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Re-examination of the dates of large blade technology in China: A comparison of Shuidonggou Locality 1 and Locality 2

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A B S T R A C T

The presence and age of large blade technology at the Shuidonggou site is a pivotal issue in discussions of the spread of blade technology in East Eurasia. Madsen and colleagues' influential work uses the dates (24,000–29,000 rcy BP [radiocarbon years before present]) they obtained from Shuidonggou Locality 2 to estimate the age of blade technology in this region, and suggested a very late arrival of Levallois-like blade technology from the north. This paper re-examines the evidence for the age of blade technology at Shuidonggou by comparing the lithic assemblages from the new excavations at Locality 2 with those from Locality 1. Several important points are demonstrated: (1) the lithic industry of cultural layers 1 through 4 at Locality 2 is not based on large blades, so reported dates from these layers cannot be an indicator of the age of large blade technology; (2) comparing Locality 1 and 2, the age of large blade technology appears to be around 34,000–38,000 calendar years BP (before present) in this region, suggesting a relatively rapid technology dispersal from the west and/or north; (3) the so-called 'Shuidonggou lower cultural layer' at Locality 1 includes both large blade and simple flake industries.

Introduction

Blade technology was once considered as a marker of modern humans. While that notion is no longer accepted, the presence of different varieties of systematic blade production in transitional and Initial Upper Paleolithic industries remains a topic of considerable scientific interest (e.g., Mellars, 1990; Bar-Yosef and Kuhn, 1999; Bar-Yosef and Pilbeam, 2000; Mellars et al., 2007). This is especially true in North China. Very few sites in China posses the general features of material culture, including blade production, that distinguish the early Eurasian Upper Paleolithic (Lin, 1996; Gao, 1999; Gao and Norton, 2002). Consequently, the Shuidonggou site (Fig. 1), which has yielded evidence of large blade production as well as the use of personal ornaments, plays an essential role in discussions of the spread of blade technology and other Upper Paleolithic traits across eastern Eurasia (Li et al., in press). However, two crucial questions about the Shuidonggou site have not been completely resolved. The first concerns the characteristics of the early Upper Paleolithic at Shuidonggou, and especially variation among the industries or assemblages. The second concerns the ages of the assemblages.

Brantingham et al. (2001) compared the Initial Upper Paleolithic assemblages from three sites in Northeast Asia, Kara Bom (Siberian Altai), Chikhen Agui (Mongolia) and Shuidonggou Locality 1. They argued for a strong resemblance among lithic industries from the three sites, as well as continuity between the regional Middle and Initial Upper Paleolithic in Siberia. However, in regards to the retouched tools at Shuidonggou Locality 1, Brantingham et al. (2001: 744) stated "regardless of the counting procedure, Shuidonggou has a strong Middle Paleolithic typological signature".

Madsen et al. (2001) conducted dating work at Shuidonggou. Their results are based on charcoal samples taken from the natural erosional profile at Locality 2, including recently exposed hearths. Their results appeared to place Shuidonggou firmly in the range of 29,000–24,000 rcy BP (radiocarbon years before present), leading them to hypothesize a very late arrival of large blade technology in this area, probably from the North (Mongolia). These age estimates for large blade technology in the Shuidonggou region have been widely cited (e.g., Brantingham et al., 2001; Gao et al., 2002, 2008; Zhang et al., 2010; Derevianko, 2011; Guan et al., 2011, 2012; Pei et al., 2012).

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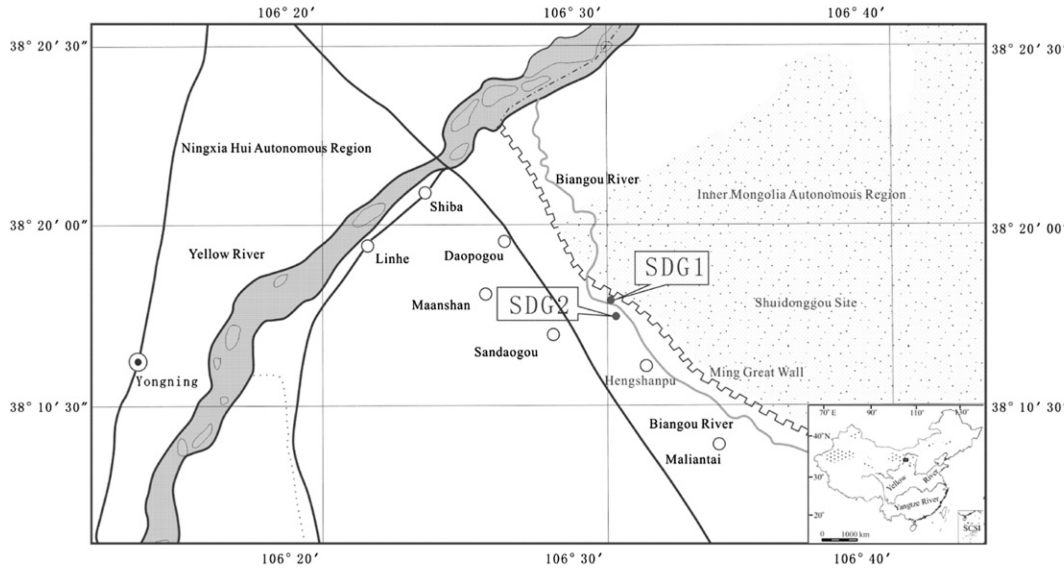

Figure 1. Location of the sites involved in this study and its position in North China (modified after Liu et al., 2009). SDG1, Shuidonggou Locality 1; SDG2, Shuidonggou Locality 2.

