Dating Shuidonggou and the Upper Palaeolithic blade industry in North China

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Shuidonggou is unique within the Chinese Palaeolithic sequence and its assemblage is reminiscent of Upper Palaeolithic core-and-blade technologies in Mongolia and southern Siberia. Limited chronological controls have prevented evaluation of this technology in both the Chinese and greater Eurasian Palaeolithic. Dating of recently discovered hearths at Locality 2 places Shuidonggou firmly at 29,000–24,000 BP, and suggests the spread of the Eurasian large blade technology was primarily from north to south. The concurrent production of small microblade-like bipolar bladelets at the site may also presage the development of a microlithic industry.

Key-words: China, lithic technology, microlithic, Shuidonggou, Upper Palaeolithic

Introduction

Shuidonggou, located in North China ~10 km east of the Yellow River on the margins of the Ordos Desert (FIGURE 1), was first identified and excavated by Emile Licent and Pierre Teilhard de Chardin in 1923 (Licent & Teilhard de Chardin 1925; see also Boule *et al.* 1928). It was re-excavated in the 1960s and again in 1980 (e.g. Jia *et al.* 1964; Ningxia Museum 1987), and has been the focus of numerous ancillary studies (Chen & Yuan 1988; Chen *et al.* 1984; Geng & Dan 1992; Sun *et al.* 1991; Zhou & Hu 1988). There have also been a number of re-analyses of this excavated material (e.g. Brantingham 1999; Kozlowski 1971; Yamanaka 1995), as well as a variety of attempts to fit the site within the general Eurasian Palaeolithic sequence (e.g. Bordes 1968; Li 1993; Lin 1996; Movius 1948).

This continued focus is the result of Shuidonggou's unique position within the Chinese Upper Palaeolithic sequence. Initially, Licent & Teilhard de Chardin (1925) considered Shuidonggou to be an evolved Mousterian with Upper Palaeolithic features, a classification supported by Bordes (1968). Early Chinese scholars (e.g. Pei 1937) also thought the site contained aspects of Middle Palaeolithic technology, but later work has placed the site firmly within the Chinese Upper Palaeolithic (e.g. Jia *et al.* 1964; Li 1993; Lin 1996). However, the occurrence of early Upper Palaeolithic sites in China is extremely limited (Gao 1999; Lin 1996), since only a handful of sites in China contain evidence for the use of large blade technologies, and only a few equivocal specimens were recovered from these sites (e.g. Li 1993; Miller-Antonio 1992). Shuidonggou is one of the few sites in North China that exhibits a systematic Initial Upper Palaeolithic core-and-blade technology similar to that found farther north in Mongolia and Siberia (e.g. Bar-Yosef & Kuhn 1999; Brantingham 1999; Brantingham *et al.* in press).

Due to the unique position of Shuidonggou, dating of the depositional sequence at the site has received considerable attention. At Locality 1 (FIGURE 2), there are two finite radiocarbon dates of 17,250±210 BP and 25,450±800 BP from the late Pleistocene strata containing the Upper Palaeolithic materials (CQRC 1987: 37). The first of these is a collagen date from what

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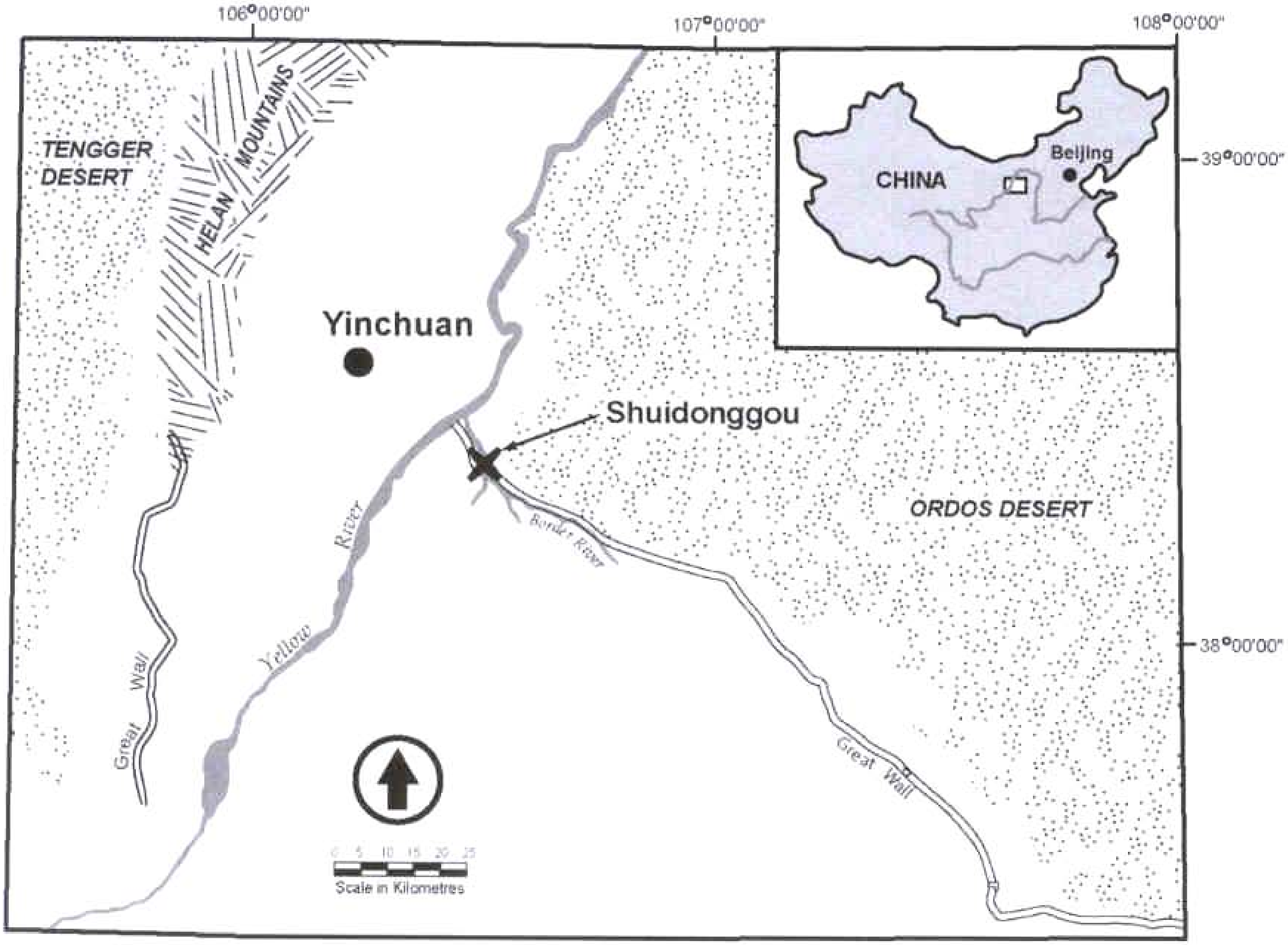

