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Age and paleoenvironment of Paleolithic stone artifact remains discovered in the Tengger Desert, northern China

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ABSTRACT

In northern China, environmental changes in the transitional zone from the sandy desert to the loess plateau have been regarded as an important issue in the understanding of climate changes and the remains of hominin activities found in this zone provide a solid line of evidence to support the reconstruction of environmental conditions during the late Pleistocene. In 2006, many stone artifacts were collected on the surface in the southeastern Tengger Desert, Northern China. The Tengger lithic assemblage is correlated to the Late Middle to Early Upper Paleolithic stage and with the typical and extensively investigated Shuidonggou site some 140 km north–east of the Tengger localities. In order to evaluate both the age and the environmental conditions prevailing during human occupation despite the lack of associated stratigraphies, we have tried to place the Tengger localities into the Late Pleistocene climatic framework using the available published data provided by Mu Us Desert sand–loess sections and records of Tengger paleolake levels, respectively eastwards and westwards from the newly discovered localities. Additionally, an unpublished sand–loess section was studied by optically stimulated luminescence (OSL) near Zhongwei city, around 170 km to the south. All the data suggests that the optimal time for hominin activity in the Tengger Desert would have been from 42 to 22 ka, during a period of relatively humid conditions when the climate of the area was governed by the strengthened summer East Asian monsoon.

1. Introduction

The desert–loess transitional zone in northern China is an informative area for studying climatic changes and, more generally, climatic variations during the late Pleistocene in the Northern Hemisphere (Lu et al., 2005; Madsen et al., 2003; Mason et al., 2009; Sun and Ding, 1998; Sun et al., 2006; Yang and Liu, 2003; Zhou et al., 2009). At present, this transitional zone displays a distinctive climate dominated by wet/dry changes with seasonal variations. In the area, relict sand sheets and dune sediments, characterized by alternating sandy loam soils and sand units, have recorded the response of eolian activity attributed to the strengthening and weakening of the East Asian monsoon during the Upper Pleistocene (Dong, 2002). Additionally, both the paleolake fluctuations and sand–loess sections have been investigated many times in an effort to reconstruct the paleoenvironmental changes in this sensitive zone (Li et al., 2007, 2002; Lu et al., 2006, 2005; Sun et al., 2006; Yang and Liu, 2003; Zhao et al., 2007; Zhou et al., 2009).

This zone has also been suggested as a potential area for locating records of the activities of Middle and Upper Paleolithic hominins. It is likely that the dry/wet climatic variations of this zone had a substantial effect on hominin activities and migrations (Brantingham et al., 2001, 2003, 2004; Barton et al., 2007; Gao et al., 2008), because the strengthened East Asian summer monsoon may have allowed intensive hominin occupation of the cold desert environments of northern China. Therefore, the remains of hominin activity in this transitional zone may provide solid evidence to support human occupation and hence help to reconstruct Pleistocene environments. Numerous Paleolithic remains have been found in the loess deposits close to sand fields and deserts in northern-central and north-eastern China (Chen and Wang, 1989; Gai and Wei, 1977; Gao et al., 2004; Huang and Hou, 2003; Jia and Huang, 1985; Licent & Teilhard de Chardin, 1925; Wang et al., 1978, 1982, 2007; Zhang, 1959), but few stone artifacts have been discovered in the present-day desert environment.

During a survey in 2006, we discovered stone artifacts in semi-active and mobile dunes in the south-eastern Tengger Desert,

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northern China. In this paper, these artifacts, attributed to a unique Paleolithic culture located deep within the desert–loess transitional zone of northern China, are described for the first time. Paleoclimatic regional records have been used to estimate their antiquity and environmental context.

2. Paleolithic localities of the Tengger Desert

The Tengger Desert is located in the loess–desert transitional zone south–west of Alashan Zuoqi city, central Inner Mongolia Autonomous Region, near the Yellow River Basin in northern China (Figs. 1 and 2). The current climate of the Tengger Desert is arid, with an annual average temperature of 7°–9 °C, an annual rainfall of 116–148 mm and annual evaporation of 3000–3600 mm. The desert consists primarily of mobile dunes that occupy 70% of the total area. A small number of fixed and semi-fixed sand dunes appear only at the margins of the desert. In the study area, the chains of sand dunes are small, principally comprising crescent dunes. Scattered small lakes make up 7% of the desert area. Most are shallow or have become swamps with herbaceous vegetation, and are surrounded by moving dunes. Some lakes at the south-eastern margin of the desert near the Helan Mountains appear to be related to groundwater supplied by alluvial fans (Madsen et al., 2003). Most of the Tengger lakes are freshwater lakes.

An area located to the west of the road between Alashan Zuoqi city and Moon Lake 30 km south–west of the city is the principal site of our archeological research. Three localities with abundant stone artifacts have been discovered (Figs. 2 and 3): Tengger 1 (N 38°35′59.4″, E 105°30′27.1″), Tengger 2 (N 38°35′17.3″, E 105°27′56″) and Tengger 3 (N 38°35′22.1″, E 105°27′49.9″). All artifacts found on the surface in this area were collected and labeled.