Results from recent excavations at Shuidonggou Locality 2 (Li et al., in press) allows us to re-examine the relationship between Locality 1 and 2, using not only stratigraphy but also the technological features of the assemblages, and to suggest a revised Upper Pleistocene cultural chronology in the Shuidonggou region, including the age of early blade technology. The findings forming the most recent studies show that 1) there is more technological diversity than previously described in the Shuidonggou sites, and 2) the layers yielding evidence of large blade production are significantly older than the most widely cited dates suggest.

Stratigraphy and dates at SDG1 and SDG2

Locality 1

Locality 1 (SDG1) was the site of the first excavation at Shuidonggou, which took place in 1923. There were subsequent campaigns in 1960, 1963 and 1980 (Licent and Teilhard de Chardin, 1925; Jia et al., 1964; Qiu and Li, 1978; Ningxia Museum et al., 1987). The profile of SDG1 has been described by several different geologists and archaeologists during and after the various excavation projects (Jia et al., 1964; Ningxia Museum et al., 1987; Zhou and Hu, 1988; Brantingham, 1999; Gao et al., 2008; Liu et al., 2009).

The stratigraphic sequence at SDG1 is typically divided into two main parts, the Late Pleistocene and Holocene deposits, respectively. This paper concerns only the Late Pleistocene strata yielding Paleolithic assemblages, the so-called 'Shuidonggou cultural layer' or 'Shuidonggou lower cultural layer' (Jia et al., 1964; Ningxia Museum et al., 1987; Gao et al., 2008). Some scholars treat the lower cultural layer at SDG1 as a single stratum (e.g., Jia et al., 1964; Zhou and Hu, 1988; Gao et al., 2008), but others indicate that it could be subdivided into different strata (Fig. 2) (Ningxia Museum et al., 1987; Liu et al., 2009). According to the description by Ningxia Museum et al. (1987), the SDG lower cultural layer consists of two different depositional units. The geologist Liu et al. (2009) actually recognize four distinct geological strata within it. According to the Ningxia Museum's report (see Fig. 2a), 'SDG lower cultural layer' consists of a gray-yellow loess-like fine sand. The upper layer (layer 3) contains carbonate nodules and its thickness is about 50–100 cm; the upper part of lower layer (layer 2) contains a few redoximorphic mottles and its thickness is 60–70 cm, the lower part of layer 2 contains no redoximorphic mottles and very few artifacts (Ningxia Museum et al., 1987). Liu et al. (2009) (see Fig. 2b) describe four strata within the 'SDG lower cultural layer' including: layer 3, grayish yellow silt, blocky structure, calcareous cement with some nodules, 90 cm; layer 4, grayish yellow silt, blocky structure, a few redoximorphic mottles, 280 cm; layer 5, grayish yellow fine sand, coarse sand, planar bedding, 40 cm; layer 6, light grayish yellow silt, planar bedding, redoximorphic mottles, containing no artifacts, 190 cm. These two descriptions are very different, but it must be recalled that they were made at different times. The description by the Ningxia Museum was made during excavation when connections between the stratigraphy and archaeological content could be recognized, whereas Liu and colleagues visited the site much later. In this paper, we use the two-part subdivision of the Late Pleistocene deposit. We use the terms 'SDG1 lower cultural layer A' (SDG1-LCL-A), equivalent to the layer 3 in the Ningxia Museum's report, and 'SDG1 lower cultural layer B' (SDG1-LCL-B), equivalent to the layer 2 as described by the Ningxia Museum (see Fig. 2a).

The excavations at Locality 1 in the 1980s have combined artifacts from the entire 'SDG lower cultural layer', making it impossible to isolate the assemblages from the different strata within it. Fortunately, the original publication (Ningxia Museum et al., 1987) and other reports on excavations during the 1960s (Qiu and Li, 1978; Derevianko, 2011) give us some clues as to the features of different cultural deposits within the lower cultural layer. 'SDG1-LCL-A' (layer 3 or the upper part) yielded two grinding tools and one ostrich eggshell bead. The exact positions of these grinding tools are not clear, but the bead is quite probably unearthed from the lower part of 'SDG1-LCL-A' (Qiu and Li, 1978; Derevianko, 2011). Whatever the technological nature of assemblages from the different layers may be, what is important is that the 'SDG lower cultural layer' includes at least two cultural deposits, which are 'SDG1-LCL-A' and 'SDG1-LCL-B', as previously mentioned by Gao et al. (2008).

Since 1984, there have been several attempts to date the Shuidonggou Locality 1 deposits using different chronometric methods (Chen et al., 1984; Li et al., 1987; Ningxia Museum et al., 1987; Liu et al., 2009; see also Gao et al., 2008, Table 1). Radiocarbon dates provide a wide range of ages: finite radiocarbon dates include 17,250 ± 210, 16,760 ± 210, 25,450 ± 800, 26,190 ± 800 and

