



A luminescence dating study of the sediment stratigraphy of the Lajia Ruins in the upper Yellow River valley, China



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ABSTRACT

Pedo-sedimentological fieldwork were carried out in the Lajia Ruins within the Guanting Basin along the upper Yellow River valley. In the eolian loess-soil sections on the second river terrace in the Lajia Ruins, we find that the land of the Qijia Culture (4.20–3.95 ka BP) are fractured by several sets of earthquake fissures. A conglomerated red clay covers the ground of the Qijia Culture and also fills in the earthquake fissures. The clay was deposited by enormous mudflows in association with catastrophic earthquakes and rainstorms. The aim of this study is to provide a luminescence chronology of the sediment stratigraphy of the Lajia Ruins. Eight samples were taken from an eolian loess-soil section (Xialajia section) in the ruins for optically stimulated luminescence (OSL) dating. The OSL ages are in stratigraphic order and range from (31.94 ± 1.99) ka to (0.76 ± 0.02) ka. Combined OSL and ^{14}C ages with additional stratigraphic correlations, a chronological framework is established. We conclude that: (1) the second terrace of the upper part of Yellow River formed 35.00 ka ago, which was followed by the accumulation of the eolian loess-soil section; and (2) the eolian loess-soil section is composed of the Malan Loess of the late last glacial (MIS-2) and Holocene loess-soil sequences.

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1. Introduction

The Lajia Ruins, situated on the second terrace of the Guanting Basin along the upper Yellow River, was a significant settlement of the Qijia Culture (4.20–3.95 ka BP) in Eastern and Central Asia (Fitzgerald-Huber, 1995, 2003; Ye, 2002; Xia et al., 2003; Lü et al., 2005). The excavation of the Lajia Ruins has revealed evidence of the human struggle for survival during catastrophes (Ye, 2002; Xia et al., 2003). Similar to Pompeii, it is a rare archaeological site preserved by a natural disaster (Ye, 2002). Scholars have long been committed to identifying the disasters that occurred in the Guanting Basin where an important settlement of the Qijia Culture was devastated (Xia et al., 2003; Tarasov and Wanger, 2005; Qian, 2007; Wu et al., 2009). Unfortunately, until now there has not been a detailed study of the chronological framework of the sediment stratigraphy of the Lajia Ruins.

Optically stimulated luminescence (OSL) dating has been used extensively to establish the sediment burial ages that span the timescale of the last glacial-interglacial cycle (Prescott and Robertson, 1997; Aitken, 1998; Zhou et al., 2009; Lai, 2010a; Lai et al., 2010b). Loess is an eolian sediment that is ideal for OSL

dating (Aitken, 1998). In the last decade, the single-aliquot regeneration-dose (SAR) protocol (Murray and Wintle, 2000) has been successfully applied to quartz grains from Chinese loess (Lai, 2010a; Lai et al., 2010b; Zhou and Shackleton, 2001).

Pedo-sedimentological fieldwork were carried out at the Lajia Ruins in the Guanting Basin along the upper Yellow River valley. An eolian loess-soil section (Xialajia section, XLJ) was identified on the second river terrace of the ruins. In this section, a layer of conglomerated red clay has covered the ground of the Qijia Culture and is intercalated with the mid-Holocene paleosol (S_0). We also discovered several sets of earthquake fissures that had broken through the ground at the Lajia Ruins and were filled with the conglomerated red clay, where various human remains, including pottery shards, burnt earth, ash, charcoal, stones and earth clods, were also trapped. We therefore selected the Xialajia section for detailed study. Using OSL dating, Quaternary geomorphology, sedimentology and environmental archaeology, we construct the chronological framework of the eolian loess-soil stratigraphy of the Lajia Ruins.

2. Geographical setting

The Guanting Basin, a ca. 50 km² basin in the upper Yellow River valley, is located in Minhe county, Qinghai province, China (Fig. 1A and B). The region is semi-arid and sub-arid with a

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monsoonal climate (Huang et al., 2013) and a mean annual temperature, rainfall and evaporation of 8–9 °C, 250–400 mm and 2000–2100 mm, respectively.

The fluvial plain of the Yellow River within the Guanting Basin consists of several eolian loess-blanketed river terraces found at elevations of 1760–1860 m asl. The second river terrace (TII), resting on the Pliocene red clay, is a pedestal terrace (Huang et al., 2013). The upper and low parts of the river terrace consist of eolian loess-soil and fluvial deposits. The river terrace largely follows the original landscape and inclines from north to south because of the slope of the alluvial fan. The terrace is approximately 1–2 km wide on the northern riverbank and 1 km wide in the south. The front section of the second terrace is located approximately 30–35 m above the modern Yellow River water table.