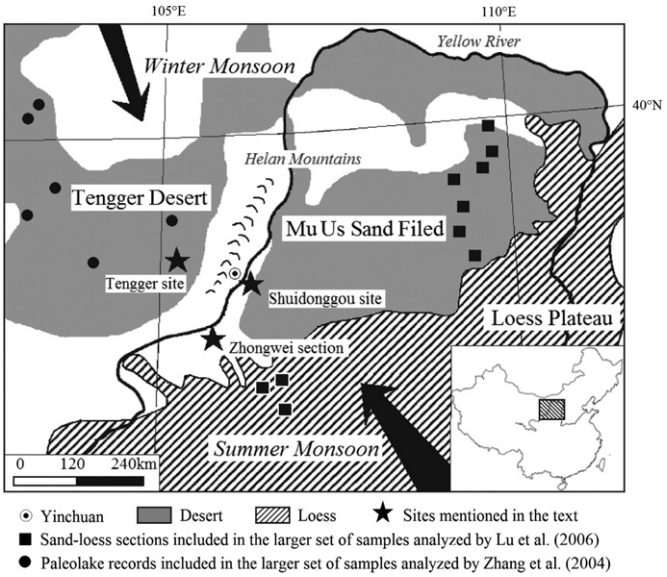

Fig. 1. Map showing the desert–loess transitional zone and the sites mentioned in the text. The Tengger site is surrounded by the Zhongwei sand–loess section site, the Shuidonggou paleolithic site, paleolake records in the Tengger Desert, and the sites of sand–loess sections investigated in the Mu Us Desert and the Loess Plateau. When this area is controlled by the strengthened winter East Asian monsoon, northwesterly winds bring cold air to the desert area, and dust storms prevail. When the area is controlled by the strengthened summer East Asian monsoon, southeasterly winds are dominant and bring humid maritime air masses originating from the South China Sea and the western Pacific Ocean as the dominant air masses in this desert area.

At Tengger 1, the dunes are approximately 5–8 m high and 10–20 m apart. A total of 173 stone artifacts were collected, concentrated within an area of approximately 100 square meters (Table 1). The Tengger 2 and Tengger 3 localities are less than 200 m apart. The dunes in this area are smaller, with a height of 3–4 m and a spacing of 40–50 m. The artifacts were found in a large inter-dune basin. At Tengger 2, 34 artifacts (Table 1) were collected from an area covering approximately 500 square meters. The Tengger 3 locality yielded 71 artifacts (Table 1) from a large area of approximately 1000 square meters.

The Tengger lithic assemblages are dominated by flakes that are generally of small size. A total of 11 cores were found in the Tengger localities. They are small and similar in size, only three being larger than 6 cm (Fig. 4). They have various shapes, including simple discoid cores, complex discoid cores and uni/bipolar cores. They do not appear to have produced a large number of flakes, with four to 20 flaking scars on the cores.

The lithic tools include scrapers, points, denticulates (Fig. 4) and pitted hammerstones (Fig. 5). The dominant tool types are scrapers and points. Among the scrapers, a fine bifacially retouched scraper was discovered at Tengger 3. Its raw material is light-colored flint, with some cortex. This piece bears two functional units (Fig. 4b): a point, and a cutting edge resembling a saw. The right-hand side of this scraper may be the handle part, with the opposite side being the functional unit. The operational scheme suggests that this tool was designed well for its purpose, and was produced by retouching with soft-hammer percussion.

The raw materials of the stone artifacts in the Tengger localities include light-colored quartzite, quartz sandstone and flint. Quartzite is dominant (>90%). The texture of the quartzite is hard, and most of the quartzite artifacts are milk-yellow. The quartzite artifacts were manufactured using round or irregularly shaped pebbles and cobbles, which are readily found on the alluvial fans approximately 20–30 km to the east, at the base of the Helan Mountains.

Thus, the Tengger lithic assemblage is composed of small stone tools manufactured from high-quality quartzite cobbles by direct percussion using a hard hammer, as supported by the discovery of several pitted hammerstones. The outstanding characteristics of the Tengger lithic assemblage are as follows: 1) cores, flakes, scrapers and points are the principal classes; 2) cores are mainly discoid; 3) skilled bifacial techniques are evident, for which soft-hammer technology has been used. These characteristics appear to link the Tengger lithic assemblage with the Late Middle–Early Upper Paleolithic flake-tool tradition of northern China.

Stone artifacts found on the surface in and near the sand fields and deserts of Inner Mongolia, Ninxia, and Xinjiang provinces are generally regarded as having been produced by different groups of people at different times. We acknowledge the possibility that the Tengger site may not be a single-component site. Homologous hominin groups may have manufactured the Tengger artifacts in the same time periods, but it is also possible that other groups produced some of the artifacts at different times.

3. Upper Paleolithic in northern China

In northern-central China, the initial Upper Paleolithic assemblages are generally characterized by the presence of blades or microblades. These technologies are characteristic of both Middle and Upper Paleolithic traditions (Chen and Wang, 1989; Hou, 2005; Li, 1993) and it is difficult to distinguish Middle Paleolithic from Upper Paleolithic assemblages. Lithic technology changed relatively