中国南方早古生代碳酸盐台地形成与发展

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[内容提要] 中国南方碳酸盐台地从震旦纪到志留纪十分发育,它对认识中国南方沉积地壳演化和油气勘探具有重要意义。90年代以来,中国南方碳酸盐台地从台地内部结构研究发展到对碳酸盐台地边缘、台地几何形态、台地边缘形态的研究,并把它们的形成和演化与大地构造、全球海平面变化、沉积层序、动力演化过程结合起来,进行碳酸盐台地发展、演化、沉降、生长的定量模拟。此外,还特别重视重大地质事件和非现实主义沉积作用探索。

中国南方早古生代碳酸盐台地,随着扬子板块的裂谷拉张、被动大陆边缘构造热沉降和前陆挠曲,经历了碳酸盐台地产生、发展和消亡的完整威尔逊旋回动力演化。最终这个巨大的碳酸盐台地因挠曲沉降淹没和大量碎屑岩覆盖而消亡,是具有非常良好远景的油气资源探区。

关键词:中国南方 早古生代 台地演化 油气资源

FORMATION AND DEVELOPMENT OF THE EARLY PALAEOZOIC CARBONATE PLATFORM IN SOUTHERN CHINA

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ABSTRACT

The Early Palaeozoic carbonate platform in southern China shows a long and complex history with a complete dynamic evolution of the Welson cycle, spanning the initiation, development and termination due to extensional rifting of the Yangtze plate, tectonic thermal subsidence of the passive continental margins, and foreland warping. This huge carbonate platform was finally died and buried by thick piles of siliciclastic rocks from the Cathaysian plate, and now is inter-

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preted as a potential area for the prospecting and exploration of oil and gas resources.

Key words: southern China, Early Palaeozoic, platform evolution, oil and gas resources

The carbonate platform on the Yangtze plate in southern China was well developed from the Sinian to Silurian. Much research has focused in recent years on the investigation of platform margin, platform geometry and marginal structures, in combination with tectonic movements, global sea-level changes, sedimentary sequences and hydrodynamics[1], resulting in the presentation of the quantitative models for the initiation, development and evolution of the carbonate platform. Meanwhile, great attention has also been paid to important geological events[2] and non-actualistic sedimentation on the carbonate platform.

1. The initiation stage of the Yangtze carbonate platform was initiated after the termination of the global glaciation in the Early Sinian, when much of peneplains of the Yangtze oldland was submerged, and developed on the volcanic and terrigenous clastic basement that underwent the intensive rift faulting between the Yangtze and Cathaysian plates. The climates varied in a cold-humid-dry cycle. The hydrodynamic and biological conditions allowed for the growth of the carbonate platform.

From the Late Sinian onwards, the climates became progressively warmer in the Yangtze craton. The glaciers melted and retreated with the sea-level rises and large-scale transgressive onlaps, the Yangtze oldland was drowned into the shallow-marine environments. The differential tectonic subsidence gave rise to the differences in the development of the carbonate platform; the tidal-flat sediments predominate in the central part, while on the margins the open platform sediments are common.

The carbonate platform grew from the margin to the centre. At the early stage the thin- to thick-bedded dolostones are interspersed along the margins of the platform (Fig. 1). The high-energy dolostones and grainstones prevail over the whole platform, whereas the low-energy shales and muddy dolostones are recognized in the interplatform basin and shelf areas.

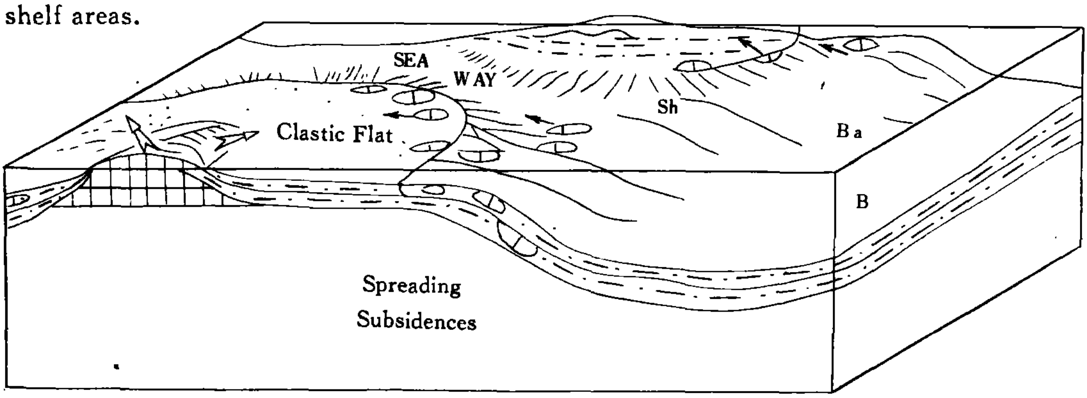

Fig. 1 Model for the Yangtze carbonate platform in the initiation stage during the early Late Sinian

Ba=bathyal sea; B=basin; Sh=shelf

The tectonic settings were relatively stable during the Late Sinian. These early carbonate sediment bodies are typical of a ramp type[3] rather than a rimmed platform. The geodynamics is characterized by block faulting, or sudden tilting, indicating an extensional rifting stage.

