

GEOCHEMICAL FEATURES AND GENESIS OF THE NATURAL GAS IN NANPANJIANG BASIN, CHINA

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The natural gas with high N₂ content in the Nanpanjiang Basin is not generated by crude oil cracking but sourced from kerogen cracking of the Middle Devonian argillaceous source rock. The accumulation of the natural gas at the late stage of the source rock evolution is the main reason for the gas being of high N₂ content and heavier carbon isotopes.

1 Geochemical features of natural gas

The natural gas from the bottom of the Triassic Feixianguan tuffaceous sandstone reservoir in Well Luoping 4 accounts for 87% of N₂ and 13% of methane, and its drying coefficient is 1. Methane, N₂ and C₂H₆+ in the natural gas from the Chehe anticline in Nandan are 54.93%, 44.98% and 0.08%, respectively and its drying coefficient is near 1. It is notable that natural gas in Well Yang 1 is comparatively complicated, the testing components of the gas from the same well section of 2573~2594 m are greatly different, basically belonging to two types, namely the one with high N₂ content (for the first sampling on July 15-16, 2001) and the one with high CO₂ content (for the secondary sampling on July 30 to Aug. 8, 2001).

$\delta^{13}\text{C}_1$ of the natural gas for the first sampling is -33.19‰ and its $\delta^{13}\text{C}_{\text{CO}_2}$ is -30.93‰. But Liao (2002) reported that this gas had $\delta^{13}\text{C}_1$ of -38.2~ -38.4‰ and $\delta^{13}\text{C}_{\text{CO}_2}$ of -29.3‰, respectively. However, when CO was removed, the gas had $\delta^{13}\text{C}_1$ of -33.9‰, basically consistent with our measurements. The analysis results for the secondary sampling are much similar but obviously different from the data for the first sampling. The $\delta^{13}\text{C}_1$ and $\delta^{13}\text{C}_{\text{CO}_2}$ of the gas are -28.3‰~-28.7‰ and -3.5‰~-3.8‰, respectively.

The natural gas in Well Yang 1 can be divided into two types, namely the one with high N₂ content and another one with high CO₂ content. We conclude that the natural gas with high N₂ content sampled in the first time is of the features of organic thermal evolution and can reflect the hydrocarbon accumulation in the Nanpanjiang Basin.

2 Gas generation and formation

The bitumen in the Nanpanjiang paleo-oil reservoir is pyrobitumen generated by crude oil cracking, so it should be presumed that natural gas in the Nanpanjiang Basin is generated by crude oil cracking. But our study indicates that the natural gas with high N₂ content in the

Nanpanjiang Basin is mainly generated by kerogen cracking of the Middle Devonian muddy source rock at the later stage, the reasons are as follows:

Heavier $\delta^{13}\text{C}_1$ values. The natural gas in the Nanpanjiang Basin with the heavier $\delta^{13}\text{C}_1$ is generated by kerogen cracking. $\delta^{13}\text{C}_1$ of the crude-cracked gas sourced from the same source rock is lighter than that of the kerogen-cracked gas.

Genesis for high N_2 content in natural gases. The content of N_2 for the Nanpanjiang natural gas is high, up to 54.92%~73.89%, and the $\delta^{13}\text{C}_1$ is -33.2‰~-33.9‰. The natural gas accumulated in Nanpanjiang Basin is generated from the Devonian source rock with the R_o over 3.0%. Under this kind of maturity, the amount of the generated hydrocarbon gas becomes less and the main reaction is N_2 formation by NH_4^+ ions cracked from clay minerals at high temperature (Idiz et al., 1995).

Rare gases in the natural gas. The highest helium content in Well Yang 1 natural gas is 1.28%. The Devonian in the Nanpanjiang Basin contains not only hydrocarbon source rocks but also ore source beds for various minerals, which are associated with high contents of uranium and thorium (Tu, 1989).

The Devonian is the main source for hydrocarbons with the oil-generation peak in Early Carboniferous and gas-generation peak in Later Carboniferous. Crude cracking happened in Later Carboniferous with the peak in Permian. In the end of Later Permian and Early Triassic, oil generated by the Middle Devonian source rock cracked into natural gas completely. When crude oil in paleo-oil reservoirs cracks into natural gas in great quantity, certain amount of natural gas is also generated by kerogen cracking. Since the maturity of source rocks in this stage is over 3.0%, the natural gas formed by kerogen cracking is rich in N_2 and accumulates with normal pressure adjacent to the crude-cracked gas reservoir that has abnormal high pressure.

It is more important that although the Middle-Lower Triassic desposit is thick in the Nanpanjiang Basin at present, generally ranging between 1000 m and 3500 m, the eroded thickness of the Triassic is 2000~4500 m. The erosion destroyed the pressure system of the original gas reservoir, thus, the crude-cracked gas reservoir with abnormal high pressure was completely destroyed while the kerogen-cracked gas reservoir with normal pressure has been preserved under locally sealed conditions.