

Research article

Exploration practices and prospect of Upper Paleozoic giant gas fields in the Ordos Basin

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Abstract

Natural gas resources is abundant in the Ordos Basin, where six gas fields with more than 100 billion cubic meters of gas reserves have been successively developed and proved, including Jingbian, Yulin, Zizhou, Wushenqi, Sulige and Shenmu. This study aims to summarize the fruitful results and functional practices achieved in the huge gas province exploration, which will be regarded as guidance and reference for the further exploration and development in this basin. Based on the past five decades' successful exploration practices made by PetroChina Changqing Oilfield Company, we first comb the presentation of geological theories at different historical stages as well as the breakthrough in the course. Then, we analyze a complete set of adaptive techniques obtained from the long-time technological research and conclude historical experiences and effective measures in terms of broadening exploration ideas, such as the fluvial delta reservoir-forming theory, giant tight gas reservoir-forming theory, the idea of sediment source system in the southern basin, etc., and innovating technical and management mechanism, such as all-digit seismic prediction, fine logging evaluation for gas formations, stimulation of tight sand reservoirs, flat project and benchmarking management, and so on.

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Keywords: Ordos Basin; Exploration history; Geological theory; Supporting technology; Management innovation; PetroChina Changqing Oilfield Company

1. Discovery of large gas fields

The Ordos Basin is the second largest sedimentary basin in China. Natural gas resources in this basin are up to $15.16 \times 10^{12} \text{ m}^3$, including $12.61 \times 10^{12} \text{ m}^3$ in Upper Paleozoic [1]. Currently, PetroChina Changqing Oilfield Company (hereinafter referred to as “Changqing Oilfield”) has discovered nine gas fields (i.e. Sulige, Jingbian, Wushenqi, Yulin, Shenmu, Mizhi, Zizhou, Shenglijing and Liujiazhuang) in this basin; except the Jingbian gas field, the other eight ones are Upper Paleozoic gas fields (Fig. 1). By the end of 2014, the proved gas reserves (including basically proved) in this basin

was up to $5.7 \times 10^{12} \text{ m}^3$, and the annual gas production was $382 \times 10^8 \text{ m}^3$. Discovery of these gas fields presents the successful process of practice – cognition – re-practice, and is the fruitful results achieved by people in the Changqing Oilfield through their continuous searching of new exploration methods, summarizing of exploration experiences and stressing of technical innovations. In practices, the oil and gas exploration activities have been increasingly challenged by higher exploration maturity and higher complexity of exploration targets. Through changing exploration conceptions and dedicating more to exploration studies to make theoretical, technical and management innovations, further new breakthroughs have been made in natural gas exploration in the Ordos Basin. Therefore, Changqing Oilfield has developed to be the largest natural gas production base and the hub of natural gas pipe network in China.

