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Paleo-megalake termination in the Quaternary: Paleomagnetic and water-level evidence from south Bohai Sea, China

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ABSTRACT

Asian marginal seas play an important role in moderating material and energy flux linkages between Asia and the Northwest Pacific, and thus have profound climatic and environmental effects. In this study, by combining paleomagnetic study with sediment grain-size analysis on the Lz908 borehole sedimentary sequence from the southern Bohai Sea, new insights into regional geomorphological process since the late early Pleistocene are obtained. The main results are as follows. (1) Paleomagnetic findings suggest that the sequence recorded the Brunhes normal chron and the late Matuyama reverse chron, including the Jaramillo normal subchron. (2) The sedimentary processes in the study area since 1327 ka show a three-stage pattern, with depositional rates of 4.3, 17 and 107 cm/ka during 1327–260 ka (later part of the early and middle Pleistocene), 260–10 ka (late middle and late Pleistocene), and the Holocene, respectively. (3) The sedimentary basin was a part of the Bohai Paleolakes (BHPL) prior to 260 ka, whose water levels were consistently higher than 3 m above the present-day level. After 260 ka, seawater entered the Bohai basin, and relative sea level cyclically fluctuated with global sea-level changes. We therefore infer that the Miaodao Islands, which were the natural barrier of the BHPL blocking seawater entry, had partially subsided before 260 ka, only allowing seawater to enter the basin during a global sea-level maximum. The BHPL terminated around 260 ka, and the "barrier" subsided completely around ~130 ka, causing the Bohai basin to become an inner shelf sea.

1. Introduction

Under Cenozoic deformation of the Asian continent and subduction of the Pacific plate, a series of marginal seas, from the Bering Sea in the north to the Banda Sea in the south, were separated from the Asian continent (Wang, 2004). The presence of these marginal seas caused significant modification of the material and energy flux linkages between Asia and the Northwest Pacific, and the seas have subsequently had profound climatic and environmental impacts (e.g., Jin and Yu, 1978; IOCAS, 1985; Qin et al., 1987; Tamaki and Honza, 1991; Jolivet et al., 1994; Wang, 1999, 2004).

The Bohai Sea in China is part of these Asian marginal seas, with a sedimentary basin formed by subsidence during the Cenozoic (Allen et al., 1997; Hu et al., 2001; He and Wang, 2003). Prior to this, the Miaodao (Changxing) Islands (Fig. 1) were part of the Liaodong–Jiaodong Uplift, and were a natural geomorphological "barrier" blocking the escape of lake water from and influx of seawater into the basin (e.g., Li et al., 2008). As a result of this geomorphological constraint, the major sedimentary environment was lacustrine, and this period has been called the Bohai Paleolakes (BHPL) (IOCAS, 1985; Li et al., 2008; Yi, 2010). During this time, more than 2000 m of fluvial and lacustrine sediments were deposited in the basin (IOCAS, 1985). After this time, as a result of subsidence of Miaodao Islands, vast amounts of fresh water escaped from the basin,

