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The late Cenozoic deep-water channel system in the Baiyun Sag, Pearl River Mouth Basin: Development and tectonic effects

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ABSTRACT

Twenty modern submarine channels and buried channels were examined using high-resolution 3D/2D seismic data in the Baiyun Sag, Pearl River Mouth Basin. The channels were dominantly straight, sub-parallel with one another, and oriented perpendicular to the slope contours. Four stages of the deep-water channel system (DCS) were identified according to seismic facies and spatial distribution. The stages were controlled by sediment input and tectonic activities. DCS I is distributed in the middle of the Baiyun Sag, with small individual channels. DCS II expanded because of decreasing sediment input and stable subsidence of the Baiyun Sag increased the slope. DCS III had the broadest distribution and nearly covered the entire Baiyun Sag. Further decreases in sediment input and the Dongsha Event increased the gravity flow domain and greatly promoted the development of the DCS. DCS IV narrowed to the southwest because the buried channels in the northeastern Baiyun Sag ceased after 5.5 Ma as the result of active fault activity. This study highlights that the channel system plays an important role in recording the sedimentary evolution of the Pearl River Mouth Basin and affects the deep-water resource (hydrocarbon and gas hydrate) distribution.

1. Introduction

Deep-water channels are common and important sedimentary features in the continental slope and generally develop through four evolution stages: eroding, infilling, overflowing, and sediment covering (Mutti and Normark, 1987, 1991; Navarre et al., 2002; Abreu et al., 2003; Peakall et al., 2007). The channel system contributes to clastic sediment being transported from the shelf to the deep-water basins, which forms significant oil and gas reservoirs (Dixon and Weimer, 1998; Navarre et al., 2002; Mayall et al., 2006; Deptuck et al., 2007; Hutchinson et al., 2008; Vangriesheim et al., 2009; Amos et al., 2010; McHargue et al., 2011; Lonergan et al., 2013). Generally, gravity flows and bottom currents are viewed as the main causes of submarine channels (Abreu et al., 2003; Deptuck et al., 2007; Kane et al., 2007; Di Celma, 2011; Gong et al., 2011; Saller and Dharmasamadhi, 2012).

A series of papers have been published that reveal abundant oil and gas resources, such as gas hydrate and shallow gas, in the northern South China Sea (SCS) (Wu et al., 2007; Gong et al., 2009; Wang et al., 2011; Sun et al., 2012). Deep-water channels in the Baiyun Sag of the Pearl River Mouth Basin (PRMB), northern SCS have been active since the Middle Miocene (Liu et al., 2006; Zhu et al., 2010; Gong et al., 2013). The deep-water channel system (DCS) becomes valuable in hydrocarbon exploration because the channel system plays a very special role in the formation of petroleum source rocks. We conducted the study to determine the evolution of DCS and to investigate the favorable distribution of oil and gas reservoirs.

The channels originated in a period of strong regression (ca. 13.8 Ma), which contributed to voluminous sediment unloading on the shelf edge and triggered widespread gravity flows (Zheng et al., 2007; Zhu et al., 2010; Ding et al., 2013; Gong et al., 2013). Previous studies indicate that the channels form in three stages: (1) erosion by turbidity currents during the relative sea level fall and low-stand, (2) infilling by mass-transport deposits (MTDs) and lateral accretion packages during relative sea level rise, and (3) burying by deep-water mud during the relative sea level high-stand (Zheng et al., 2007; Zhu et al., 2010; Lü et al., 2012; Gong et al., 2013; Li et al., 2013). Previous studies have mainly focused on small 3D seismic surveys, and tectonic controlling factors for channel development are still unclear.

