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Research paper

Marine strata morphology of the South Yellow Sea based on high-resolution aeromagnetic and airborne gravity data

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ABSTRACT

The paper focuses on the nature and the distribution of Paleozoic and Mesozoic marine strata of South Yellow Sea. The depths to the magnetic basement (bottom of the marine strata) and the Indosinian suture (top of the marine strata), and hence the gross thickness of marine sediments, are calculated and interpreted for the first time using the latest high-resolution aeromagnetic and airborne gravity data in South Yellow Sea. The residual thickness of marine strata is suspected to be greatly influenced by the uplift and denudation induced by Indosinian orogeny. The preliminary subdivision of Paleozoic and Mesozoic tectonic units is conducted. The Middle Depression and Southern Depression have the high preservation of the Paleozoic and Mesozoic marine sedimentation. A NW-trending fault belt is found to exist in the western onshore-offshore transition zone, and possibly control the Cenozoic and Mesozoic sedimentation. This study contributes to the oil-gas exploration of Paleozoic and Mesozoic marine strata in South Yellow Sea.

1. Introduction

Marine areas have become increasingly important, both in terms of their resources and politics, during this century. The South Yellow Sea, a large multicycle basin consisting of a Paleozoic – Mesozoic marine basin and a Mesozoic – Cenozoic terrestrial basin (Cai, 2002; Ren et al., 2002; Lee et al., 2006; Ouyang et al., 2009; Yuan et al., 2016), is of tremendous value because of its energy resources. The basins developed over a crystalline basement of pre-Sinian (The last period of the Neoproterozoic) metamorphic rocks, and marine strata of considerable thickness and terrestrial strata have been deposited subsequently (Zhang et al., 2014; Yao et al., 2005). The features of the terrestrial sedimentary basin of the South Yellow Sea are well-known after more than 50 years of regional oil and gas exploration. However, research on its Paleozoic – Mesozoic marine strata developed slowly prior to the availability of effective seismic reflection (Deng and Ou, 1995; Lin and Yao, 2009; Sun et al., 2014). Although previous studies have demonstrated the value of seismic reflection data as the main tool for the exploration of marine strata, sophisticated seismic data analysis (Lin and Yao, 2009; Qi et al., 2013, 2015; Zhang et al., 2014; Chen et al., 2016; Liu et al., 2016; Yuan et al., 2016) has failed to determine the thickness distribution of the marine strata of the South Yellow Sea as a result of the low reflectivity of deep Paleozoic strata. Gravimetric and magnetic data have also been used to study the sedimentary basin (Wang and An., 2000; Dai et al., 2002; Liang et al., 2003; Zhang et al., 2007; Li et al., 2014a,b; Luo et al., 2014; Xing et al., 2014), but considerable discrepancies remain in the definition of marine strata morphology of the South Yellow Sea because of the limited precision of the geophysical data and its subsequent integration.

The current paper focuses on the calculation and interpretation of the depth to top and bottom of the Paleozoic and Mesozoic marine strata of the South Yellow Sea based on the latest high resolution aeromagnetic and airborne gravity data, covering latitudes 31to 37°N and longitudes120 to124°E. On this basis, we determined the thickness distribution of Paleozoic – Mesozoic marine strata, conducted the corresponding geophysical and geological interpretation, and proposed a new schema for the morphology of the Paleozoic and Mesozoic marine strata.

