



The pre-Sinian rift in central Sichuan Basin and its control on hydrocarbon accumulation in the overlying strata



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Abstract: Based on the latest seismic data, resistivity profile, outcrop evidence and logging data, the structural features of basement in Sichuan Basin and its control on the hydrocarbon accumulation in the Sinian-Cambrian strata was discussed. It was found that a NE striking pre-Sinian rift was developed across the whole basin. Controlled by a series of rift-parallel normal faults, horst-graben structures were developed inside the rift, large horst-graben structures and later activity of their boundary faults controlled the distribution of beach facies of the overlying strata. The horst-graben structures induced the formation of local highs of ancient landform and controlled the successive development of overlapped bioherm beach facies in long-term marine setting from the Sinian period to the Permian period, and as a result a widely distributed favorable sedimentary facies belt was developed. The pre-Sinian rift and later activities of related normal faults controlled the development of the grain beach and karst reservoirs and the deposition of high quality source rock, which form structural-lithologic traps. Through comprehensive evaluation, two large structural-lithologic composite trap favorable exploration areas in the south and north of the Gaoshiti-Moxi area, were selected.

Key words: Sichuan Basin; pre-Sinian; rift; horst-graben structure; Sinian-Cambrian; hydrocarbon accumulation model; structural- lithologic trap

1. Geological background

The giant Anyue gas field in the Sichuan Basin is an un-compartmentalized carbonate gas field developed in the oldest marine facies and it has the largest reserve in China. Its discovery has opened the exploration prospect of ancient deep-seated oil and gas resources in the Sichuan Basin^[1]. The discoveries around the Sinian–Early Cambrian Gaoshiti-Moxi paleo-uplift and Deyang-Anyue intracratonic rift in central Sichuan Basin are mainly located in the platform margin of the Sinian Dengying Formation and the plateau intraplatform beach of the Cambrian Longwangmiao Formation in the core of the central Sichuan paleo-uplift^[2–4]. The central Sichuan Basin is the most stable tectonic zone in the Sichuan Basin with excellent geological conditions for oil and gas accumulation. After the discovery of the giant Anyue gas field, to search new exploration fields and expand the exploration results have become major problems for gas prospecting in the Sichuan Basin. Previous studies have shown that in the Ordos Basin, Junggar Basin, Sichuan Basin, due to the differences in paleogeomorphology of the basement, structural heterogeneity in the fault systems, rifts and uplifts and the impact of late

activation, these pre-existing basement structures had controls over the distribution of sedimentary facies, hydrocarbon migration and tectonic deformation of the overlying strata, and consequently the formation and distribution of oil and gas reservoirs^[5–8]. Therefore, it is of great importance to study the basement structure and tectonic characteristics of the central Sichuan Basin as well as their control over hydrocarbon accumulation in the overlying strata, and predict favorable zones in order to search for high-yield and enriched deep-seated oil and gas fields, expand the scope of exploration in the central Sichuan Basin, and find major alternate areas after the giant Anyue gas field.

The predecessors have conducted many meaningful and exploratory studies on the basement characteristics in the Sichuan Basin and concluded that the basement has a dual nature, namely (1) the Kangding Group developed in the Archean–Early Proterozoic formed the deep crystalline basement dated back to 1 700–1 900 Ma through the Zhongtiao Movement; (2) the Ebian Group developed in the Mesoproterozoic–Neoproterozoic formed the fold base dated back to 780–1 700 Ma through the Jinning movement^[9–10]. The study

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suggests that the Upper Yangtze Plate dominated by the pre-Sinian rift (or the Nanhua rift) before the formation of the Neoproterozoic structure was dated back to 635–800 Ma, and controlled by global Neoproterozoic extensional environment and corresponded to the splitting of the ancient Rodinia land in 570–860 Ma^[11–14]. Four intracontinental rifts, namely Kangdian, Central Sichuan, Exianggui, Northern Zhejiang-Southern Anhui rifts are developed in South China. The Nanhua System inside the rifts is composed of fillings of volcanoclastic rocks, sandstone, mudstone and tillite. The basement of the Yangtze Plate is mainly composed of the Neoproterozoic. Granite is well developed in the top of the Qingbaikou System, which is different from the Nanhua clastic rocks^[15–23]. The distribution of the pre-Sinian rift in the Sichuan Basin has been preliminarily outlined. Yang et al.^[24] used seismic data to clearly identify the existence of the pre-Sinian rift in the Gaoshiti-Moxi region, preliminarily understanding its influence on the distribution of deep-seated oil and gas in the region. At present, there are some problems, as follows, in understanding the rift structure in the Sichuan Basin: (1) Due to little knowledge of the pre-Sinian System, it is not enough to understand the structure based on petrological evidence; (2) The predecessors used seismic data to roughly delineate the pre-Sinian rift, but the understanding on its distribution and internal structure is not fine and deep, and high-quality seismic data and fine processing and interpretation need to be used to describe the external and internal structure, and clarify the forming mechanism; (3) The control

of the pre-Sinian structure over the formation of the Sinian–Cambrian gas field was rarely involved. Using the latest seismic, electrical and drilling data, this paper carries out in-depth studies on the pre-Sinian rift and the developmental characteristics of the inside horst-graben structure (or horst-graben for short) and the control of the overlying the Sinian–Cambrian System in central Sichuan Basin.

