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Hominin distribution in glacial-interglacial environmental changes in the Qinling Mountains range, central China

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ABSTRACT

The Qinling Mountain Range (QMR) in central China encompasses innumerable Paleolithic sites. The hominin settlement in the QMR is comparable with that in the Nihewan Basin in northern China. The recorded information on the loess deposition in the QMR include both hominin remains and environmental changes. Since 2004, geological, geomorphological, archaeological, and chronological investigations were conducted by our team. By systematically using luminescence, paleomagnetic, and $^{26}Al/^{10}Be$ burial dating methods to obtain age controls, and by correlating the pedostratigraphy and magnetic susceptibility of the Luochuan loess section, we established the loess–paleosol sequence and chronology of the lithic artifact levels for 35 Paleolithic sites and spots in the QMR. This work remarkable found shifts from glacial-to interglacial-driving hominin settlement patterns. During the stage between 1.2 and 0.7 Ma, large drying events, such as L15 (MIS 38) and L9 (MIS 22, 23 and 24), may have driven hominin migrations when the Loess Plateau was depopulated; moreover, the southern QMR was a glacial refugium. During the stage after ~0.60 Ma, the contrasts between glacial and interglacial scales are the greatest; furthermore, longer and warmer humid interglacial environments were dominant. S5 (MIS 13, 14, 15) and S1 (MIS 5) interglacial periods provided the optimal environments for hominin settlement and dispersal. On the basis of investigations, we also found that the hominin settlement is relatively continuous from ~1.20 Ma to ~0.05 Ma in the QMR. The human occupation of the QMR decreased considerably after ~0.05 Ma, probably because of changes in climate and human adaptations.

1. Introduction

Over the last two decades, important progress has been made in the discoveries, studies, and dating of the Chinese Paleolithic (e.g., Gao, 1999; Hou et al., 2000; Zhu et al., 2001, 2004; Gao and Hou, 2002; Wang and Huang, 2002; Wang et al., 2004, 2005; Deng et al., 2008; Wang et al., 2008a,b; Shen et al., 2009; Lu et al., 2007, 2011a; 2011b, 2017; Sun et al., 2012, 2013; Gao, 2013; Pei et al., 2015; Zhu et al., 2018; Zhang et al., 2018). Major achievements have also been made in the studies on the loess and paleosol sequence in China (e.g., Liu, 1985; An et al., 1990; Ding et al., 2002; Lu et al., 1999). This sequence is particularly important because it records not only the climate changes but also the Paleolithic artifacts and fossil hominin remains in the area (Liu and Ding, 1984, 1999; An and Ho, 1989; Ranov, 1995; Liu, 1999; Xia et al., 1999; Huang, 2000; Xiao et al., 2002; Yang et al., 2005; Lu et al., 2007; Du et al., 2008). Loess-covered Paleolithic sites are therefore important for studying the relationship between Paleolithic settlement and climate change.

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Studies on the climatic context of particular Paleolithic sites in China (e.g., Xia et al., 2001, 2008; Gao et al., 2008; Pei et al., 2009; Zhang and Chen, 2013; Li et al., 2014a; Ji et al., 2005; Li et al., 2016a,) and on earth surface processes and human evolution (e.g., Lu et al., 2017) have been conducted, but only a few of them have focused on long-term responses of Paleolithic societies to several glacial–interglacial shifts. The Qinling Mountain Range (QMR) in central China is one of those areas where this type of investigation is possible. The QMR encompasses ca. 400 Paleolithic sites and spots (i.e., "spots" refer to sites with lithic discoveries but no excavation was conducted). In particular, 30 Paleolithic sites and spots were identified in the Lantian area from 1963 to 2009 (Wang et al., 2014a), 268 Paleolithic sites and spots were found in the Luonan Basin between 1995 and 2004 (Shaanxi Provincial Institute of Archaeology, 2007), 52 Paleolithic sites and spots were found in the Danjiangkou area in 1994 (Li et al., 2009), and a 43 Paleolithic sites and spots were recorded in the Danjiangkou area in 2004 (Li et al., 2012). These sites and spots have been found to occur in the Early, Middle, and Late Pleistocene climatic contexts. Therefore, the QMR is a potential target area for studying how hominin societies responded to glacial–interglacial climate and environmental changes.

Before our investigations, the only sites in the QMR that had been dated were the Lantian hominin (Gongwangling) and Chenjiawo sites (An and Ho, 1989) and the Longyadong Cave (Wang and Huang, 2002). Since 2004, systematic geological, geomorphological, archaeological, and chronological investigations have been conducted by a joint team from Nanjing University, the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Beijing, of the Chinese Academy of Sciences, and the Shaanxi Provincial Institute of Archaeology in the QMR.

2. Geologic and geomorphologic setting

Since the Cenozoic period, several fault basins have formed in the QMR, such as the Hanzhong, Ankang, and Luonan basins (Zhang, 1981; Xia, 1984). Tertiary red sandstone, siltstone, and mudstone were deposited in most basins. During the Quaternary period, eolian loess was deposited in all these basins to combine with eolian deposit. The rivers in these basins were dominated by erosion, and multistage terraces developed along rivers. These terraces were then covered with several meters of loess.