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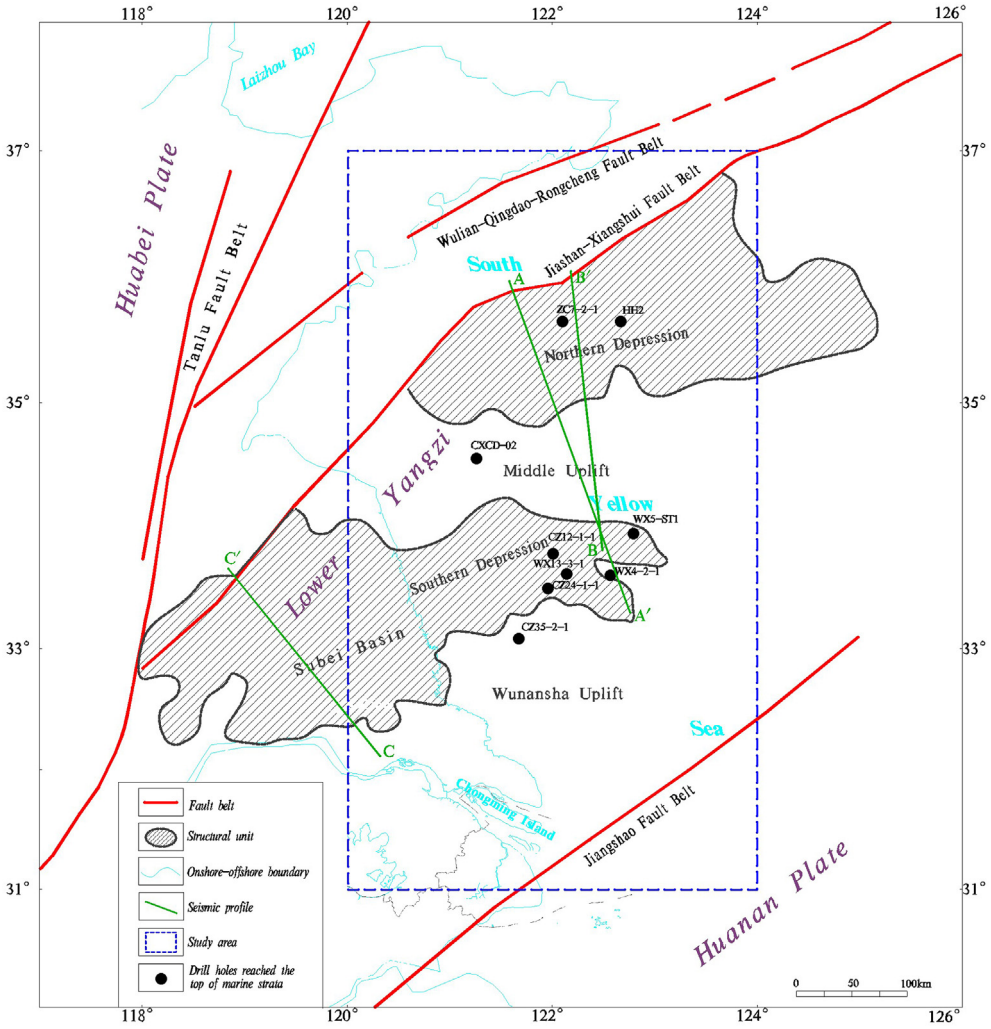

Fig. 1. Tectonic setting and structural outline of the South Yellow Sea (extended and modified from Guo et al., 1997 and Zhang et al., 2007). The blue dashed rectangle is the study area, which is also shown in Figs. 3, 7, 8, 9 and 12. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

2. Regional setting

2.1. Geological setting

The study area in this paper covers latitudes 31to 37°N and longitudes120 to124°E (Fig. 1), located in the northeastern lower Yangtze block. It is bounded by the Tanlu fault belt to the west, the Jiashan-Xiangshui fault belt to the north, and the Jiangshao fault belt to the south.

According to the distribution of the Mesozoic and Cretaceous terrestrial strata, the structural units of the South Yellow Sea can be subdivided tectonically from north to south into two uplifts and two depressions: namely, the Northern Depression, the Middle Uplift, the Southern Depression (adjacent to the Subei Basin), and the Wunansha Uplift (Fig. 1) (Guo et al., 1997; Zhang et al., 2007). The Paleozoic–Mesozoic marine sedimentary strata were formed during the Jinning orogeny and evolved until the Indosinian and Yanshanian orogenies, within which, the Cambrian, Ordovician, Carboniferous, Permian, and Lower Triassic marine strata developed (Yue et al., 2014; Pang et al., 2016). Several significant interfaces formed during the tectonic movements of the South Yellow Sea, including the upper interface of the pre-Sinian metamorphic rocks, caused by the Jinning orogeny (Wu et al., 2008; Hao et al., 2010; Shinn, 2015); the Caledonian suture that resulted from the tectonic events of the late Silurian to early Devonian; and the Indosinian suture that was caused by Indosinian orogeny from the late Permian to the early Mesozoic (Grimmer et al., 2002; Yao et al., 2005; Shinn et al., 2010; Zhang et al., 2014). The crystalline basement has been shown to comprise pre-Sinian metamorphic rocks; thus, the upper interface of the pre-Sinian metamorphic basement was the base of the marine strata during the regional tectonic evolution (Zhang et al., 2007; Li et al., 2014a,b; Xing et al., 2014). The interpreted seismic profile of the South Yellow Sea clearly shows that the deformation character of the Lower Triassic and Permian strata differs from those of the Upper Triassic, Cretaceous, Jurassic, Paleogene, and Neogene, which establishes that the Indosinian suture was the top of the marine strata of the South Yellow Sea (Fig. 2) (Qi et al., 2013, 2015; Zhang et al., 2014; Liang et al., 2017).

2.2. Regional physical properties

The density and susceptibility of the strata are the basis of geophysical interpretation of magnetic and gravity data. They are key parameters in the identification of geophysical morphology. We measured more than 8000 susceptibility and density data from 350 rock sampling locations distributed in different strata in southern Shandong Peninsula and northern Jiangsu Province. Parameters from the same location, but different strata, were combined by an arithmetic mean. Physical properties that are based upon this study and published