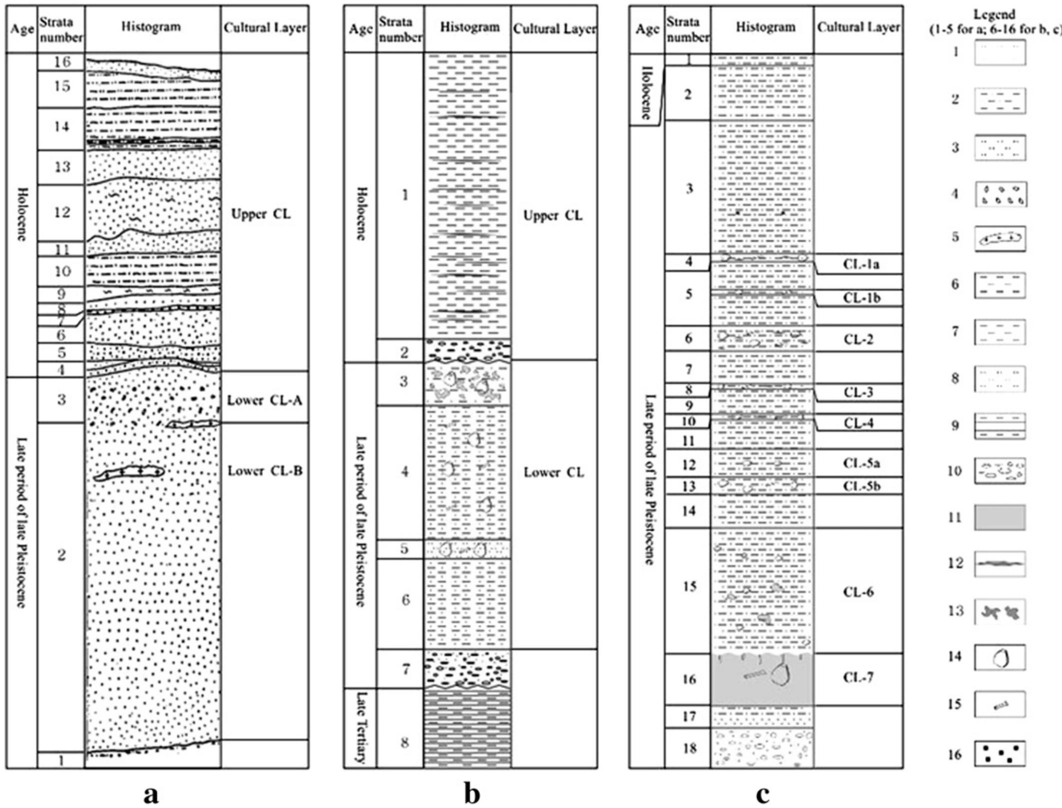

Figure 2. Cumulative stratigraphic profiles and cultural layer division at SDG1 and SDG2 (modified after Ningxia Museum et al., 1987; Liu et al., 2009). (a) SDG1 profile reported by Ningxia Museum et al. (1987); (b) SDG1 profile described by Liu et al. (2009); (c) SDG2 profile described by Liu et al. (2009). 1, fine sand; 2, silt; 3, sand and gravel; 4, carbonate nodule; 5, hearth figure; 6, clay-rich silt; 7, silt; 8, fine sand; 9, mudstone; 10, gravel; 11, peat; 12, peat band; 13, carbonate nodule; 14, stone artifact; 15, animal fossil; 16, charcoal.

26,230 ± 800 rcy BP (Li et al., 1987; Ningxia Museum et al., 1987; Institute of Archaeology, CASS, 1991; see also; Institute of Archaeology of Ningxia Hui Autonomous Region, 2003). The original ^{14}C dates reported by Li et al. (1987) are 16,760 ± 210 and 25,450 ± 800 rcy BP. Other, divergent dates are due to use of a different radioactive half-life (the 17,250 ± 210 and 26,190 ± 800 dates are calculated using the half-life of 5730 years, reported by Institute of Archaeology, CASS, 1991) or unknown factors (such as the age of 26,230 ± 800 years, reported by Ningxia Museum et al. (1987)). The Institute of Archaeology of Ningxia Hui Autonomous Region (2003) reports that the most recent of their dates on bone comes from the upper part of 'SDG1-LCL-A', and the older one on carbonate nodules comes from the lower part of 'SDG1-LCL-A'. Madsen et al. (2001) and Gao et al. (2002, 2008) argue that the younger group is a result of contamination with organic carbon likely redeposited from sediments higher in the sequence. However, there is currently no geoarchaeological research to back this up. In addition, the thickness of 'SDG1-LCL-A' is about 50–100 cm, so it is quite possible that the upper and lower parts have different ages. This paper assumes the two radiocarbon dates are both reasonable.

Several other dating methods have been applied to the SDG1 site. Chen et al. (1984) report on bone-derived U–Th (Uranium–Thorium) ages from the 'lower cultural layer' and the Institute of Archaeology of Ningxia Hui Autonomous Region (2003) also indicates that the samples come from layer 2 as described by 1980s excavators, which is 'SDG1-LCL-B' in this paper. They are given as 34,000 ± 2000 and 38,000 ± 2000 U–Th BP (Chen et al., 1984).

Table 1
Dating results from Shuidonggou Locality 1 (SDG1).

Cultural layer	Original unit (Fig. 2a, b)	Context	Material	Dating method	Lab #	Age (BP)	Cal (BP)[a] (95.4%)	Reference
SDG1-LCL-A	Upper part of stratum 3	In situ	Bone	^{14}C	PV-331	16,760 ± 210	19,919 ± 257	Li et al., 1987
SDG1-LCL-A	Lower part of stratum 3	In situ	Carbonate nodule	^{14}C	PV-317	25,450 ± 800	30,196 ± 713	Li et al., 1987
SDG1-LCL-B	Stratum 2	Profile	*Equus* teeth	U–Th	BKY-82042	38,000 ± 2000		Chen et al., 1984
SDG1-LCL-B	Stratum 2	Profile	*Equus* teeth	U–Th	BKY-82043	34,000 ± 2000		Chen et al., 1984
SDG1-LCL	Stratum 3	Profile	Sediment	OSL	IEE1889	28,700 ± 6000		Liu et al., 2009
SDG1-LCL	Upper part of stratum 4	Profile	Sediment	OSL	IEE1890	29,300 ± 4100		Liu et al., 2009
SDG1-LCL	Lower part of stratum 4	Profile	Sediment	OSL	IEE1891	32,800 ± 3000		Liu et al., 2009
SDG1-LCL	Stratum 5	Profile	Sediment	OSL	IEE1892	15,800 ± 1100		Liu et al., 2009
SDG1-LCL	Upper part of stratum 6	Profile	Sediment	OSL	IEE1893	17,700 ± 900		Liu et al., 2009
SDG1-LCL	Middle part of stratum 6	Profile	Sediment	OSL	IEE1894	34,800 ± 1500		Liu et al., 2009
SDG1-LCL	Lower part of stratum 6	Profile	Sediment	OSL	IEE1895	35,700 ± 1600		Liu et al., 2009
SDG1-LCL	Stratum 3	Profile	Charcoal	AMS	UGAMS-9682	36,200 ± 140	39,410 ± 183	Peng et al., 2012

[a] ^{14}C dates were calibrated using OxCal 4.1 online software (IntCal 09 curve).

