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# Evolution of the buried channel systems under the modern Yellow River Delta since the Last Glacial Maximum

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ABSTRACT

A combined seismic survey and borehole analysis revealed a series of buried channels under the modern Yellow River Delta. These data also provide evidence for the evolutionary study of the paleo-channel system. Seismic units were correlated with the sedimentary facies along the borehole. Two sets of paleo-channels, phase I and phase II, are identified within different seismic units spanning the last deglaciation (~13–8.5 ka B.P.). The phase I channels formed between the Last Glacial Maximum and the Last Deglaciation. Estimates of paleo-discharge and analysis of local depositary environment link the phase I channels with the main stream of the paleo-Yellow river. These channels were fed by melting ice caps and were abandoned with the rechanneling of the Yellow River. The phase II channels were formed during the early Holocene and exhibited a dendritic pattern. Further investigation is needed to fully understand the origin and evolution of the phase II channels.



## 1. Introduction and background

The sea level during the Last Glacial Maximum (LGM) was 130–155 m lower than present (Lambeck and Chappell, 2001), which resulted in a wide exposure of the continental shelf along the Western Pacific. Unlike the humid climate in Europe (Jost et al., 2005), exposed shelves of the Bohai, Yellow, and East China, and South China Seas experienced a cold, arid or even desert climate (Xia et al., 1991; Zhao, 1991; Zhao et al., 1996), and were usually accompanied with developments of paleo-rivers, lakes and depressions (Ye, 2012). Interpretation of the sedimentary environment of these once-exposed shelves remains controversial and varies over different regions. For the East China Sea, while an extensive shelf arid zone was proposed (e.g. Zhao, 1991; Zhao et al., 1996), others indicated the existence of a wide-spread paleo-Yangtze system (e.g. Li et al., 2005; Liu et al., 2009b). For the Yellow and South China Seas, due to its limited thickness, most of the paleo-channel strata has been explained as part of the shelf fluvial drainage prior to the LGM (Kou and Du, 1994; Bao, 1995; Kong et al., 2011). Specifically in the South Yellow Sea (SYS), absence of the LGM strata has been documented (Zheng, 1988; Zhang, 2012). For the Bohai Sea, Xia et al. (1991) proposed an arid environment during the LGM, which is consistent with the wide aridification among the Chinese Shelves (Zhao, 1991; Zhao et al., 1996). However, fluvial and lacustrine facies were also revealed on the exposed shelves (e.g. Starkel, 1983; Cheng, 1991, 1997; Liu et al., 2009a), although details of these paleo-channels are still unclear.

As a semi-enclosed sea, the modern Bohai Sea has a mean water depth of <30 m and has been strongly affected by sea-level variations during the Quaternary. Stratigraphic studies indicated at least one regression and one transgression occurred since the LGM (Qin, 1989; Marsset et al., 1996). They correspond to the second terrestrial strata succession during the LGM, and the first marine strata during the Holocene, respectively. For the Post-glacial transgression, seawater first entered the Bohai Sea around 11.6 cal ka B.P. (Liu et al., 2007), and reached a position about 50–90 km west of the present coastline during the maximum transgression around 6–7 cal ka B.P. (Liu et al., 2009a). Although the sea-level variations still remain controversial (Wilks, 1979; Xia, 1981), most of the Bohai

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Sea is considered to have been constantly covered during the Holocene (Qin et al., 1985).

Located in the southwest part of the Bohai Sea, the modern Yellow River Delta was formed around 1855 AD after the Yellow River's major rechanneling from the SYS to the Bohai Sea (Liu et al., 2009b, Fig. 1). Due to variations of local sea-level and continuous rechanneling, the delta has been filled and exposed alternately (Xue et al., 2004; Cheng et al., 2010), forming complex stratigraphic sequences. It is composed of several large lobes resulted from shifts of the river's lower reach. Small scale sub-lobes are developed on each of the delta lobes, forming a complicated imbrication pattern (Xue, 1993). Seaward, two subaqueous delta systems were revealed (Li et al., 1998a). The first one was located to the northwest of the modern delta plain, forming between 1855 and 1934. The second one is located around the modern estuary and was formed after 1934 (Wang et al., 2006).

The paleo-channel systems on the modern Yellow River Delta were first reported in the 1990s (Yang, 1995; Han et al., 1998). Since then, efforts have been made trying to understand their structure and impact on local oil and gas explorations (Yang, 1995; Zhou et al., 2004). For example, a dredging accident in 1984 has been associated with these paleo-channels (Zhou et al., 2004). Based on stratigraphic data with limited coverage, Li et al. (2013) recently proposed that these paleo-channels might be the result of the incision during LGM. Most recently, Liu et al. (2013) discovered a series of paleo-channels in the shallow waters (<10 m water depth) between the Yellow River Harbor and the Yellow River mouth. Although some of the seismic features and their potential for trigging accidents have been reported (Liu et al., 2013), in this study we focus on the origin and evolution of these paleo-channels since the LGM.

