Available online at www.sciencedirect.com

ScienceDirect

Natural Gas Industry B 2 (2015) 406–414

www.elsevier.com/locate/ngib

Research article

Geological significance of paleo-aulacogen and exploration potential of reef flat gas reservoirs in the Western Sichuan Depression ☆

Liu Shu [a,*], Ning Meng [b], Xie Gangping [a]

[a] *Sinopec Southwest Branch Company, Chengdu, Sichuan 610041, China*
[b] *School of Geosciences, Yangtze University, Wuhan, Hubei 430100, China*

Received 19 March 2015; accepted 8 September 2015
Available online 26 February 2016

Abstract

Confirming thick hydrocarbon generation center and discovering thick porous reservoirs are two key factors to start the Permian gas exploration of the Western Sichuan Depression. In this paper, the Sinian-Cambrian structures of this area were studied by adopting the layer-flattening technology and the Lower Paleozoic thickness map was prepared in order to describe the Permian hydrocarbon generation center. Then, combined with seismic facies analysis and field outcrop bioherm discovery, the distribution of Middle Permian reef flat reservoirs were predicted. Finally, the favorable conditions for reef flat reservoir dolomitization were analyzed based on fault features. The study indicates that: (1) Sinian top represents a huge depression in the profile flatted by the reflecting interface of Permian bottom, with normal faults filled by thick Lower Paleozoic sediments at both sides, revealing that a aulacogen formed during the Khanka taphrogeny exists in the Western Sichuan Depression, where very thick Cambrian strata may contain hydrocarbon generation center, making Permian strata have the material conditions for the formation of large gas pools; (2) the Middle Permian strata in the Western Sichuan Depression exhibit obvious abnormal response in reef flat facies, where three large abnormal bands are developed, which are predicted as bioherm complex combined with the Middle Permian bioherm outcrop discoveries in surface; and (3) deep and large extensional faults are developed in reef flat margin, manifesting as favorable conditions for the development of dolomite reservoirs. The results show that the Middle Permian traps in the Western Sichuan Depression contain resources up to 7400 × 10^8 m^3, showing significant natural gas exploration prospects. By far, one risk exploration well has been deployed.
© 2016 Sichuan Petroleum Administration. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Keywords: Sichuan Basin; Western Sichuan Depression; Middle Permian; Reef flat facies; Bioherm; Dolomite; Reservoir; Aulacogen; Khanka taphrogeny

In the Middle Permian gas reservoir, one of the major gas reservoirs in the southern and Southwestern parts of the Sichuan Basin, natural gases were once thought to reside in pores, cavities and fractures, especially in the cave system formed in the process of Dongwu Movement [1–3], which has only been drilled by a few wells [2] with low production. In 2014, Well Shuangtan 1 drilled at Shuangyushi buried structure in the Northern Sichuan Basin and Well Nanchong 1 drilled in the Central Sichuan Basin yielded commercial gas flow from the Middle Permian reservoirs, the reservoir space of which was found to be pores and fractures-pores. As per some further researches [4,5], the Middle Permian porous dolomite reservoirs may have high yield of gases, which expands the prospect for exploration. The Middle Permian gas resources in the Sichuan Basin were proved to reach 1.47 × 10^{12} m^3, and the proved reserves were only 811.68 × 10^8 m^3 mainly found in Southern and Eastern Sichuan Basin. Remaining gas resources were estimated to be 1.38 × 10^{12} m^3, indicating a huge potential.

☆ Supported by National Science and Technology Major Project "Clastic reservoir identification and prediction in the Sichuan Basin" (Grant No. 2008ZX05002-004-003).
* Corresponding author.
E-mail address: 904988392@qq.com (Liu S.).
Peer review under responsibility of Sichuan Petroleum Administration.

http://dx.doi.org/10.1016/j.ngib.2015.09.016
2352-8540/© 2016 Sichuan Petroleum Administration. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Within the region with Sinopec mineral rights in the Western Sichuan Basin, the Permian System has not been drilled by any well yet. This is because (1) large burial depths around 6500 m, (2) a small volume of the cave system predicted with large uncertainties in accordance with the model composed of pores, cavities and fractures developed for Middle Permian gas reservoirs [1,2], and (3) stratigraphic break of the Silurian System in the Western Sichuan Basin. The last one is the most important because the argillutite of the Liangshan Formation, which is Middle Permian source rock, is not thick enough to generate a large amount of natural gases in such a deep zone for exploration. Therefore, gas accumulation is closely related to the existence of porous dolomite reservoirs and large-scale source rocks. As per recent studies, organic reefs may exist not only in the Changxing Formation [6] but also in the Middle Permian Series in the Western Sichuan Depression in light of typical seismic reflection signatures of organic reefs and banks, i.e. blank to chaotic reflections with convex external forms, which were interpreted to represent organic reefs and banks in accordance with the outcrops of the Middle Permian Maokou Formation. In addition, major faults were interpreted to extend along the margin of predicted reef and bank facies, which would be favorable for the generation of dolomite reservoirs [4,5,7–10]. Besides, a paleo-aulacogen has been confirmed to exist in the Western Sichuan Basin [6], which may function as the hydrocarbon generating center with thick source rocks to generate a large amount of natural gases. The Middle Permian traps in the Western Sichuan Depression were predicted to exceed 1800 km^2 and corresponding gas resources were estimated to be 7400 $\times$ 10^8 m^3, more than a half of the remaining resources (1.38 $\times$ 10^{12} m^3). So it is possible to find large gas reservoirs in the Western Sichuan Basin.

