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The early appearance of Shuidonggou core-and-blade technology in north China: Implications for the spread of Anatomically Modern Humans in northeast Asia?

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ABSTRACT

The identification and dating of South Temple Canyon 1 (STC 1), an Early Upper Paleolihic (EUP) site in north-central China near Shuidonggou (SDG), helps confirm that SDG is one of the earliest EUP sites in northern Asia. Materials from STC 1 bear a strong resemblance to the early SDG core-and-blade lithic technology that includes flat-faced cores and elongate blades. We obtained a ^{14}C age estimate of 41,070 ± 890 ^{14}C yr BP on the innermost lamina of a calcium carbonate pendant attached to one of the quartzite flakes from the site. The purity of the micrite lamina, the care taken in obtaining the carbonate sample for processing and dating, and the geomorphological setting from which the flake came suggest the age estimate represents a reasonable assessment of an accurate minimum age for STC 1. Together with recently derived age estimates of >35 ^{14}C ka for the initial EUP occupations at SDG 1 and 2, it appears that the EUP in the SDG area is as old as any of the handful of EUP sites in Mongolia and Siberia dating to about 40 ^{14}C ka, and brings into question a postulated north-to-south spread of the EUP lithic technology present at SDG. Whether or not the dispersal of this technology is associated with the spread of Anatomically Modern Humans remains unknown.

1. Introduction

The early occupational phase at Shuidonggou (SDG), a site with multiple stratified localities on the southern margin of the Ordos Desert, is characterized by a unique core-and-blade lithic technology that includes flat-faced, Levallois-like cores and elongate blades (e.g., Brantingham et al., 2004; Li et al., 2013). This technology has been dated at only a few sites, most of which are located in Mongolia and southern Siberia. Several of these sites, such as Kara-Bom and Tolbor-4, date to ~40 ^{14}C ka or earlier (Brantingham et al., 2001; Goebel, 2004; Gladyshev et al., 2012; Morgan et al., 2014). The appearance of this technology at SDG was thought to date much later (Madsen et al., 2001), leading to speculation that the technology originated in northern Asia and spread south, reaching SDG sometime after ~30 ka (Brantingham et al., 2001, 2004; Qu et al., 2013). Recent re-dating of SDG Localities 1 and 2 now places the age of the early occupational phase much closer chronologically to the Mongolian and Siberian sites, leading to speculation that the hypothetical north-to-south spread was comparatively rapid (Li et al., 2013).

Here we report discovery and dating of South Temple Canyon 1 (STC 1), a site on the margin of the southwestern flank of the Helan Mountains near SDG. STC 1 has been only briefly investigated, limited surface artifacts have been studied, and the presence of buried deposits remains unknown. However, the studied collection suggests STC 1 is a single component site, with flat-faced cores and blades manufactured from quartzite stream cobbles bearing a close resemblance to those in early SDG occupations. We obtained an age

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of ~41 ka ^{14}C BP from the innermost layer of a carbonate pendant formed on a quartzite flake. The age estimate, assuming it is accurate, helps confirm the early age of the initial SDG components and suggests occupations in the Helan Shan area of northern China are contemporaneous with those in more northern areas of Asia. This raises the question of a north-to-south spread of this technology, and we suggest this hypothesis may be the result of simple sampling error due to the discovery and dating of only a small number of sites. Alternatively, we hypothesize the distribution of this Early Upper Paleolithic (EUP) technology may be related to the appearance and rapid dispersal of Anatomically Modern Humans in northeast Asia. While the direction of this spread remains unknown (south-to-north or west-to-east), a north-to-south dispersal pattern seems less likely.

2. South Temple Canyon #1

In 2001 we identified a number of sites at the mouth of a canyon on the southwestern flank of the Helan Mountains 80 km northwest of SDG. STC 1 is located at 1800 m a.s.l. near the mouth of a major canyon on the head of a large alluvial fan that extends 13 km west to the Tengger Desert (38.68° N, 105.76° E) (Fig. 1). The ancient fan is heavily dissected and the modern permanent stream has incised more than 30 m into the older fan surface. The coarse cobbles and gravels of the fan are well cemented by calcium carbonate and the deposit appears to date to the early Pleistocene or earlier. The STC stream is one of the major streams draining the Helan Mountains and its waters now feed major agricultural towns along the margin of the Tengger dunes, but it likely fed extensive marsh systems along the fan/dune interface when the site was occupied. Current vegetation has been extensively impacted by modern grazing, and consists of a sparse cover of low shrubs. Where protected these exposed lower slopes support scrub rose (*Rosa xanthina*), *Caragana* spp., elm (*Ulmus glaucescens*), and juniper (*Juniperus rigida*), which are found along lower stream margins (Di, 1986; Zheng et al., 2013). Higher elevations in the Helan Mountains support a mixed hardwood/coniferous forest of poplar (*Populus* spp.), birch (*Betula* spp.), choke cherry (*Prunus mongolica*), red pine (*Pinus tabulaeformis*), and spruce (*Picea asperata* and *Picea crassifolia*). The STC stream and canyon, supporting riparian vegetation such as Siberian elm (*Ulmus pumila*) and willow (*Salix* spp.) at lower elevations, provided an access route along which prehistoric foragers could readily move between the marshes of the desert margin and the highlands of the Helan Mountains. Much of the upper Helan Mountains is now protected from grazing and development, but animal populations are only beginning to recover. Blue sheep (*Pseudois nayaur*) and red deer (*Cervus elahus*) are now the principal large game animals found in the range, with small populations of musk deer (*Moschus chryogaster*) (Liu et al., 2007; Zhang et al., 2012), but historically, the mountains also supported herds of argali (*Ovis ammon*) and possibly moose/Eurasian elk (*Alces alces*) (Prejevalsky, 1876).