Liu et al. (2009) applied the optically stimulated luminescence (OSL) dating method to Locality 1. The 'SDG lower cultural layer' is assigned to a time span from 34,800 ± 1500 to 28,700 ± 6000 OSL BP. (See Liu et al., 2009 for details). Peng et al. (2012) reported an accelerator mass spectrometry $_{14}$C (AMS) date, 36,200 ± 140, which came from stratum 3 described by Liu et al. (2009). Although there appears to be some concurrence in date ranges with the radiocarbon and U–Th dates, it is not safe to compare them with OSL dates because of the different subdivision of cultural layers used by Liu and the Ningxia Museum. In this paper, we use the original stratigraphic description by the excavators and dates connected with the original stratigraphic subdivision to infer that the age of the upper part of 'SDG1-LCL-A' is around 16,760 ± 210 rcy BP; the age of the lower part of 'SDG1-LCL-A' is approximately 25,450 ± 800 rcy BP; the age of 'SDG1-LCL-B' is between 34,000 ± 2000 and 38,000 ± 2000 U–Th BP. This last set of ages is consistent with the OSL results for the lower part of the sequence reported by Liu et al. (2009).

Locality 2

Locality 2 (SDG2) is located on the opposite bank of the Biangou River from SDG1, less than 100 m away (see Fig. 1). Two separate trenches (units 1 and 2) up to 100 m^2 were excavated close to the natural profile as part of field campaigns in 2003–2005 and 2007. The stratigraphic sequence, with a total thickness of 12.5 m, consists mainly of lacustrine deposits. The sequence for unit 2 as described by Liu et al. (2009) is more complete. It includes 18 substrata (see Fig. 2c) (see Liu et al., 2009 for complete and detailed descriptions of stratigraphy), seven of which contain Paleolithic remains: these are designated culture layers 7 through 1 (CL7–CL1) (see Fig. 2c) from bottom to top (Li et al., in press). During excavation, all archaeological materials were collected from 2 to 5 cm artificial levels within geological strata. The three-dimensional locations of all specimens found in situ were recorded with a total station and all of the archaeological sediments were dry sieved though fine mesh (c. 2 mm).

Overall, the lithic assemblages from the different cultural layers may be divided into two broad groups. CL7 and CL5a yielded two large blade cores similar to the ones described from SDG1. The specimen from CL5a is a Levallois-like flat-faced core with two faceted platforms, and the other from CL7 is an edge-faceted blade core with two opposing platforms (Fig. 3). The assemblages from CL6, CL5b, and CL4-CL1 show consistent features, which include irregular flake production and simple side-scraper-dominated tool assemblages. Materials from these strata fit within the flake-tool tradition that is widespread in North China (see Fig. 3) (see Li et al., in press for details of technological features). While we will not describe the assemblages from CL6, CL5b and CL4-CL1 in detail, it is important to emphasize that they contain no evidence for systematic production of large blades.

Three separate dating projects have been conducted at Locality 2 since 2001 (Table 2). As discussed above, Madsen et al. (2001, see also Gao et al., 2002, 2008) collected their samples around hearths