2. The accretion stage of the Yangtze carbonate platform

During the late Late Sinian, the Yangtze carbonate platform continued to develop vertically and horizontally at the highest speeds in response to the slow eustatic falling and relatively rising of the fourth-order sea level. The sediments represented by the dolostones and algal dolostones in the Dengying Formation on the platform have a maximum thickness of more than 1000 m. Moreover the dolostones in the formation exhibit the shallowing-upward sequences (Fig. 2). At the end of the Sinian, the rapid sea-level falls resulted in the exposure and erosion of the uppermost dolostones in the formation. Therefore the palaeoweathering crust structures are widespread at the Sinian/Cambrian boundary.

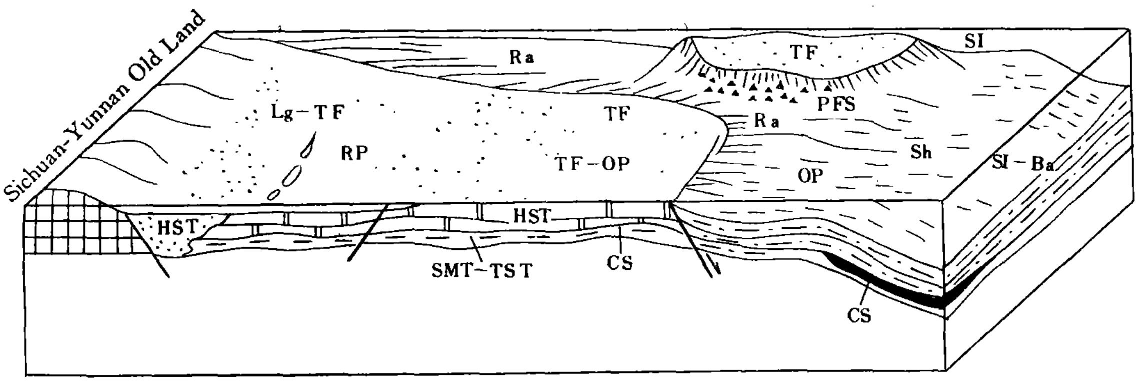

Fig. 2 Model for the Yangtze carbonate platform in the accretion stage
Lg=lagoon; TF=tidal flat; RP=restricted platform; Ra=ramp; OP=open platform; SL=slope; Ba=bathyal sea; PFS=platform foreslope; Sh=shelf; CS=condensed section; HST=highstand systems tract; SMT=shelf-margin systems tract; TST=transgressive systems tract

During this period, the platform slope migrated basinwards about 50 km, with an average velocity of 1 to 2 km/Ma.

The Qiongzhusian (Early Cambrian) black shales well represented throughout the Yangtze carbonate platform resulted from the rapid rises of sea level due to the breakup of the Palaeozoic Pangea. These black shales as the products created by the global oceanic anoxic events may be compared with those in all parts of the world. They prograded in the early stage from the lower slope and margin to the centre of the platform, and only occupied the central part of the platform in the late stage. This implies perhaps that the platform basin was in steady spreading in the early stage, whereas in the late stage the rates of sedimentation approximate to those of tectonic subsidence.

The carbon flux was extremely large during the drowning of the platform. For instance on the Lower Yangtze platform, there is a total carbon flux of about 5.7928^{11}, with a maximum accumulation rates of 3.19×10^{-4} g/cm^2. a and a munimum accumulatiom rates of 3.58×10^{-5} g/cm^2. a, which lie within the range of the organic carbon accumulation rates (5.3×10^{-5} g/cm^2. a) calculated by Arthur (1987) for the Cretaceous.

3. The development stage of the Yangtze carbonate platform

The platform basement turned gradually into the mature continental margine in this stage. The falling of sea level and aggradation of the Yangtze carbonate platform led to the formation of the gravity flow and effluent flow deposits on the margin of the platform during the Canglangpuan and Longwangmiaoan (Early Cambrian), and the development of the carbonate ramps came to an end. The sediments in the Longwangmiaoan Qingxudong Formation are composed dominantly of mudstones, marls and micritic limestones. The carbonate mud mound and algal mound developed on the shoals became progressively smaller from bottom to top, and migrated gradually toward the outer shelf, thus resulting in the formation of the broad and flat carbonate platform.

In the Middle to Late Cambrian, this region was in the stage of sea-level falling, which provided a favourable background for the seaward progradation of the carbonate platform[4]. The fourth- and fifth-order sea-level rises and falls are responsible for the formation of a number of small platforms with accretionary margins, and for the development of the rimmed carbonate platform into grooved platform[5] (Fig. 3).

