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Research paper

Applying seismic geomorphology to delineate switched sequence stratigraphic architecture in lacustrine rift basins: An example from the Pearl River Mouth Basin, northern South China Sea

Hongtao Zhu [a, b, *], Sen Li [a, b], Yu Shu [c], Xianghua Yang [a, b], Lianfu Mei [a, b]

[a] Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China
[b] Faculty of Earth Resources, China University of Geosciences, Wuhan 430074, China
[c] Shenzhen Branch of China National Offshore Oil Corporation Ltd., Shenzhen 510240, China

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ABSTRACT

Switched sequence stratigraphic architectural units were developed in the Eocene Wenchang Formation stratigraphic section of the Pearl River Mouth Basin (PRMB), northern South China Sea. Utilizing a high-quality 3D seismic data set, well logs and restored paleogeomorphology, the architecture and genesis of switched sequence stratigraphic units have been systematically investigated. The Wenchang Formation, a second-order sequence, can be subdivided into seven third-order sequences (from base to top: SQ1, SQ2, SQ3, SQ4, SQ5, SQ6, and SQ7). The sequence stratigraphic architecture of the Wenchang Formation is characterized by continuous lateral stacking patterns from sequences SQ1 to SQ7. Sequences SQ1–SQ4 mainly developed in the HZ26 sag, whereas sequences SQ5–SQ7 mainly developed in the XJ24 sag. The depositional centres of the Wenchang Formation appear to have migrated from the HZ26 sag to the XJ24 sag-along the northwest direction from sequences SQ1 to SQ7. Multiple tectonic activation episodes or alternating tectonic subsidence of the HZ26 and XJ24 sags resulted in the distinctive geomorphological features that effected the development of the switched sequence stratigraphic architecture in the study area. The switched sequence stratigraphic architecture presented in this study may provide new insights into a better understanding of sequence stratigraphic stacking patterns in continental lacustrine rift basins.

1. Introduction

The Paleogeomorphology influences sequence stratigraphic architecture and stacking patterns, depositional patterns, depositional facies distribution, and the distribution of potential reservoir and source rocks (Martin, 1966; Posamentier, 2004; Zeng and Hentz, 2004; Posamentier et al., 2007; Wood, 2007). It is a more useful approach to integration of geomorphology and seismic data analysis. Within the last decade, the most logical workflow of using seismic data follows the transition from seismic stratigraphy, to sequence stratigraphy, to seismic sedimentology (Zeng and Hentz, 2004), and to seismic geomorphology (Posamentier, 2001, 2004; Wood, 2007). Seismic geomorphology was defined by Posamentier et al. (2007) as "the application of analytical techniques pertaining to the study of landforms and to the analysis of ancient, buried geomorphic surfaces as imaged by 3D seismic data." Three-dimensional seismic geomorphology is a valuable analytical approach at multiple time scales and the study can potentially provide more detailed information about 1) lithology distribution; 2) the sequence stratigraphic and depositional history, processes, and infill architecture of a basin; 3) diagenesis; 4) tectonic analyses; 5) basin evolution (Posamentier, 2004; Posamentier et al., 2007; Wood, 2007). In addition, Wood (2007) provided a new direction in the application of seismic geomorphology that Quantitative seismic geomorphology was defined as "Quantitative analysis of the landforms, imaged in 3-D seismic data, for the purposes of understanding the history, processes and fill architecture of a basin." Therefore seismic geomorphology, when integrated with seismic and sequence stratigraphy, is a powerful and effective tool for analyzing stratigraphy, understanding depositional processes, and predicting the spatial-temporal distribution of sedimentary facies in marine and terrestrial sequences.

The development of stratigraphic sequences is classically related to driving mechanisms, including eustasy, subsidence or uplift, and

* Corresponding author. Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, China.
E-mail address: htzhu@cug.edu.cn (H. Zhu).

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variations in sediment supply, and climate (Vail et al., 1991; Emery and Myers, 1996; Catuneanu, 2004). The lacustrine sequence stratigraphic study may be more complex than considered previously. Although sequence stratigraphy has also been widely used in the terrestrial basins (Wright and Marriot, 1993; Boyd and Diessel, 1994; Shanley and McCabe, 1994; Zaitlin et al., 2002), the architecture of their sequence stratigraphic units has not yet been well understood because of the dominant factors for the formation of sequence stratigraphy varying among different terrestrial basin types.

The PRMB, located in the central part of the northern South China Sea margin, is one of the most important petroliferous basins in the whole region (Fig. 1). Tertiary successions and basin evolution of the PRMB comprised a classic non-marine stage (65.0–30.0 Ma) and a marine stage (30.0–1.8 Ma) (Fig. 2). Our study interval is the Wenchang Formation of non-marine stage, which comprises the main hydrocarbon-bearing strata of the Huizhou depression. Despite the existence of few wells in the study area, the stacked and migrated 3D seismic data from the study area make it possible to conduct sequence stratigraphy and seismic geomorphology analysis of the Wenchang Formation.

