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Blade production of Shuidonggou Locality1 (Northwest China): A technological perspective

Fei Peng [a,b,*], Huimin Wang [d], Xing Gao [b,c,*]

[a] University of Chinese Academy of Sciences, Beijing 100049, China
[b] Key Laboratory of Vertebrate Evolution and Human Origins of Chinese Academy of Sciences, Chinese Academy of Sciences, Beijing 100044, China
[c] Institute of Vertetrate Paleontology and Paleoanthropology, Beijing, Chinese Academy of Science, Beijing 100044, China
[d] Institute of Culture Relics and Archaeology of Ningxia Hui Autonomous Region, Yinchuan 750001, China

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ABSTRACT

Shuidonggou Locality 1 (SDG1) contains one of the most important early blade assemblages in East Asia, and has been excavated and studied in detail since its discovery in 1923. However, most studies focus on typology and qualitative analysis along with contextual problems such as chronology and stratigraphy. This article outlines current debates on its chronology and stratigraphy, and supports a conservative wide temporal range for the SDG1 lower cultural layer of 40,000–25,000 BP. Using a combined chaîne opératoire and attribute analytical approach, we provide a quantitative technological analysis of the SDG1 lithic assemblage. Our analysis indicates that blade production was applied using two different strategies. (1) The main reduction sequence produced standard blades, elongated flakes and bladelets from broad-faced cores, and mostly from bidirectional knapping. On some broad-faced cores, the flaking surface expands to the narrow facets. In this case, the strategy shifts from a broad-faced to sub-prismatic core approach. (2) The second (and less common) reduction system produced blades and bladelets from prismatic and narrow-faced cores. Our results also indicate that SDG1 blade production was based exclusively on direct percussion and not on pressure or indirect percussion flaking, though marginal percussion was sometimes used. Comparing SDG1 with other Initial Upper Paleolithic and Early Upper Paleolithic (EUP) in Northeast Asia, we suggest the SDG1 assemblages are typologically and technologically similar to the IUP assemblage in the Altai region of Siberia and Mongolia. Given the wide chronological range of SDG1 with some EUP technological features in SDG1 assemblage, we cannot exclude the possibility of incursion of EUP technology.

1. Introduction

Blades, a kind of special elongated and parallel-side flake, are considered to reflect high cognitive capabilities and technological efficiency of Upper Paleolithic tool makers. Systematic blade production had been considered to be the exclusive ability of *Homo sapiens* based on archaeological sites mainly from Western Europe (Mellars, 1989; Ambrose, 2001). However, accumulative evidence from Middle and Lower Paleolithic sites has challenged this view (Kozlowski, 2001). Furthermore, several securely dated blade assemblages in earlier phases of the Middle Pleistocene from Africa (Johnson and McBrearty, 2010; Wilkins and Chazan, 2012) and the Levant (Shimelmitz et al., 2011) have been reported in recent years. Detailed technological analysis of laminar assemblages supports the multiple origins hypothesis for the practice of blade production (Wilkins and Chazan, 2012). Also, experiments comparing blade- and flake-based technologies have challenged traditional impressions about the "efficient" and "cognitive" advantages of blade technology (Eren et al., 2008). Exclusive direct links between blade technology, *H. sapiens* and the Upper Paleolithic are clearly no longer obvious (Bar-Yosef and Kuhn, 1999). Recently, researchers have focused attention on the technological variability and complexity of blade production (Soriano et al., 2007; Villa et al., 2010; Shimelmitz et al., 2011; Wilkins and Chazan, 2012). Technological analysis for laminar production has allowed for more precise comparisons of the features of Initial Upper Paleolithic and Early Upper Paleolithic assemblages (see e.g., Rybin, 2004; Meignen, 2012; Zwyns, 2012; Zwyns et al., 2012).

Although blade technology was present very early in Western Eurasia, it is still often considered as a hallmark of the onset of the

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* Corresponding authors. Key Laboratory of Vertebrate Evolution and Human Origins of Chinese Academy of Sciences, Chinese Academy of Sciences, Beijing 100044, China.

E-mail addresses: fly5063@hotmail.com, archaeologypf@gmail.com (F. Peng), gaoxing@ivpp.ac.cn (X. Gao).

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Late Paleolithic in Eastern Eurasia (Gao and Norton, 2002; Bae, 2010). Blade-dominated assemblages appeared mainly during the early stage of the Late Paleolithic (ca. 40,000–30,000 BP) and were incorporated into the indigenous monotonous core and flake technology in this region (Seong, 2009; Bar-Yosef and Wang, 2012). In North China, some "blade technology" sites were identified only through morphology of flakes (i.e., elongate shape), but few of them were systematically studied apart from Shuidonggou locality 1(SDG1) (Li, 1993; Shinji, 2006). Shuidonggou also was called Shuitungkou or Choei-Tong-Keou in some references because of different phonetic transliterations. SDG1 has attracted the interest of many scholars since 1923, as it was the first discovered blade site in China. Although the assemblages have been studied in considerable detail, most previous studies followed a typological approach. The present study attempts to combine the techno-economic approach of the *chaîne opératoire* with an attribute analysis to restudy the collections that were excavated during the 1980s, and to systematically clarify the knapping strategy and reduction systems in the light of the technological features of assemblages.

