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RESEARCH PAPER

Petroleum geological characteristics of two basin belts in southern continental margin in South China Sea

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Abstract: Based on the seismic, drilling, cores and outcrops data, the formation of basins, source rocks and hydrocarbon accumulations in the southern South China Sea (SSCS) were systematically analyzed to reveal the petroleum geological features of continental margin basins and summarize the distribution rule of oil and gas in the SSCS. The results show that the South China Sea (SCS) has experienced three tectonic stages, namely, the formation and development of proto-SCS, the subduction of proto-SCS and development of neo-SCS, the rapid subsidence and shrinking of SCS. The tectonic evolution of proto-SCS and neo-SCS controlled the regional tectonic pattern of continental margin in the SSCS, forming southern and northern basin belts, and also dominated the formation of basins, source rocks and hydrocarbon accumulation characteristics. The source rocks were mainly Miocene coal source rocks in the southern basin belt, with different thermal evolution degree, and the near-shore source rock was chiefly oil-generating while the off-shore source rock was mainly gas-generating. Compressive folding structural belts and reefs were the favorable belts. Within the northern basin belt, the source rocks were gas-prone and dominated by the Eocene to Oligocene, with high thermal evolution degree. Reefs and faulted blocks were the major accumulation areas. Our study demonstrates that the continental marginal basins of SSCS still have great exploration potential and is an important strategic area of oil and gas exploration and development. The southern basin belt focuses on oil and gas exploration and the northern basin belt focuses on gas exploration.

Key words: proto-South China Sea; neo-South China Sea; tectonic evolution; tectonic cycle; continental margin; sedimentary facies; basin formation; hydrocarbon accumulation

1. Overview of the study area

The South China Sea (SCS), one of the largest marginal seas in west Pacific, consisted of the central oceanic basin and the east, south, west and north continental (or island) margins. The southern continental margin mainly has Zengmu basin and Brunei-Sabah basin etc. (Fig. 1). Since the exploration in the early 20th century, hundreds of oil and gas fields have been discovered in the Cenozoic, making this area one of giant oil and gas areas in the world, with conventional oil reserves more than ten billion tons.

A lot of basic geology and petroleum geology surveys have been done within the nine-dotted line by China, mostly focusing on each basin. However, the understanding of regional distribution of oil and gas needs to be deepened. This paper studies the basin groups in the background of SCS regional evolution with the theory of marginal sea tectonic cycle of the SCS[1], and finds two basin belts in SCS with different basin formation, hydrocarbon generation and accumulation conditions. Additionally, new hydrocarbon exploration domains have been predicted by comprehensive analysis, in the hope of guiding the next step hydrocarbon exploration there.

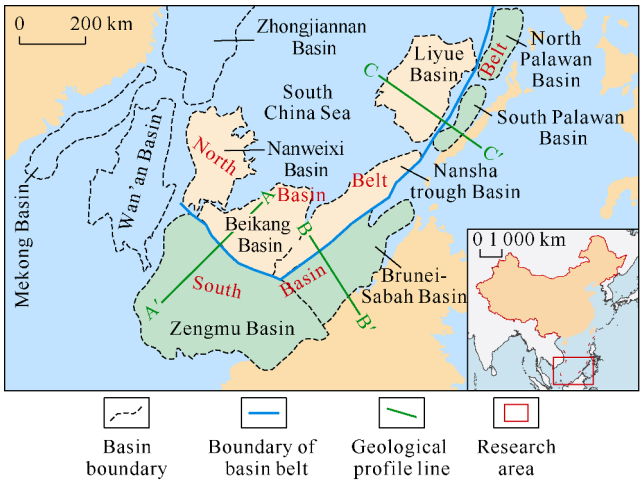

Fig. 1. Distribution of two basin belts in the southern continental margin of the South China Sea.

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2. Tectonic evolution of SCS marginal sea

Since the Late Mesozoic, the SCS region experienced three stages of proto-SCS and neo-SCS marginal sea tectonic evolution (Fig. 2), with different structural patterns in different stages.

2.1. The formation and development stage of proto-SCS (Late Jurassic-Early Oligocene)

During the Late Mesozoic, the SCS region might be a uniform proto-SCS landmass, pieced together by several blocks, including three parts, namely, the South China plate consisting of Nansha, Palawan and other micro-blocks with similar lithostratigraphic features of pre-Cenozoic basement, Indochina block and Borneo block. The subduction of ancient Pacific plate caused the splitting of the proto-SCS landmass. The rifting happened along the weak zone between the pan-Nansha block and Borneo block, forming the proto-SCS oceanic basin, with pan-South China continent and its southern passive continental margin located on the north, and Borneo block and its passive continental margin located on the south, respectively (Fig. 2).

