



Tectonic evolution from Late Sinian to Early Paleozoic and natural gas exploration in northwestern Sichuan Basin, SW China



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Abstract: Based on the field outcrops, drilling and seismic data of northwestern Sichuan Basin, this paper systematically discusses tectonic evolution characteristics from the Late Sinian to the Early Paleozoic, analyzes the petroleum geological significance, and points out the recent favorable exploration directions in this area. The area experienced mainly three times of tectonic evolution during the Late Sinian to the Early Paleozoic: (1) During the Late Sinian to the early period of Early Cambrian, this area was affected by tension action and formed two sets of nearly north-south trending continental rifts, and two sets of platform margins in the Sinian Dengying Formation. (2) During the middle period of the Early Cambrian to the Middle Ordovician, this area was eroded strongly (stronger in the northwest than in the southeast) because of multi-period uplifting of the northwestern Bikou paleo-land. (3) During the Late Ordovician to the Late Silurian, this area was eroded strongly again because of the compression of the Kwanghsian Orogeny, and the erosion was stronger in the southwest than in the northeast. During the Late Sinian to the Early Cambrian, the formation of continental rifts controlled the development of bioherm beach facies reservoirs on the platform margins in the Dengying Formation and the high quality source rock in the Lower Cambrian series. During the middle of the Early Cambrian, the uplifting of the Bikou paleo-land controlled the distribution of the Kongmingdong Formation oolitic beach facies reservoirs around the paleo-land. It is suggested that, vertically, the fourth Member of the Dengying Formation and the Kongmingdong Formation be the main exploration targets, and, horizontally, the Jiulongshan structural trap be the most beneficial exploration belts recently due to its matching with petroleum migration and accumulation.

Key words: Sichuan Basin; Late Sinian - Early Paleozoic; tectonic evolution; natural gas exploration; intracontinental rift; Bikou paleo-land; Dengying Formation; Kongmingdong Formation; Jiulongshan structure

Introduction

Since 2011, major discoveries have been made in the exploration of the Sinian Dengying Formation and Cambrian Longwangmiao Formation in Gaoshiti-Moxi area of Sichuan Basin, forming the gas province with the magnitude of trillion cubic meters. The formation of this huge gas province is mainly controlled by two factors: (1) From the Late Sinian to early stage of Early Cambrian, the formation and evolution of intracontinental rift controlled the development of the Lower Cambrian high-quality source rock and bioherm beach facies karst reservoir in Dengying Formation; (2) During the Early Paleozoic, the formation and evolution of Leshan-Longnusi palaeohigh controlled the development of grain-beach facies reservoir of Longwangmiao Formation^[1–2]. Therefore, to make breakthrough in Sinian-Cambrian natural gas exploration

of northwestern Sichuan Basin, the characteristics of tectonic evolution in Late Sinian-Early Paleozoic must be figured out.

For the Late Sinian-Early Paleozoic tectonic evolution in this area, previous studies were mainly based on outcrops around the basin^[3–19], for example, the formation and evolution of “Hannan ancient land”^[3] and “Motianling ancient land”^[10], and the research on “Nanjiang uplift” in Late Sinian period^[20], “Zhenba uplift” between the Early Cambrian Meishucunian Age and Qiongzhusian Age^[16], “Nanzheng uplift” between the Middle Cambrian and Late Ordovician^[15], “Xixiang uplift” between the Early and Middle Llandoverian^[15] and “Kwanghsian Orogeny”^[21–22], but there are few papers on tectonic evolution in the basin during these periods published. Based on comprehensive analysis of outcrops around the basin and drilling data, through fine interpretation

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of 2-D and 3-D seismic data covering an area of 14 000 km², the characteristics and petroleum geologic significance of the Late Sinian-Early Paleozoic tectonic evolution have been examined, and the prospective natural gas exploration areas are pointed out in this paper.

1. Geologic background

Located at northwestern Sichuan Basin, the study area adjacent to Longmenshan orogenic belt, Bikou block and south Qinling orogenic belt in the west, and Micangshan orogenic belt, Hannan block and south Qinling orogenic belt^[23–24] in the north, is in the joint point where these blocks and orogenic belts meet. The outcrops in this area mainly expose the Jurassic and Cretaceous, as well as sporadic Quaternary. In addition, there is an anticline with N-E major axis in Jiulongshan region. Taking Anxian fault, Beichuan fault and Qingchuan-Yangpingguan fault as the boundary, the Longmenshan orogenic belt in the western margin of the basin can be divided into front and back Longmenshan orogenic belts^[25]. The basement doesn't crop out, while the Lower Cambrian and Ordovician-Triassic crop out in the front Longmenshan orogenic belt; while in the back Longmenshan orogenic belt, the epimetamorphic volcanic rock system of Liujiaping Group and Tongmuliang Group, Datan granite mass and Jiaoziding