2. Problems of stratigraphy and chronology at Shuidonggou locality 1(SDG1)

Twelve localities with estimates ranging from ca. 40,000–10,000 BP have been identified in the Shuidonggou region since SDG1 was discovered and excavated in 1923 by Licent and Teihard de Chardin (Licent and Teilhard de Chardin, 1925; Boule et al., 1928; Pei et al., 2012). Among these localities, SDG1 is the most important one due to its unique and numerous elongated blanks and Levallois-like or flat-faced cores which are significantly different from those in other Paleolithic assemblages in North China and East Asia (Brantingham, 1999; Brantingham et al., 2001, 2004). Excavation at SDG1 was carried out in 1923, 1960, 1963 and 1980, resulting in many publications on its lithic industry (Jia et al., 1964; Bordes, 1968; Kozlowski, 1971; Yamanaka, 1993; Boëda et al., 2012), chronology and stratigraphy (Zhou and Hu, 1988; Geng and Dan, 1992; Madsen et al., 2001; Liu et al., 2009; Gao et al., 2008; Li et al., 2013a; Morgan et al., in press). In the l980s excavation by Ningxia Museum, the stratigraphic sequence of SDG1 was divided into two culture units, which were called "Shuidonggou Upper and Lower cultural layer (SDG1-UCL/LCL)" and belonged to the Holocene and Pleistocene respectively (Ningxia Museum, 1987; Institute of Culture Relics and Archaeology of Ningxia Hui Autonomous Region, 2003); this led to a long-term debate about the chronology and stratigraphy of SDG1-LCL (Gao et al., 2013). The age of SDG1-LCL was pushed back to 34,000–38,000 BP, and to even more than 40,000 BP in recent publications (Li et al., 2013a; Morgan et al., in press). Li et al. (2013a) evaluated the SDG1 chronological framework by comparison with SDG Locality 2, suggesting that SDG1-LCL could be sub-divided to SDG1-LCL-A and SDG1-LCL-B based on the description provided by Ningxia Museum (1987). According to their comparisons, a large blade technology appeared in SDG1-LCL-B corresponding 38,000 ± 2000 and 34,000 ± 2000 a (U–Th). Subsequent simple core and flake-tool assemblages probably arose in SDG1-LCL-A corresponding to 25,450 ± 800 BP. However, there are two problems with this hypothesis. One problem is the precise stratigraphic position of the blade-dominated assemblage. The original publication of the 1980s excavation (Ningxia Museum, 1987; ICRA-NHAR, 2003) indicated that the upper part of SDG1-LCL (termed SDG1-LCL-A by Li et al., 2013a) contained mass carbonate nodules and yielded most of lithic artifacts including two polished stones and some microlithics. Most of the blade or elongated flake production was unearthed from SDG1-LCL-A, contradicting Li et al.'s (2013a) conclusion that the large blade technology appeared in SDG1-LCL-B and was replaced by simple core and flake-tool assemblages in SDG1-LCL-A.

The second problem is the uncertainty about the age of SDG1-LCL. Twelve age estimates are available for SDG1-LCL, ranging from ca. 40,000–10,000 BP (Table 1). Li et al. (2013a) interpreted the age of SDG1-LCL-A to be 16,760 ± 210 BP and 25,450 ± 800 BP, but more OSL and ^{14}C data from Liu et al. (2009), Morgan et al. (in press) and Nian et al. (this volume) indicate an older age than Li et al. (2013a) suggested. In addition, although the excavators divided SDG1-LCL to two strata, they combined all the artifacts from SDG1-LCL in one layer. Therefore, the chronology and cultural significance of the two strata cannot be comprehensively subdivided. A more conservative approach is to accept a wide chronological range for the SDG1 assemblage, between 40,000 and 25,000 BP. We agree with Li et al. (2013a) that the solution for establishing the precise relationships of chronology, stratigraphy, and technology at SDG1 LCL can be resolved only with future excavation.

Table 1
Dates of SDG1-LCL.

