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Characteristics of tectonics and genetic types of bearing-oil-gas basins in South China Sea region

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Abstract

In order to probe into the Late Mesozoic tectonic framework of the South China Sea (SCS) region, the author, through the structural analysis of seismic profiles, found obvious reverse thrust nappe structures respectively with northward thrusting in the Mesozoic strata on northern margin of the SCS, and with southward thrusting in Mesozoic strata in northern Liyue block on southern margin of the SCS. Both of the reverse thrust nappe structures associately formed a pair of back-trusting-type of trust-fold belt in late Mesozioc before the openning of the SCS, similar to the typical thrust-fold tectonic style of collision orogenic belt. Based on this, The concept of "the ancient Shuangfeng-Bijia subduction-collision orogenic belt"(SOB) was proposed by the authors. Combined with the results of comprehensive analysis on the data of Mesozoic stratum lithology-lithofacies of the SCS and adjacent areas, paleontology, gravity, magnetism and paleomagnetism.

Using the method of tectonic analysis, the authors put forward a new project for Late Mesozoic tectonic unit division of the research area: from north to south, there were geotectonic units such as the South China plate, southern Guangdong back-arc area (including the Qiongzhong block in the West), Dongsha Island volcano arc, Chaoshan forearc basin, Ancient Shuangfeng-Bijia subduction zone, Ancient North Liyue ocean basin (ANLB) (remnant of Paleo-Tethyan ocean basin in Mesozoic) north on Liyue block, Liyue block (including Kangtai –Yongshu-Zheng He strong fold belt in northern Nansha, Nanwei-Andu - Xianbin Mesozoic mezzo compressional fold belt in central Nansha, and Zenmu--NW Palawan passive continental margin of northern ancient SCS in southern Nansha), the ancient SCS (Meso-Tethys), in turn.

Then, the authors elaborated the formation and evolution of the SOB and its relationship with splitting-drift of fragments from the northern margin of Gondwana, subduction of Tethys, accretion of SE Asia in Mesozoic, and splitting of Southern China continental margin in Cenozoic. The movement characteristics of the main block of South China Sea and its relationship with Gondwana and Tethys can be boiled down as following:

During Devonian to late Permian, Qiongzhong (i.e. middle Hainan Island) block was separated from Sanya (southern Hainan Island) block (including Xisha, Zhongsha and Liyue sub-blocks on the south) by Qiongnan (i.e. south Hainan Island) oceanic basin (eastern extension of Tethyan main ocean basin). The Sanya-Liyue blocks might be connected with Gondwana on the south, and were in absence of Lower Carboniferous strata, like South Africa, India, and Australia blocks which originated from northern Gondwana.

In the Early Carboniferous, Qiongzhong block was located in 6.01°N, received marine sediment of the Nanhao formation, which is rich in marine invertebrate fossils such as South Tethys cold water type *Neospirifer*. In Middle-Upper Carboniferous, blocks in the northern Gondwana developed glacial deposition, and continuely produced cold water fauna fossils represented by *Eurydesma* and *Mesosaurus* of aquatic reptiles. Qiongzhong block northwards drifted to 28.1°N in the Middle Carboniferous, reached its most northerly position 35.8°N in the Late Carboniferous, then moved southward. The northern Gondwana developed of a large number of *Glossopteris* flora to early Permian, and widely appeared molecules of vertebrate fauna such as *Dicynodont* in Late Permian, while the Qiongzhong block had southward returned to the nearby 21.87°N, and developed cold water limestone of the E'ding formation and ice-sea mix-conglomerate sediments of Nanlong formation, these evidences indicate there are possibility for Qiongzhong block sourced from the Gondwana. On other hand, the Qiongzhong block was rich in warm water type *fusulinida* and *brachiopods*, but also in cold water type *brachiopod* fauna molecule of South Tethys. But, most of ancient plant fossils in the Qiongzhong block were with fern genus. This shows the Qiongzhong block was basically closed to the warm type of Cathaysian flora. But in the Qiongzhong block, it has not yet found typical Cathaysian flora such as *gigantopterids* etc, also not yet found molecular of Glossopteris flora which extensively developed in Gondwana. This indicates the Qiongzhong block had been far away from Gondwana and relatively close to the Southern China continent in Late Permian. The Qiongnan basin oceanic crust began to northwards subducted under southern margin of Qiongzhong block in Late Permian.

The southern margin of Qiongzhong became active plate margins, and a series of early mid Permian to Triassic I-type and S-type calcium and calc-alkaline granites were formed on this margin. To the Middle Triassic, the Qiongnan basin was closed, the Sanya and Qiongzhong blocks collaged and sutured along the Jiusuo- Lingshui line in 16.5°N. And then, the two blocks together northward moved to 25.5°N in early Cretaceous. Taken approximately to present-day NS-direction Zhongnan transform belt as a bound, the ANLB, as the residual part of the Qiongnan basin in the east, continue northward subducted beneath the southern margin of the South China plate.

To the late Jurassic, Liyue block and South China plate was connected. Some plant fossils similar to *Podozamites* of South China were found in the late Jurassic delta phase siltstone in the Liyue Bank. This indicates that the Nansha block and South China plate began to have an alliance relationship.

In Early Cretaceous, the ANLB was closed, and the Liyue block northwards collaged and collided with the southern margin of South China plate along a ancient position approximately equivalent to the current Shuangfeng-Bijia seamount line, This collision made the SOB built and SE Asia accreted. In the end of the Mesozoic, Nansha micro-plate including Liyue block in the east was still on the verge of the ancient SCS on the south.

Since the Cenozoic, on the basis of extension and collapse of the SOB and delamination of the SOB root, seafloor spreading emerged in the SCS, and promoted the ancient SCS on south of Nansha micro plate southward subducted beneath the northern Kalimantan arc. The ancient SCS survived as present-day Nansha trough.

With the formation and evolution of the SOB, since the Mesozoic, the study area experienced three stages of compressional stress, extensional stress, extrusion shrinkage. A series of large Mesozoic and Cenozoic basins were formed. Mesozoic basins include: the southern Guangdong Mesozoic back-arc basin, Chaoshan forearc basin, Nanweixi-Beikang-Liyue passive continental margin basin. Cenozoic basins include: extensional basin prototype related to extensional environment, such as Beibu Gulf basin, Qiongdongnan basin, Pearl River Mouth basin; fault-depression basins developed interior craton, such as Liyue basin and Northern Palawan basin; West Palawan and Nansha Trough forearc basins, residual oceanic basin on northern part of Zengmu basin; peripheral foreland basin in southern Zengmu basin; Yinggehai and Wan'an pull-apart basins related with strike-slip zone; Zhongjiannan, Nanweixi, and Beikang shear extensional basins related to shear-extension. Nanweixi, Beikang, and Liyue basins are typical residual-superimposed basins which have not only relict Mesozoic sediments but also superimposed Cenozoic sediments. Seismic profiles from Beikang basin show that the transgression of Meso-Tethys seawater entered into the southern South China Sea area from the south to the north, and formed Mesozoic benificial environment enriching in organic matter represented by deep sea facies sediments. Therefore, the exploration of oil and gas resources in the hinterland of Nansha should pay more attention to the deep reservoir forming factors of the residual -superimposed basins.

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