Petroleum Research xxx (2018) 1–19

Contents lists available at ScienceDirect

Petroleum Research

journal homepage: http://www.keaipublishing.com/en/journals/petroleum-research/

Full Length Article

Gas accumulation conditions and key technology for exploration & development of Sulige gasfield

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ARTICLE INFO

Article history:
Received 30 October 2017
Received in revised form
30 January 2018
Accepted 10 February 2018
Available online xxx

Keywords:
Sulige gasfield
Upper paleozoic
Tight gas
Accumulation condition
Key technology

ABSTRACT

Up to now, the Sulige area in Ordos Basin has the favorable exploration area of 55×10^3 km^2, the total reserve of natural gas of nearly 6×10^{12} m^3 and the proven reserve (including basic proven reserve) of 4.77×10^{12} m^3, where the annual production of natural gas reaches 23×10^9 m^3, and the Sulige gasfield is the largest onshore natural gas field in China. The pay zone of the Sulige gasfield mainly is Member 8 of Shihezi Formation and Member 1 of Shanxi Formation of Permian which belong to the typical tight sandstone gas reservoir. The coal measure strata in Carboniferous Benxi Formation, Permian Taiyuan Formation and Shanxi Formation provide abundant gas sources for the Gulige gas reservoirs. An open-flow sedimentary model of lacustrine delta is developed, the gentle bottom, sand supply from multi-source, strong hydrodynamic force and multi-period superposition control the distribution of large-area reservoir sand body. Lithology of the reservoir is the sandstone of the fluvial-delta facies, the physical property is poor and the heterogeneity is strong, the average porosity ranges from 4% to 12% and the average permeability varies from 0.01 to 1 mD. The gas reservoir is characterized by wide hydrocarbon generation, pervasive hydrocarbon charging, short-range migration and massive accumulation. The pressure coefficient of the gas reservoir ranges from 0.62 to 0.90, indicating the low-pressure gas reservoir, and the single-well yield is low. Full digital seismic technique in the desert area, non-longitudinal seismic technique in the loess plateau, accurate logging evaluation technique, tight sand reservoir stimulation technology and horizontal well development technology are key technologies for exploration and development of Sulige gasfield.

1. Introduction

The Sulige gasfield is located in northwestern Ordos Basin, of which the north part of the gasfield is subordinate to the Inner Mongolia Autonomous Region, the earth surface environment is dominated by desert and grassland, the terrain is relatively flat with an altitude of 1200–1350 m; the southern part of the gasfield is subordinate to Shaanxi Province, the earth surface environment is dominated by loess plateau areas with an altitude of 1100–1400 m. The gasfield extends across three tectonic units, namely Yimeng uplift, Tianhuan depression and Yishan slope (Fig. 1), covering the favorable exploration area of 55×10^3 km^2 and natural gas resources of nearly 6.0×10^{12} m^3.

The main pay zone of Sulige gasfield is Upper Paleozoic Shihezi Formation and Shanxi Formation (Fig. 2), characterized by multiple gas-bearing strata, thin single layer, poor reservoir physical property, strong heterogeneity, low pressure coefficient and low reserve abundance, indicating it belongs to the typical tight gas reservoir with low permeability, low pressure and low abundance (Zhao et al., 2005; Dai et al., 2012; Yang et al., 2016).

Since discovered in 2000, through the early evaluation stage, overall exploration stage and overall development stage, the proven reserve (including basic proven reserve) of the Sulige gasfield is 4.77×10^{12} m^3, the proven gas-bearing area is 38.8×10^3 km^2, and the annual production reaches 23×10^9 m^3; the Sulige gasfield has become the largest onshore natural gas field in China so far.

The successful exploration and development of Sulige gasfield

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https://doi.org/10.1016/j.ptlrs.2018.06.002