Material	Dating method	Lab number	Age (BP)	Reference
Charcoal	^{14}C	SDG01-001	36,200 ± 140 BP	Morgan et al., in press
Sediment	OSL	S1-3	28,700 ± 600 BP	Liu et al., 2009
Sediment	OSL	S1-4	29,300 ± 400 BP	Liu et al., 2009
Sediment	OSL	S1-5	32,800 ± 300 BP	Liu et al., 2009
Sediment	OSL	S1-6	15,800 ± 1100 BP	Liu et al., 2009
Sediment	OSL	S1-7	17,700 ± 900 BP	Liu et al., 2009
Sediment	OSL	S1-8	34,800 ± 1500 BP	Liu et al., 2009
Sediment	OSL	S1-9	35,700 ± 1600 BP	Liu et al., 2009
carbonate nodules	^{14}C	PV0317	25,450 ± 800 BP	Li et al., 1987
Bone	^{14}C	PV0331	16,760 ± 210 BP	Li et al., 1987
Tooth	U-series	BKY82042	38,000 ± 200 BP	Chen et al., 1984
Tooth	U-series	BKY82043	34,000 ± 200 BP	Chen et al., 1984

3. Material and methods

The lithic materials included in this analysis were collected during the 1980s excavation. More than 5500 stone artifacts and some fragments of vertebrate fossils which belong to eight species or genera were unearthed from SDG1-LCL: *Coelodonta antiquitatis*, *Equus przewalskyi*, *Equus hemionus*, Cervidae, *Cervus* sp., *Bubalus* sp., *Gozella przewalskyi*, *Struthio* sp. (ICRA-NHAR, 2003).

A sample of 2078 stone artifacts from SDG1-LCL, including 110 cores, 100 chunks, 1866 flakes and two ground stone artifacts were analyzed. While we identified various reduction strategies including laminar blade and radial flake production, the former is the most dominant technology within the SDG1 assemblage. Core types for blade production include broad-faced cores ($n = 54$), narrow-faced cores ($n = 1$), prismatic cores ($n = 3$), and semi-prismatic cores ($n = 6$). A burin-core, classified in retouched tools, can also be considered as a bladelet core.

Previous publications about the 1980s assemblage have described the typology and the Levallois or Levallois-like technology in SDG1 (Ningxia Museum, 1987; Brantingham, 1999; ICRA-NHAR, 2003; Boëda et al., 2012). Nevertheless, some of the technological categories of *débitage* used in this paper (e.g., *débordants*, elongated flakes and bladelets) are used in their technological sense, and are different from previous descriptions. The division between blade productions including standardized blades, elongated flakes and bladelets is made here according to metric and technological features. All the blanks are considered as parallel/sub-parallel edges in shape. Length/width ratios of blades are larger than 2 and elongated flakes are between 1 and 2. Bladelets in this study refers to small blades with a length/width ratio larger than 2 and a width less than 12 mm. According to these criteria, we identified 130 standard blades, 424 elongated flakes and 5 bladelets from complete blade production ($n = 559$). The technique of blade production is direct percussion (hard or soft hammer). Lithic analysis follows the principles of *chaîne opératoire* supported by quantitative presentation of specific analytical categories relevant to technological features. Cores are classified by both typological and technological attributes.

4. Lithic technology

The dominant raw materials at SDG1 are siliceous limestone ($n = 1422$, 68.4%) and quartzite ($n = 464$, 22.3%). The knapping quality of these two materials is comparable to flint in hardness but is less homogeneous. This is confirmed by one of authors (FP) in knapping experiments. Other raw material types (flint, quartz, quartz sandstone) are used in lower frequencies. The closest available source of siliceous limestone and quartzite is in the gravel bed around the SDG region. Nonetheless, several artifacts were made from a higher quality flint than the local flint from inside siliceous limestone pebbles, indicating possible raw material sources outside the SDG region.

4.1. Core preparation and exploration

In general, cores abandoned after lengthy exploitation left relatively little information about core preparation, but attributes on production and cores give some indications. First, productions with at least 50% cortex ($n = 85$) are present but in low frequencies (14.6%) in the complete flakes ($n = 591$) of SDG1. In contrast, 59.9% ($n = 354$) of complete productions are without cortex. On nearly all cores, especially broad-faced ones, the back surface remains cortical but the flake surface displays non-cortex (Table 2 B). The low frequency of flakes without cortex indicates the possibility of pre-treatment to the raw material before taken back to the site, and probably also reflects the consequence of intensive pretreatment of cores. We cannot fully demonstrate that the entire reduction sequence was systematically knapped at SDG1, nor can we exclude the possibility that the initial reduction of cores took place elsewhere, so that cores may have been transported to SDG1 in an advanced state of reduction.

Blade productions were generally removed from two opposed platforms in broad-faced cores and occasionally from narrow-faced and prismatic cores. Among 54 broad-faced cores, more than 44 (80%) have two opposite and oblique platforms. The first item detached from the core while opening the *débitage* surface usually occurs along the natural outline of the raw material. Most of scars left on the *débitage* surface of broad-faced core are from opposite directions ($n = 40$) and their number is normally more than 4 ($n = 37$) (Table 2 C, D). All the semi-prismatic cores ($n = 6$) show obvious features of broad-faced cores on one wide surface, and indicate the change of knapping strategy.

Table 2
Frequencies of some of the attributes observed on broad-faced cores in SDG1 assemblage ($N = 54$).