The thick loess-soil cover forms flat and fertile land on the second river terrace (Fig. 1B) that has been occupied and cultivated extensively since the Neolithic (Yang et al., 2004). The Neolithic and Bronze Age sites, including those from the Majiayao Culture (Majiayao style, 5.30–4.80 ka BP), the Qijia Culture (4.20–3.60 ka BP), the Kayue Culture (3.60–2.60 ka BP) and the Xindian Culture (3.40–2.60 ka BP) have been discovered in the Guanting Basin (Xie, 2002; Dong et al., 2012).

Accelerated erosion related to human activities has resulted in intensified mass wasting on the surrounding hillsides. Several dry gullies or seasonal streams (such as Baojiagou, Lüjiagou, and Ganggou gullies) that originated from the surrounding hillsides dissect the second river terrace. Flash floods, mudflows and debris flows occur frequently in the head waters of these tributary gullies

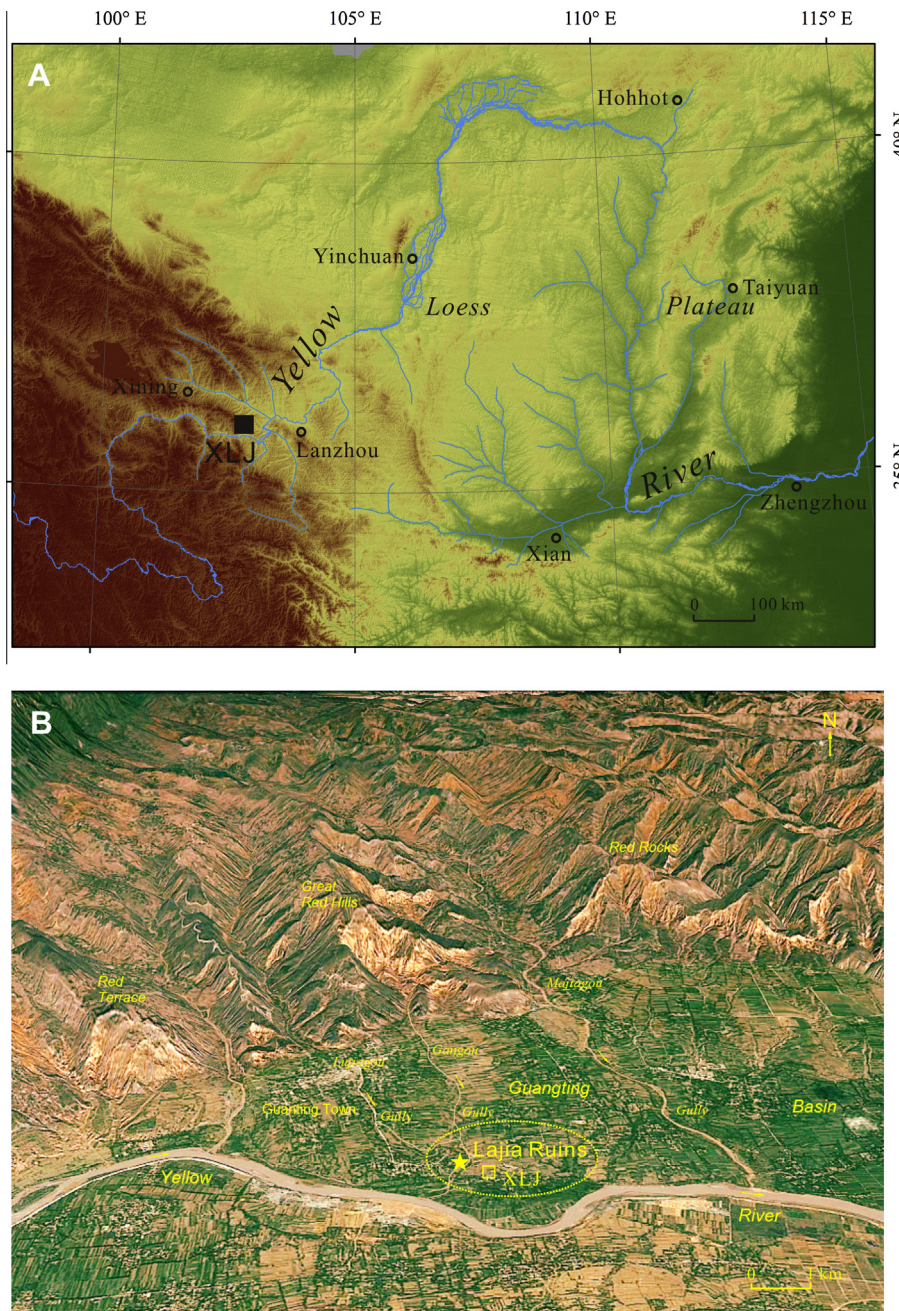


Fig. 1. (A) Site map showing the location of the Yellow River and the Xialajia site. (B) Google Earth satellite image showing the location of the Lajia Ruins and the Xialajia site and the landscape features of the Guanting Basin. The area with the red mudflow deposit is indicated by the dotted line circle.

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