The site itself consists of an array of lithic debris eroding out from below a ~1 m thick loess cap that covers the cobble and gravel surface of the ancient fan. While this local loess cap remains undated, similar thin loess depositions in northwestern China appear to post-date the cold/dry conditions of the Last Glacial Maximum (e.g., Liu et al., 2012; Yu and Lai, 2012) and this surficial loess deposit is likely of a similar age. The lithic debris appears to lie directly on a well-developed soil on the ancient fan surface, and the ~1 m-thick loess cover deposition post-dates the age of the cultural deposition by an unknown amount.

2.1. Artifact descriptions

We recovered an array of quartzite flakes and tools from the sands and gravels of the fan surface where the loess cap has been completely removed by deflation. A number of these flakes have

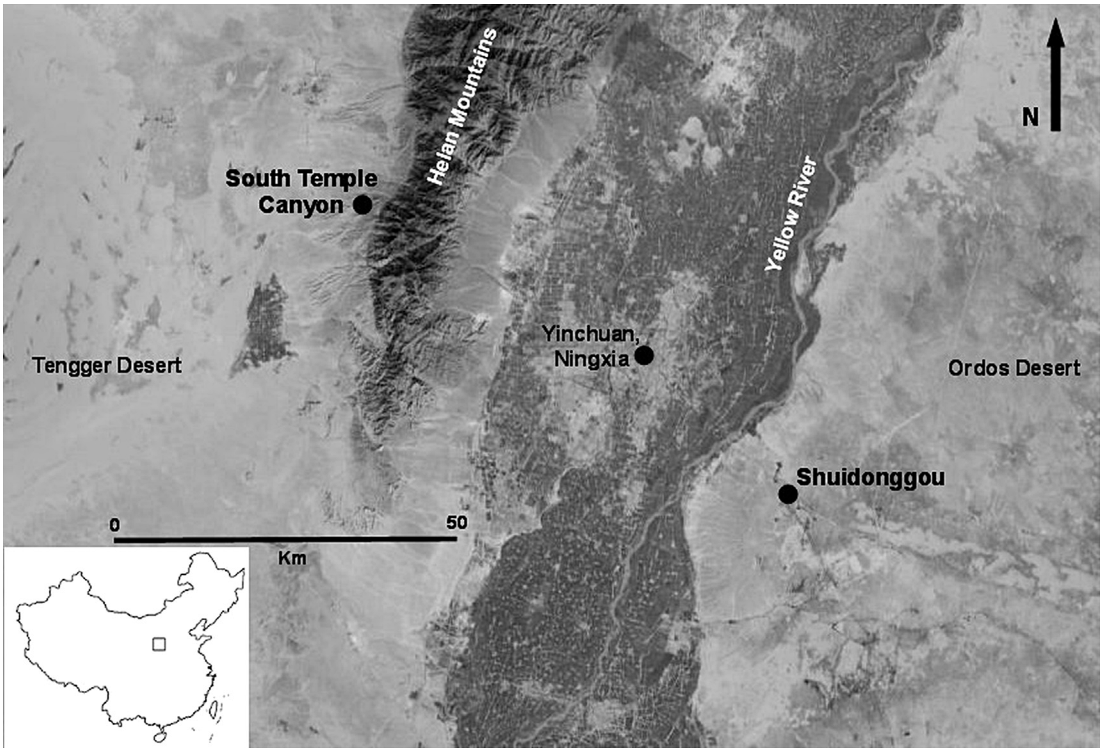

Fig. 1. Location of South Temple Canyon and Shuidonggou in relation to major physiographic features of the region.