## 2. Data and methods

### 2.1. Seismic profiling and interpretation

Two seismic surveys were conducted in the study area in July 2012 and August 2013. A total of 650 km of high-resolution seismic profiles were acquired using a CSP2200 sparker sub-bottom profiling system (Applied Acoustic Engineering, United Kingdom). The sparker system was fired at 350-ms intervals with a power of 300–500 J and a 200–7000 Hz band-pass filter was applied. The seismic survey

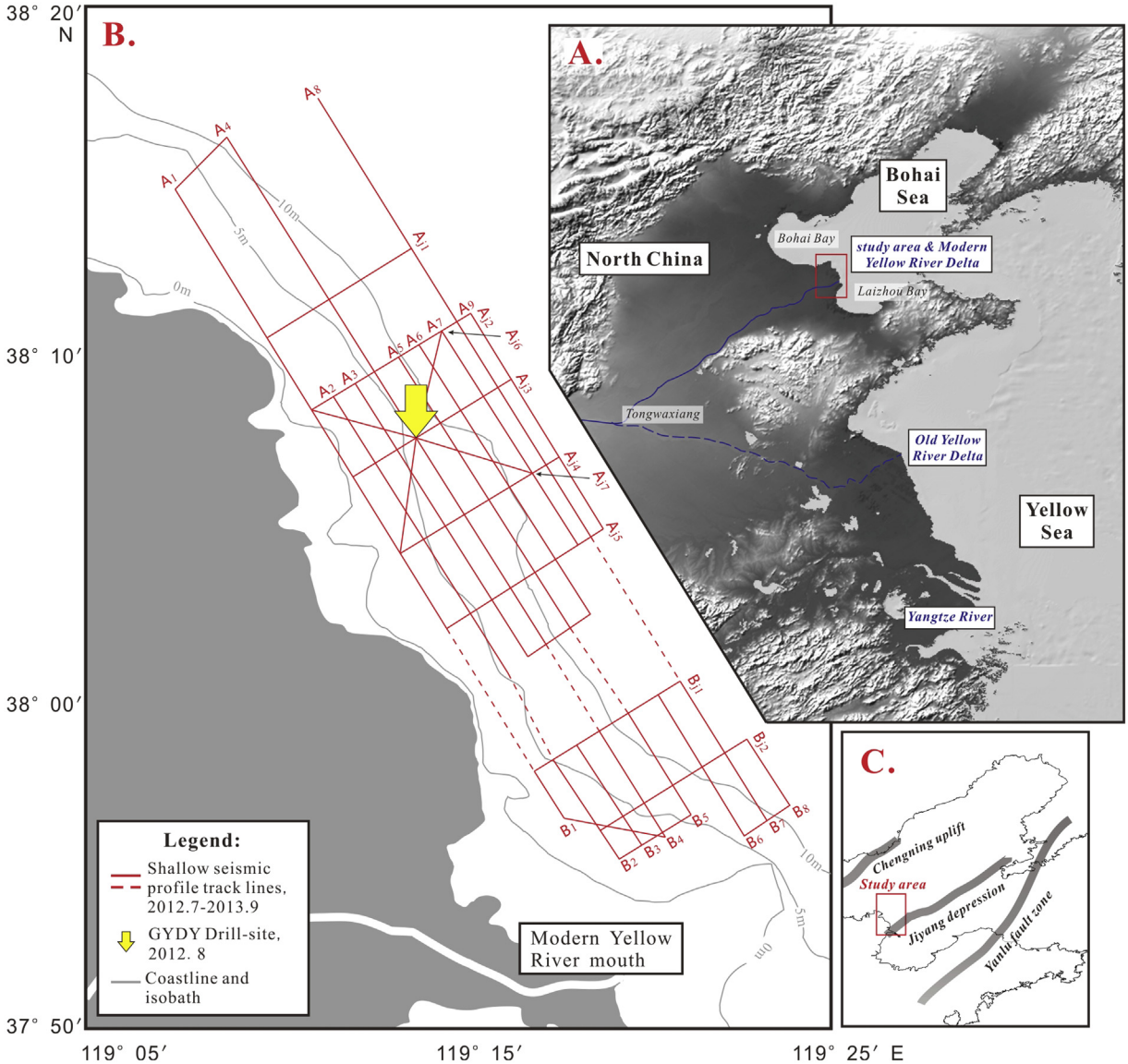


**Fig. 1.** (a) A map of the study area, (b) locations of the seismic track lines and core GYDY (also shown are 5 m and 10 m isobath), and (c) typical tectonic structures in the Bohai Sea area following Chen et al., 2009. The seismic profiles of the lines Aj3 and Bj2 are shown in Figs. 5 and 9, respectively.