1 Introduction

With almost five years of efforts, we have made major breakthrough and important advances in shale gas in many areas, such as the marine and continental shale in Sichuan Basin, the continental shale in Erdos Basin and the transitional shale in North China. China has begun shale gas productivity constructions in many shale gas development demonstration areas, such as Chongqing Fuling and Sichuan Changlin-Weiyuan, where early stage large-scale development of shale gas has been started (Zhang, 2010; Li, 2012; Dong et al., 2012; Luo and Li, 2013; Pan and Huang, 2009; Wang, 2014). China, following U.S. and Canada, has become the third country realizing commercial development of shale gas.

2 Great Breakthrough in Exploration of Marine Lower Silurian Longmaxi Formation in Southern China

Since 2009, the first geological survey well of shale gas in Chongqing, well Yuye-1 presented favorable shale gas show in Longmaxi formation. China has made its first breakthrough in exploration and development of marine shale gas in Sichuan Basin. SINOPEC has realized development of the first large-scale shale gas field in Chongqing Fuling. Up to now, the gas field has accumulated produced over 12×10^8 m^3 of gas, and obtained 2500×10^8 m^3 of proved, probable and possible reserves (PPPR), including 1067.5×10^8 m^3 of proven geological reserves. Well JY1HF was the first commercial horizontal well to get 16.7×10^4 m^3/d, after 15 stages of fracturing (Zhou et al., 2014). Moreover, drilling of well Dingye-2HF is expected to make Dingshan Area become SINOPEC's second commercial development field of shale gas following Fuling.

CNPC has realized a series of breakthrough in high shale gas production in Longmaxi formation successively in Sichuan Changling and Weiyuan, and Yunnan Zhaotong, with 16.5×10^4 m^3/d of initial production after staged fracturing in well Wei-20415×10^4 m^3/d of testing production in well Ning-201, 1.2×10^4 m^3/d of initial production in well Zhao-104 and 20×10^4 m^3/d of maximum production in horizontal well YS108H1-1. CNPC has also obtained 2000×10^8 m^3 of PPPR because of its breakthrough in shale gas investigation in Changling, Weiyuan and Zhaotong. Other bid winners have obtained favorable shale gas discoveries during drilling of wells Zhuoye-1 and Baoye-1 targeting Longmaxi Formation. In the blocks such as Chongqing Qianjiang and Hunan Baojing, with gas content up to 1-4 m^3/t. Among them, the maximum production of well Baoye-1 during the production test after fracturing reached 2000 m^3/d, and that of well Longcan-2 reached 6000 m^3/d.

The analysis of exploratory drilling in Longmaxi Fm. shale in southern China (Fig. 1) shows that the wells with production over 104 m^3/d are mostly distributed in Sichuan Basin, and the drilling results on the periphery of Sichuan Basin present favorable shale gas shows, but the wells far away from Sichuan Basin present relatively poor shows.

3 High Gas Production in Parts of Marine Lower Cambrian Niutitang Shale in Southern China

Through analysis, it is found that the exploration efforts targeting Niutitang realized high shale gas production merely in Weiyuan Structure of southwestern Sichuan. SINOPEC has obtained high gas production of 8×10^4 m^3/d during production test in well Jinye-1HF. In well Ciye-1, there are 13 layers showing gas logging abnormalities in Lower Cambrian Niutitang Formation, and the desorbed gas was successfully ignited onsite. Moreover, favorable
shale gas shows were obtained successively in wells Cenye-1, Youye-1, Wuye-1, Maye-1 and Zidi-1 in Guizhou, Hubei and Chongqing. The drilling operations of other bid winners in Chongqing Chengkou and Guizhou Cengong showed favorable development potential as well. Among them, the production of well TX-1 during production test after fracturing reached 3000 m³/d. However, shale gas shows bad in most of the exploratory drilling efforts targeting Niutitang, which encounters problems such as low gas and methane content, high nitrogen content and water-bearing strata. We can say that the Structural complexity will be the key factor affecting exploration and development of shale gas in Niutitang. (Fig. 2).

4 Breakthrough Investigation of Transitional Shale Gas in North China Area

China has obtained breakthrough and discoveries in shale gas successively in Triassic Series in Erdos Basin, and Carboniferous-Persian transitional in north China. For the wells operated by Yanchang Petroleum, the production of well Liuping-177 reached 2350 m³/d, and that of well Yunyeping-1 in Permian Shanxi in the Yishan Slope of
Erdos Basin reached \(2 \times 10^4\) m\(^3\)/d after staged fracturing, realizing great breakthrough in transitional shale gas. In well Weican-1, 49 m of Shanxi Formation organic-rich mudstone was encountered with desorbed gas content of 2.9 m\(^3\)/t.

5 Breakthrough Investigation of Continental Shale Gas in China

China has also obtained breakthrough and discoveries in shale gas successively in Triassic Xujiahe Formation in western Sichuan Basin, Lower Jurassic Series in northeastern Sichuan Basin and Qaidam Basin. For well Xinye HF-2 in western Sichuan, the maximum production reached \(4.6 \times 10^4\) m\(^3\)/d during the production test after fracturing. For well Yuanye HF-1 in Yuanba Block of northeastern Sichuan, the shale gas production reached 7000 m\(^3\)/d after fracturing. For well Jianye HF-1 in Jiannan Block, the tested production reached \(1.23 \times 10^4\) m\(^3\)/d. In addition, some significant discoveries were made in the continental facies and the Permo-Carboniferous transitional facies in North China. In well Chaiye-1, totally 54m/19 layers with gas logging abnormalities were found in Middle Jurassic Dameigou Formation in the interval of 1901-2180 m, with gas content of 1-5 m\(^3\)/t.

6 Trends and Prospect of Shale Gas in China

China, with many shale gas bearing series of strata, has great potential in shale gas resources. As the exploration and development of shale gas resource goes further, China will make more shale gas discoveries in other series of strata and areas, such as Wuling Mountain Area, Dianqiangui area and the middle and lower Yangtze Region in Marine facies. Some new discoveries may be get in Continental and Transitional facies in north china area. After the breakthrough of Fuling, Changning, Zhaotong, Pengshui and Dingshan area may also can get new commercial production in the future.

References