1. Geological features

The Western Sichuan Depression extends in NE direction in the west of the Sichuan Basin and is separated from Songpan-Ganzi fold belt by Longmenshan Mountains on the west and from Central Sichuan palaeohigh by Longquanshan Mountains on the east. Micangshan fold belt and Sichuan-Yunnan structural belt are on the north and south of the depression, respectively. The lateral extension basically coincides with the present Cretaceous-Quaternary outcrops region (Fig. 1).

Tectonically the Western Sichuan Depression lies in the west margin of the Yangtze Block (Fig. 1) and is a foreland basin caused by tectonic compression during the Indosinian and Himalayan orogenies [11]. It evolved from marine facies from the Sinian Period to the Middle Triassic Epoch into transitional facies in the early Late Triassic Epoch and finally into continental facies from the late stage of the Late Triassic Epoch to the Quaternary Period [12,13]. During the Khanka taphrogeny from the Late Proterozoic to the Early Paleozoic (Pt_1-ϵ_1), huge Chinese protoplatform disintegrated; Kunlun, Qinling, Longmenshan and Tianshan geosynclines outspread; the Yangtze, North China and Tarim Plates came into being [14,15]. The west margin of the Yangtze Plate was a passive continental margin from the Sinian Period to the Middle Triassic Epoch and regional unconformable surfaces occurred within the marine sequence due to several major tectonic movements [13,15]. The Caledonian orogeny gave birth to the Central Sichuan palaeohigh (Guangxi movement). Ordovician and Silurian formations may be lost in the Western Sichuan Depression [13].

2. Features and geologic significance of Sinian − Lower Paleozoic paleo-aulacogen

2.1. Geologic features of paleo-aulacogen

The volume of hydrocarbon accumulations is dependent on the volume of source rocks; generally oil and gas fields lie within source beds (there is no fault) or close to source beds (there are faults) [16]. In the Sichuan Basin, natural gas distribution in the lower assemblage is dependent on several factors, i.e. extensional troughs forming in the Khanka taphrogeny, palaeohighs, and basin-mountain structures [17]. In the Western Sichuan Depression, the volume of Permian gas reservoirs is dominated by the scale of hydrocarbon generating center.

Now at least two Sinian-Lower Paleozoic extensional rifts have been confirmed to exist in the Sichuan Basin, which are Guangwang-Kaijiang-Liangping trough in the Northeastern Sichuan Basin and the extensional rift in the Western and Central Sichuan Basin [6,17–22]. The latter occurs inside the craton and some small gas reservoirs of reef-bank facies have been discovered in the margin. But there is not sufficient knowledge about their geneses. Luo Zhili [18] predicted another aulacogen with potential gas accumulation around Mianzhu and Zhongjiang in the Western Sichuan Basin, which was confirmed in 2010 and named by Zhao Wenzhi as Pengxi-Wusheng upper shelf [19] possibly caused by continental rupture and reactivation of the basement fault. Luo Zhili [20] suggested naming it as the aulacogen Mianzhu-Pengxi-Wusheng aulacogen as per the concept of mantle plume and proposed that Mianlue fault activity during the Permian and Triassic Periods resulted in ocean basin deepening and basement fault reactivation in the northwest margin of the Yangtze Plate; the latter gave birth to the aulacogen in the margin of the Yangtze Continent. Li Qiufen used another nomenclature, Yanting-Tongnan trough [21], and suggested the trough was generated by NW basement fault activity in the Sichuan Basin during Mianlue Ocean spreading in the Late Permian Epoch based on seismic and geologic studies of the depositional framework. Liu Shugen [17] used another nomenclature, Mianyang-Lezhi-Longchang-Changning extensional trough, as per the view point of the Khanka taphrogeny and proposed the extensional trough experienced Tongwan movement at the end of Dengying depositional stage and then Maidiping deposition and reached the climax at Qiongzhusi depositional stage; after Canglangpu deposition, the trough finally disappeared during the Longwangmiao deposition. This rift was confirmed by Wei Guoqi et al. [22].

An aulacogen (also known as the rift or rifted graben) is defined as the geosyncline or graben developed within a craton

Download English Version:

https://daneshyari.com/en/article/1747812

Download Persian Version:

https://daneshyari.com/article/1747812

Daneshyari.com