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A 15,400-year record of environmental magnetic variations in sub-alpine lake sediments from the western Nanling Mountains in South China: Implications for palaeoenvironmental changes

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ABSTRACT

A detailed environmental magnetic investigation has been performed on a sub-alpine sedimentary succession deposited over the past 15,400 years in Daping Swamp in the western Nanling Mountains of South China. Magnetic parameters reveal that fine grains of pseudo-single domain (PSD) magnetite or titanomagnetite are the dominant magnetic minerals in the lake sediments and surface soils collected from the catchment, which suggests that magnetic minerals in lake sediments mainly originated from surface soil erosion of the catchment. Variation of surface runoff caused by rainfall is interpreted as the main process for transportation of weathered soils into the lake. In the Last Deglacial period (LGP, 15,400–11,500 cal a BP), the influx of magnetic minerals of detrital material may have been significantly affected by the severe dry and cold conditions of the Last Glacial Maximum. Stabilised conditions of the catchment associated with increased vegetation coverage (e.g., 8000–4500 and 2500–1000 cal a BP) limited the input of magnetic minerals. Intensive soil erosion caused by increased human activity may have given rise to abnormal increases in multiple magnetic parameters after 1000 cal a BP. Because changes in runoff and vegetation coverage are closely related to Asian summer monsoon (ASM) intensity, the sedimentary magnetism of Daping Swamp provides another source of information to investigate the evolution of the ASM.

1. Introduction

Environmental magnetism techniques have been found to be useful for generating large amounts of quantitative information from suitable sediment archives to identify variations in detrital influx and authigenic processes in response to regional climate variability (e.g., Duan et al., 2014; Evans and Heller, 2003; Irurzun et al., 2014; Liu et al., 2016; Maher and Thompson, 1995; Sandeep et al., 2015; Thompson and Oldfield, 1986). To date, numerous studies have been conducted on the magnetic properties of lake sediments to explore past environmental and climatic changes because lake sediments often record such changes with high temporal resolution, and because they provide evidence for continental regions that reflects regional responses to large-scale climate change (Li et al., 2006). Variations of environmental conditions may result in changes in the concentrations, grain sizes, and/or compositions of magnetic minerals in lake sediments (Thompson and Oldfield, 1986). If the effects of various factors that may influence the mineral magnetic characteristics of lake sediments, such as organic carbon supply, biogenic and authigenic growth of secondary ferrimagnetic minerals, and post-depositional diagenesis and dissolution, are found to be minor or non-existent, the concentration of magnetic material in lake sediments can be used as an indicator of total detrital influx from the lake catchment to explore the climate response controlling erosive and depositional processes (Rawat et al., 2015).

The Nanling Mountains (NLM) (~24°00′–29°00′N, 110°00′–120°00′E, ~1500–2000 m a.s.l.), which form an important geographic division between the middle and southern subtropical zones of China and the watersheds of the Yangtze River and Zhujiang River systems, are located at the centre of the area influenced by the tropical monsoon (Gao et al. (1962)). This setting makes the NLM a key region for reconstruction of palaeoclimatic changes and past Asian summer monsoon (ASM) dynamics. The two important summer systems of the ASM, the East Asian summer monsoon (EASM) and the Indian summer monsoon (ISM), are both able to affect the western parts of NLM because these mountains are located in the transitional belt between the two summer monsoon systems (Fig. 1) (Qian et al., 2007). Few

