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Optically stimulated luminescence dating of Holocene palaeoflood deposits in the middle reach of the Yongding River, China

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ABSTRACT

Palaeoflood deposits record extreme climatic and environmental events. While historic data show that floods occurred frequently in the Yongding River in China and have caused many natural disasters. The sedimentologic records of palaeoflood in the Yongding River have not been well studied. This study investigates the palaeoflood deposits at the Tanmugou site in the middle reach of the Yongding River. Six episodes of palaeoflood were identified in the sediment profile. Optically stimulated luminescence (OSL) dating method was applied to establish the chronology of the palaeoflood deposits. Both the improved single-aliquot regenerative-dose (SAR) protocol and standard growth curve (SGC) method were employed for equivalent dose (D_e) determinations. The minimum age model (MAM), central age model (CAM) and arithmetic mean were applied to calculate the D_e values. The OSL dating results show that these palaeoflood events occurred in the Holocene and concentrated during three stages, including 8.5–7.3 ka, 2.8–2.4 ka and 1–0.5 ka. The timings of these palaeoflood events in the Yongding River coincide with the timings of palaeoflood events in other river systems in China. Compared with the continuously high-resolution climate record in China, these palaeoflood events occurred during climate transition periods.

1. Introduction

Floods can cause substantial economic losses, play havoc with economic development, and even deprive human beings of their survival. Therefore, it is important to understand the causes of floods in order to minimize their impact on our society. Many large rivers of China are prone to flooding and historic data show these rivers had frequent floods (Yang et al., 2000; Zhu et al., 2005; Huang et al., 2011). These floods scourged Chinese ancestors for thousands of years. For example, a famous Chinese legend is about King Yu combated the flood in the Yellow River at ca. 2100 BC. Floods are associated with extreme climate changes, thus record major environmental events in history (Knox, 2000; Milly et al., 2002). Researches on sedimentary records of palaeofloods can provide us not only knowledge of magnitudes, timings and frequency of palaeofloods, which is important for hazard estimation and prediction (Sheffer et al., 2008), but also palaeofluvial geomorphology and response of hydrological systems to palaeoclimate. Researches on this topic typically include geological, geomorphic, sedimentological and hydrologic analyses of past floods (Benito and Thorndycraft, 2005; Sheffer et al., 2008).

A large number of field practices and research on palaeofloods have been conducted both in China (e.g., Yang et al., 2000; Zhu et al., 2005; Huang et al., 2011; Wu et al., 2016) and in other countries (e.g., Ely et al., 1993; Jones et al., 2001; Sheffer et al., 2003; Thorndycraft et al., 2005; Sridhar, 2007; Stokes et al., 2012). These studies show that palaeoflood records, particularly during the Holocene, complement the gauge data and historical documentation of floods. Such studies have extended flood records to

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thousands or tens of thousands of years before gauge and historic data to reconstruct environmental and climate histories (Benito and Thorndycraft, 2005; Baker, 2006, 2008; Sheffer et al., 2008).

Previous palaeoflood research in China mainly focused on the Yellow River, the Yangtze River and their tributaries. Palaeoflood studies in other river system are sparse. Because the geographical and geological background of each river is different from the others, palaeoflood situations are expected to be variable among rivers. The Yongding River, which flows through Beijing, is an important river on the North China Plain (Fig. 1b). According to historically documented records, floods have occurred frequently on the Yongding River and have caused massive casualties and economic losses (Zhao et al., 2013). The Yongding River has therefore been identified as one of China's key rivers for flood prevention and control.

Several other factors make the Yongding River a unique study target for palaleoflood. First, the Yongding River is located farther north than the Yellow River and Yangtze River, information gained from this river may be used to understand the temporal-spatial patterns of palaeoflood in China. Second, although the Yongding River is prone to flooding, the river valley is too steep to preserve slack water deposit (SWD), which presents a chance to apply other paleostage indicators to reconstruct palaeoflood events. Third, the Yongding River is located in the East Asian monsoon region, and there may be a casual link between of monsoon climate and palaeofloods. Finally, because major cities, including Beijing and Tianjin, are located in the flooding areas of the Yongding River, palaeoflood history of the river can help to learn the relations between flood and civilization or urban development.