A: Core size	Length (mm)	Width (mm)	Thickness (mm)
Max	36.72 mm	33.39 mm	14.03 mm
Min	98.21 mm	69.01 mm	47.92 mm
Mean	62.26 mm	46.94 mm	29.72 mm
Sd	13.56	9.02	8.24

B: Percentage of cortex	0	1–25%	26–50%	51–75%	76–99%	100%
Back	5	5	7	9	26	2
Débitage surface	51	/	2	1	/	/

C: Direction of scars	Convergence	Unidirection	Opposite	Irregular	
N	3	7	40	4	
D: Number of scars on débitage surface	1	2	3	4	>4
N	2	1	6	8	37
E: Number of Striking Platform			1	2	
N			10	44	

Based on the observation of the interior angle on platforms and the volumetrics of cores, we suggest that the prismatic and narrow-faced cores were not heavily worked but left a large area of cortex. The SDG1 knappers selected relatively medium-sized blocks or pebbles, normally less than 100 mm in length. The reduction sequence starts following the contour of the core but left cortex on the distal end (Fig. 1). The only narrow-faced core identified in the SDG1 assemblage displayed the small laminar elements detached from the intersection of a narrow flaking face which are typical features of bladelet production.

4.2. Maintenance and platform preparation

For broad-faced and semi-prismatic cores, the broad *débitage* surface was maintained by *débordant* flakes/blades with a unidirectional or bidirectional dorsal surface (Fig. 2). In this case, flaking started from the lateral side of the core. These edge removals were the only way to continue the reduction. The main aim of this method was for the creation of convexity on the *débitage* surface. The two opposite platforms are normally oblique. On broad-faced cores, the preparation for striking the platform is not by heavy faceting: all abandoned cores have a plain platform and display no evidence of faceting. This feature can be further demonstrated by the high frequency of plain platforms ($n = 505$, 48.37%) on *débitage* productions (Table 3 A).

Table 3
Frequencies of some of the attributes observed on the *débitage* in SDG1 assemblage.

A. Platform type	Number	Percentage (%)
Plain	505	48.37
Cortical	112	10.73
Punctiform	27	2.59
Linear	24	2.3
Dihedral	105	10.06
Facet	228	21.84
En chapeau de gendarme	14	1.34
Crush	29	2.78
Totally	1044	100%

B. Thickness of Platform (not account crush, linear and punctiform)

Number	Min (mm)	Max (mm)	Mean (mm)	Sd
$N = 964$	1.32	80.8	7.53	4.72

C. Profile of complete blade productions

Straight	Slightly curve	Curve	Convex	Irregular
471	63	11	6	40
79.7%	10.66%	1.86%	1.02%	6.77%

D. Exterior platform angles (not account crush, linear and punctiform)

Number	Min (°)	Max (°)	Mean (°)
$N = 964$	45	129	84.5

Nonetheless, the striking platforms of prismatic and narrow-faced cores are different in that some small scars were left on the striking platform. We observed elaborate retouch on the striking platform of these two core types. In addition, several rejuvenated core edges were identified as evidenced by the presence of blades with centripetal preparation on platform.