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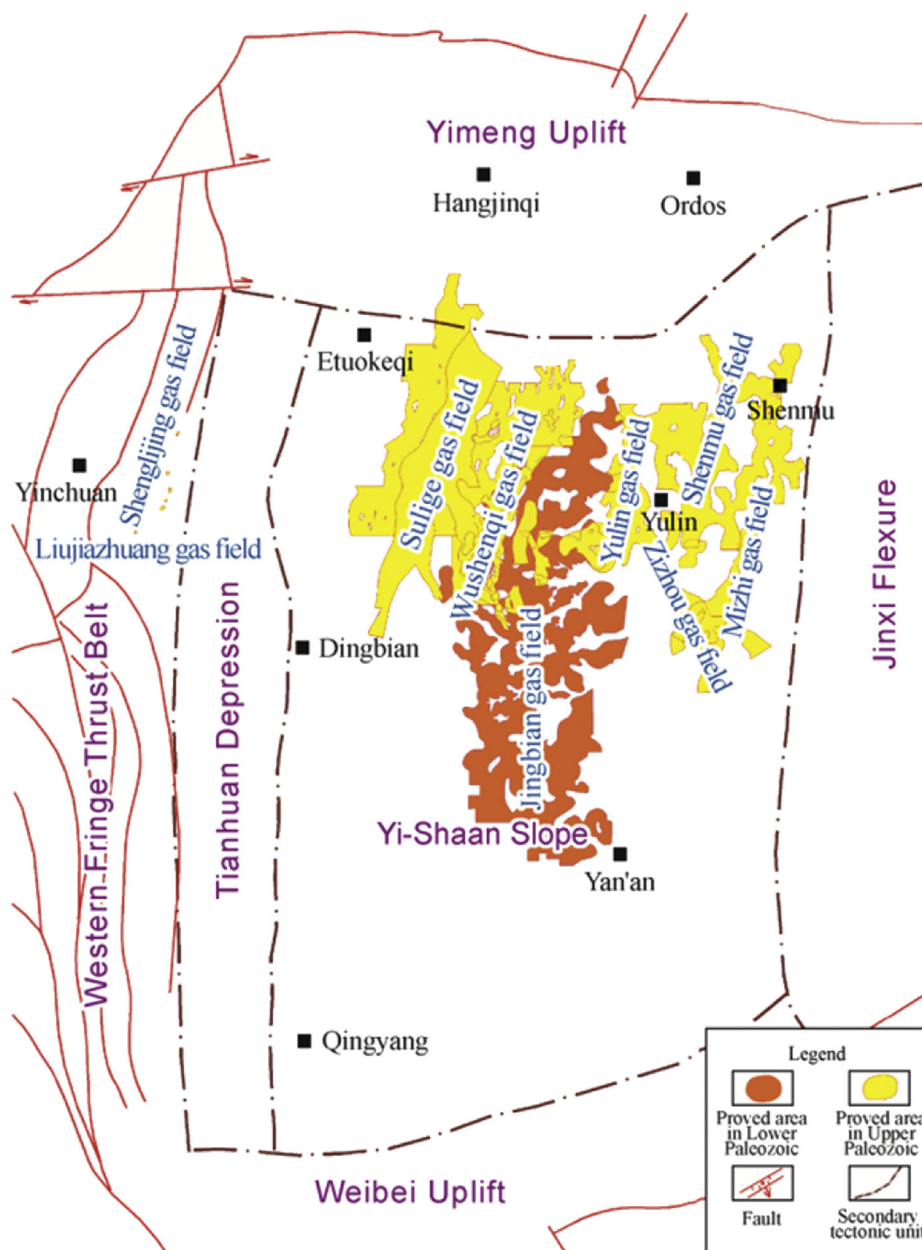


Fig. 1. Distribution of gas fields in the Ordos Basin.

Petroleum industry history of China has demonstrated that the petroleum explorationists should continuously develop new techniques, with a liberated mind, and apply them in practice, rather than drown themselves in predecessors' experiences and conclusions. During the over 50 years of natural gas exploration history of the Ordos Basin, generations of explorationists always insisted on thought liberation to break the boundaries of knowledge, which thus contributed to more and more breakthroughs in natural gas exploration in this basin. Natural gas exploration in this basin successively underwent several major strategic adjustments “from basin periphery to basin hinterland, from structural traps to lithologic–stratigraphic traps, from low permeability carbonate gas reservoirs in Lower Paleozoic to tight sandstone lithologic gas reservoirs in Upper Paleozoic” [2].

Natural gas exploration in the Ordos Basin started from the 1950s. Early exploration focused on structural gas reservoirs, mainly those in structural traps on the basin periphery; however, only some small gas reservoirs (e.g. Liujiazhuang and Shenglijing) were discovered, without substantial breakthrough. Until the end of 1970s, with the natural gas researches made during the periods of 6th and 7th Five-year Plans of China, researchers recognized that the Upper Paleozoic in the Ordos Basin was a large coal-rich cratonic basin covering a wide area [3]. In this regard, coal-formed gas theory was introduced, and the focus of natural gas exploration in the Ordos Basin changed from the basin periphery to the basin hinterland [4–7]. In 1987, industrial gas flows were obtained in Wells Zhenchuan 1 and Zhenchuan 4 in the eastern basin by gas testing, with the

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