FIGURE 1. *Map of Northern China showing the location of Shuidonggou.*

is likely a redeposited bone, while the second is on a carbonate nodule. Though potentially accurate, these dates are more safely assumed to be minimum ages due to potential problems with radiocarbon assays of bone collagen and carbonate (Pendall *et al.* 1994; Stafford *et al.* 1991). A third infinite radiocarbon date, on unknown material underlying the archaeological horizons (Geng & Dan 1992: 49), is difficult to evaluate. Chen *et al.* (1984) report on bone-derived U-Th ages from the 'Lower Cultural Level' at Shuidonggou. These are given as 40,000–32,000 BP (see also Chen & Yuan 1988). Though not unreasonable given the character of the Shuidonggou industry, U-Th dating of bone has to be treated with extreme caution because of the uncertainty surrounding the mechanisms of uranium uptake and loss from bone tissues (Bischoff *et al.* 1988). In contrast, palynological evidence suggests that the late Pleistocene deposits at Shuidonggou accumulated under generally cold and dry conditions (Zhou & Hu 1988: 268). For this reason, Zhou & Hu favour a literal interpretation of the younger radiocarbon dates and suggest the Shuidonggou industry dates to the Last Glacial Maximum, about 20,000 radiocarbon years ago.

This wide array of age estimates leaves the core-and-blade industry at Shuidonggou in chronological limbo, making it difficult to understand how it fits within the Chinese and greater Eurasian Palaeolithic sequences. During the last decade in an attempt to resolve this temporal confusion by examining exposed loess profiles along the Border River bisecting Shuidonggou (e.g. Madsen *et al.* 1996). Teilhard de Chardin's discovery of the site in 1923 involved his recognition of a hearth in the late Pleistocene loess, suggesting a detailed survey of other exposed surfaces along the stream might detect additional hearths containing both datable material and associated artefacts. In 1999 and 2000 we identified, described, and sampled an array of hearths and hearth-related features at Locality 2. Here