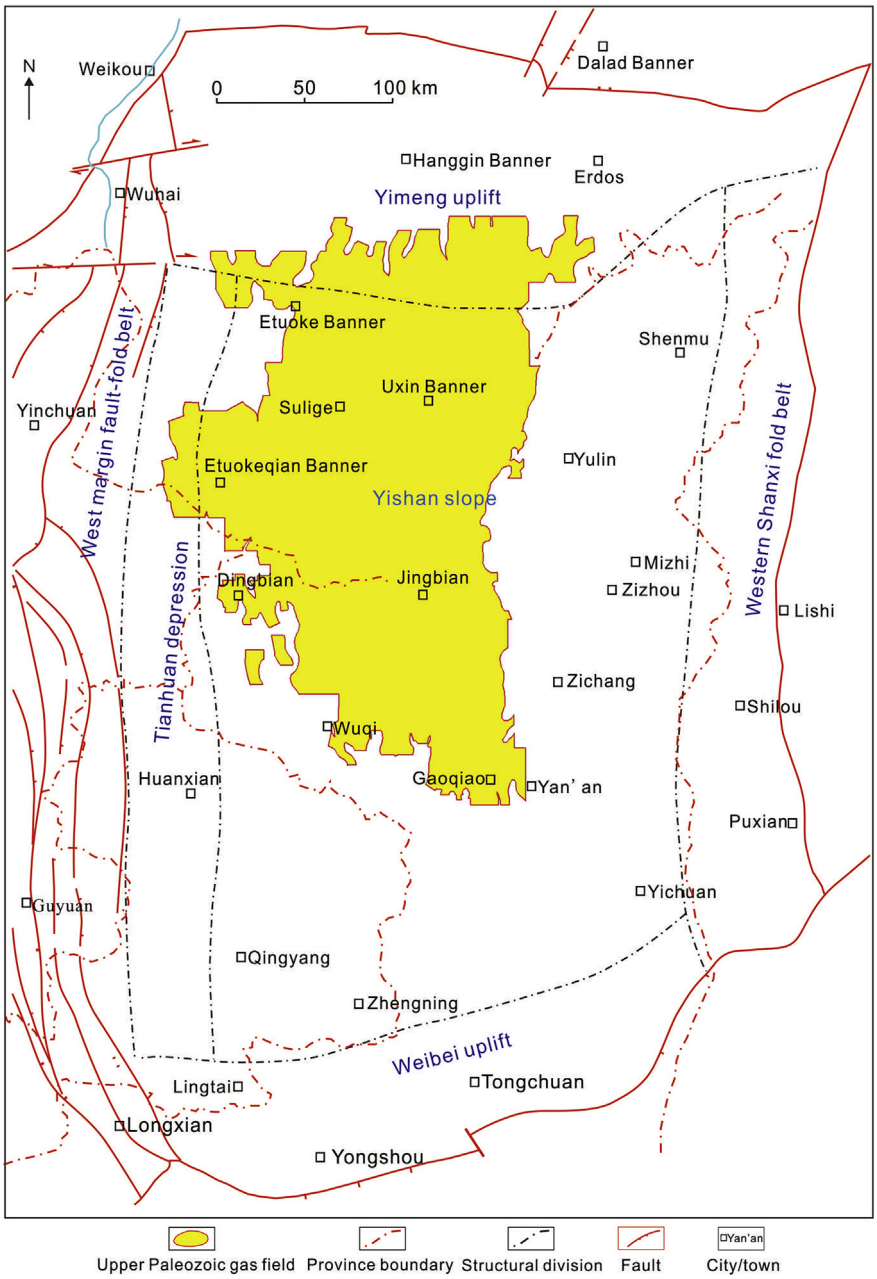

Fig. 1. Tectonic characteristic and location of the Sulige gasfield in Ordos Basin showing that the gasfield extends across Yimeng uplift, Tianhuan depression and Yishan slope.

has broadened the new idea for natural gas exploration in the terrestrial concealed tight sandstone. This study intends to review exploration and development history of the gasfield, summarize geological characteristics and gas accumulation conditions as well as key exploration technologies, and provide experiences and references for development of geological theory of natural gas in China and exploration & development of similar gas reservoirs in other basins.

2. Discovery of the gasfield and its exploration & development history

2.1. Discovery of the gasfield

In the 1980s, guided by the coal-derived gas theory, the exploration target of natural gas in Ordos Basin was shifted from the margin of the basin to the hinterland, and the exploration field was transferred from structural traps to lithologic traps, and the Lower Paleozoic Ordovician gas reservoir of ancient weathering crust represented by Jingbian gasfield and the Upper Paleozoic Carboniferous-Permian lithologic gas reservoir of clastic rock represented by Yulin gasfield were discovered respectively (Yang et al., 2012a). Especially since the discovery of the Yulin gasfield, based on the comprehensive analysis of river-delta depositional system and gas reservoir formation conditions, it was recognized that good configuration of wide-distributed coal-series gas source rocks and river-delta sand body provided favorable conditions for formation of large-scale gas reservoirs of sandstone. On this basis, the large-scale river-delta composite sand body in the northern part of the basin was regarded as a key target for priority exploration. In 2000, a high-yield industrial gas flow was obtained in Well S6 with an open-flow capacity of 1201.6×10^3 m^3/d in Member 8 of Permian

Please cite this article in press as: Fu, J., et al., Gas accumulation conditions and key technology for exploration & development of Sulige gasfield, Petroleum Research (2018), https://doi.org/10.1016/j.ptlrs.2018.06.002