The study area located in the south of the present low and gentle tectonic belt covers an area of 6×10^4 km². It is between the western Huaying Mountain and the eastern Longquan Mountain, on its north is the foreland fold belt of the Micang Mountain–Daba Mountain and on its south is a low and steep tectonic belt (Fig. 1). The long-term exploration targets are marine Sinian–Cambrian, Permian and Middle–Lower Triassic carbonate rocks and continental Upper Triassic and Jurassic clastic rocks. The short-term exploration targets are the Sinian Dengying Formation, Cambrian Longwangmiao Formation and Middle Permian Qixia Formation – Maokou Formation. In the focused Longwangmiao Formation and Dengying Formation, the main favorable facies belts consist of grain beach, platform margin beach and intra-platform beach bodies, where reservoirs are dominated by fractured-porous dolomites and have three sets of high-quality source rocks including the Cambrian Qiongzhusi Formation, the Maidiping Formation and the Member 3 of Sinian Dengying Formation (Z_2dn^3), and the hydrocarbon source conditions are superior. In central Sichuan Basin, after the Sinian, the Dengying Formation and adjacent formations have developed the most

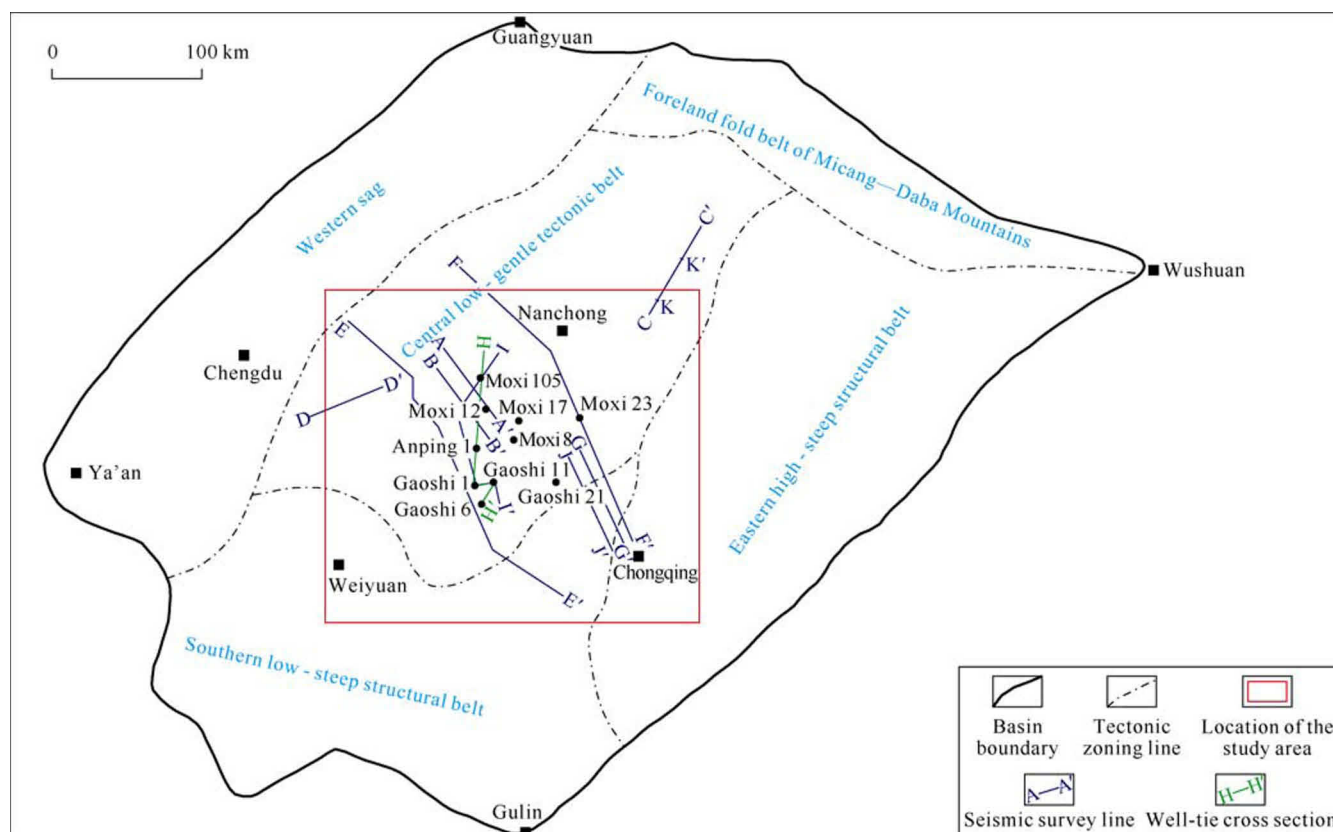


Fig. 1. Tectonic outline of Sichuan Basin and the location map of the study area.

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