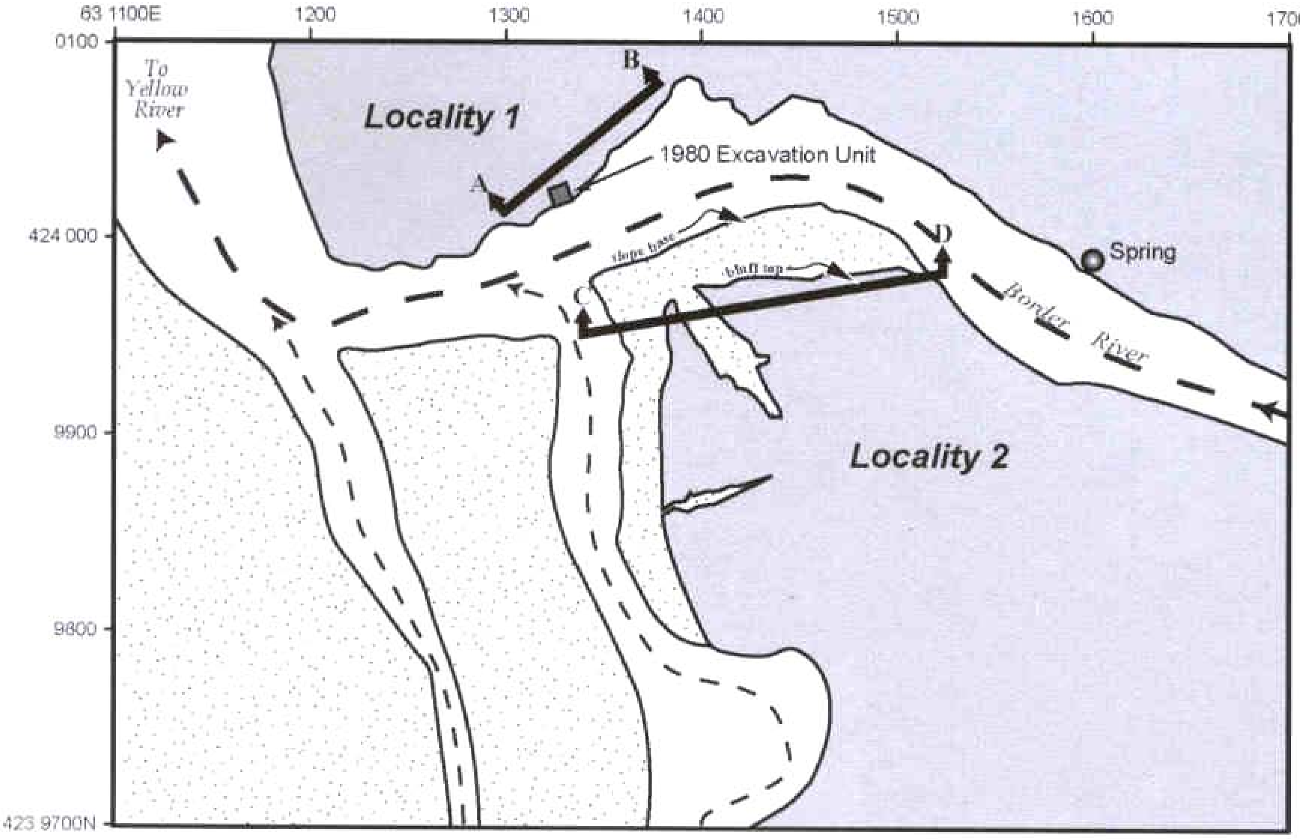

FIGURE 2. *Map of the Shuidonggou area showing the location of the Locality 1 (A–B) and Locality 2 (C–D) stratigraphic profiles (see FIGURE 3). Measurements are given as UTM coordinates in 100-m intervals. Dashed lines with arrows indicate direction of channel flow.*

we report the radiocarbon ages of these hearths and briefly describe associated materials.

Stratigraphy at Localities 1 & 2

Shuidonggou is in the Ningxia Hui Autonomous Region on a tributary drainage system of the Yellow River. The site occupies an ecotonal boundary dividing the semiarid desert steppe, associated with the Yellow River and foothills of the Helan Mountains, from the significantly more arid Ordos Desert. Quaternary sediments reflect this boundary situation. The region is dominated by a thick (10–40 m) sandy-loess platform that is increasingly intercalated with alluvial sediments as one approaches the flood-plain of the Yellow River. Sandy-loess deposits in the immediate vicinity of Shuidonggou appear to correspond to the late Pleistocene early Malan Loess (L1), but Middle Pleistocene sandy-loess deposits also may be present in similar contexts regionally (Sun *et al.* 1996). The Quaternary sequence is inset into a thick, Tertiary red clay that is found extensively throughout the region. At Shuidonggou, the Border River has dissected the sandy-loess platform producing channel cuts with steep 10–20-m deep exposures.

Four archaeological localities have been formally designated at Shuidonggou. Herein, we focus on Localities 1 and 2, which face one another across the small channel of the Border River (FIGURE 2). Locality 2 is located on the southern bank at a confluence with a small tributary. Gravel deposits in both the streams are abundant sources of silicified limestone, which is fine-grained and variously gray, buff, pink, or white in colour. Most pieces are quite homogeneous, but some contain internal fracture planes and vugs (cavities). Quartzite is also abundant in the stream gravels. Small chert/chalcedony pebbles are present, but occur infrequently.

Late Pleistocene sediments at Locality 1 occur within a fluvial cut-and-fill sequence (FIGURE 3). The base of the late Pleistocene section is represented by finely bedded medium sands (Stratum 8c) lying unconformably in a channel cut into the Tertiary red clay unit. The overlying unit (Stratum 8b) is a massive, fine silt