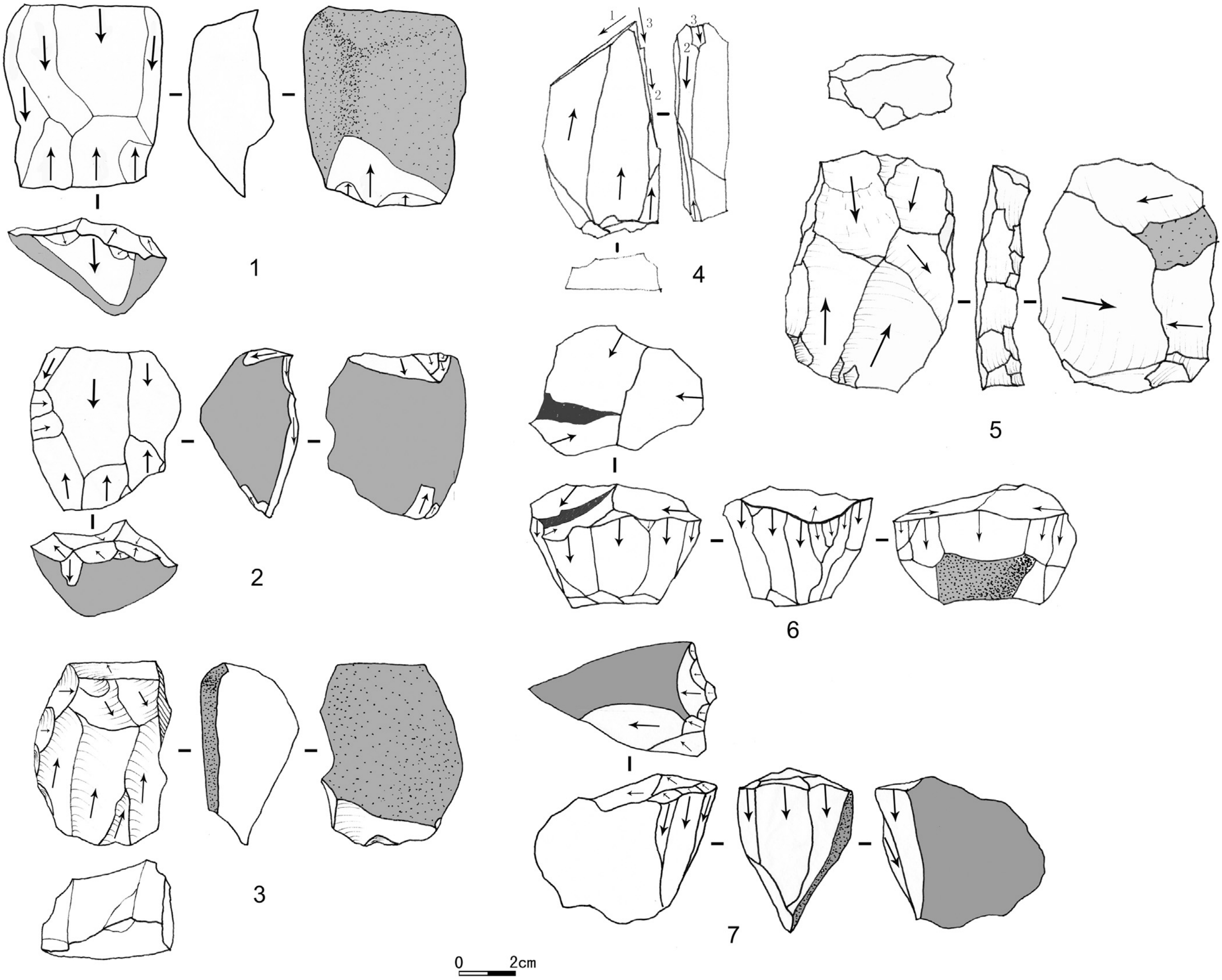

Fig. 1. SDG1 cores. 1,2,3,5. Broad-faced core; 4. Burin-core; 6. Prismatic core; 7. Narrow-faced core.

4.3. Abandoned cores

Typically, exhaustion was the main reason for core abandonment. The intensive exploitation of cores is also reflected in the comparison between the mean length of core and blade productions (Shimelmitz et al., 2011). The mean length of broad-faced cores (62.26 mm) is slightly longer than standard blades (59.79 mm). The thinnest core is only 14.03 mm thick, and the smallest core is only 36.72 mm in length (Table 2 A and Fig 1.1). In some cases, knapping accidents (e.g., hinge scars, large overshots) are also reasons for core abandonment. In contrast, prismatic and narrow-faced cores were abandoned while still retaining potential for further removal of laminar items (Fig 1).

4.4. Techniques and knapping tools

Different knapping techniques (e.g., indirect percussion), and knapping tools (e.g., hard hammer) are difficult to identify. Although French scholars have contributed much on these topics (e.g., Pelegrin, 1988, 2000; Inizan et al., 1999), the criteria of identification of different techniques need a wider experimental database based on different kinds of raw material. At SDG1, knapping experiments in siliceous limestone and quartzite are still ongoing. However, the types of platform provide rough information about the techniques which were applied by the SDG1 knappers. Our database contains 1044 blanks including completed and uncompleted blanks with proximal ends (Table 3 A). Most (60%) platforms are plain and cortical, fewer (35%) are dihedral, facet and *en chapeau de gendarme*, illustrating the features which are different from both European Middle Paleolithic and Altai Initial Upper Paleolithic assemblages (Table 3 A). The complete blank profiles are mainly straight and slightly curved (Table 3 B). More than 96% blank platforms are larger than 2 mm in thickness and the mean value is larger than 7 mm (Table 3 B). Based on these quantitative data and combined with our observations (including 70% with a visible bulb of percussion), direct percussion was the only method applied by the SDG1 knappers and internal percussion was their first and foremost choice. A few thin platforms in our database indicate that marginal percussion near the edge of the platform also existed in the SDG1 knapping motions. The broad range in the exterior platform angles, with a peak at 75°–85° (Table 3 D) also corresponds to the optimal values observed by Pelegrin (2000) for soft stone hammers used in marginal percussion. According to the experimental data from flint, we suggest that both soft and hard stone hammers were applied in knapping processes at SDG1.