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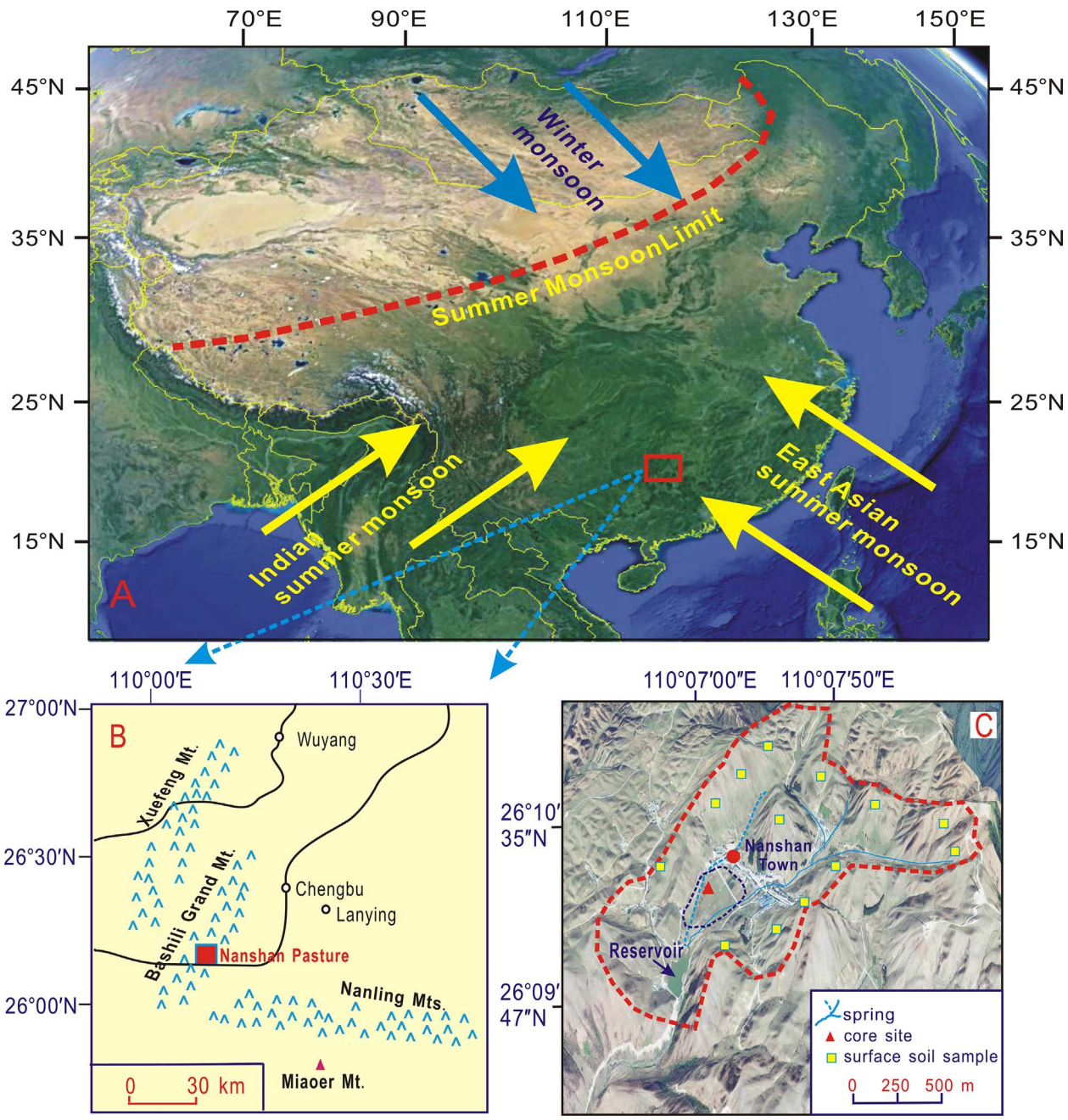

Fig. 1. (A) Present climatic background of the study region. Dashed red line represents the averaged modern summer Asian monsoon limit. The red solid box shows the location of the study area. (B) Sketch map showing the location of the sub–alpine intermontane Daping Basin. (C) Geomorphology, catchment area of the Daping Basin, the site of the studied core DP-2011-02 and locations of the surface soil samples. The area indicated by red dash line represents the catchment scope of the lake. The area indicated by dark blue line represents the swamp in which the buried lake sediments were developed. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

palaeoclimatic studies have been conducted in the western NLM. Based on pollen data (Zhong et al., 2015a), humification, and grain sizes (Zhong et al., 2015b), as well as organic carbon and nitrogen isotopes (Zhong et al., 2017) in lake sediments of Daping Swamp, we have revealed that this region experienced complex climatic variations over the past 15,400 years that are inconsistent with concurrent climatic changes in the solely EASM- and ISM-influenced regions. Further exploration of the features and forcing mechanisms of palaeoenvironmental changes in this region requires more detailed study based on a variety of geological proxies, including the magnetic study of lake sediments, to reveal the characteristics and processes of ASM evolution. However, until now, no environmental magnetic study had been conducted in the western NLM. In this study, we present a new magnetic record of a lake sediment sequence from Daping Swamp, with the aim of revealing the possible responses of the magnetic properties to past environmental changes.

2. Materials and methods

2.1. Study area

Daping Swamp (~26°10′11″N–26°10′42″N, 110°08′00″E–110°07′25″E; ~1600–1630 m a.s.l.) lies within the small sub-alpine intermontane Daping Basin, which is located in the Nanshan Pasture of Chengbu Miao Autonomous County, Hunan Province (Fig. 1A and B). This swamp is ~300 m long and ~150 m wide, and is supplied by several small springs and overland flow. The bedrock of the study region is dominated by medium-grained porphyritic granites of the early Yanshan stage. The