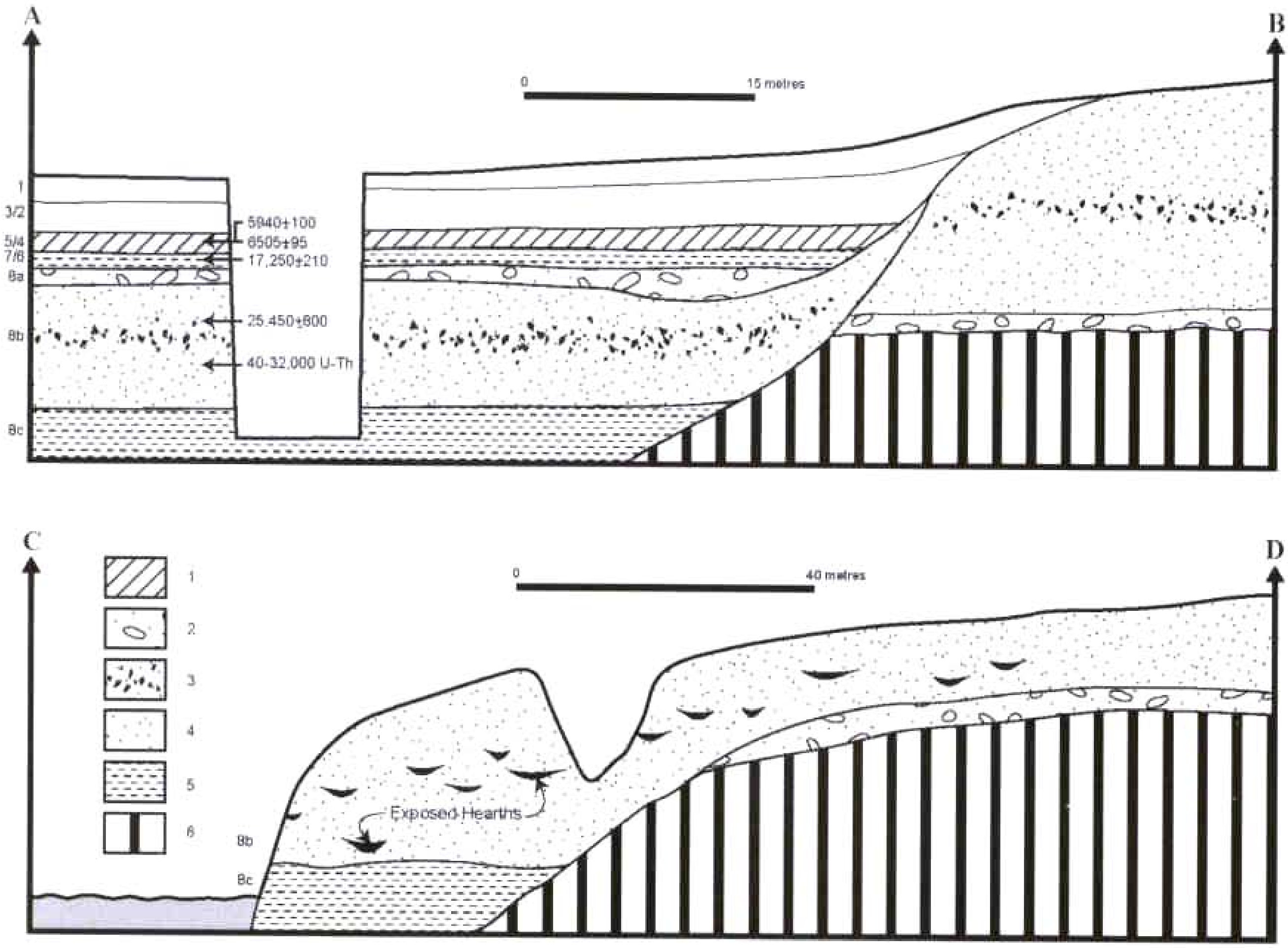

FIGURE 3. *Stratigraphic sections at Locality 1 (top, modified from Zhou & Hu 1988) and Locality 2 (bottom). The Locality 2 section is a schematic composite of the north- and west-facing profiles. Profile locations are indicated in* FIGURE 2. *Locality 1 age estimates are conventional radiocarbon ages except where indicated. Radiocarbon age estimates from Locality 2 are reported in* TABLE 1. *Sediments:* 1 *gleyed, organic-rich sands;* 2 *alluvial gravels;* 3 *carbonate nodules;* 4 *sandy loess;* 5 *bedded sands;* 6 *Tertiary red clay.*

with abundant carbonate. The middle portion of Stratum 8b contains a well-defined zone of hard carbonate nodules (5–10 cm each), possibly of pedogenic origin. These nodules may correlate with a broadly recognized, carbonate-rich soil dividing the early and late Malan Loess (INQUA 1991: 6). An unconformity marks the transition to a second cut-and-fill sequence of uncertain age (Strata 8a–1). Stratum 8a represents a sequence of channel gravels and cross-bedded medium sands of fluvial, or possibly mixed fluvial and aeolian origin. Strata 7–5 represent a continuation of fluvial sedimentation comprised primarily of interbedded gravels and medium sands. The uppermost channel fill consists of low-energy water-laid silts and sands containing abundant organic matter and aquatic snail shells (Strata 4–1). The Shuidonggou stone industry derives primarily from Stratum 8b. Similar archaeological materials from Strata 7 and 6 may be redeposited.

The deposits at Locality 2 are generally similar to those at Locality 1, although there are some differences in the early and later portions of the sedimentary sequence. The Border River and the smaller tributary have isolated a stack of alluvial and aeolian sediments 10–15 m high in a long peninsula bounded by sheer to steeply sloping bluffs (FIGURE 4). The upper surface of the peninsula is flat to undulating; a large erosional cut drains the peninsula surface to the north. The same Pleistocene cut-and-fill sequence inset into the Tertiary soil is present, although the basal fluvial deposits within the channel are more fine-grained than at Locality 1. These are overlain by aeolian sands and silts