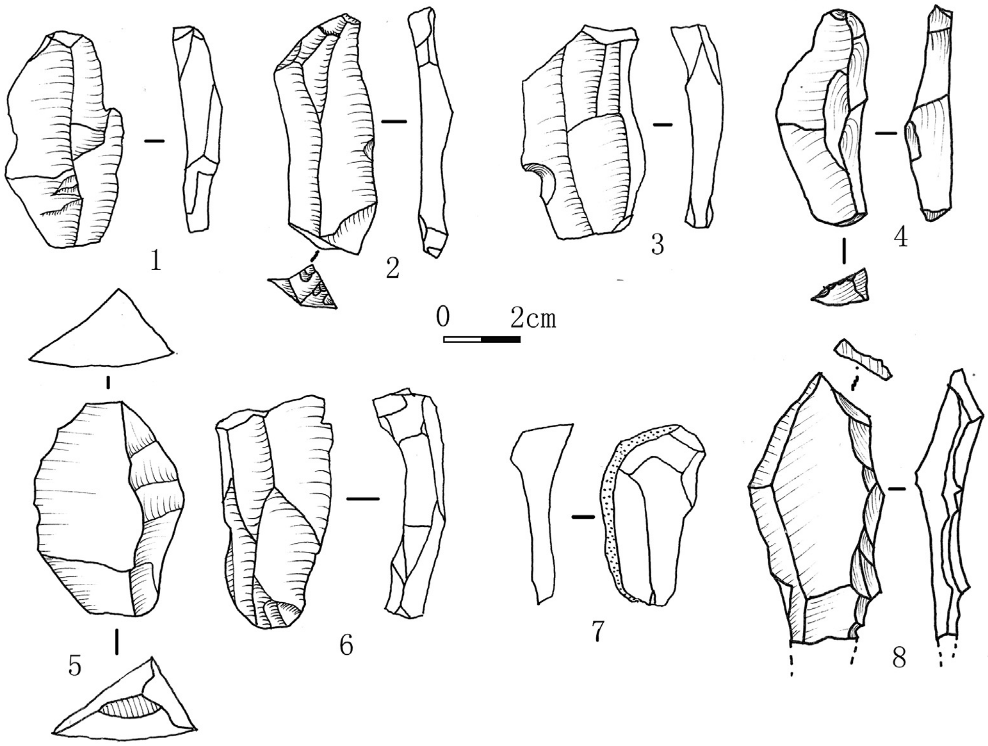

Fig. 2. SDG1 débordant blades.

In some previous publications about SDG1 assemblage (Ningxia Museum, 1987; ICRA-NHAR, 2003; Brantingham et al., 2004), 'microblade' was a term adopted to describe some small blades. The original purpose of this usage was not relevant to technological analysis but only to metric statements about size. In East and Northeast Asia, and even in North America, microblades are normally directly related to the use of pressure flaking and are associated with wedge- and pencil-shaped cores in the late Upper Paleolithic (Bar-Yosef and Wang, 2012). Also, because of confusion between the distinction between technology and typology, Brantingham et al. (2004) regarded some so-called "bipolar bladelet technology" in SDG2 as the ancestor of microblade technology in other Late Upper Paleolithic assemblages of North China. The same misunderstanding happened in discussions about the origin of microblade technology in Northeast Asia (Keates, 2007; Kuzmin, 2007). In the SDG1 assemblage, we did not find any features that were typical of pressure flaking as identified by Inizan et al. (1992). It is therefore inappropriate to adopt 'microblade' as a term in analyses of the SDG1 assemblage on the basis of only a few small sized blades and narrow-faced cores for which the flaking technique has not been identified. Such a misattribution would give rise to more confusion in the study of microblades in East Asia. We suggest that the term *bladelet* in the SDG1 assemblage to denote small blades is given priority (Tixier, 1963) and metric meaning (Hassan, 1972).

4.5. Reduction sequences

The lithic analysis of blade technology shows that there are two main blade reduction systems at SDG1. In the first reduction system, the raw material is shaped and reduced as a core with two opposite platforms. Knappers then applied the Levallois recurrent strategy on one surface of the core from which elongated flakes and sometimes blades were detached. In addition, many diagnostic *débordants* blanks were found in the assemblage. This strategy is related to Levallois as defined and confirmed by Boëda (1995, 2012). Only one flaking surface is used for blade production, and the thickness of the core tends to decrease along the whole reduction process. However, on some of these "broad-faced" cores, the flaking surface expands to both narrow faces. In this case, the knapping shifts from a broad-faced to a sub-prismatic core conception. Thus, blades, bladelets and elongated flakes were detached from the broad and the narrow faces of sub-prismatic cores. This changed trajectory is similar to the "volumetric conception of the Upper Paleolithic" (Boëda, 1995) that is also described in the Altai IUP assemblages (Zwyns, 2012) (Fig. 3 A).

The second reduction system shows a production of blades and bladelets from prismatic and narrow-faced cores. The latter types of core are characterized by the use of crested blades to initialize the reduction. They share similar platform maintenances and reduction patterns and differ only in their general shape (Fig. 3 B). Generally speaking, the SDG1 laminar blanks have relatively thick platforms which reflect internal percussion in motion.

4.6. Retouched pieces

Retouched pieces represent 14.3% ($n = 297$) of the analyzed SDG1-LCL sample. In Brantingham's (1999) article and the report of the 1980 excavation (ICRA-NHAR, 2003), the frequencies of retouched pieces are 18.6% and 19.5% respectively. The low frequency of retouched pieces indicates the possibility that some formal tools were taken away from the site.