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thick laminated calcium carbonate coatings or pendants. Most of the artifacts are of a non-diagnostic nature and are not reported here, but four suggest an affinity with the Upper Paleolithic core-and-blade technology found in the early levels of SDG localities 1 and 2. These are described as follows:

2.1.1. *STC-1*

Bi-directional Levallois blade core (Fig. 2) made from a flat, sub-angular quartzite stream cobble (length = 83 mm, width = 56 mm, thickness = 36 mm, blade scar lengths = 72 mm and 71 mm). The core has a slight convexity converging on sub-prismatic. A lateral crest was prepared on the core, but the intended crested blade was not removed because of a severe hinge at the proximal platform. There are two complete blade removals, one from each opposed platform. The platforms are both complex, with some remaining cortex. The left lateral edge (with platform down) was prepared as a crest towards the core counter-front. A severe error on the proximal platform, with an attempt at correction, made crested blade removal impossible. Platform angles are ∼80–90 °. The proximal platform error may be the reason why the core was discarded. The right lateral edge has two lateral removals that hinged on the primary face. The distal platform has one major error on the primary face. Overall, the core is very reminiscent of early SDG Locality 1 materials.

2.1.2. *STC-2*

A medium grained white/gray quartzite proximal Levallois blade fragment (Fig. 2) with a faceted platform (length = 31 mm, width = 30 mm, thickness = 11 mm). The platform is a weak Chapeau de Gendarme and faceted. A small patch of original cortex on the dorsal surface (<10%) indicates that the material package was a well-rounded alluvial cobble. There are three parallel dorsal scars and four proximal scars. The proximal central scar has a steep step fracture. Both lateral edges have scalar, fine retouch or utilization scars. The blade is very reminiscent of early SDG materials in overall technology, especially in that decortification and blade production proceed together.

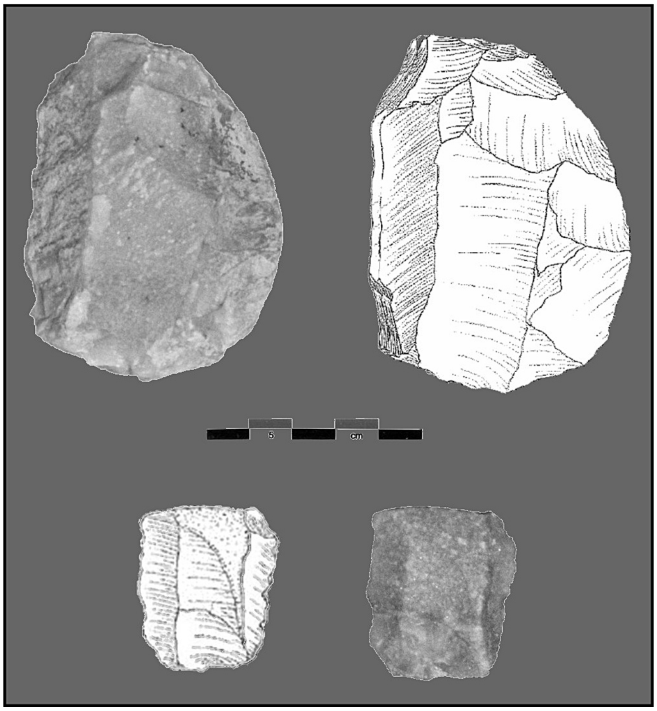

Fig. 2. Diagnostic artifacts from South Temple Canyon characteristic of the early core-and-blade technology at Shuidonggou: (upper) Bi-directional quartzite Levallois blade core (STC-1); (lower) quartzite Levallois blade segment STC-2. The scale is in cm.

2.1.3. *STC-4*

Medium grained white quartzite elongate, pointed flake-blade. The flake-blade has a simple platform with unidirectional convergent flake scars and nibbling retouch along both edges. There are four dorsal scars and one proximal scar. The flake-blade is consistent with, but not necessarily diagnostic of early SDG technology.

2.1.4. *STC-6*

White quartzite flake, expanding with possible use wear along distal margin like a transverse scraper (length = 29 mm, width = 41 mm, thickness = 9 mm). The flake has a simple platform with 5 dorsal scars and 1 proximal scar. The right lateral and distal margin is coated with 1 cm-thick laminated $CaCO_3$ (Fig. 3).

2.2. *Carbonate pendants*

We attempted to determine the age of these early SDG-like Levallois core-and-blade materials by carefully removing, evaluating, and sampling the innermost $CaCO_3$ layer on two of the quartzite flakes (Fig. 3). Like others at the site, the two flakes (STC-6 and STC-7) have carbonate pendants on one end and are not completely coated in carbonate. Because pendants typically form on the undersides of pebbles in the soil, both flakes must have been oriented vertically in the profile. The flakes were found at the ground surface rather than in-place in an exposure, thus suggesting that the upper horizons of the soil profile may have been eroded and the flakes were left as a lag at the surface. It seems likely that they were held vertically between larger gravel clasts in the B horizon of the soil as the carbonate precipitated on their lower tips.