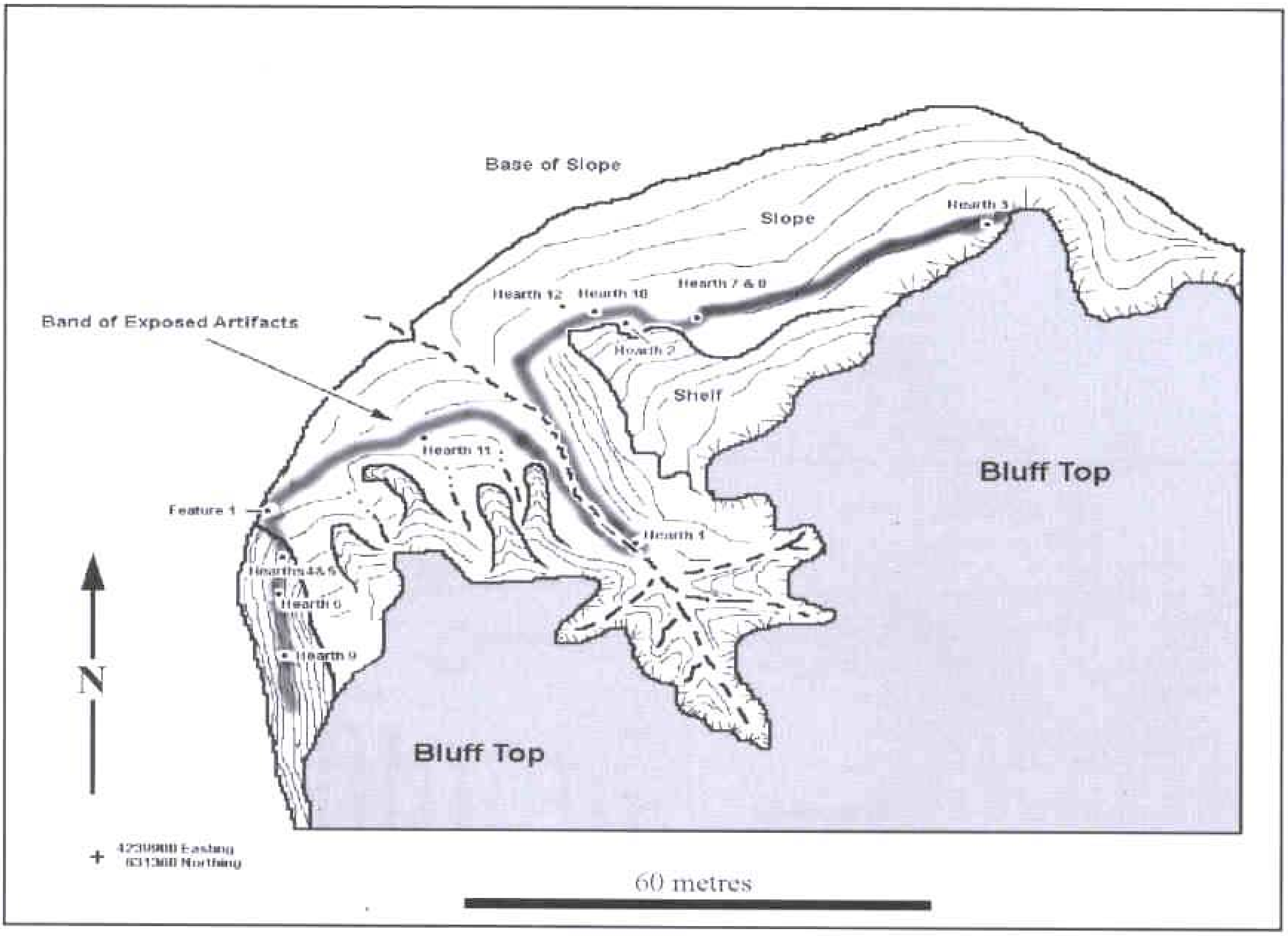

FIGURE 4. *Map of Shuidonggou Locality 2 showing the location of identified hearths and the primary band of archaeological materials recorded* in situ.

with localized horizontal and cross bedding. These units are tentatively correlated with Strata 8c and 8b at Locality 1, respectively. Importantly, Stratum 8b at Locality 2 is at least twice as thick as its counterpart at Locality 1. The later cut-and-fill sequence is apparently missing at Locality 2, and there are no deposits corresponding to Strata 8a–1.

Traditional reconstructions of the Locality 1 sequence (e.g. Zhou & Hu 1988) also suggest the earlier Pleistocene channel cuts through thick loess deposits as well as the Tertiary soil, and that the loess at Locality 1 is thus much younger than that immediately upstream (FIGURE 3). At Locality 2, the channel cut does not appear to extend up into the overlying loess, but its presence may be obscured by erosion. Overall, it appears that Locality 2 at Shuidonggou preserves a much thicker, continuous sequence of late Pleistocene sediments as compared with Locality 1, but lacks a Holocene component.

Locality 2 hearths

Seven hearths and five depositional features, which may be hearths or related to hearths, were identified within a ~3-m wide depositional band contained in a ~100x100 m area within the fine-grained sands and silts of Locality 2 (FIGURE 4). The number of hearths is unclear because investigation was restricted to materials on the exposed faces of Locality 2 and no excavations were undertaken. Seven hearths appear to be true hearths in that they consist of dense concentrations of charcoal and ash overlying fire-reddened soil. All seven are simple unprepared hearths ranging in diameter from 30–80 cm. They are flat to slightly basin-shaped in cross section and range from 4–10 cm in thickness (FIGURE 5). Fire-cracked stream cobbles were found in or immediately adjacent to most of the hearths. Three features (2, 6 and 12) consist of scattered charcoal and artefacts overlying fire-reddened soil. These appear to be hearth-related materials immediately surround-

FIGURE 5. *View of Hearth 4 exposed in the west-facing profile of Locality 2. The hearth is typical of those at Locality 2. The bone tool described in the text can be seen protruding from the hearth.*

ing hearths that either have eroded away or still lie within unexposed deposits. Two other 'hearths' (3 and 9) are not hearths at all, but merely concentrations of charcoal fragments that may be derived from hearths. However, all 'hearths' have large mammal bone, small cobbles and lithic debris associated with them. They occur on a number of different surfaces that can be traced laterally some 2–6 m away from each hearth and may extend farther. The relationship of these surfaces is unclear, but they appear to be stratigraphically separate. Small carbonate nodules (1–2 cm diameter) occur in the aeolian silts immediately below most of these compact surfaces, and they appear to represent short weathering episodes within the depositional sequence.

Without full-scale excavation, the exact stratigraphic relationship of the hearths is difficult to determine. Hearth 9, the lowest hearth in the western exposure, occurs on a surface 0·08 m above the top of the water-laid deposits. From earliest to latest the sequence on the western face in relation to the water-laid deposit is: Hearth 9 (0·08 m), Hearth 4 (0·5 m), Hearth 5 (0·75 m), and Hearth 6 (0·9 m). The relative stratigraphic positions of the hearths in the northern exposure are even more difficult to determine as the deposits appear to be dipping downstream to the west and the surface of the underlying Tertiary soil is obscured by erosion. Hearth 7 appears to be the lowest, and therefore earliest, hearth on the northern exposure at about 0·5 m above fluvial gravel deposits. Heights of other hearths above the gravels are: Hearth 3 (~1·0 m), Hearth 8 (~1·0 m), Hearth 12 (~1·2 m), Hearth 11 (~1·5 m), Hearth 2 (~2·0 m), and Hearth 10 (~3·5 m). Hearth 1 is located along a small erosional channel between the western and northern faces where neither the underlying gravels nor fluvial sands are exposed. Hearth 7 appears to be stratigraphically the lowest of the dated hearths, and Hearth 10 the highest, positions in accord with age estimates for these hearths.

