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An integrated geophysical study on the Mesozoic strata distribution and hydrocarbon potential in the South China Sea

Weijian Hu [a,*], Tianyao Hao [a], Weiwei Jiang [a], Ya Xu [a], Baimin Zhao [b], Didi Jiang [a]

[a] Key Laboratory of Petroleum Resources Research, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
[b] China Aero Geophysical Survey & Remote Sensing Center for Land and Resources, Beijing 100083, China

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ABSTRACT

A series of drilling, dredge, and seismic investigations indicate that Mesozoic sediments exist in the South China Sea (SCS) which shows a bright prospect for oil and gas exploration. In order to study the distribution of Mesozoic strata and their residual thicknesses in the SCS, we carried out an integrated geophysical study based mainly on gravity data, gravity basement depth and distribution of residual Mesozoic thickness in the SCS were obtained using gravity inversion constrained with high-precision drilling and seismic data. In addition, the fine deep crustal structures and distribution characteristics of Mesozoic thicknesses of three typical profiles were obtained by gravity fitting inversion. Mesozoic strata in the SCS are mainly distributed in the south and north continental margins, and have been reformed by the later tectonic activities. They extend in NE-trending stripes are macro-controlled by the deep and large NE-trending faults, and cut by the NW-trending faults which were active in later times. The offset in NW direction of Mesozoic strata in Nansha area of the southern margin are more obvious as compared to the north margin. In the Pearl River Mouth Basin and Southwest Taiwan Basin of the north continental margin the Mesozoic sediments are continuously distributed with a relatively large thickness. In the Nansha area of the south margin the Mesozoic strata are discontinuous and their thicknesses vary considerably. According to the characteristics of Mesozoic thickness distribution and hydrocarbon potential analyses from drilling and other data, Dongsha Uplift-Chaoshan Depression, Southwest Taiwan Basin-Peikang Uplift and Liyue Bank have large thickness of the Mesozoic residual strata, have good hydrocarbon genesis capability and complete source–reservoir–cap combinations, show a bright prospect of Mesozoic oil/gas resources.

1. Introduction

The South China Sea is a unique marginal sea in the west Pacific Ocean. It is located at the junction of three major plates of Eurasia, Pacific and Indo-Australia, between the Tethys tectonic domain in the west and the Pacific tectonic domain in the east. Since the Mesozoic, the SCS has been transformed from an active continental margin to passive continental margin (Liu, 2011). It is not only a natural laboratory for studying the dynamics of continental margin, but also very rich in petroleum resources. Therefore, it attracts lasting attention of geoscientists.

Oil/gas resources in the SCS are very rich, and the prospecting of Cenozoic oil/gas has achieved fruitful result (Yao et al., 2004), at the same time, Mesozoic sedimentary strata are widespread in the SCS. A number of wells in the SW Taiwan Basin, Peikang Uplift and Liyue Bank have revealed Mesozoic strata and oil/gas structures. In the recent years, series of studies indicated that pre-Cenozoic residual basins have a good prospect for oil/gas exploration (Cai, 2003; Hao and Zhang, 2003; He et al., 2007; Hu, 2013; Liu et al., 1999, 2010; Liu and Chen, 2005; Qiu and Wen, 2004; Xia and Huang, 2000). In September of 2003, the LF35-1-1 Well on the north slope of Chaoshan Depression drilled about 1500 m Mesozoic strata, revealing the existence of Mesozoic marine sediments and Jurassic hydrocarbon genetic rocks (Shao et al., 2007; Wang et al., 2009). These findings showed a good prospect of Mesozoic oil/gas in the SCS. However, there are controversies over some questions such as whether the Mesozoic strata, especially marine strata in the SCS belong to Tethys or Pacific domain? What differences in Mesozoic strata and resource distribution exist between the southern and northern part of the SCS? The present knowledge of Mesozoic strata in the SCS comes from a limited number of wells or profiles, lacking knowledge of their distribution

* Corresponding author at: No. 19, Beitucheng Western Road, Chaoyang District, 100029 Beijing, China. Tel.: +86 1082998104.
E-mail addresses: huweijian@mail.iggcas.ac.cn (W. Hu), tyhao@mail.iggcas.ac.cn (T. Hao), wwjiang@mail.iggcas.ac.cn (W. Jiang), xuya@mail.iggcas.ac.cn (Y. Xu), zhaobm2001@163.com (B. Zhao), jiangdidi@mail.iggcas.ac.cn (D. Jiang).

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in entire region. Therefore, we collected available geological and geophysical data in the SCS and its adjacent areas, especially the recent multi-channel seismic and ocean bottom seismometer (OBS) data (blue solid lines in Fig. 1) (Ding and Li, 2011; Ding et al., 2013; Li et al., 2011; McIntosh et al., 2005; Qiu et al., 2001, 2011, 2012; Ruan et al., 2011; Wang et al., 2006; Wei et al., 2011; Yan et al., 2001; Yao and Wang, 2006), and carried out an integrated geophysical study based mainly on gravity data to obtain the distribution of Mesozoic residual thickness. It helps to acquire the regional knowledge of Mesozoic strata and their hydrocarbon potential in the SCS, which may also provide basis for studying the above mentioned questions.