As calcium carbonate precipitates in the B horizon of a soil, its volume increases through time, and its morphology progresses through a series of stages that are recognizable in the field (Gile et al., 1966). In young gravelly soils, carbonate usually begins to precipitate on the undersides of clasts, where soil water, which has infiltrated from the surface, accumulates and eventually evaporates or is transpired by plants (Gile et al., 1966; Amundson et al., 1994). Ca^{2+} ions, and possibly some $CaCO_3$, are derived from wind-blown dust (Machette, 1985). Machette (1985) notes that Stage I carbonates in gravelly soils generally consist of thin, discontinuous coatings on the undersides of pebbles. Stage II soil carbonate coatings may be thin to thick, but in the lower part of the B horizon are continuous and cover both the undersides and tops of clasts. In the Southwestern U.S., Stage I carbonate morphologies are found in profiles of Holocene age, but may be older (up to about 90,000 years) in areas of higher annual precipitation. Stage II carbonate horizons may range in age from about 10,000 to 12,000 years in arid settings, to as old as 200,000 years in wetter sites (Machette, 1985, Table 2). Unfortunately, there were no exposures at the STC 1 site deep enough to allow us to use calcic soil morphology to directly assess the age of soil development and the approximate age of the flakes. Based on the partial coverage of carbonate on the flakes, the pendant thickness, and internal structure, a reasonable guess is that the pendants are early Stage I or late Stage II in age, and were in the upper part of the B horizon of the soil.

Sample STC-6 consists of a quartzite flake with a calcium-carbonate coating on one end. The coating, or pendant, has a maximum thickness of 5 mm. The flake was cut along its long axis to bisect the carbonate pendant, and a thin section was made. Half of the cut flake was embedded in epoxy and sectioned; the other half was used for radiocarbon dating. The innermost lamina consists of dense, fine-grained carbonate (micrite) about 0.1–0.5 mm

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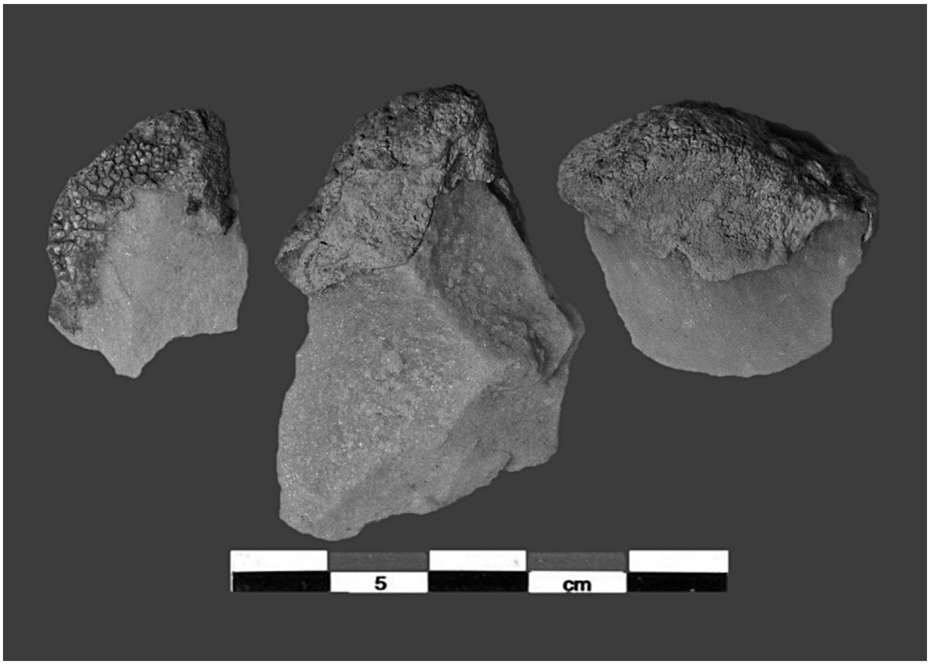

Fig. 3. Calcium carbonate pendants on quartzite flakes from South Temple Canyon. The innermost lamina on the center flake (STC-6) is radiocarbon dated to ~41 ^{14}C ka.

thick (Fig. 4). The micrite lamina was firmly attached to the quartzite flake prior to thin-sectioning, but apparently separated from the flake as the thin section was being made. It is overlain by a lamina of lighter-colored and coarser-grained (sparry) calcite that contains sand-size grains of quartz and other silicate minerals. The sparry calcite is overlain by an irregular lamina consisting of tiny rounded nodules of micrite surrounded by sparry calcite, and this is overlain by massive micrite that contains abundant detrital sand. This outer micrite is segregated into irregular laminae by sparry calcite fillings in thin, wavy stringers and straight fractures. Detrital sand grains consist of quartz and other silicate minerals; no detrital carbonate grains were observed in the thin section.