The study area is Huizhou depression, situated in the central part of the northern continental shelf of the PRMB. To be more specific, it is the HZ26 and XJ24 sags of Huizhou depression (Fig. 1). Because few wells have been drilled or penetrated the target stratigraphic intervals, this paper attempts to document switched sequence stratigraphic architecture that developed in the Eocene successions between HZ26 and XJ24 sags by using a seismic-geomorphology approach based on recently acquired 3-D seismic data over the Huizhou depression in the PRMB, northern South China Sea (Fig. 1). The main goals of this article include (1) providing a new case using seismic geomorphology to characterize switched sequence stratigraphic architecture; (2) illustrating the characteristics of switched sequence stratigraphic architecture; (3)

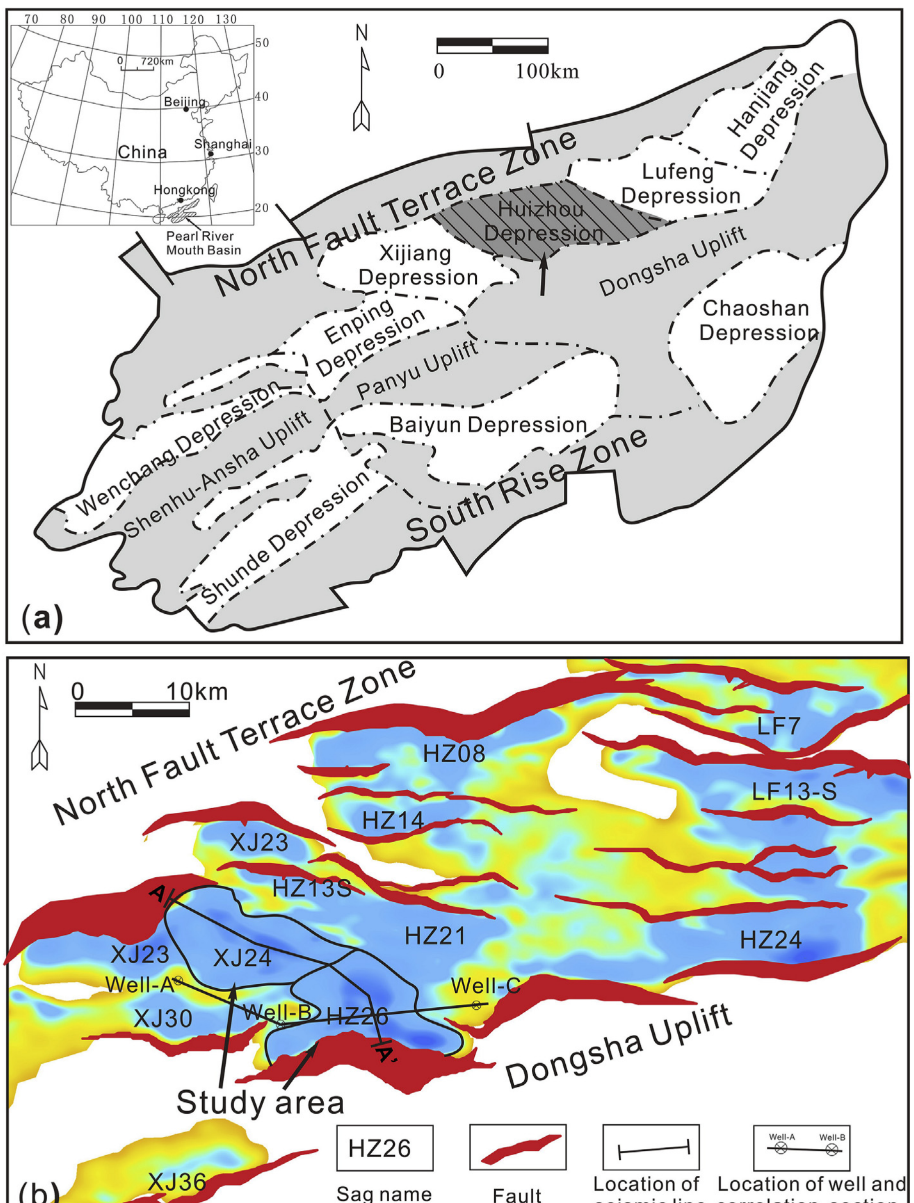

Fig. 1. Study area (HZ26 and XJ24 sags) in the Huizhou depression, PRMB. (a) Depressions in the PRMB (Shao et al., 2005; Gong et al., 2014; Zhong et al., 2014). (b) Close-up view of the Huizhou depression showing sags, faults, and locations of well, seismic lines and well correlation sections used in this paper.