2. Data and method

2.1. Data

The study region (Fig. 1) is within 105°E–122°E, 0°–25°N. The free air gravity data used in this paper from actual measurements of Guangzhou Marine Geological Survey on a scale of 1:500,000, global satellite gravity data (longitudinal and latitudinal grid size $1' \times 1'$) published by Scripps Institution of Oceanography (Sandwell and Smith, 2009; Sandwell et al., 2014) was used in the areas without measurements.

2.2. Method

Based on petrophysical properties analysis, taking high-precision drilling and seismic data as priori constraints, gravity data were inverted for the depths of gravity basement in the SCS, and then Mesozoic residual thicknesses were extracted. In addition, gravity fitting inversion along three typical profiles was carried out under the constraint with recent multi-channel seismic and OBS data. The density structures of profiles were constructed in order to further constrain and verify the planar distribution of Mesozoic residual thickness. Combining planar and profile results we obtained the macro-distribution of Mesozoic strata thickness in the SCS. The flowchart of this study is shown in Fig. 2.

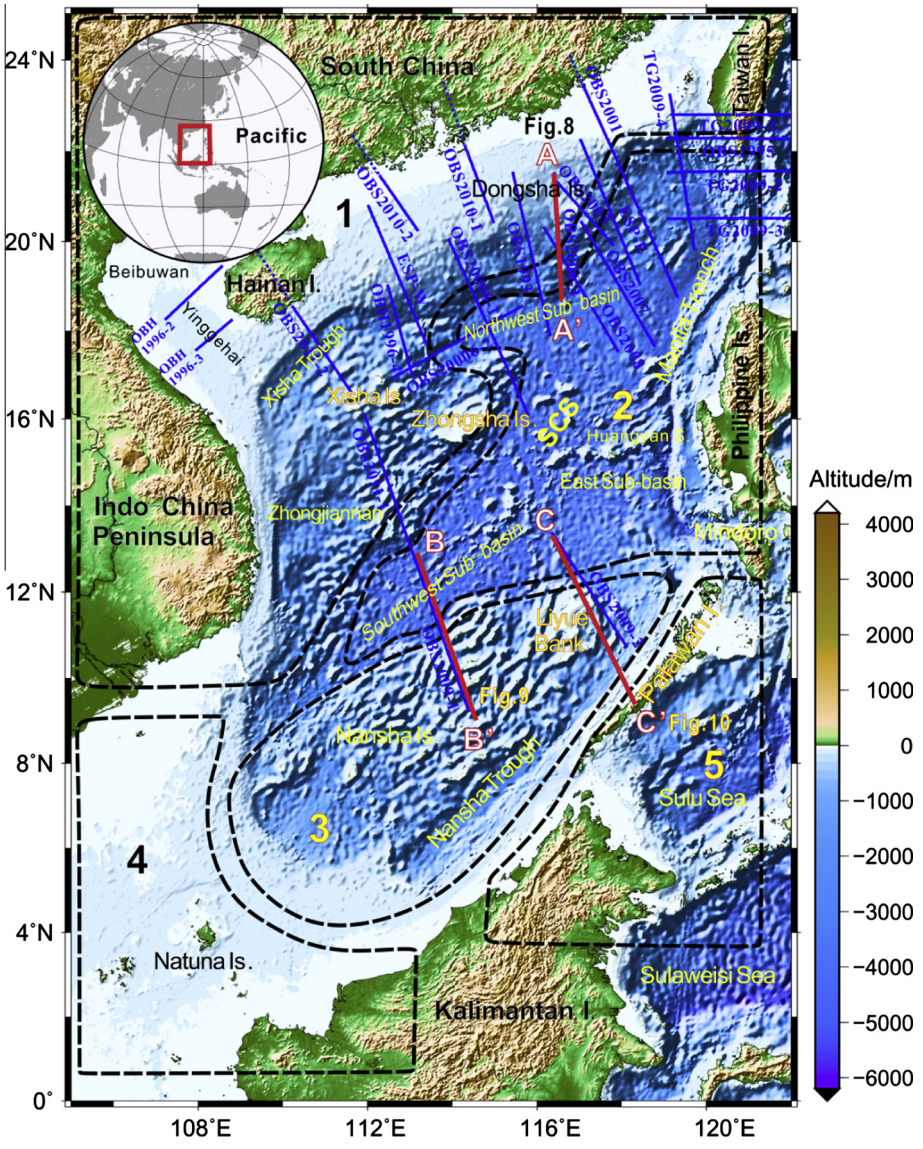

Fig. 1. Topography and the division of sub-regions in the SCS. The black dashed lines mark sub-regions boundary for gravity inversion. The study region is divided into 5 sub-regions: 1. Northern continental shelf, 2. Sea basin, 3. Nansha, 4. Southwest of the SCS, 5. Southeast of the SCS. The red solid lines are inversion profiles of this study, the inversion result for profile AA′ is in Fig. 8, BB′ in Fig. 9, and CC′ in Fig. 10. The blue solid lines are seismic profiles used for priori constraints. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)