The innermost micrite lamina was separated from the outer layers and prepared for dating. The carbonate pendant was tapped lightly with a hammer to break it free from the quartzite – it detached into two larger pieces plus many smaller fragments. A variety of methods were then used to remove the outer layers of sparry calcite, which contained detrital sand, from the micrite in the two larger fragments. These methods included chiseling with a chisel made from a small nail, scraping with a steel file, and scraping with a thin knife blade. Carbonate fragments were held with a pair of forceps under a binocular microscope under low power, and the sparry calcite was carefully scraped off the fragment with the knife. After several minutes of scraping, the fragment was briefly immersed in dilute (~10%) HCL, then dried and reexamined to see if more material needed to be removed. Sparry calcite was easy to identify on the fragments because it was lighter in color than the micrite and contained grains of quartz and unidentified dark mineral grains. These steps were repeated until none of the sparry calcite was left adhering to the micrite. The fragments were then dried, weighed, and sent for radiocarbon analysis.

Sample STC-7 was also cut and sectioned. The STC-7 carbonate coat is slightly thinner and lacks the dense micritic carbonate lamina adjacent to the quartzite as in STC-6. Due to the lack of this inner dense layer of micrite, attempts to sample and date this artifact pendant were abandoned.

2.3. Radiocarbon and stable isotope analyses

Radiocarbon dating of soil carbonate is known for being problematic (Birkeland, 1999). Good results have been obtained, however, in cases where investigators have thoroughly examined the carbonate samples and understood the geomorphology, soil-development processes, and geochemistry of the soils where the carbonate has precipitated (Amundson et al., 1989; Chadwick et al., 1989; Amundson et al., 1994; Birkeland, 1999). Amundson et al. (1994) note that in Stage I and Stage II carbonates “the innermost laminations are dense, nearly pure pedogenic carbonates with minor inclusions of detrital silicates and possibly (where present) limestone. In contrast, the outermost layers, where deposition is occurring, can consist of a heterogeneous mixture of pedogenic carbonate and detrital grains. The deposition of the dense laminations appears to exclude the inclusion of non-pedogenic minerals, particularly silicates.” This general description seems to apply to sample STC-6, except that the innermost micrite lamina is not internally laminated itself, but is massive. In any case, the innermost lamina contains only a few isolated quartz grains, and no detrital carbonate grains were observed.

The measured radiocarbon age of the innermost micrite on STC-6 is 41,070 ± 890 ^{14}C yr BP (Beta-161632). The innermost lamina of micrite was chosen for dating because it was dense and fine-grained, and showed no obvious indication of contamination by either old or young carbon. Amundson et al. (1989) cite evidence that the innermost layer of carbonate in a coating will yield a more reliable radiocarbon age than the outer layers. They note that in paired ages from a single sample, the outer layers usually give younger ages than the inner layers, suggesting that young (secondary) carbonate has affected the outer ages. The primary assumption in dating soil carbonate is that the carbon that is dated was principally derived from soil CO_2 that was in equilibrium with the atmosphere at the time the carbonate precipitated. After adjusting for fractionation effects (by using the δ^{13}C value of the carbonate) this should be a valid assumption (Amundson et al., 1989). The accuracy of the STC-6 radiocarbon age is dependent on

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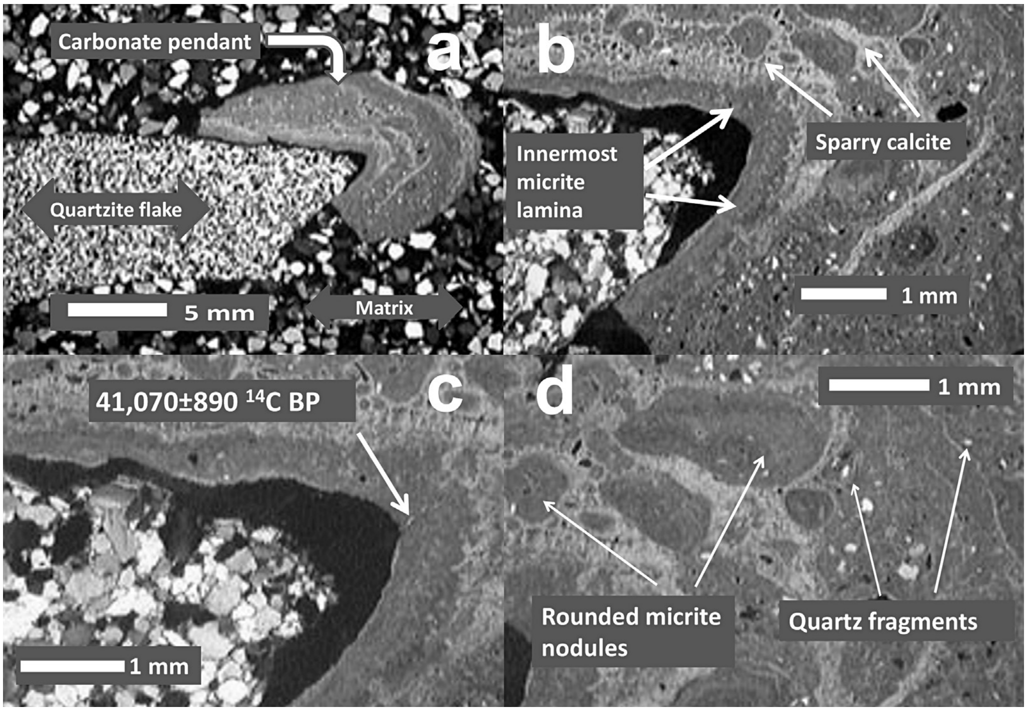