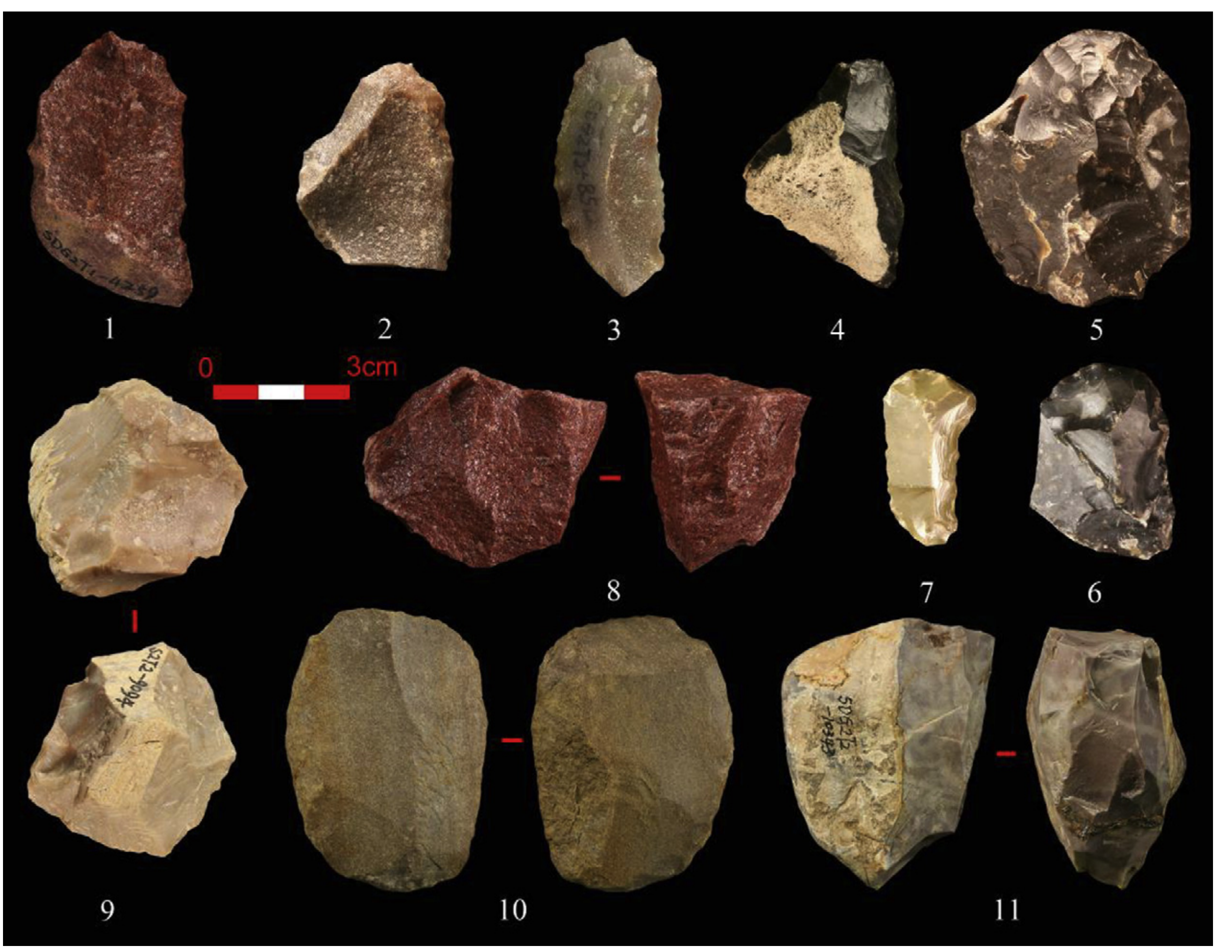

Figure 3. Cores and retouched tools from SDG2. 1, 8 are from CL1a; 2–7 are from CL2; 9 is from CL3; 10 is from CL5a; 11 is from CL7. 1–4: sidescrapers; 5–7: endscrapers; 8, 9: free-hand percussion cores; 10, 11: blade cores.

Table 2
Dating results from Shuidonggou Locality 2 (SDG2).

Cultural layer	Original unit	Context	Material	Dating method	Lab #	Age (BP)	Cal (BP)[a] (95.4%)	Reference
SDG2-CL1	Stratum 4	Profile	Sediment	OSL	IEE1880	20,300 ± 1000		Liu et al., 2009
SDG2-CL2	Hearth 1	Profile	Charcoal	AMS^{14}C	Bata-132982	26,350 ± 190	30,984 ± 152	Gao et al., 2002; Madsen et al., 2001
SDG2-CL2	Hearth 2	Profile	Charcoal	AMS^{14}C	Bata-132983	25,670 ± 140	30,519 ± 175	Gao et al., 2002; Madsen et al., 2001
SDG2-CL2	Hearth 2	Profile	Ostrich eggshell	AMS^{14}C	Bata-132984	26,930 ± 120	31,273 ± 88	Gao et al., 2002; Madsen et al., 2001
SDG2-CL2	Hearth 3	Profile	Charcoal	AMS^{14}C	Bata-134824	26,830 ± 200	31,239 ± 111	Gao et al., 2002; Madsen et al., 2001
SDG2-CL2	Hearth 4	Profile	Charcoal	AMS^{14}C	Bata-134825	25,650 ± 160	30,503 ± 197	Gao et al., 2002; Madsen et al., 2001
SDG2-CL2	Hearth 5	Profile	Charcoal	AMS^{14}C	Bata-146355	26,310 ± 170	30,966 ± 147	Gao et al., 2002; Madsen et al., 2001
SDG2-CL2	Hearth 7	Profile	Charcoal	AMS^{14}C	Bata-146357	29,520 ± 230	34,149 ± 342	Gao et al., 2002; Madsen et al., 2001
SDG2-CL2	Hearth 10A	Profile	Charcoal	AMS^{14}C	Bata-146358	23,790 ± 180	28,607 ± 290	Gao et al., 2002; Madsen et al., 2001
SDG2-CL2	Stratum 6	In situ	Ostrich eggshell	AMS^{14}C	Bata-207935	28,420 ± 160	32,734 ± 330	Gao et al., 2008
SDG2-CL2	Stratum 6	In situ	Charcoal	AMS^{14}C	Bata-207936	28,330 ± 170	32,605 ± 344	Gao et al., 2008
SDG2-CL2	Stratum 6-2L3	In situ	Charcoal	AMS^{14}C	BA110217	26,450 ± 120	31,071 ± 92	
SDG2-CL2	Stratum 6-L18	In situ	Charcoal	AMS^{14}C	BA110218	30,360 ± 120	34,881 ± 124	
SDG2-CL2	Stratum 6-L20-H6	In situ	Charcoal	AMS^{14}C	BA110219	25,090 ± 90	29,933 ± 199	
SDG2-CL2	Stratum 6-2L4	In situ	Charcoal	AMS^{14}C	BA110220	26,040 ± 90	30,802 ± 142	
SDG2-CL2	Stratum 6-L20-H7	In situ	Charcoal	AMS^{14}C	BA110221	2520 ± 30	2606 ± 77	
SDG2-CL2	Stratum 6-L21-H7	In situ	Charcoal	AMS^{14}C	BA110226	895 ± 30	824 ± 53	
SDG2-CL3	Stratum 8-L27	In situ	Bone	AMS^{14}C	BA110223	28,290 ± 110	32,561 ± 300	
SDG2-CL3	Stratum 8-L28	In situ	Bone	AMS^{14}C	BA110222	27,190 ± 100	31,385 ± 94	
SDG2-CL3	Stratum 8	Profile	Sediment	OSL	IEE1881	27,800 ± 1400		Liu et al., 2009
SDG2-CL4	Stratum 10	Profile	Sediment	OSL	IEE1882	20,500 ± 1100		Liu et al., 2009
SDG2-CL4	Stratum 10-L30	In situ	Charcoal	AMS^{14}C	BA110224	985 ± 30	883 ± 48	
SDG2-CL5	Stratum 13	Profile	Sediment	OSL	IEE1883	29,200 ± 2100		Liu et al., 2009
SDG2-CL5	Stratum 13	In situ	Bone	AMS^{14}C	BA110227	20,280 ± 70	24,191 ± 151	
SDG2-CL6	Upper part of Stratum 15	Profile	Sediment	OSL	IEE1884	23,600 ± 2400		Liu et al., 2009
SDG2-CL6	Lower part of Stratum 15	Profile	Sediment	OSL	IEE1885	38,300 ± 3500		Liu et al., 2009
SDG2-CL7	Upper part of Stratum 16	In situ	Sediment	AMS^{14}C	BA07940	29,759 ± 245	34,395 ± 328	Liu et al., 2009
SDG2-CL7	Lower part of Stratum 16	In situ	Wood	AMS^{14}C	BA07943	36,329 ± 215	41,445 ± 213	Liu et al., 2009
SDG2-CL7	Stratum 16	In situ	Wood	AMS^{14}C	BA110228	980 ± 30	877 ± 47	

