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Climate control on the palaeo-lake evolution in the southern Datong Basin, North China: Evidence from 800-ka core records

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ABSTRACT

Integrated sedimentological and clay mineral analyses of a 300-m-depth core reveal the history of the palaeo-lake and palaeoclimatic evolution of the southern Datong Basin over the past 800 ka. The sedimentary facies, including deep lake, shallow lake, alternation of lakeside and shallow lake, and the river environment are identified based on the general characteristics of the grain size analysis. Two episodes of warm–humid events are responsible for the palaeo-lake expansion during the period of 800–480 ka, corresponding to the presence of S7, S6, and S5 in the Loess Plateau. A stepwise cooling and drying trend since approximately 480 ka is strongly linked to the gradual shrinkage and extinction of the palaeo-lake. Our results demonstrated that climate change has played an essential role on the palaeo-lake expansion/shrinkage during the Middle Pleistocene. Breaching of Shixia Gorge by active neotectonic movement since the middle Late Pleistocene enhanced the shrinkage and extinction of the palaeo-lake, coupled with a cold–dry climate in the Last Glacial. The climatic changes documented by clay minerals and grain size parameters in the Datong Basin are consistent with the loess–paleosol sequences in the Loess Plateau and fluvio-lacustrine sediments in the Nihewan Basin, mainly controlled by the East Asian Monsoon in response to the regional global change since the Mid-Late Pleistocene.

1. Introduction

The Nihewan and Datong Basins are located on the northern Shanxi Grabens, which all belong to a rift basin that has been developing since the late Pliocene from the movement of the Himalayas (Yang, 1961; Xia, 1992a). Due to the intensive differential vertical displacement, the Pliocene peneplain disintegrated into blocky mountains surrounding the graben intermontane basin. Both the Datong and Nihewan Basins have been under the control of active tectonic movement and volcanic activity between the Oligocene and Pleistocene (Li et al., 2000), and the occurrence of a rift basin provided the essential space for the formation and development of the lake since the Miocene (Cheng, 1983). The subsidence of the Shanxi Graben and the shift of climate pattern from hot–dry to warm–wet in Pliocene in the united Datong-Nihewan Basin resulted in formation of the lake (Cheng, 1983; Xia, 1992b; Wang et al., 2008). Due to the different sedimentation rate, the thicknesses of Cenozoic sediments in the south and north centers of the Datong Basin are 3500 m and 1500 m, respectively (Cheng, 1983).

Due to the discovery of a series of Paleolithic sites and the Nihewan faunas during the Early Pleistocene, high-resolution magnetostratigraphic and palaeoenvironmental investigations have revealed the tectonosedimentary processes in the Nihewan Basin during the Plio-Pleistocene (Barbour et al., 1927; Teilhard de Chardin and Piveteau, 1930; Long et al., 1980; Wei, 1985; Xie and Cheng, 1990; Qiu, 2000; Zhu et al., 2001, 2003, 2004, 2007; Xie, 2006; Xie and Liu, 2006; Deng et al., 2008; Keates, 2010). Magnetostratigraphic and sedimentary investigations suggest that the expansion/shrinkage of palaeo-lake in the Nihewan Basin are generally affected by the tectonic movement, climate change and accumulation process of the palaeo-lake (Cao, 1959; Yang, 1961; Xia, 1992a; Wang et al., 2008; Ao et al., 2009; Ao, 2010; Li et al., 2014). In the late Early Pleistocene, two stages of palaeo-lake shrinkage are coincidental with the occurrence of a large number of Paleolithic sites marked by abundant vertebrate and non-vertebrate fossils in the Nihewan Basin (Xia, 1992b; Li et al., 2000; Qiu, 2000; Zhu et al., 2001, 2003, 2004, 2007; Xie, 2006).

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In contrast to the Nihewan Basin, there is no report on palaeo-lake expansion or shrinkage during the Middle Pleistocene and its links to climate change and tectonic movement or volcanic activities in the Datong Basin. This paper aims to reconstruct the sedimentary evolution of the palaeo-lake based on the lithology, dating, and grain size analysis and clay minerals from the core sediments. Our research will provide important materials for further understanding the interactions among basin evolution, climate change, and neotectonic movement.

2. Geological setting

The geomorphological types in the research area are mainly composed of alluvial plain, pluvial terraces, eolian loess, volcanic cones, and erosion-planation surfaces (Fig. 1). The erosion-planation surfaces, which have been developed since the Pliocene, are located on the flat top surfaces with a residual elevation of 1500–2300 m. Volcanic cone geomorphology occurs in the east of the Datong Basin, consisting of extinct groups that existed in the Early-Middle Pleistocene. Pluvial terraces are widespread along the piedmonts, consisting of Qp_3^{pl} (pluvial fan) with numerous sand and gravel layers. An alluvial plain lies in the Sanggan River valley, consisting of Qp_3-Qh^{al} with a dual structure composed of sand and gravel layers. Eolian loess has occurred since the Middle Pleistocene and covered nearly all geomorphological types, from the flat planation surface to the alluvial plain, consisting of Qp_{2-3}^{eol} and Qh^{eol} (Fig. 1).