The Qinling Mountains act as a collective natural barrier, and it depicts the boundary between the southern and northern climatic regimes of China, a sensitive area of climate change controlled by the East Asian Monsoon (EAM). The Loess Plateau is situated to the north of the Qinling Mountains (Fig. 1). Loess deposition in the Loess Plateau has been on a massive scale, reaching 300 m in the northwest, 175 m in the central part, 130 m in the Lantian area in the northern Qinling Mountains, and 100 m–30 m in the eastern and southern part of Qinling Mountains. The climate varies from arid to semi-arid and semi-humid. The Qinling Mountains can block most of the dust transport from northwest to southeast China, consequently lessening the loess deposition in the QMR basins. Compared with those in the Loess Plateau, the loess is thinner, the grain size is finer, the sedimentation rate is lower, and the color is considerably more reddish in the QMR, but it can still be correlated with the classic Luochuan loess–paleosol sequence (Lu et al., 2007, 2012; 2017; Zhang et al., 2012; Sun et al., 2012; 2104, 2016; 2017a, 2017b).

In the QMR, the South Luohe River originates in the Luonan Basin in the eastern Qinling Mountains, flows through several basins, and joins the Huang He (Yellow River) in Luoyang. The Hanjiang River and its main branches originate from the southern slopes of the Qinling Mountains, flow through several basins, and join the Yangtze River in Wuhan. The Bahe River originates from the northern slopes of the Qinling Mountains and joins the Weihe River in Xi'an. Although the Qinling Mountains are an obvious natural barrier between northern and southern China, the rivers that flow through them also provide several natural corridors for the humid and sub-tropical regions of southern China and the temperate and semi-arid regions of northern China.

According to the elevation measurements of the bedrock and gravel layers of the terraces along the abovementioned rivers by using the Trimble R8 GNSS system, and on the basis of previous investigations (e.g., Shen, 1956; Lu et al., 2017), we set up a three-terrace system along the Bahe and South Luohe River Valleys and a five-terrace system along the Hanjing River Valley.

3. Archeological setting

Paleolithic artifacts have been found in the Luonan and Lushi basins along the South Luohe River Valley in eastern QMR (Fig. 2B), in the Hanzhong, Ankang, and Yunxian basins and the Danjiangkou area along the Hanjiang River Valley in southern QMR (Fig. 2C), and in Lantian area along the Bahe River Valley in northern QMR (Fig. 2A).

3.1. South Luohe River Valley

Eight Paleolithic sites and spots (Shizilukou, Zhanghuokou, Mengwa, Guoyan, Liuwan, Sangbaichuan, and the Longyadong Cave sites in Luonan Basin, and Qiaojiayao Paleolithic site and Zhuangzicun Paleolithic spots in the Lushi Basin) were excavated and discovered by our team (Fig. 2B).

Nearly 77,000 lithic artifacts were excavated in the Longyadong Cave site (Shaanxi Provincial Institute of Archaeology, 2007) from 1995 to 1997. Thousands of lithic artifacts were excavated in Shizilukou (3538) (Xing, 2014), Zhanghuokou (unpublished), and Guoyan (unpublished). Hundreds of lithic artifacts were excavated in Mengwa (unpublished), Qiaojiayao (880), and Liuwan (216) (Lu et al., 2007, 2011a; 2012; Sun et al., 2014). Several lithic artifacts were also collected at the Zhuangzicun spot (Wang et al., 2008a). All these sites and spots along the South Luohe River have been dated (Wang and Huang, 2002; Lu et al., 2007, 2011a; b; 2012; Sun et al., 2013, 2014; Wang et al., 2008a; Wang and Lu, 2016).

3.2. Hanjiang River Valley

Five Paleolithic sites and spots (Hejialiang, Yaochangwan, Longgangsi-1, Longgangsi-2, and Longgangsi-3) were found in the Hanzhong Basin, two Paleolithic spots (Luojiacun and Wutaicun) were discovered in the Ankang Basin, and two Paleolithic sites (Dishuiyan and Houfang) in the Yunxian Basin were excavated by our team long the Hanjiang River (Fig. 2C).

Thousands of artifacts at Longgangsi-1 (unpublished), Longgangsi-3 (N = 4441) (Xia et al., 2018), and Longgangsi-2 (N = 83) (Sun et al., 2017a) were excavated. Hundreds were also scientifically excavated at Houfang (N = 162) (Li et al., 2014b), Dishuiyan (N = 600) (Liu and Feng, 2014), and Hejialiang (N = 252) (Wang et al., 2014b). Several artifacts were discovered at the Yaochangwan, Luojiacun, and Wutaicun spots. All these Paleolithic sites and spots along the Hanjiang River have been dated (Sun et al., 2012; 2017a; Wang and Lu, 2016; Li et al., 2016b).

3.3. Bahe River Valley

Ten Paleolithic spots, including those in Jijiawan, Diaozhai, and Ganyugou in the Lantian area, were found and artifacts were collected by our team (Fig. 2A). Hundreds of artifacts in Ganyu