[a] ^{14}C dates were calibrated using OxCal 4.1 online software (IntCal 09 curve).

in the natural exposed profile at SDG2. Their samples indicated a time span from 29,000 to 24,000 rcy BP. However, they did not have access to the stratigraphic information from the excavation. Liu et al. (2009) conducted a program of dating using OSL and AMS methods, obtaining ages for CL7 to CL3 and CL1. The authors of this paper used bones and charcoal from the excavations to obtain another group of dates for all cultural layers except for CL6 and CL1.

The deposit at Locality 2 is a coherent, well-ordered sequence, and there is little evidence of significant redeposition (Liu et al., 2009). In view of this, it is reasonable that dates that are significantly younger than the age of layers above can be abandoned. In aggregate, the various dates from SDG2 are highly coherent. There is one OSL date from CL1, 20,300 ± 1000 OSL BP. CL2 is the layer with the largest number of radiocarbon dates. Thirteen of a total of 16 dates cover a span from 25,090 ± 90 to 26,930 ± 120 rcy BP, which represent the best estimate for the age of CL2. From CL3, there are two AMS dates, 27,190 ± 100 and 28,290 ± 110 rcy BP, and one OSL date, which is 27,800 ± 1400 OSL BP. There is a single AMS date from CL4, which is 985 ± 30 rcy BP and one OSL date, which is 20,500 ± 1100 OSL BP. These two dates are considered to be erroneous because they are so much younger than the age above this layer. There is one AMS date from CL5, 20,280 ± 70 rcy BP, and an OSL date, which is 29,200 ± 2100 OSL BP. The AMS is anomalous because it is more recent than the many dates from layers above it. The two OSL dates from CL6 are 23,600 ± 2400 OSL BP, from the upper part and 38,300 ± 3500 OSL BP, from the bottom. The upper one is too recent to be accepted. Finally, CL7 yielded three AMS dates, 980 ± 30, 29,700 ± 250 (upper part) and 36,270 ± 220 (lower part) rcy BP. The first is clearly too young and is abandoned.

To compare the AMS and OSL dates, it is necessary to calibrate the radiocarbon dates. Although there is no universally agreed-on radiocarbon calibration for the time span from 30,000 to 40,000 BP, the existing systems provide considerable agreement (e.g., Weninger and Jöris, 2008; Reimer et al., 2009). All of the AMS dates were calibrated by OxCal 4.1 online software (IntCal 09 curve). Many of the AMS dates at CL2, which are in close agreement from 29,933 ± 199 to 31,273 ± 88 cal BP (calibrated years before present) can be taken with a high degree of confidence. The single OSL date from CL3 (27,800 ± 1400 OSL BP) is somewhat younger than the calibrated AMS dates (31,385 ± 94; 32,561 ± 300 cal BP). Although CL5 has one OSL date but no AMS date, that date is a little younger than the estimate for the ages of CL2 and CL3. The lower part of CL6 provided one OSL date (38,300 ± 3500 OSL BP), which came from the boundary between CL6 and CL7, and is in reasonable agreement with the dates from CL7 (34,395 ± 328; 41,445 ± 213 cal BP).

Although the reason is not clear, for the most part the OSL dates from SDG2 are younger than AMS dates at the same layer or the layers above. Given that the OSL dates are not in clear diachronic sequence from bottom to top, and in light of the close agreement among AMS dates from the same layer (CL2), this paper relies more on the AMS dates. Taking into account of results from both dating methods, it is suggested that the age of CL1 is roughly 20,300 ± 1000 OSL BP, the age of CL2 is between 29,933 ± 199 and 31,273 ± 88 cal BP, the age of CL3 and CL4 is between 31,385 ± 94 and 32,561 ± 300 cal BP, the age range of CL5 and CL6 is 32,561 to 34,395 BP (by stratigraphical comparison), the age range of CL7 is between 34,395 ± 328 and 41,445 ± 213 cal BP. We argue that the overlap in age estimates for cultural layers 2, 3 and 4 is due to the limited time span of these layers and the unavoidable uncertainties of AMS ^{14}C dating.