A high percentage of broken blade production (62.71%, $n = 940$) was also observed in the report of the 1980s excavation. The authors of this report supposed that it was the consequence of intentional breakage by the SDG1 knappers because broken blades were probably used as composite tools (ICRA-NHAR, 2003). However, we did not find any clearly truncated retouch on the broken surface, but only a clean snap. One of the authors (FP) observed that

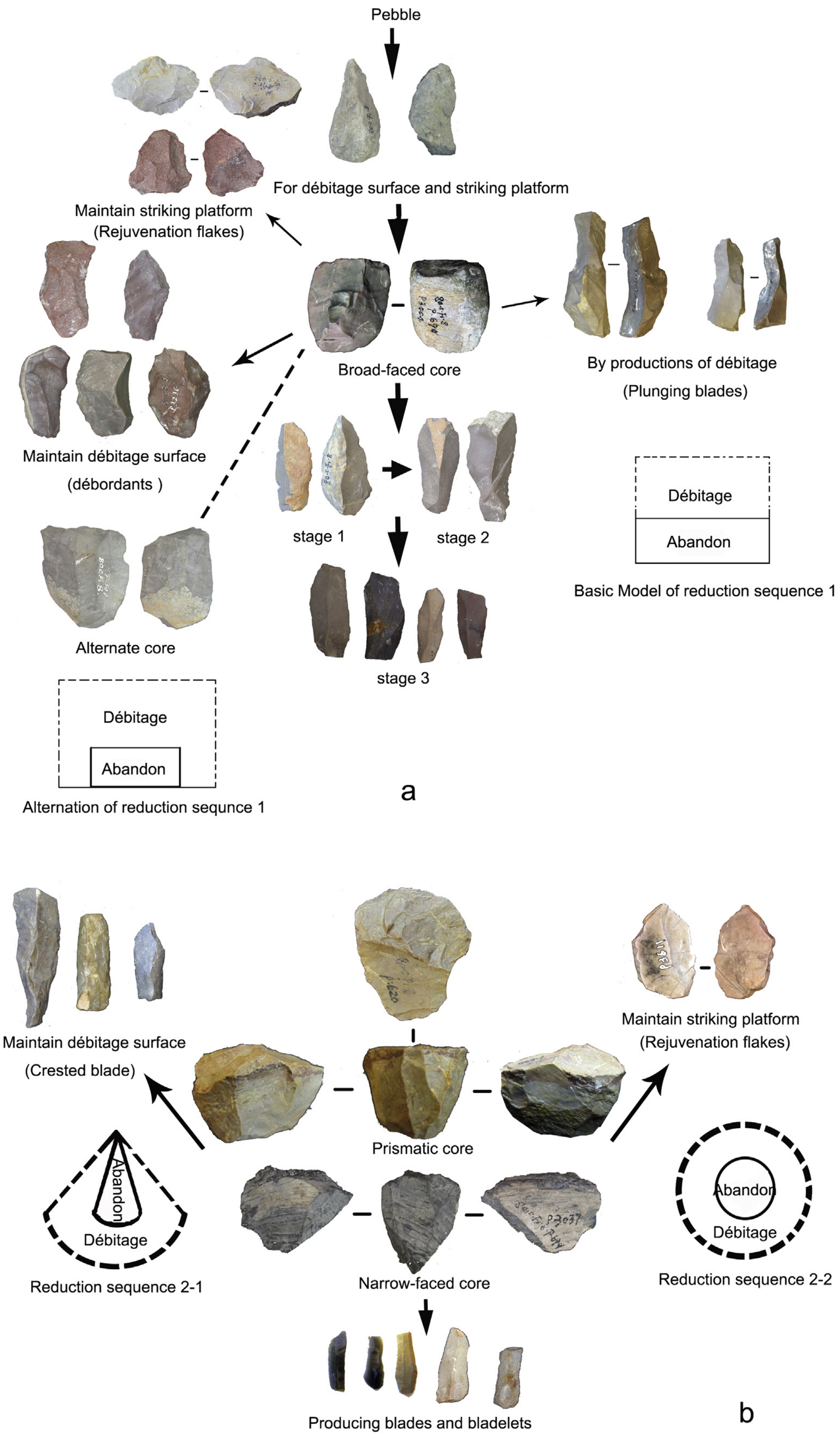

Fig. 3. Two blade reduction sequences in SDG1.

this phenomenon happened frequently and accidentally in knapping experiments on siliceous limestone which was collected in the SDG region. It indicates that the breakage of some blades was probably unintentional. More experimental research is needed to evaluate this pattern.

47.89% ($n = 136$) of retouch occurred on both sides of blanks. This matches previous observations that side scrapers, typical Middle Paleolithic tools, dominated the category. There still are 17.61% ($n = 50$) of modifications appearing on the distal ends of blanks. The mixed feature of retouched tools is also one of the IUP characteristics in the Levant (Liliane, 2012). Among the retouched pieces, one burin-core was identified (Fig. 1). The blank is a thin broad-faced core. Bladelets were detached from one striking platform and repeated along one narrow side. This technology also is one of characteristics of IUP assemblages in the Altai region (Zwyns et al., 2012).