Lithic and faunal materials associated with the hearths were collected and analysed at the Ningxia Archaeological Institute laboratory. Charcoal in the hearths was reduced to very small fragments (in some cases microscopic fragments), and no charred seeds or other plant macrofossils could be identified. With the exception of a single tooth (P3 or P4) of an antelope (*Spiroceros kiakhtensis*), an unidentified phalange of a gazelle-sized animal (possibly *Gazella przewalskyi*), and a bone tool from an unidentified large-mammal long bone mid-shaft, the faunal remains consisted almost entirely of splintered long-bone fragments of mid-sized to large mammals. Numerous ostrich (*Struthiolithus* sp.) eggshell fragments were recovered from the silts around the hearths, but these could not be directly related to human deposition.

Eight radiocarbon age estimates were obtained from Locality 2 (TABLE 1). Seven of these age estimates are on charcoal taken directly from the hearths. The eighth is an age estimate run on an ostrich eggshell fragment from compact silts ~1 cm below Hearth 2.

Locality 2 archaeological materials

Archaeological materials at Locality 2 occur in two very different contexts. Mixed surface assemblages are prevalent on top of the Locality 2 bluff, while stratified materials occur in varying densities throughout the sedimentary stack identified with Locality 1 Stratum 8b. Lithic artefacts were observed *in situ* both in proximity to and at greater distances from hearths and charcoal lenses exposed on the bluff face. Other artefacts were recovered directly from soil and charcoal samples removed from hearth fill. While the present sample of artefacts from stratified contexts at Locality 2 remains small and absolute spatial and chronological relationships between recovered materials are uncertain, there are some significant patterns that contrast with the Locality 1 lithic assemblage. At Locality 1, the lithic production system is predominantly focused on the production of blades and elongated flakes struck from single or opposed platform, flat-faced ('Levallois') cores. This technology comprises nearly 30% of the assemblage overall and is predominantly based on silicified limestone. Small cores and bladelets are very uncommon (only two small bipolar cores were noted) and no true microblades have been observed.

Lithic artefacts on the Locality 2 surface include

1. microblades, microblade cores, and microblade core maintenance debitage;
2. bipolar cores and debitage;
3. a variety of artefacts representing generalized core-and-flake technologies, and
4. a small component of Helan point technology dating to the Pleistocene/Holocene transition (see Elston *et al.* 1997; Zhang 1999).

Silicified limestone accounts for most of the lithic items on the surface, but quartzite is also present. In the surface assemblage, two strategies of lithic reduction employ bipolar technology. In one strategy, more classically 'bipolar', small pebbles of silicified limestone undergo bipolar reduction to generate flakes and sharp pieces. Some of the bipolar flakes are linear and blade-like, falling within the small end of the true microblade size range. Some of these blade-like flakes have platforms, but often the platform has collapsed; bulbs are frequently sheared, and the flakes are often split longitudinally. Bipolar flakes, cores, and shatter are abundant in the peninsular surface assemblage. In the second strategy, the bipolar technique is employed as an early critical stage in microblade production from small cortical pebbles. More specifically, bipolar percussion is used to split and/or remove one or both ends of elongate pebble core blanks as initial steps in shaping

feature	material	age estimate	age range @ 2σ	lab. no.
Hearth 1	charcoal	26,350±190	26,730–25,970	Beta-132982
Hearth 2	charcoal	25,670±140	25,950–25,390	Beta-132983
	eggshell	26,930±120	27,170–26,690	Beta-132984
Hearth 3	charcoal	26,830±200	27,230–26,430	Beta-134824
Hearth 4	charcoal	25,650±160	25,970–25,330	Beta-134825
Hearth 5	charcoal	26,310±170	26,650–25,970	Beta-146355
Hearth 7	charcoal	29,520±230	29,980–29,060	Beta-146357
Hearth 10A	charcoal	23,790±180	24,150–23,430	Beta-146358

TABLE 1. *Radiocarbon age estimates from Shuidonggou Locality 2. All age estimates are $^{13}C/^{12}C$ adjusted.*

the core before microblades are removed. Such cores and failed core blanks are common on the peninsula surface.

Materials recovered in situ from Locality 2 provide strong evidence for the use of a bipolar pebble reduction strategy of the first type, but nothing that is unequivocally diagnostic of a formal microblade strategy. In particular, both the hearths and the sediments surrounding them contained multiple lithic specimens clearly derived from a bipolar pebble strategy. Such cores are very small (2–4 cm in length), show severe crushing at one or both ends, and display sub-parallel, bladelet-like removals. The recovered debitage includes short linear flakes that could be easily confused with microblades. They are comparable in size to true microblades dating between 12,710 and 10,020 BP in the Pigeon Mountain basin just across the Yellow River (Elston *et al.* 1997). However, unlike true microblades, the linear bipolar flakes from Locality 2 have either unidirectional flake scars with single, sub-parallel arrises (FIGURE 6, A) or bidirectional flake scars and multiple arrises (FIGURE 6, B–C) along with crushed or sheared bulbs of percussion; some flakes are split (FIGURE 6, B). A medial fragment of one of these bipolar bladelets (FIGURE 6, D) is retouched in a manner consistent with later microblade technologies.