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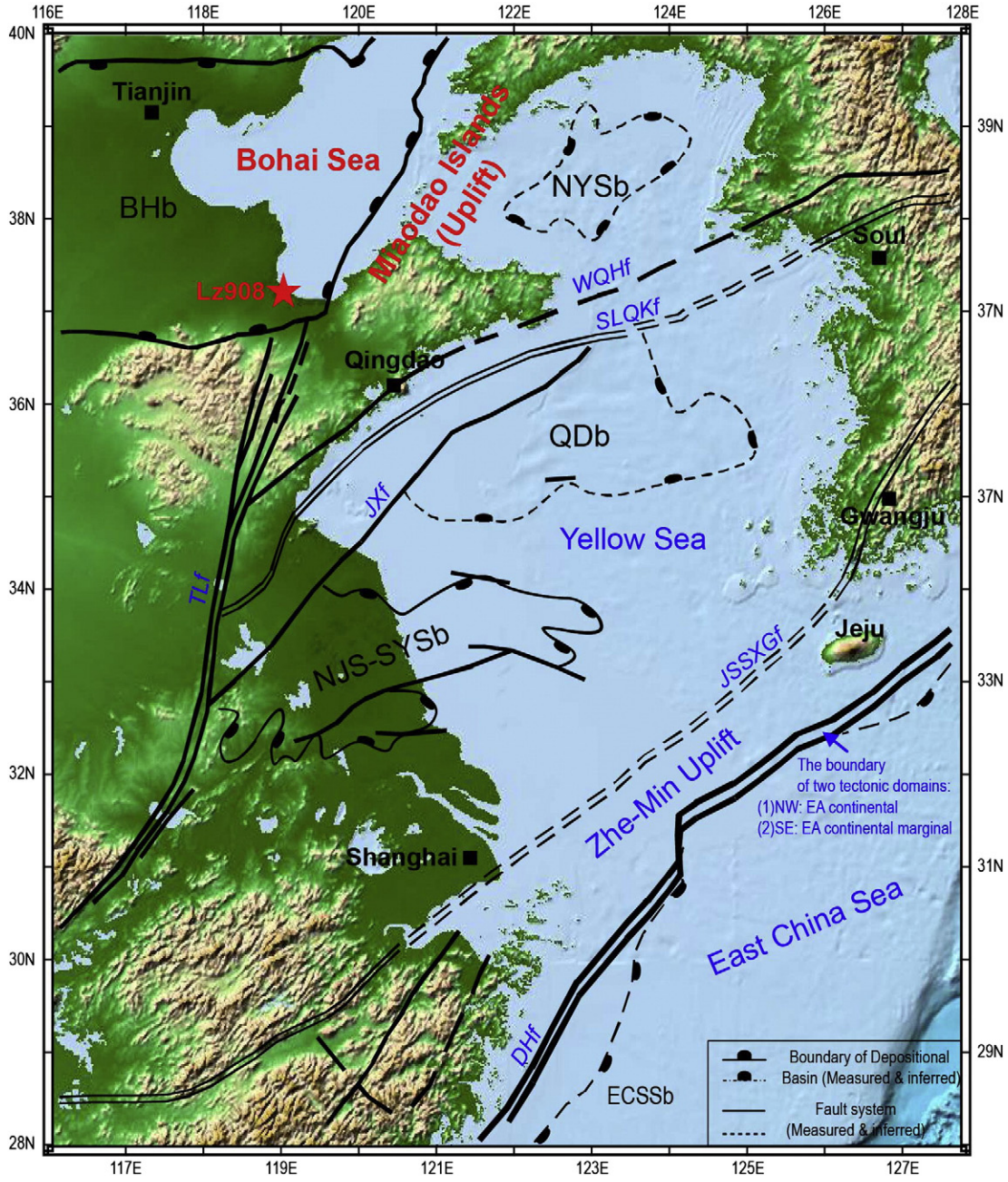

Fig. 1. Map showing the location of the Lz908 core in the south Bohai Sea, China. The major depositional basins include from the south to the north: East China Sea shelf basin (ECSSb), Subei (north Jiangsu province)–Nanhuanghai (south Yellow Sea) basin (NJS–SYSb), Qingdong basin (QDb), Beihuanghai (north Yellow Sea) basin (NYSb), and Bohai basin (BHb). The major fault systems contain: Dongyin–Haijiao fault (DHf) (which is the boundary of two tectonic domains: East Asia continent in the north and continent margin in the south), Jiangshan–Shaoxing–Gwangju fault (JSSXGf), Jiashan–Xiangshui fault (JXf), Siyang–Lianyungang–Qianliyan–Kaicheng fault (SLQKf), Wulian–Qingdao–Haizhou fault (WQHf), and Tan-Lu fault (TLf). The Zhe-Min (Zhejiang–Fujian) Uplift was constrained by the DHf in the south and JSSXGf in the north (Jin and Yu, 1978). These basins and faults were replotted from Guo et al. (1997). The base map data was from http://www.ngdc.noaa.gov/mgg/global/global.html.

seawater occupied the space, and the Bohai Sea formed. In the south, the Yellow Sea experienced a similar process, being formed as part of the subsidence of the Zhe-Min Uplift in the early Quaternary (e.g., Jin and Yu, 1978; Qin et al., 1987; Yi et al., 2014). Before the formation of the marginal seas, large amounts of fresh water and ~10% of global sediment flux, carried by the Yellow (Huanghe) River and Yangtze (Changjiang) River (Milliman and Syvitski, 1992), were trapped in the Bohai Sea and Yellow Sea basins. The total area of the two basins was >460,000 km^2, roughly twice as large as the Great Lakes of North America. The presence of the fresh water and sediments inevitably affected environmental processes in northern China and East Asia, and might also have significantly influenced the living environment of early humans, such as at the Zhoukoudian (Choukoutien) site that is located at the coast of the BHPL (e.g., Teilhard de Chardin and Young, 1929).

Little evidence has been reported in previous studies revealing when and how this lake-to-sea transition occurred, significantly affecting our assessment of the possible paleoenvironmental and paleoanthropological responses. Herein, we integrate magnetostratigraphy with a previously published chronology (Yi et al., 2012a) to date the transition from lacustrine to marine deposition. We use sediment grain-size analysis to reconstruct water-level changes in the southern Bohai Sea and provide a long-term dataset to reveal how it became connected to the open sea in the Pleistocene.