5. Discussion and conclusion

Our analyses indicate a dominant use of a recurrent Levallois reduction sequence that applied bidirectional removals for elongated flakes, standard blades, or bladelets from broad-faced facets only, or sometimes included both sides of cores. Prismatic or narrow-faced cores were also occasionally used to produce blades and bladelets.

The origin of the SDG1 blade technology has been long debated. Some scholars prefer to trace the origin of blade technology at SDG1 in other Chinese Paleolithic assemblages, e.g., Dingcun (Jia et al., 1964) and Changwu (Gai and Huang, 1982). Nevertheless, in recent years, more and more scholars have realized the close relationships between Middle and Upper Paleolithic assemblages in Altai region, Siberia and contemporary lithic assemblage in Northwest China (Brantingham et al., 2001; Bar-Yosef and Wang, 2012; Peng, 2012; Gao et al., 2013; Qu et al., 2013). In the Altai region, the Middle to Upper Paleolithic transition and the attribution of these different technologies are quite complex, especially with the new discovery of “Denisovans” (Krause et al., 2010) as likely tool-makers. The blade-based assemblages have been defined by scholars in two different laminar technology traditions according to the technological features of Kara-Bom and Ust-Karakol 1 corresponding to the Initial Upper Paleolithic and Early Upper Paleolithic respectively (Derevianko and Volkov, 2004; Derevianko, 2005a,b; Zwyns, 2012). The origin and spread of these two different traditions is a crucial topic in studying the migration and interaction of *H. sapiens*, Neanderthals and Denisovans in Northeast Asia. This study of blade production at SDG1 adds to our knowledge about variability of laminar technology and an emerging appreciation for technological diversity in the Late Paleolithic of Northeast Asia. Our analysis also offers a technological perspective on the particular form of two different reduction sequences practiced at SDG1. Based on our analyses, the main reduction system of the SDG1 assemblage is clearly similar to the IUP tradition in the Altai region. Some data from the SDG1 assemblage indicates the use of symbols, such as ostrich eggshell beads and an engraved bone tool (Qiu and Li, 1978; Peng et al., 2012a). Our analyses indicate that the lithic assemblage belongs to the IUP recognized in the Near East and Altai region (Meignen, 2012; Zwyns et al., 2012). However, considering the wide range of possible ages at SDG1, the secondary reduction system of SDG1 indicated the possible incursions of EUP technology, even though the sample size of EUP technological productions is small.

The SDG1 assemblage has been viewed as the southernmost and latest extent of IUP blade technologies based on the old age estimates around 29,000–24,000 BP which were reported by Madsen et al. (2001). By integrating the chronological data from Siberia and Mongolia, scholars tried to build a dispersal route of IUP technology in Northeast Asia that appeared in Siberia around 43,000 years ago, spread to the Mongolian Gobi between 33,000 and 27,000 years ago, and finally spread into northwest China at Shuidonggou by 25,000 years ago (Brantingham et al., 2001). However, the earlier range of ages at SDG1 dates the appearance of IUP technology at SDG1 to ca. 40,000 years ago (Li et al., 2013a; Morgan et al., in press). Compelling recent genetically based demographic evidence makes it more difficult to interpret the complex later Pleistocene human biology and behavior (Reich et al., 2010). Dennell (2009) and Dennell and Roebroeks (2005) noted that compared with Africa and western Eurasia, the emergence of modern human biology and behavior in eastern Eurasia has been neglected, due in part to its geographical remoteness from Western Europe. Driven by new genetic evidence, this region is increasingly attracting the interest of scholars.

The origin of SDG1 blade technology has been linked with the Altai region, Mongolia, and even Central Asian IUP and EUP assemblages. However, the overall distribution of this technology, especially in North China, remains unclear. Evidence from SDG2 (Li et al., 2013a,b), Luotuoshi (Derevianko et al., 2012; Peng, 2012) and Jinsitai (Wang et al., 2010) has offered some clues. Barton and Brantingham (2007) provide temporal and spatial patterns based on archaeological data from the Late Pleistocene of North China. On the basis of their model, significant climate change in Late Pleistocene had an immediate and profound impact on human mobility and cultural evolution. If this model matches the demographic expansion and contraction of hominid populations with IUP and EUP technology in Late Pleistocene Northeast Asia, how far did the technological diffusion spread to the south from Siberia? Are there are some assemblages in North China that reflect the combined effect of acculturation and environmental adaptation processes? To address these questions, more investigation of the technological and chronological relationships among SDG1 blade technology and other Chinese Late Paleolithic blade assemblage is critical.

Approaches to lithic analyses of Chinese Paleolithic assemblages have long been limited to typology and simple descriptions of retouched tools. Scholars provided important data and key insights, but typological approaches have resulted in ambiguity regarding the sources of assemblage variability and the nature of technological diversity. Technological concepts should be added to the traditional methods of analysis in future work to clarify important issues about the behavioral changes in late Pleistocene Eastern Eurasia.

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