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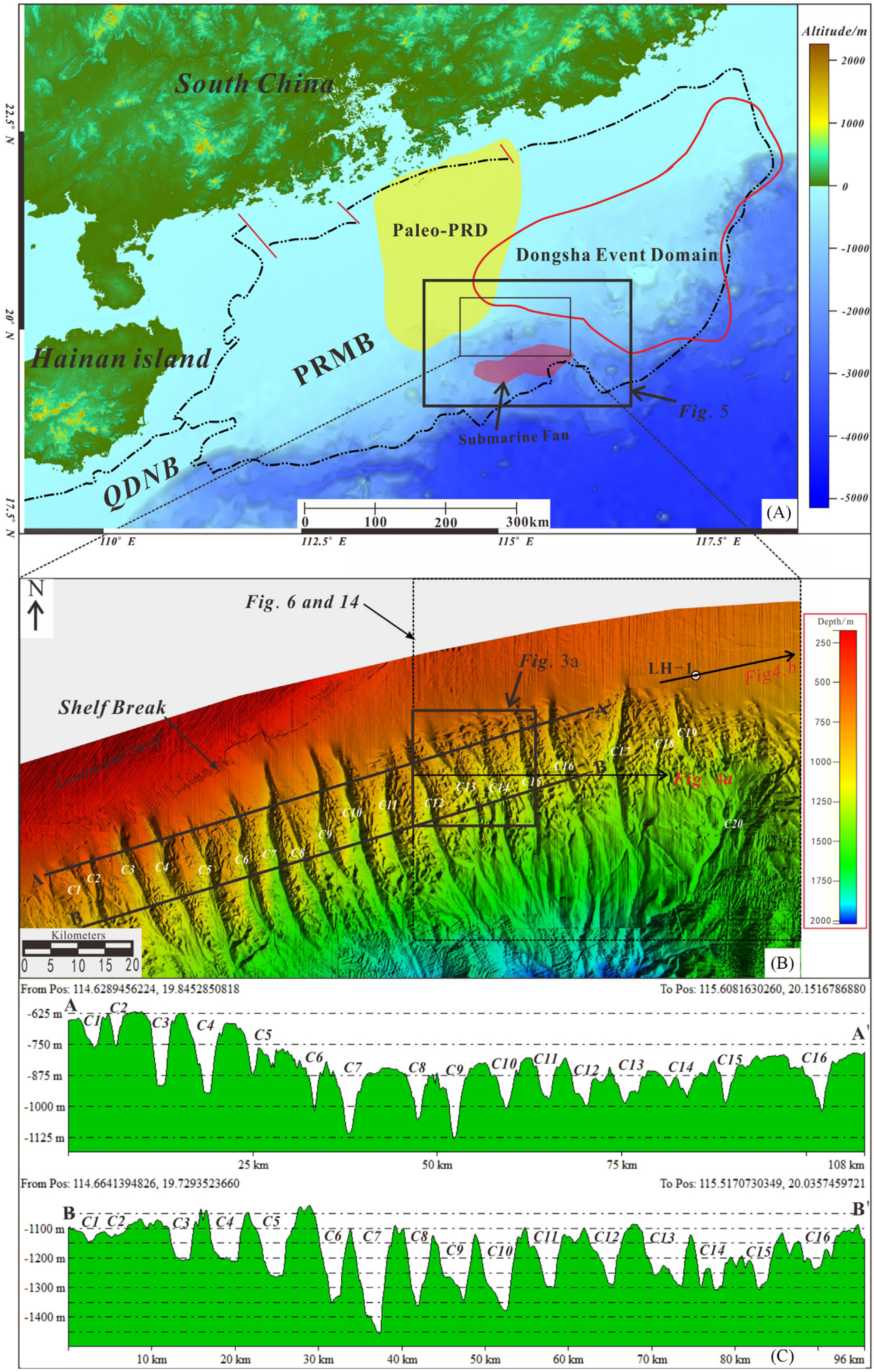

Fig. 1. (a) The tectonic division and geomorphologic map north of the SCS. The location of the paleo-Pearl River Delta (paleo-PRD) and submarine fan from Pang et al. (2007); the red line represents the area affected by the Dongsha Event from Wu et al. (2014). (b) A map of the modern submarine channels; 20 submarine channels are distributed on the slope, with similar geometries. C1–C20: submarine channels on the modern sea floor. (c) The crossing sections of modern submarine channels. The channels show the V-shaped sections in the top (A–A') and U-shaped sections in the tail (B–B'). See the positions in (b). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)