In addition to bipolar pebble reduction debris, cores recovered from near Hearth 1 and Hearth 7 provide direct correlations with the Locality 1 stone industry (FIGURE 7). The flat-faced core from Hearth 1 is a bi-directional convergent core with the final removals suggestive of flake-blade production. The primary striking platform is faceted, as is the case with the majority of flat-faced cores from Locality 1. The gray quartzite core is somewhat unique since the majority of flat-faced cores from Locality 1 are silicified limestone. Nevertheless, technologically this specimen is diagnostic of the Locality 1 industry and provides a point of direct correlation between the localities. The gray quartzite flake-blade core found in association with Hearth 7 is based on the ventral surface of a large flake blank and shows removals from both opposed (proximal-distal) and unopposed (lateral) directions. The core resembles the flat-faced blade technology characteristic of Locality 1, but

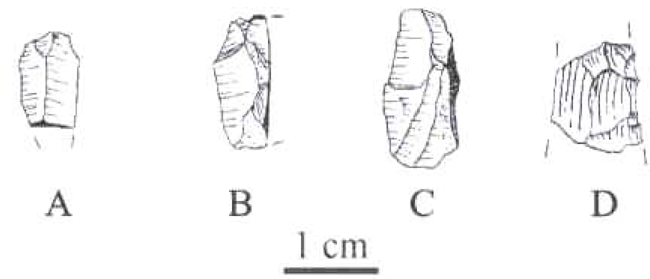

FIGURE 6. *Bipolar linear flakes associated with Hearths 1 (A–C) and 4 (D): Unidirectional (A); bidirectional (B–C); split (B); retouched medial fragment (D).*

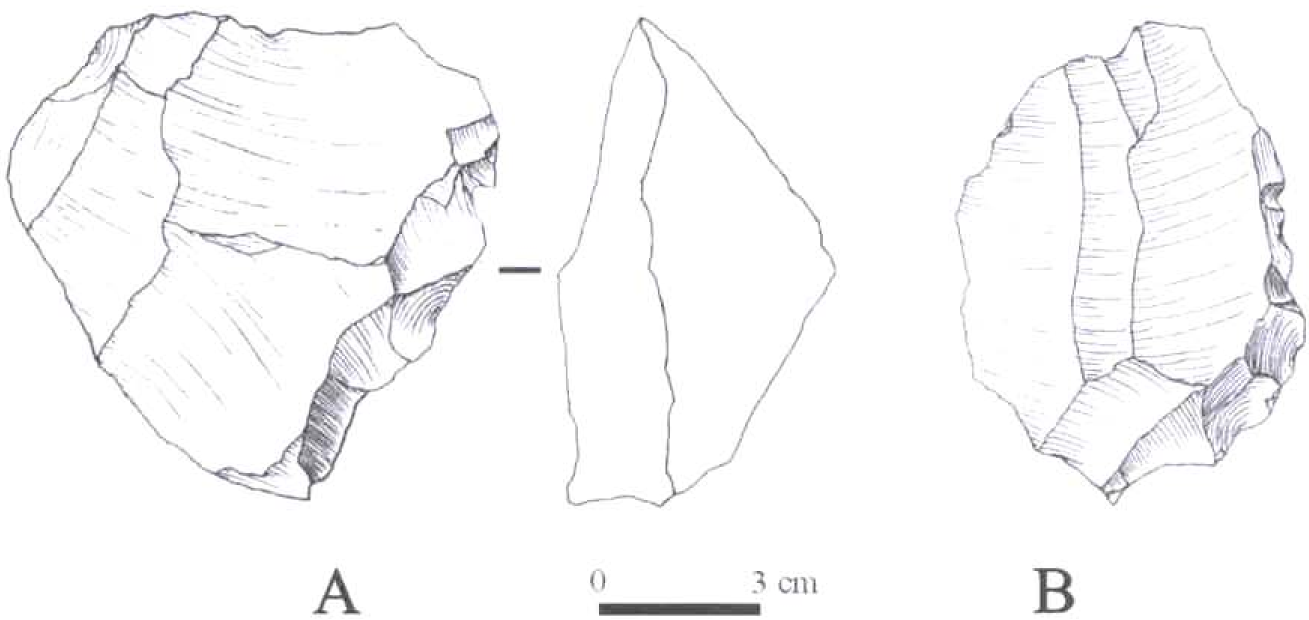

FIGURE 7. *Diagnostic Locality 1 cores recovered from Hearths 1 (A) and 7 (B) at Locality 2.*

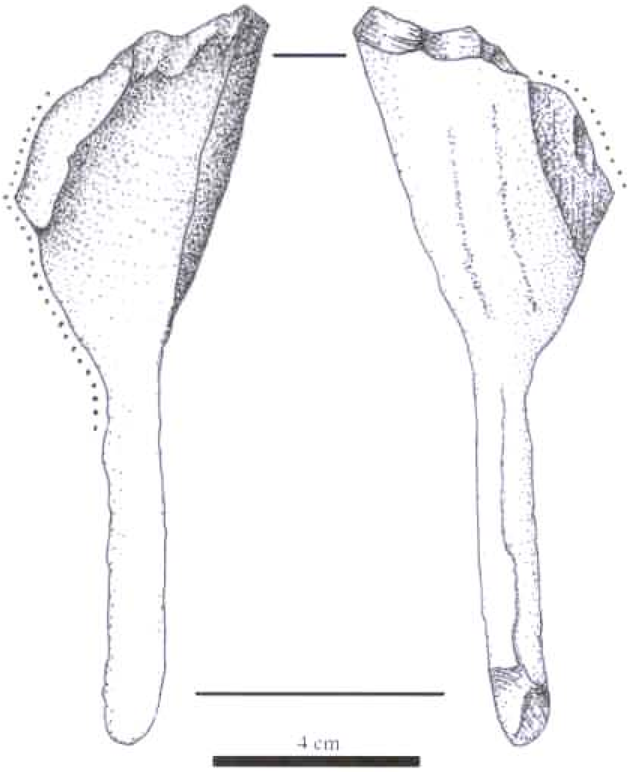

FIGURE 8. *Bifacially flaked and use-wear polished bone tool from Hearth 4 (interior [*left*] and exterior [*right*]; dots denote ground/worn edges). This tool is similar to those from Salawasu, another early Upper Palaeolithic site in the Ordos Desert (e.g. Miller-Antonio 1992). Maximum length is 15·2 cm.*

is also irregular in a number of respects. It is more casual than most Locality 1 flat-faced cores because it is based on a large flake blank requiring minimal preparation for reduction and because it is coarse-grained quartzite. Other materials found *in situ* at Locality 2 consist primarily of quartzite and silicified limestone flake debitage and debris, and, while consistent with the Locality 1 assemblage, are not technologically diagnostic.