Fig. 4. Microscopic views of the calcium carbonate pendant on the dated quartzite flake (STC-6) from South Temple Canyon: (a) cross-section showing the pendant adhering to the flake; the "matrix" is a sandy grit in epoxy used to stabilize the flake and pendant for cross-sectioning; (b) closer view of the pendant and flake showing the clean inner micrite lamina and outer sparry calcite layers; (c) redeposited materials (detrital grains) within the sparry calcite; (d) detailed view of the clean micrite lamina dated to ~41 ^{14}C ka.

the absence of: 1) detrital contamination from older carbonate grains, 2) either old or young carbonate delivered to the site as windblown dust and incorporated in the carbonate coating, and 3) secondary sparry calcite in the dated micrite. As noted above, no detrital grains of carbonate rocks, such as pre-Quaternary limestone, dolomite, or marble, were observed in the thin section. This does not completely eliminate the possibility of contamination from such "old" or "dead" carbon sources, because very small grains of unidentified detrital carbonate could have been present in the sample of micrite that was dated. Given the site's location on the eastern edge of the Tengger Desert, it is reasonable to infer that carbonates are delivered to the STC 1 site by wind. If some of these carbonates are translocated down the soil profile, either mechanically or in solution, they could be incorporated in the soil carbonates at depth in the profile. Depending on the age of the carbonate in the dust, and whether the dust carbonate is incorporated in the clast coatings, the measured age of the micrite in the STC-6 pendant could be either too old or too young.

The stable isotope values of the STC-6 carbonate are: $\delta^{13}C = -1.9‰$ and $\delta^{18}O = -6.4‰$, within the normal ranges for these isotopes in typical calcic soils in North America (Cerling and Quade, 1993) and China (Wang et al., 2005). The $\delta^{13}C$ value of soil carbonate primarily reflects the isotopic composition of the soil CO_2, which is largely determined by the ratio of C_3–C_4 plants in the ecosystem, and the $\delta^{18}O$ value is correlated with the isotopic composition of the meteoric water that infiltrates through the soil profile and precipitates the $CaCO_3$ (Cerling and Quade, 1993). The isotopic composition of the STC-6 carbonate suggests that the carbonate carbon was derived from soil CO_2 and not from other sources such as carbonate dust.

With the caveats noted above aside, and given the extreme care taken to identify and remove secondary calcite particles, we believe the given radiocarbon age represents a reasonable assessment of an accurate minimum age of the South Temple Canyon site. It is a minimum age because the carbonate pendant obviously post-dates the flake's production by an unknown amount of time.

3. Discussion

3.1. Comparison to other sites

South Temple Canyon is most akin to the early component of Shuidonggou, located southeast of the Helan Mountains and east of the Yellow River along a stream that separates the Ordos (Mu Us) Desert from high mountains to the south. Preliminary dating of charcoal from exposed hearths weathering out of late Pleistocene loess at Locality 2 led Madsen et al. (2001) to conclude the Levallois-like core-and-blade technology characteristic of the earliest occupations at Localities 1 and 2 were deposited between ~29 and 24 ^{14}C ka. Locality 2 has since been the focus of intensive excavation by Xing Gao and colleagues at the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (e.g., Pei et al., 2012), leading to indications that the initial depositions may be somewhat older. Li et al. (2013; see also Liu et al., 2009; Morgan et al., 2014) have reassessed the age of the EUP core-and-blade component of SDG localities 1 and 2, using higher quality stratigraphic information and the exposure of lower/earlier features. These more comprehensive stratigraphic and chronological data suggest that the nine radiocarbon age estimates "reported by Madsen et al. (2001), cannot represent the age of large blade technology in Shuidonggou area, and in fact post-date it (Li et al., 2013: 166)." Using a combination of uranium-thorium, optically stimulated luminescence, and radiocarbon dating methods, Li et al. (2013: 167) instead contend that "a more reasonable age estimate [*for the large blade components of both SDG localities 1 and 2*] is in the range of 34,000–41,445 calendar years BP." They provide radiocarbon estimates of 36,200 ± 140 ^{14}C BP for SDG 1, and 29,759 ± 245 and 36,329 ± 215 ^{14}C BP for SDG 2.

