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Cenozoic tectonic evolution of the Bohai Bay Basin and its coupling relationship with Pacific Plate subduction

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ABSTRACT

The Bohai Bay Basin is a Mesozoic–Cenozoic rift basin in eastern China. Based mainly on a balanced-section analysis, this study compares the spatio-temporal differences of tectonic evolution in relation to strike-slip faults among different depressions within the basin. In combination with the analysis of subsidence characteristics, the study also attempts to clarify the Cenozoic tectonic evolution of the basin and its coupling relationship with the subduction of the Pacific Plate. It was found that: (1) the strike-slip faults were activated generally from south to north and from west to east during the Cenozoic; (2) there is a negative correlation between the intensity of tectonic activity in the Bohai Bay Basin and subduction rate of the Pacific Plate; and (3) the migration direction of the basin depocenters is consistent with the direction of Pacific Plate subduction.

1. Introduction

Various types of basins evolved in the North China Craton (NCC), the oldest craton in China (Li et al., 2010), evidently as the result of tectonic activity in eastern China during the Mesozoic–Cenozoic. This raises questions as to the timing, scope and mechanism of the destruction of the NCC during that time. It is generally believed that subduction of the Pacific Plate was the controlling factor in the destruction of the NCC and the consequent tectonic evolution of the Bohai Bay Basin (BBB) in the Cenozoic.

Previous studies have proposed different theories on the formation and geodynamics of Mesozoic and Cenozoic basins in eastern China. The earliest theories (Lu and Zheng, 1996; Zheng, 1999) argued from geochemical and geophysical evidence that basins of this type mainly stem from deep geological processes, and that the regulation mechanisms are relatively shallow. Other studies (Bao et al., 2013; Li, 2013; Wu et al., 2008) have analyzed the dynamic background of Eurasian tectonic evolution: restoring the positions of the Pacific Plate and the corresponding basin prototype at different times in the Cenozoic suggests an association with the formation and evolution of the Mesozoic and Cenozoic basin groups in the western Pacific island arcs.

Those studies, however, and reports of BBB exploration (Gao et al., 2004; Hou et al., 2001; Lu et al., 1997; Zhang et al., 2001) and the destruction of the NCC (Qiu et al., 2015; Tang et al., 2013; Wilde et al., 2002; Zhao et al., 2009) contain little discussion of the connection between Pacific Plate movement and the tectonic evolution of basins. Reproducing tectonic evolution of the BBB in the Mesozoic–Cenozoic indicates how the NCC was destroyed. Based on previous studies, the present study has restored balanced seismic cross-sections in an attempt to reconcile the spatio-temporal differences of the tectonic evolution with the regularity of the tectonic migration. The role of Pacific Plate subduction in the destruction of the NCC was also investigated from the internal perspective of basin evolution to clarify their spatio-temporal relationship.

2. Regional geological setting

The BBB is a Cenozoic rift basin in eastern China (Chi and Zhao, 2000; Lu et al., 1997) with a total area of 20×10^5 km^2 (Fig. 1). The BBB is also known to be a major continental petroliferous basin. The basin contains four major strike-slip zones (Teng et al., 2014), and is bounded by the active right-lateral Tan-Lu fault zone to the east and the active oblique-slip Taihang fault zone to the