A single charred bone tool, made from the split mid-shaft of a large-mammal long bone, was recovered from Hearth 4 (FIGURE 8). One end was bifacially flaked to form a crescent-shaped cutting/scraping edge. A portion of the edge is ground, apparently through use, and both the interior and exterior surfaces exhibit evidence of polish. Two manufacturing episodes are evident: the initial production phase, and a second resharpening phase following extensive use. The tool apparently splintered during this resharpening episode and was discarded. Similar bone tools were recovered at Salawasu, an earlier Upper Palaeolithic site in the Ordos Desert (e.g. Miller-Antonio 1992), but have not been previously reported for Shuidonggou.

Discussion and implications

Radiocarbon age estimates for the Locality 2 hearths range from ~29,500 to ~23,800 radiocarbon years ago, but cluster more tightly at 27,000–25,000 BP. The date of 25,450±800 on the only *in situ* radiocarbon-dated sample at Locality 1 falls within this cluster, and, together with stratigraphic details at the two localities and their close proximity on either side of the same stream channel, suggest the occupations were approximately contemporaneous and can be considered together.

The distribution of the 12 hearths and hearth-related features at Locality 2 suggests a pattern of simple, intermittent, short-term occupations by relatively small groups. The hearths are small, unprepared, and exhibit only moderate oxidation of the underlying aeolian silts. Artefactual debris surrounding the hearths is limited in terms of both density and variability. Subsistence data are also limited. Seeds and identifiable plant macrofossils were not preserved in the Locality 2 hearths, and faunal material is limited to a single antelope, a possible gazelle, and an unidentified large mammal. Ostrich eggshell was present, but may be incidental. Large mammals, including the woolly rhinoceros (*Coelodonta antiquitatis*), horse (*Equus przewalskyi*), and ass (*E. hemionus*), recovered from the Locality 1 deposits, have yet to be identified at Locality 2. Antelope, identified at Locality 2, were not recovered during the Locality 1 excavations.

Although several of the radiocarbon estimates overlap at 2σ, the stratigraphic separation between the hearths suggests it is unlikely that more than one hearth was in use at any one time. However, given the concentration of hearths on exposed surfaces around the periphery of Locality 2, considerably larger numbers potentially exist within the stack of aeolian sediments, and it is possible the site was occasionally occupied by more than a single family group. Together with the hearth discovered by Teilhard de Chardin at Locality 1, and considering the large amount of sediment cut away between the two localities, visitation may also have been much more frequent than is indicated by the age range of the known hearths.

The lithic industry from Shuidonggou Locality 1 falls squarely within the range of variability defined for the Initial Upper Palaeolithic based on western Eurasian examples (Brantingham *et al.* in press). New radiocarbon age determinations from Locality 2 provide strong evidence that this blade-based industry appeared in North China 29,000–24,000 years ago, and is closely related to similar assemblages from the Mongolian Gobi and southern Siberia dated to 33,000–27,000 BP and 43,000–39,000 BP, respectively. The oldest Initial Upper Palaeolithic occurrences from Siberia such as Kara Bom are of comparable age to the earliest western Eurasian examples. Yet the Shuidonggou Initial Upper Palaeolithic is perhaps 7,000–11,000 years younger than the latest western Eurasian Initial Upper Palaeolithic assemblages such as the Bohunician of Central Europe dated to approximately 36,000 BP (Svoboda *et al.* 1996). Shuidonggou is thus the latest Initial Upper Palaeolithic assemblage yet known in all of Eurasia.

Locality 2 differs from Locality 1 in preserving a small, but significant, sample of what may be termed a bipolar bladelet technology. This technology was apparently employed alongside the large blade component, and may reflect constraints imposed by the use of small chalcedony pebbles. On the other hand, given the prevalence of larger blades, small pebbles were clearly being intentionally selected to produce these bladelets, and at least one of the Locality 2 specimens is retouched in a manner similar to that found on later microblades. The use of this bipolar pebble technology may thus have provided an important foundation for the development of formal microblade technologies, which emerged rapidly in Northeast Asia shortly after the peak of occupation at Shuidonggou.

Pebble-based microblade cores in China and other areas of Northeast Asia are commonly initiated with bipolar reduction, and then enter a trajectory of more organized microblade production. These technologies appear sometime around the Last Glacial Maximum and come to dominate the Siberian, Mongolian, and North Chinese sequences by the Pleistocene–Holocene transition (Derevianko *et al.* 1998; Lie 1998). We wonder what conditions may have fostered the development of microblade technologies on this technological substrate in the latter part of the late Pleistocene and not earlier. Given the array of bipolar-initiated microlithic material and transitional Pleistocene/Holocene Helan technology tools on the Locality 2 surface and upper bluff margins, and the large stack of intact deposits postdating the 29,000–23,000 BP interval, Shuidonggou Locality 2 may potentially play a very important role in answering this question.

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