Comparison of chronology between SDG1 and SDG2

The close proximity of the Locality 1 and Locality 2 allow us to compare those sites using dates and some archaeological features. The earlier excavations at SDG1 did not control the context of different cultural layers with any precision and mixed all artifacts from the Pleistocene deposit together, treating it as a single unit, the so-called 'Shuidonggou cultural layer' containing an assemblage with Levallois-like blade technology. SDG2 has a more finely divided and complete archaeological sequence including different cultural layers yielding different kinds of assemblages. Some similar technological features allow us to draw connections between the two sites, to narrow down the age of large blade technology in the region, and to identify possible signatures of different cultural components at Locality 1.

Madsen et al. (2001) used dates from hearths exposed in the natural profile (Gao et al., 2002, 2008) at Locality 2 to represent the age of large blade technology in the Shuidonggou area. However, it now appears that the hearths they dated occurred within CL2, which is the only cultural layer with abundant well-preserved fireplaces adjacent to the natural profile sampled by Madsen and colleagues. Moreover, their reported dates are consistent with the dates obtained during the excavation for CL2. The artifacts unearthed from SDG2-CL2 (and in fact, CL6, CL5b and CL1-4) show no evidence of blade production. Instead, the assemblages are characterized by flake production from relatively informal cores and a sidescraper-dominated tool inventory (see Fig. 3). The assemblages are quite large so the absence of blade production is not a result of small sample size. Therefore, the ages from SDG2-CL2, including those reported by Madsen et al. (2001), cannot represent the age of large blade technology in Shuidonggou area, and in fact post-date it. Fortunately, some artifacts from CL7 and CL5a at SDG2 do provide evidence for forms of blade technology that resemble the well-described material from SDG1. Moreover, the radiocarbon ages from CL7 (34,395 ± 328; 41,445 ± 213 cal BP) and CL5a (>32,561 ± 300 cal BP) are in reasonable agreement with U–Th and OSL dates from 'SDG1-LCL-B' (34,000 ± 2000; 38,000 ± 2000 U–Th BP) (Fig. 4), in spite of some potential problems with combining radiocarbon and U–Th dates (Bischoff et al., 1988; see also; Madsen et al., 2001). Given that SDG2 preserves a more complete and clearly-defined archaeological sequence spanning roughly 40,000–20,000 calendar years BP, and that CL7 and CL5a are the only layers that yield blade cores and related technological products, we can conclude that the dates from CL7 and CL5a at SDG2 represent the best estimate for the age of large blade technology in the Shuidonggou area. The presence of similar blade technology and the close dates in CL7 and CL5a at SDG2 and 'SDG1-LCL-B' at SDG1 support the hypothesis that the large blade technology assemblage at SDG1 comes from 'SDG1-LCL-B', although the precise cultural layer and geological contexts are unknown.

Although it is not reasonable to use the dates of Madsen et al. (2001) to represent the age of large blade technology in the Shuidonggou area, the various dates from SDG2-CL2 are in close agreement with the dates from lower part of 'SDG1-LCL-A' at Locality 1 (see Fig. 4). There are other reasons to correlate the two layers. A single ostrich eggshell bead was unearthed from 'SDG1-LCL-A' at Locality 1, coming from around the hearth which belongs to the lower part of 'SDG1-LCL-A' (Derevianko, 2011). CL2 at SDG2, which is roughly the same age as the lower part of 'SDG1-LCL-A', is the only cultural layer at SDG2 to yield ostrich eggshell beads. Although it would be better to have much larger samples of beads and lithic artifacts to compare, we draw a tentative technological and chronological connection between SDG2-CL2 and the lower part of 'SDG1-LCL-A' at Locality 1. There could even be a third component in the lower cultural layer at SDG1. The two grinding tools found in 'SDG1-LCL-A' resemble artifacts found in CL1 at SDG2. No similar artifacts were found in any of the cultural layers at SDG2 below CL1.

Discussion

The age of large blade technology in China is crucial to discussions of the dispersal of Upper Paleolithic technology in North Asia from west to east in Eurasia. There is no likely ancestral technology

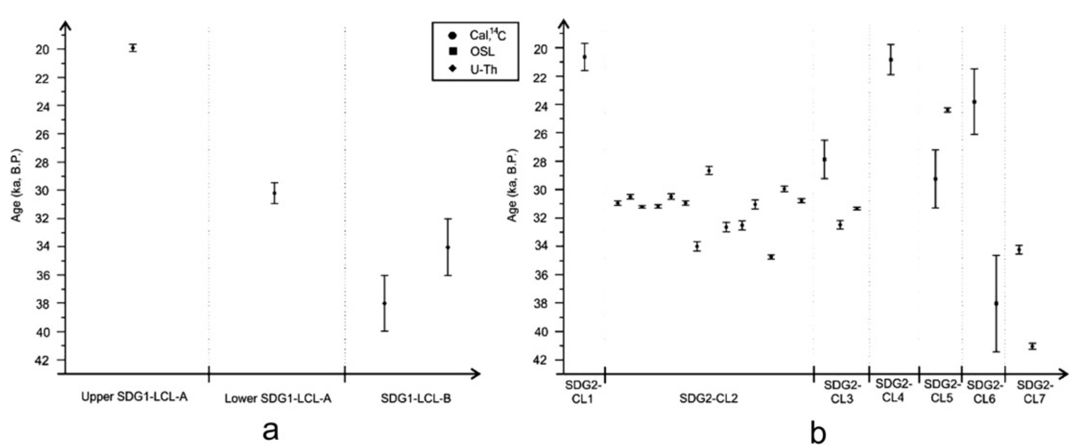

Figure 4. Age comparison between SDG1 and SDG2. (a) Age from possible different cultural components at SDG1. We have excluded the dates reported by Liu et al. (2009) because that cannot be correlated with the stratigraphic sub-division of the lower cultural layer by the original 1980s excavators; (b) ages from different cultural layers at SDG2 except for the extremely younger ones (<10 ka [thousands of years ago]).