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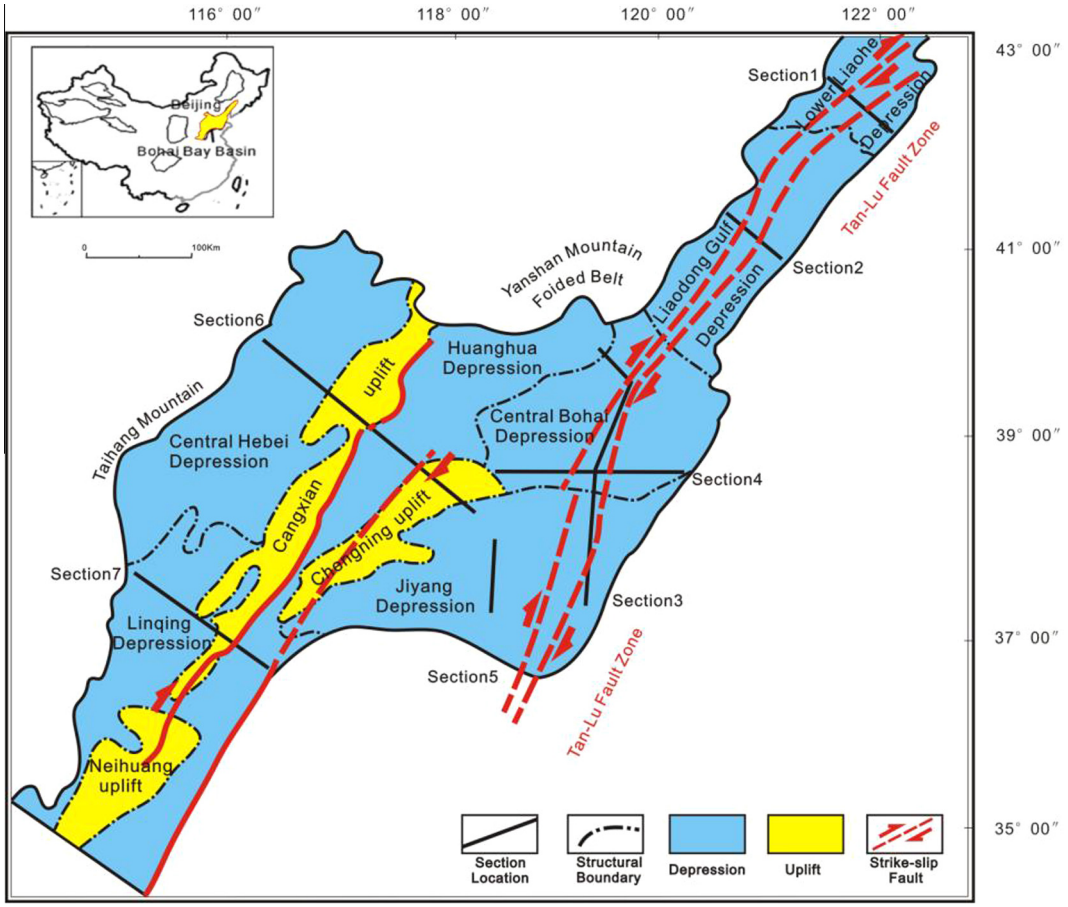

Fig. 1. Sketch tectonic map showing the Cenozoic subdivision of the Bohai Bay Basin, including depressions, salients and uplifts. Blue areas represent depressions; yellow areas represent uplifts. Black linesshow the location of the balanced sections analyzed in this study. Broken red lines show strike-slip faults; red arrows show strike-slip directions. Restored balanced sections are shown in Fig. 5. Subsidence analysis are shown in Figs. 6 and 7. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

west, and by the Yanshan Mountain folded belt to the north and the Qihe-Guangrao and Lankao-Liaocheng faults to the south (Zhang, 2009).

The major N-S-striking Tan-Lu fault zone, which consists of two parallel strike-slip faults, traverses the eastern edge of the BBB (Castellanos, 2007; Mann, 2012; Yang and Xu, 2004). The late Mesozoic/early Cenozoic Tan-Lu fault zone is a narrow rift comprising two grabens and an uplifted section (Hou et al., 1998; Xu, 1993). Studies of right-lateral strike-slip faults by Tong et al. (2008) and Hsiao et al. (2004) showed that varieties of structural features, including echelon normal faults, "comb" structures, "flower" structures, and "interpretable" and "buried" strike-slip faults are all found in the BBB.

The BBB contains post-Cenozoic sedimentary formations (Kongdian, Shahejie, Dongying, Guantao, Minghuazhen and Pingyuan (Qiao et al., 2002); Fig. 2). The basin mainly consists of seven depressions. Six of these (the Linqing, Jiyang, Central Hebei, Central Bohai, Liaodong Gulf and Lower Liaohe Depressions) were investigated in this study.

3. Methods and data

Seven seismic sections in different orientations were restored using the balanced-section method to reconstruct the history of tectonic evolution in the BBB. Despite the complex trends and patterns of the faults in the BBB, the orientation of each section discussed in this study generally parallels the regional faults. Consequently the extension rates of these faults were calculated using 2DMOVE software to differentiate the evolutionary phases of each depression during the Cenozoic. The details of the calculation method are shown in Fig. 3.

The subsidence process in the BBB was analyzed in detail on the basis of these phases to illustrate its evolution during the Cenozoic. Studies of the destruction of the NCC are cited, especially those related to the Cenozoic subduction of the Pacific Plate, to demonstrate its implications in connection with the tectonic evolution of the BBB. Relevant data on BBB subsidence and Pacific Plate subduction were collated from the published literature or located from online sources.

4. Tectonic evolution characteristics of the BBB

4.1. Phases of tectonic evolution

Tectonic activity intensity is reflected by fault extension rates (Fig. 4). The findings of the balanced-section analysis (Fig. 5) revealed the characteristics and differences in fault activity in relation to the tectonic evolution of the BBB. Previous studies (Hou