new research project was launched to establish the stratigraphic relationship between the Pleistocene deposits at SDG1 and 2, and to better understand the technological content and chronological association of the Late Paleolithic lithic assemblages.

The new fieldwork focuses on SDG1 and 2. Between 2014 and 2016, a trench (T3) was excavated at SDG2 (Fig. 3); more than 5000 lithic artifacts, 1000 OES fragment/bead, dozens of hearth and ochre, a bone pendant, a few bird eggshell fragments, five mussel shell fragments, and large quantities of faunal remains were recovered from more than 12 meter's sediment (Fig. 4). The bone pendant and bird eggshells are the first of their kinds to be discovered in SDG. Obviously, these new finding provide more information for understanding the behavioral dynamics and cognitive abilities of early human groups at SDG. Importantly, the OES artifacts at SDG2 found during the previous 2002–2007 excavation was located exclusively in culture layer 2. With the new excavation at T3, OES fragments as well as beads were discovered throughout culture layers 1–3. Among these OES finds are unfinished beads with partial perforation. These materials suggest the possibility that some of these beads may have been made *in situ* at SDG2. Much of the analyses of the T3 materials are ongoing. Along with the upcoming excavation at SDG1, these renewed research efforts will undoubtedly provide new information to our understanding of early human activities at SDG.

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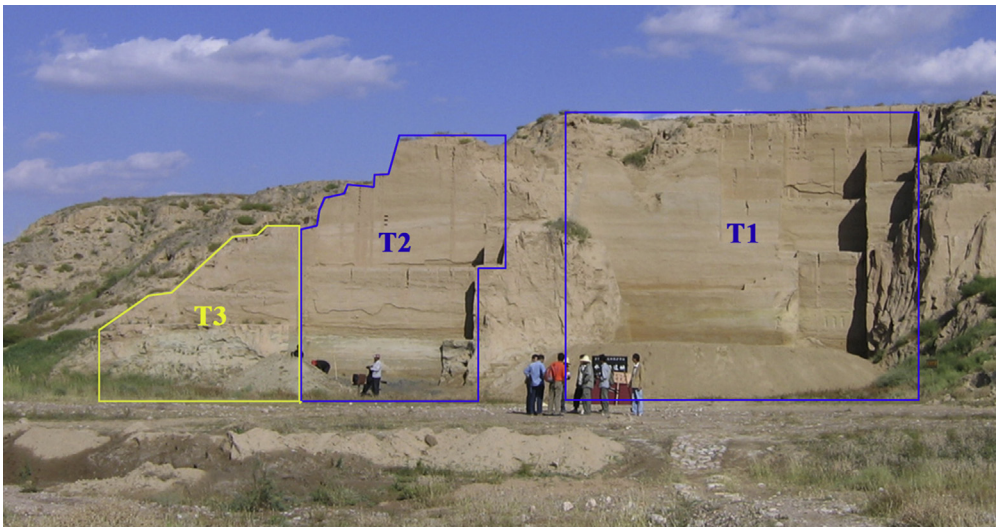

Fig. 3. Trenches at SDG2.
Coupes de SDG2.

4. Conclusion comments and perspective

After almost an entire century of research and repeated excavations, SDG has been not only an important site for human evolution research but also one of the most comprehensively studied Paleolithic sites in China. Systematic and multidisciplinary research since 2002 has helped cultivated a new generation of young scholars for Chinese Paleolithic research. Detailed research has provided contextual information clarifying the lifeways of ancient humans at SDG and the greater Northwest region during Pleistocene and early Holocene. Previous research achievements also highlighted the importance of SDG in relation to important issues including human dispersal in Northeast Asia, culture evolution at arid and semi-arid environment, and the onset of Late Paleolithic in North China.

However, a number of key research questions remains to be clarified. First, a more precise and reliable chronological framework is to be developed for the various SDG assemblages. Specifically, given the potential $>$ 30 kya ages for many of the SDG2 culture layers, the current radiocarbon dates obtained through acid-base-acid pretreatment may represent minimum ages. If the IUP layers turn out to be older than 41 ka (Li et al., 2013a,b), models of Late Pleistocene human dispersal into East Asia would have to be revised, with potentially a southeastward spread from the Altai to North China through the Tianshan corridor before moving north into Mongolia (Peng, 2012). In addition, clarifying the chronology of IUP also helps to address questions of technological change and population interaction in late Chinese Paleolithic. Stone artifacts from the upper culture layers at SDG2 lack the IUP blade technology and instead display a typical core-and-flake technology of the Chinese Paleolithic. Establishing a clear chronological sequence would help clarify whether the occurrence of the local technology overlapped with the intrusive IUP elements present in the lower layers.

Second, IUP assemblages have been identified at SDG1, 2, 7 and 9. However, the proportion of blade elements at SDG2 and 7 is extremely low in comparison to artifacts of the core-and-flake

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Fig. 4. T3 Profile.
Profile T3.

technology (Li et al., 2013a,b; Niu et al., 2016). For SDG1, because previous excavations combined all the Pleistocene artifacts into a single stratigraphic unit, the artifact collections likely represent a mixture of technologically-distinct assemblages. Taking these factors together, it remains difficult to characterize the stone artifact sequence for the SDG area. Compounding the obscurity of the SDG cultural sequence is the fact that symbolic materials and ornaments such as OES beads and bone pendants, which are a key feature of the IUP, were all found in association with core-and-flake assemblages at SDG2, 7, and 8. To clarify the connection between the SDG assemblages, the Late Paleolithic of Northeast Asia, and the broader IUP phenomenon in Central Asia, a more comprehensive and integrative assessment of the stone artifacts from the various localities is required.

Third, the onset of Late Paleolithic in East Asia (including Korea and Japan) was marked by the occurrence of blade and microblade production technology in the archaeological record (Chang, 2012; Kudo and Kumon, 2012; Lee, 2013). However, some scholars prefer to adopt the appearance of well-shaped bone tools and body decorations as hallmark of Late Paleolithic (Qu et al., 2012). In recent years, additional blade dominated assemblages have been discovered in Northeast and Central China (Wang and Wang, 2014; Li et al., 2016). Considering these new findings, what is the relationship between SDG and these other blades dominated assemblages? Furthermore, how does the overlapping sequence of blade dominated assemblages and the core-and-flake assemblages at SDG relate to the interaction and cultural dynamics of past human groups in the region? Further research of SDG1 will help clarify these issues.

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