3. Materials and methods

3.1. Coring and sampling

Core ZK0901 is located at the Dongxing, Yingxian County, with GPS position (N 39°30′ 10″, E 113° 00′ 02″, elevation 1000 m). The depth of the core is 300 m, and the average recovery is 90%. The majority of the core is composed of gray and blue clayey silt and silty clay interbedded between clay and sand layers. According to the color and lithological composition, there are 30 layers from the

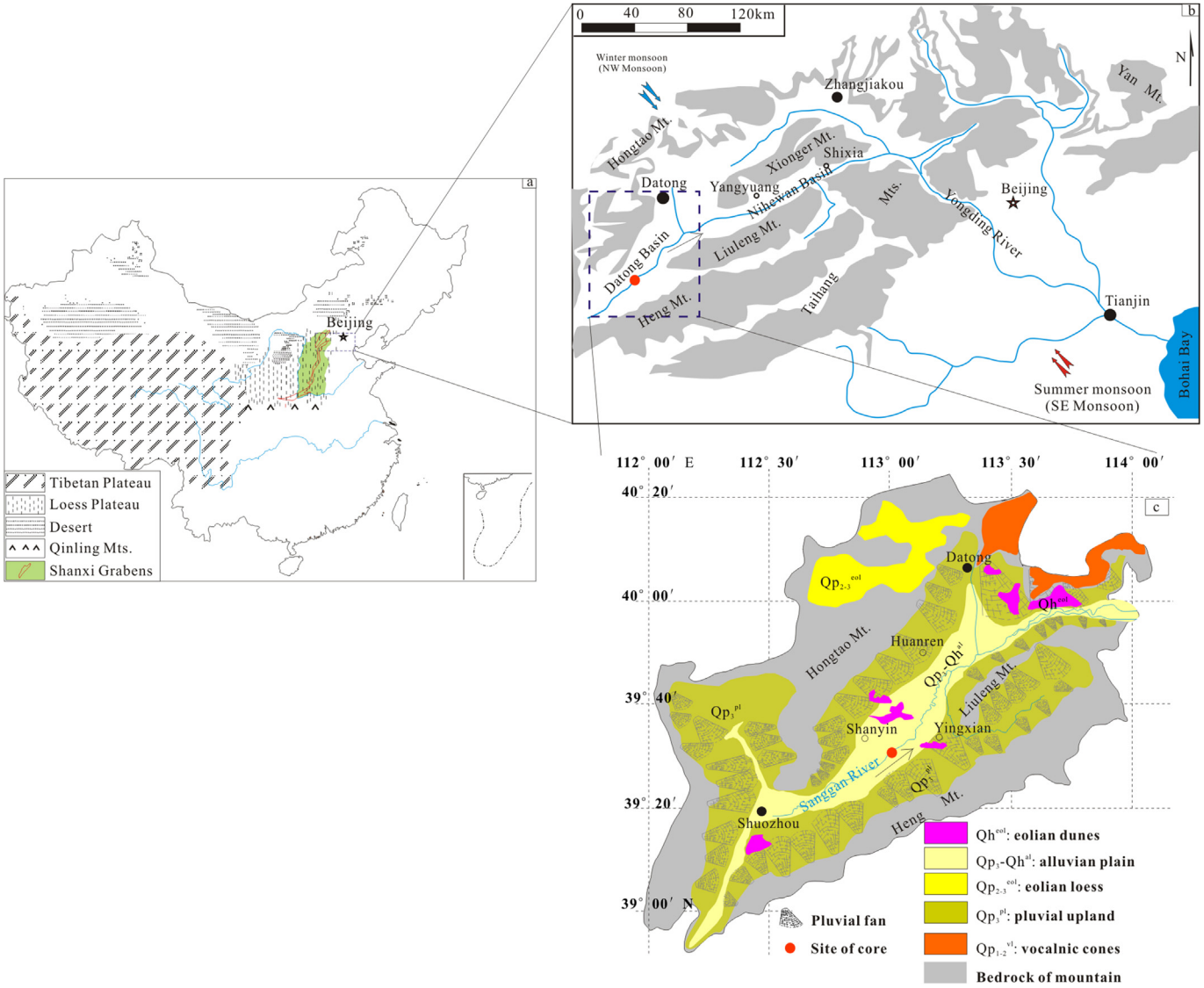

Fig. 1. Map showing the study area (a), natural geography (b) (modified from Yu, 1986; Li et al., 2000; Ao, 2010) and geomorphology and Quaternary sediments together with the site of the core in the Datong Basin and surrounding (c).