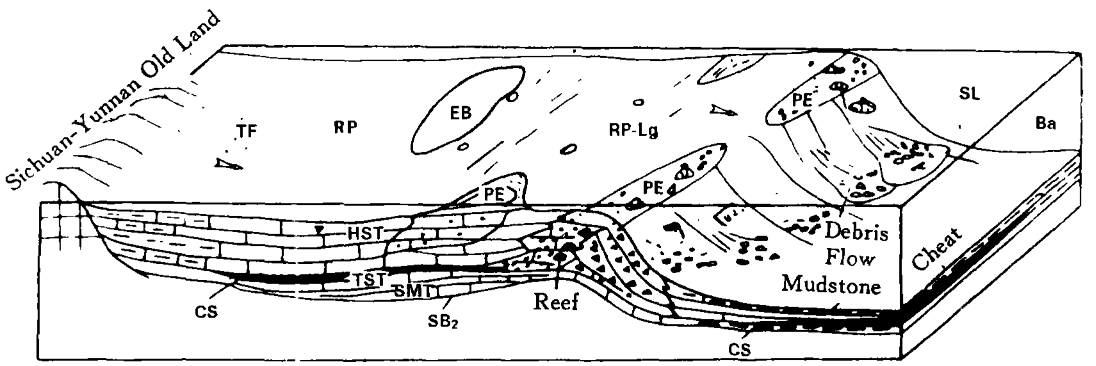

Fig. 3 Model for the Yangtze carbonate platform in the development stage during the Early Cambrian to Middle Ordovician

Ba=bathyal sea; SL=slope; PE=platform-margin shoal; RP=restricted platform; La=lagoon; EB=evaporite basin; TF=tidal flat; HST=highstand systems tract; TST=transgressive systems tract; SMT=shelf-margin systems tract; CS=condensed section; SB_2=type 2 sequence boundary

The effluent flow deposits are interpreted as a special kind of sediments produced on the platform during its mature stage. The deposits consist of grain-supported oolitic limestones and calcilutite with a thickness of several centimetres, intercalated with the background sediments consisting of lime mud. They are considered as the products of non-actualistic sedimentation during the rapid falling of sea level and under the influence of high-frequency oscillation of sea level[6,7].

4. The termination stage of the Yangtze carbonate platform

The termination of the Yangtze carbonate platform may be attributed to: the second drowning by sea water and covering by a large amount of siliciclastic sediments from the Cathaysian plate (Fig. 4).

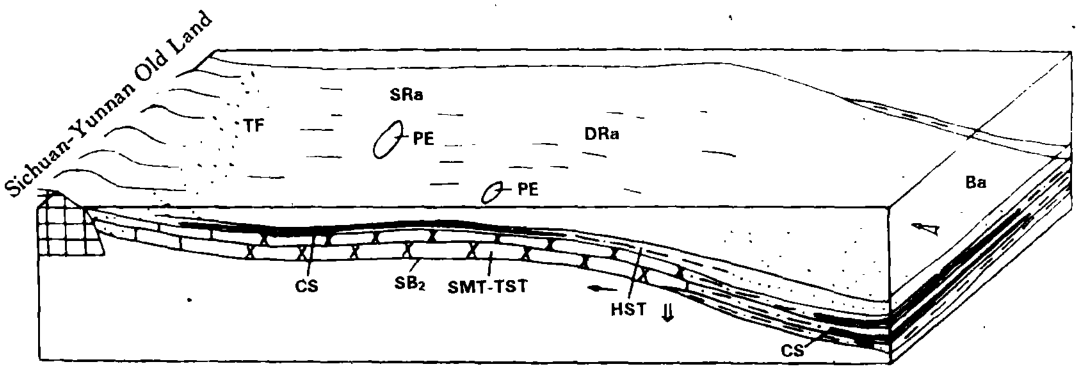

Fig. 4 Model for the Yangtze carbonate platform in the termination stage during the Silurian
PE=platform-margin shoal; SRa=shallow-marine ramp; DRa=deep-marine ramp; TF=tidal flat; B=basin; HST=highstand systems tract; SMT=shelf-margin systems tract; TST=transgressive systems tract; CS=condensed section; SB_2=type 2 sequence boundary

In the Wufengian (Late Ordovician), the peripheral foreland basin on the southeastern margin of the Yangtze platform was uplifted giving rise to the deepening of sea water along the margin and the accumulation of black shales, sandy shales, siliceous and carbonaceous shales in the foreland basin and on the platform, which then graded into the submerged basin. Till the Early Silurian, the foreland basin was migrated toward the upper part of the Yangtze plate margin. Plenty of ferruginous clastic deposits were accumulated from east to west on the Yangtze platform. Finally the collision of the Yangtze and Cathaysian plates caused the termination of carbonate deposition on the platform.

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