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The early core-and-large blade component of SDG is usually compared to similar technological complexes found at sites in Mongolia and southern Siberia farther to the north and west. Sites in the region whose initial EUP components date to ~30 ^{14}C ka, such as Chikhen Agui, are relatively common in the region and are even found in the Siberian far north, the Russian Far East, and Korea (see reviews in Brantingham et al., 2001; Goebel, 2004; Bae, 2010; Gladyshev et al., 2010; Lee, 2013; Qu et al., 2013 among others, and date compilations in Vasil'ev et al., 2002; Keates et al., 2012; Morgan et al., 2014). However, sites with initial EUP depositions dating to ~35–40 ^{14}C ka, such as Ust-Karakol in the Siberian Altai and Ortvale Klde in the southern Caucasus (Moncel et al., 2013), are much rarer, and sites with EUP components dating to older than ~40 ^{14}C ka can be counted on the fingers of a single hand. Moreover, a number of these EUP sites potentially dating to older than ~40 ^{14}C ka may not be much older than that. For example, Tolbor 4, an open air site along a tributary of the Selenge River in north-central Mongolia, has a single infinite date of >41,050 ^{14}C BP for Horizon 5, the earliest EUP deposition at the site and a second single radiocarbon age estimate of 37,400 ± 2600 ^{14}C BP for the very similar Horizon 6 component (Gladyshev et al., 2010). At Kara-Bom, located in Russian Siberia on the northern flank of the Altai Mountains and one of the better known of the earliest EUP sites, the initial EUP component has two radiocarbon age estimates of 43,200 ± 1500 and 43,300 ± 1600 ^{14}C BP (Goebel et al., 1993), which at two standard deviations could put the age of the deposition at closer to ~40 ^{14}C ka. A human bone from the Siberian site of Bargara, thought to be from an anatomically modern human, has been dated to >40,300 (Kuzmin et al., 2009), but its association with diagnostic lithic material is unclear and its identification as modern human has not been confirmed by DNA results. At Denisova Cave, also in the Siberian Altai, the age of the earliest EUP occupation, Horizon 11, is controlled by multiple radiocarbon age estimates to between 30 and 50 ka (Derevianko, 2009, 2010), but these dates appear to overlap with the age of Neanderthal Mousterian assemblages and the transition between the occupations is not completely clear.

The STC 1 collection is also similar to that found at Luotuoshi, a surface site in northern Xinjiang, north of the Autonomous Region's capital of Ürümchi and south of the Chinese Altai Mountains margin (46.65° N, 86.04° E). The large, but undated, surface assemblage consists of an array of cores, blades and flakes that is "… quite homogeneous; [with] no significant differences in the techno-typological features… (Derevianko et al., 2012: 5)." Derevianko et al. (2012: 16) attribute the collection to "the earliest stages of the Upper Paleolithic," and suggest the collection is similar to those from a number of well-dated stratified sites in central Asia such as Shuidonggou, Orkhon 1 in central Mongolia, Barlagin-Gol 2 on the southern margin of the Mongolian Altai, Tolbor 4 in north central Mongolia, and a number of the sites in the Siberian Altai mentioned above. While undated, the site's importance lies primarily in its similarities to these assemblages and to its location between Shuidonggou and EUP sites on both the northern and southern margins of the Altai Mountains. As Derevianko et al. (2012: 17) note: "Given the broad geographical range of established analogs, we conclude that the Luotuoshi site was situated on a route of dispersal of a blade-making technological tradition during the terminal Middle – initial Upper Paleolithic …"