Chronology is essential to understand palaeofloods. The determination of chronology is an important part of palaeoflood research. Optically stimulated luminescence (OSL) is a potential dating method for flood deposits because there is usually a lack of organic materials in palaeoflood deposits for radiocarbon dating. With the advancement of microelectronics technology and testing methods, especially the improved single-aliquot regenerative-dose (SAR) protocol for quartz (Murray and Wintle, 2000; Wintle and Murray, 2006), the luminescence dating has made considerable

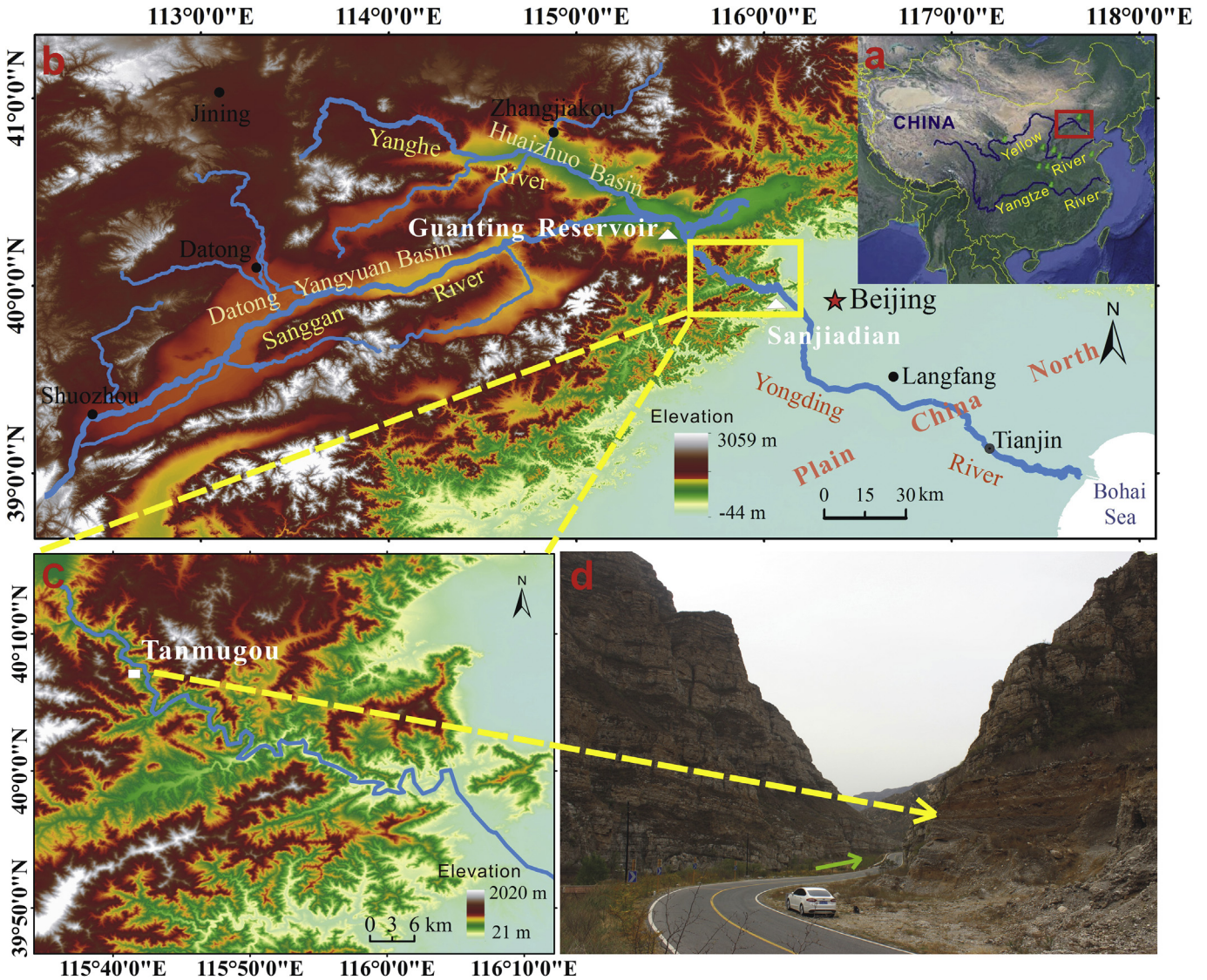

Fig. 1. (a) Map showing the location of the Yongding River in China. (b) DEM map of the catchment of the Yongding River. The yellow square denotes the middle reach. (c) DEM map of the middle reach and the location of the investigated Tanmugou site. (d) Photograph of the Tanmugou site. The green arrow shows the flow direction. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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