Since the Eocene, the Eurasian plate fully collided with the Indian plate. Blocked by the Indian plate subduction belt, under the NW direction compression the deep asthenosphere of the Asian plate flowed southeastward, and was stopped by the Pacific plate subduction zone in the southeast direction, forming mantle plume and giving birth to the neo-SCS. Hence, the regional tectonic pattern of "two seas held by three continents" came about in neo-SCS (Fig. 2).

2.2. The subduction of proto-SCS and development of neo-SCS (Late Oligocene-Middle Miocene)

Formed on the weak zone among Paracel, Macclesfield Bank, Pratas and Nansha blocks, the neo-SCS was earlier an intracontinental rift, and then gradually expanded into an oceanic basin. With ocean crust as basement and magnetic anomaly stripe age of 32–16.5 Ma, the neo-SCS was formed in Late-Oligocene to Early Miocene[2], and its east edge might

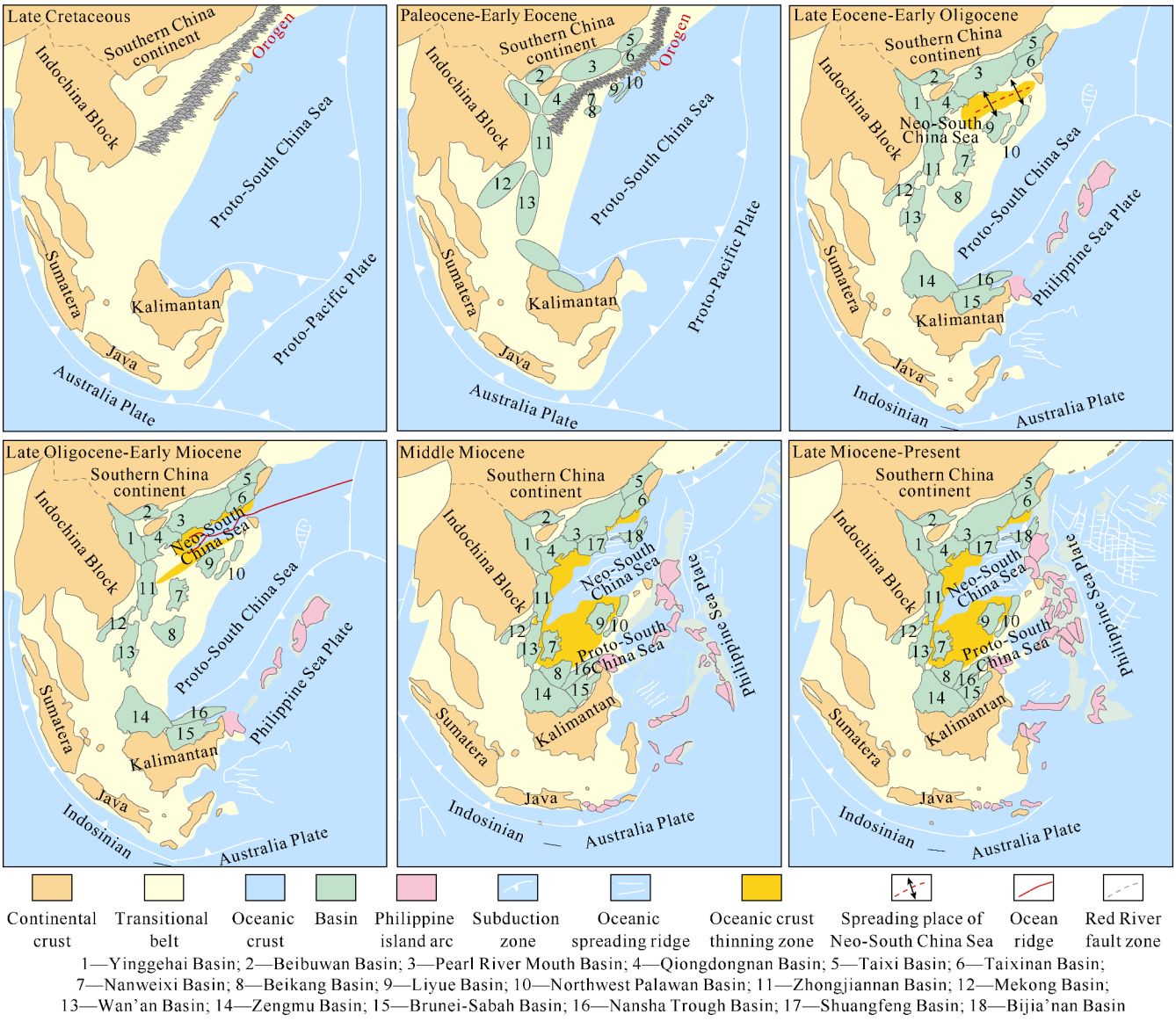

Fig. 2. Tectonic evolution of the South China Sea (modified from reference [1]).