3.2. *Dispersal routes*

Given the limited number of sites dated to the earliest phase of the central and northern Asian Upper Paleolithic, *any* speculation may be unwarranted as to the route(s) through which the early core-and-blade technology found at Shuidonggou and South Temple Canyon was distributed. Moreover, there are several major complicating factors in postulating any such route. One such factor is the lack of agreement about the uniformity of stone tool assemblages from the earliest Upper Paleolithic sites in the region. Some (e.g., Brantingham et al., 2001; Goebel, 2004; Rybin, 2005; Zwyns, 2012) contend there was a relatively uniform stone tool technology among EUP sites in north-central Asia, while others (e.g., Derevianko, 2010; Derevianko et al., 2012; Kato, 2013) suggest there were a number of distinct local variants that differed substantially from one another. If there were many local variants in stone tool assemblages, then the identification of routes of dispersal between and among those variants becomes problematic. A second major complicating factor is the presence of different hominin populations in the region shortly before and at ~40 ^{14}C ka. It is now apparent that populations of Neanderthals, Anatomically Modern Humans (AMH), and, perhaps, "Denisovans" occupied various sections of the Altai Mountains margins at roughly the same time interval and interbred at least to some extent (e.g., Krause et al., 2007; Reich et al., 2010; Bar-Yosef, 2013; Ding et al., 2013; Prüfer et al., 2014). How these populations interacted, and how, to what degree, or even if, they exchanged stone tool manufacturing techniques along with genes is an open question. Finally, given this apparent contemporaneity of these hominin populations, together with the apparent persistence of Middle Paleolithic stone tools and production techniques into the EUP (e.g, Goebel, 2004; Boëda et al., 2013), whether the spread of EUP technologies represents a dispersal of AMH populations throughout the region, the exchange of knowledge about such technologies, or some combination of the two is unclear, and, perhaps, ultimately unknowable.

Given these limiting factors, postulating a route for the spread of the EUP technologies present at STC 1 and in the earliest components of SDG is, at best, speculative. If the recently derived dates of ~35–41 ^{14}C ka for this technology at the two sites are valid, the north-to-south dispersal route suggested by Brantingham et al. (2001) and Goebel (2004) now seems much less likely. Derevianko et al. (2012: 17) have suggested what they call a "Southern" route, stretching west-to-east from "… the greater Altai Mountains in the west through eastern Kazakhstan, Dzungaria, and western and central Mongolia to the Ordos Region within the Great Bend of the Huanghe (Yellow River) in the east." Such a dispersal route seems more plausible than a north-to-south route, but their model represents only a portion of the EUP technological variants in the region. However, given the early age estimates for the initial SDG complex, alternate routes, such as one from the Mediterranean, to the southern Caucuses, to the north and west, and on to the Pacific Rim, as suggested by Boëda et al. (2013), seem equally plausible. It has also been suggested by Su et al. (1999) and Ke et al. (2001) that there was a spread of AMH from south Asia into northern China and Siberia, but how that relates to a spread of EUP technologies is unclear. Boëda et al. (2013) hypothesize that it was the "idea" of Levallois production techniques that arrived at Shuidonggou and other EUP sites in north-central Asia. However, a compilation of EUP radiocarbon dates compiled by Morgan et al. (2014: 1) suggests to them that the initial diffusion of that technology into "… East Asia occurred ~41 cal ka, a hypothesis consistent with current estimates for the evolution or arrival of modern humans in the region," and this apparent contemporaneity of AMH populations with the arrival of SDG blade technology throughout much of the region makes it difficult to accept in its entirety the hypothesis of a down-the-line learning of Levallois production

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techniques. Li et al. (2014) suggest that an intrusive population (they do not specify if this was a population of AMH), using a Levallois core-and-blade technology, moved into northern and northwestern China during early Marine Isotope Stage 3 and encountered an extant population using a simple flake core technology. They identify a definitive border zone between the two areas that roughly corresponds to the margin of the east Asian summer monsoon. Li et al. (2014) suggest further that either the intrusive group later withdrew from the region or was assimilated by the in situ peoples, but, regardless, the use of a core-and-blade technology apparently disappeared.

4. Conclusions

We identified, recorded and collected artifacts from the South Temple Canyon site at the head of an eroded alluvial fan adjacent a canyon mouth of the Helan Mountains in north-central China. Artifacts from the site bear a striking resemblance to initial EUP components at the site of Shuidonggou, located only 80 km to the east across the Yellow River. We obtained a ^{14}C age estimate of 41,070 ± 890 ^{14}C yr BP on the innermost lamina of a calcium soil-carbonate pendant attached to one of the quartzite flakes from the site. Given the nature of the micrite carbonate in the pendant and the care with which the sample was collected, examined and dated, we believe the given radiocarbon age represents a reasonable assessment of an accurate minimum age of the South Temple Canyon site. While it is probably unwise to place too much faith in this single carbonate date, together with the recently obtained radiocarbon age estimates of greater than ~35 ^{14}C ka for the age of similar materials from Shuidonggou, it does suggest that the EUP stone tool complex in north-central China may be contemporaneous with similar complexes in Mongolia and the Siberian Altai. If so, that may mean that a postulated north-to-south spread of the technology was a product of simple sampling error due to the discovery and dating of only a small number of sites and that one or more other dispersal routes were more likely. Whether or not the dispersal of this technology throughout the region of north-central Asia involved the spread of Anatomically Modern Humans, the spread of an idea, or a combination of the two remains an open question. However, the near simultaneous arrival of both AMH and the early SDG technological complex in the region suggests human population movement must be considered a primary factor.

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