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Research paper

Optical dating of flowstone and silty carbonate-rich sediments from Panxian Dadong Cave, Guizhou, southwestern China

Jia-Fu Zhang [a, *], Wei-Wen Huang [b], Yue Hu [b], Shi-Xia Yang [b], Li-Ping Zhou [a]

[a] MOE Laboratory for Earth Surface Processes, Department of Geography, College of Urban and Environmental Sciences, Peking University, Beijing, 100871, China

[b] Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, 100044, China

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ABSTRACT

Panxian Dadong Cave located in the western Guizhou is a very important Paleolithic site in China. At this site bone and stone artifacts, human teeth and mammalian fossils (known as *Ailuropoda-Stegodon* fauna) were found, and the site was previously dated to 120–300 ka using ESR/uranium-series methods. In this study, we successfully extracted fine quartz grains from flowstone and silty carbonate-rich sediments in the excavated area. The quartz extracts displayed excellent luminescence properties, and satisfied the SAR (single-aliquot regenerative dose method) acceptance criteria. The sensitivity-corrected OSL signals are not saturated at a dose up to about 1400 Gy. The cultural unit was OSL dated to 190–300 ka, corresponding to MISs 7–8. The flowstone deposits overlying the cultural unit were determined to be 13–190 ka and the silty carbonate-rich sediments underlying the cultural unit to be 300–360 ka. The optical ages are in general agreement with the coupled ESR/U-series and U-series ages.

1. Introduction

Panxian Dadong Cave is a very important Paleolithic site in China (Huang et al., 2012). This cave site was found in 1990, and excavated six times from 1992 to 2000. From the site 43 mammal species were found, most of them belong to an *Ailuropoda-Stegodon* faunal assemblage. The excavations also yielded four hominin teeth (Liu et al., 2013) and lots of stone and bone artifacts. The stone artifacts were made of limestone, basalt and chert. Additional evidence of hominin activities within the cave include burnt and cut-marked bones (Schepartz and Miller-Antonio, 2010). The lithic artifacts are composted of cores, flakes, tools, debitage and blanks, suggesting that the cave was a tool-making site (Huang et al., 2012). The characteristics of bones and artifacts also indicate that they were not brought into the cave from the outside (Karkanas et al., 2008).

The site was first dated with the U-series technique on 16 speleothem samples, the U-series ages obtained range from 18 to 316 ka (Shen et al., 1997). Karkanas et al. (2008) correlated five of them with the sedimentary layers, although Jones et al. (2004) considered that the U-series dates should be treated with caution because the geological relationship between the speleothem samples by Shen et al. (1997) with the sediments from the excavation area is unclear. The age of the site was further determined using ESR and coupled ESR/U-series dating techniques on mammalian tooth enamel from different deposit layers by Jones et al. (2004). The ESR early uptake (EU) and linear uptake (LU) model ages on fifteen teeth range from 120 to 300 ka.

Since the optically stimulated luminescence (OSL or optical dating) technique was developed (Huntley et al., 1985), it has been widely used for dating archaeological sites (e.g., Roberts et al., 1998; Jacobs et al., 2008; Feathers and Bush, 2000; Pei et al., 2006; Zhang et al., 2011; Fu et al., 2010; Feathers, 2012; Aubry et al., 2014; Li et al., 2014), even for cave sites (e.g. Jacobs et al., 2006; Berger et al., 2008; Zhang et al., 2010). Quartz or feldspar grains used in these age determinations are usually extracted from detrital sediments. However, the absence of detrital sediments in some caves limits the application of this dating method. In this case, it is possible to extract some quartz or feldspar grains from carbonate deposits, and they are used for dating with the OSL techniques. Similar work has been reported for calcarenite (e.g., Huntley et al., 1985; Woodroffe et al., 1995; Bateman et al., 2003; Pickering et al.,

* Corresponding author.
E-mail address: jfzhang@pku.edu.cn (J.-F. Zhang).

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2013), travertine (Zhang and Li, 2002) and tufa (Pickering et al., 2013) from other depositional environments. In this study, we analyzed the mineral components of some Dadong cave deposits, and extracted quartz grains from them for OSL dating. An age-depth model was constructed based on the OSL ages obtained.

2. Geomorphology, stratigraphy and sampling

Dadong Cave (N25° 37.606′, E104° 45.004′), situated in Panxian District of Guizhou Province, southwestern China, is a large karst cave. The Panxian region is located in the western Yunnan–Guizhou Plateau with an altitude of 1000–2000 m above sea level (asl), and is characterized by karst landscape including numerous caves (Fig. 1) (Sweeting, 1995). The Dadong cave is the middle of five interconnecting karstic caverns stacked within a 230-m high hill, and the eastward facing entrance is currently located ~32 m above the valley floor (about 1638 m asl). The elevation of the cave floor ranges from 1670 to 1960 m asl. The main chamber of the cave formed along a fracture has an area of approximately 8000 m^2, and is 220 m long, 23–56 m wide and 22–30 high.