granite mass^[25–26] in the basement expose, and the main sedimentary caprocks are Nanhua-Devonian system marine sedimentary rock series. In Bikou block, Late Archaean Yudongzi Group^[27], Neoproterozoic Bikou Group^[28] and the intrusive complex rock in the basement outcrop, and the sedimentary strata include Nanhua-Sinian and Devonian systems. The basement of Micangshan orogenic belt in the northern margin of the basin consists of the crystalline basement and fold basement, the former is composed of gneiss, granulite and amphibolite of Paleoproterozoic Houheyan group; the latter of meso-epimetamorphic rock in Shangliang and Mawozi Formation as well as volcanic rock series in Tiechuanshan Formation of Neoproterozoic Huodiya Group; the Devonian and Carboniferous reservoirs are absent in the sedimentary strata, but the other strata can be seen in outcrops^[18, 24, 29]. In Hannan block, the intermediate basic-intermediate acidic volcanic rock, volcanoclastic rock and the intrusive rock complex of Neoproterozoic Xixiang Group in the basement crop out^[30], and the sedimentary strata are complete (Fig. 1). From the Late Sinian to early stage of Early Cambrian, the study area was in the northeast of “Deyang-Anyue” intracontinental rift; from the middle stage of the Early Cambrian to the Silurian, it was located in the north of Leshan-Longnüsi palaeohigh^[1].

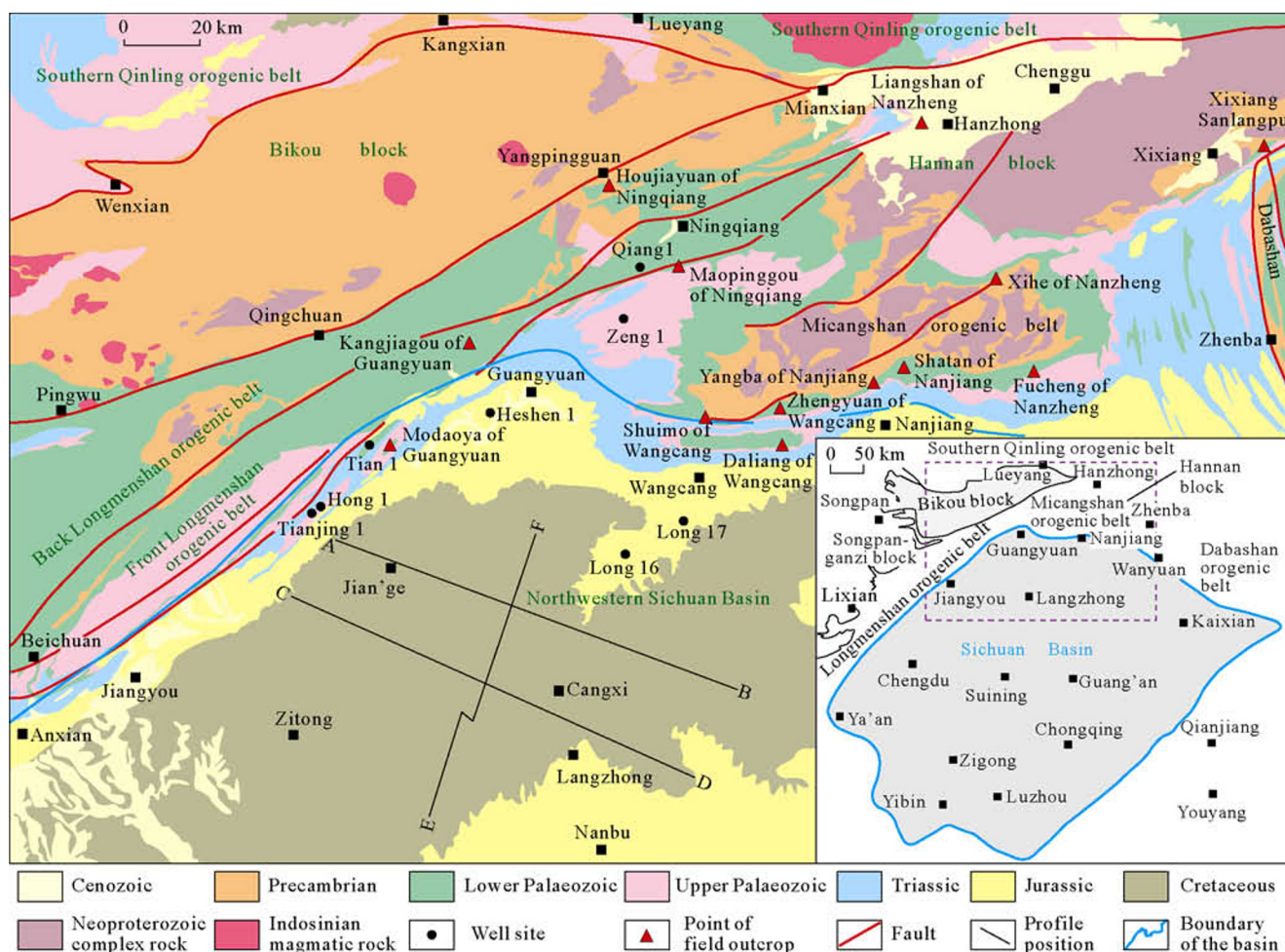


Fig. 1. General geologic map of northwestern Sichuan Basin (modified from literature [31]).

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