in China for the Levallois-like blade technology found in SDG1 and SDG2, so it is almost certainly intrusive to the region. Some scholars accept the age given by Madsen et al. (2001), and conclude that the Shuidonggou site represents a very late case of Initial Upper Paleolithic in East Asia, further suggesting a very gradual spread of large blade technology from west to east and then from north to south over several thousand years (Brantingham et al., 2001; Madsen et al., 2001; Gao et al., 2002; Derevianko, 2011). The data presented in this paper demonstrate that the previously reported ages from SDG2 cannot represent the age of blade technology, and that a more reasonable age estimate is in the range of 34,000–41,445 calendar years BP. This revised estimate is roughly contemporary with the calibrated dates from Chikhen Agui in Mongolia (32,215 ± 930, 25,879 ± 324, 35,278 ± 449, dates calibrated using OxCal4.1 with IntCal09 curve by the authors).

We cannot reconstruct the precise pathway by which blade technology spread across East Asia due to the scarcity of well-dated Paleolithic sites. However, we agree with Madsen and colleagues that the large blade technology in the Shuidonggou area probably represents dispersal of cultural elements from North Mongolia and/or the Altai mountain area, where similar blade technologies provide somewhat older dates. The earliest two Upper Paleolithic dates from the Kara-Bom site in Siberia are 43,300 ± 1600 and 43,200 ± 1500 rcy BP (Goebel et al., 1993; Derevianko et al., 2000) and the earliest dates on similar materials from Tolbor-4 in North Mongolia are >41,050 and 37,400 ± 2600 rcy BP (Gladyshev et al., 2010). However, this re-evaluation of the chronology of Locality 1 and 2 at Shuidonggou does show that the technology spread much more quickly than previous age estimates indicated. Moreover, the similarities in dates from Shuidonggou and Chikhen Agui indicate a fairly rapid spread of the large blade technology from South Mongolia to North China. Current information, limited as it is, suggests that the largest temporal gap is between the Altai sites and the South Mongolian and Chinese ones. The sharp ecological contrast between the Altai Mountains and the arid lowlands of South Mongolia and North China may have either impeded the spread of dispersing populations or acted as a barrier to communication and spread of new methods of lithic manufacture among established ones.

The re-evaluation of dates and integration of results from SDG1 and SDG2 also has implications for how the early Upper Paleolithic of North China in general, and Shuidonggou in particular, is understood. Archaeologists who have studied the Pleistocene assemblages from SDG1 have focused mainly on the distinctive large blade technology when comparing it with Paleolithic sites in East Asia, even though some of them admitted ‘SDG lower cultural layer’ may contain different cultural layers (e.g., Gao et al., 2008). Brantingham et al. (2001: 744) consider the assemblage from SDG1 to represent the Initial Upper Paleolithic, but indicate “Shuidonggou has a strong Middle Paleolithic typological signature”, based on a high percentage of side-scrapers, notches and denticulates. Without denying Brantingham’s observation, based on comparisons with Locality 2 we hypothesize that the so-called ‘SDG lower cultural layer’ at SDG1 actually contains more than one cultural component. The lower component is marked by Levallois-like technological features whereas simple flakes and sidescraper-dominated assemblages exist in the two upper layers. The appearance of a strong Middle Paleolithic typological signature in the combined assemblage at SDG1 may thus be due to the lumping together of early blade assemblages and sidescraper-dominated flake tool assemblages like those from CL6, CL5b and CL4-1 at Locality 2. Due to the likelihood that assemblages with different technological and typological features have been combined in the existing collections from Locality 1, it is not reasonable to compare the assemblage as a whole with any other assemblages. The only possible strategy is to compare it with other assemblages based on the presence and characteristics of prepared cores and other products of blade production, which should be unique to the earliest cultural layers. In other words, the prepared cores can be treated as a technological package that is unique in China and represents the signature of an allochthonous blade technology in the Shuidonggou region. However, in the existing collections from ‘lower cultural layer’ at SDG1, these distinctive elements are mixed with debris representing less diagnostic, generalized flake production coming from more recent cultural deposits.

Conclusion

Based on the archaeological sequence and chronology at SDG2 in particular, it is clear that there were at least two chronologically successive technologies in the Shuidonggou region between 40,000 and 20,000 calendar years BP. The earliest of these includes distinctive production of large blades from flat, Levallois-like cores as well as more prismatic forms. These features mark an intrusive technology spreading from north and/or west. It is succeeded by a series of ‘small flake tool’ assemblages characterized by generalized flake production and sidescraper-dominated toolkit. Comparing dates and lithic technology from different layers from SDG1 and SDG2, this paper suggests the age of Levallois-like blade technology in the Shuidonggou area is around 34,000–38,000 calendar years BP, based on agreement between the dates from SDG1, with its abundant large blade assemblage, and the dates from CL7 (34,395 ± 328; 41,445 ± 213 cal BP) and CL5a (>32,561 ± 300 cal BP) at SDG2. Whether the distinctive blade assemblages represent the intrusion of a new population or the diffusion of a set of technological ideas remains uncertain for the present.

However it arrived in the Shuidonggou area, the large blade technology did not last. Instead, it was replaced around 34,000 years ago by simple core and flake-tool assemblages. The lower part of ‘SDG1-LCL-A’ at Locality 1 quite possibly has a similar archaeological signature to SDG2-CL2, including the presence of ostrich eggshell beads, and the upper part of this same layer may have a similar archaeological signature to CL1 at Locality 2. The hypothetical stratigraphic and cultural relationship between the sequences at SDG1 and SDG2 can be tested only by future excavations at SDG1.

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