The host bedrock of the cave consists of Carboniferous and Permian limestone. Within the limestone cave, the thickness of the Quaternary deposits in some areas exceeds 19 m (Huang et al., 1995). The deposits are typically unconsolidated, and mainly composed of bedded travertines (flowstone), silty clays, breccias, and large limestone blocks. The details of the deposits were investigated by Karkanas et al. (2008), who divided the sediments in the excavated area into 12 layers (from top to bottom, marked as I, II, III … XII) based on field observation and microscopic sedimentary analyses. Fig. 2 shows the deposits of the east section of excavated area C (Fig. S1) from which OSL samples were taken. Layer I consists of ~1.5-m thick brown flowstone contaminated with clastic material. The calcareous laminae are intercalated with thin uncemented reddish clayey laminae locally. Layers II–IV are mainly composted of breccias and travertines, from which abundant bone and lithic artifacts are found. Layer V consists of brownish silty sediments with a few boulders and fine gravels, from which less abundant bone and lithic artifacts were excavated. Layers VI–VIII are composed of black breccias with gravel and silt, and contain densely distributed bone and lithic artifacts. Layers XI – IX are composed of massive silt with very few pebbles, and the sediments are yellowish brown, and slightly or moderately cemented. It is noted that some people divided the deposits into three units (e.g., Wang et al., 2004): the top (97.55–96 m), middle (96–93.75 m) and bottom (93.74-?) units. They correspond to Layers I, II–VIII and IX–XII, respectively. Almost all the archaeological findings were from the middle unit.

A total of eight samples for OSL dating were taken from Layers I, V and XII (Fig. 2). These layers were sampled because of their relatively homogenous sediments containing less breccias, simplifying gamma dose rate calculations. On the other hand, the mineral components of these layers mainly composed of calcite are similar to those of the limestone breccias, implying that the possible effect of breccias on gamma radiation field is small. All OSL samples were collected using metal tubes of 4-cm diameter and 30 cm long. The tubes were horizontally hammered into the section; after removal, their ends were capped and then sealed with aluminum foil and tape.

3. Experimental details

3.1. Sedimentology

Understanding the sedimentary characteristics and mineral components of the studied sediments may help explain their

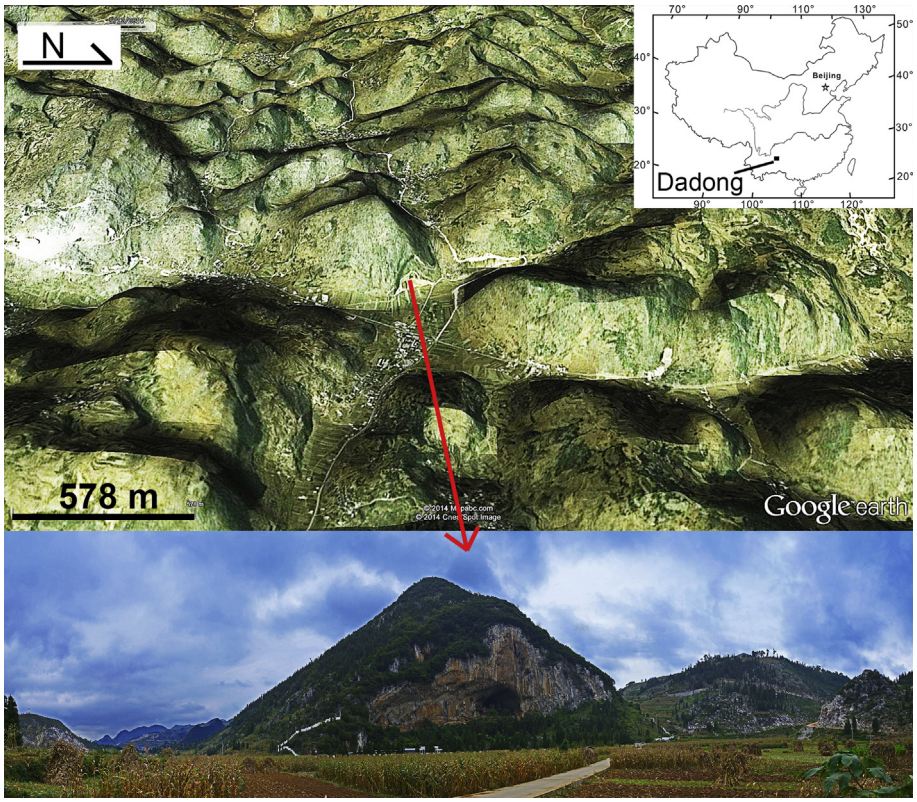

Fig. 1. Google Earth image showing the karstic landscape of the Dadong area, and Photograph showing the entrance of the Dadong cave (Eastward).

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