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Stable Carbon Isotope Characteristics of Natural Gas in the Lower Paleozoic of Southern Jingbian Gas Field and Its Significance to Gas Source, Ordos, China

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Introduction

Ordos Basin has become the oil and gas basin owning most proven reserves in China (Dai et al., 2005). Jingbian gas field is located in middle of Ordos Basin, which is the only one Lower Paleozoic large gas field discovered in the basin with the Lower Ordovician Majiagou Formation carbonate rocks as the main reservoirs (Dai et al., 2008; Liu et al., 2009). Numerous investigations on gas sources, origin, gas types and distribution, made a majority of researchers agree that gas in Jingbian gas field is mixed gases and the Upper Paleozoic reservoired gases are mainly derived from the Carboniferous–Permain coal measures, referred to as coal-derived gas (Zhang, 1994; Dai et al., 2003; Li et al., 2005). However, there is still a great debate about the type and main source of natural gas in the Lower Paleozoic (Cai et al., 2005; Dai et al., 2005).

The previous analysis of Jingbian gas field is mainly concentrated in the central and northern region, whereas analysis in the southern part is rare. These new data of gas stable carbon isotope from southern Jingbian gas field will supplement the understanding of gas stable carbon isotope reversal and gas source of the Lower Paleozoic in the whole Jingbian gas field.

Results

In the Lower Paleozoic of southern Jingbian gas field, $\delta^{13}C_1$ and $\delta^{13}C_2$ are all significantly lighter than that in the Upper Paleozoic. Different from various stable carbon isotope reversal phenomenon displaying in the Upper Paleozoic of the study area ($\delta^{13}C_1>\delta^{13}C_2>\delta^{13}C_3$, $\delta^{13}C_1<\delta^{13}C_2>\delta^{13}C_3$ and $\delta^{13}C_1>\delta^{13}C_2<\delta^{13}C_3$), alkane gas of 10 samples from the 12 natural gas samples collected in the Lower Paleozoic display reversal between CH_4 and C_2H_6 carbon isotopes ($\delta^{13}C_1>\delta^{13}C_2<\delta^{13}C_3$), with only two gas samples from Well Shan 310 and Shan 377 displaying a normal order of $\delta^{13}C_1<\delta^{13}C_2<\delta^{13}C_3$.

Using $\delta^{13}C_1$-R_o relationship can distinguish coal-type methane and oil-type methane (Dai and Qi, 1989; Hu et al., 2007). The R_o values of Paleozoic Carboniferous source rocks are 1.2% ~ 2.2% and the thermal evolution degree of the marine limestone is lower, while the R_o values of Lower Paleozoic Ordovician source rock are relatively high about 2.07% ~ 2.68% (Hu et al., 2007). According to the oil-type gas equation (Dai and Qi, 1989), the R_o values in the study area range from 0.88% to 1.69%, whereas according to the oil-type gas equation (Dai and Qi, 1989), the R_o values range from 2.79% to 5.00%, which obviously do not conform to the actual parameters. It can be seen that the thermal evolution of gas in the study area is closer to the thermal evolution of the Upper Paleozoic coal measure source rocks.

Conclusions

1. Natural gas in the Lower Paleozoic of southern Jingbian gas field is the mixed gases containing coal-derived gas and oil-type gas.
2. During the downward migration of the Upper Paleozoic natural gas in the southern Jingbian gas field, the component fractionation occurred and caused methane content increasing and further change of carbon isotope values. Additionally, isotope fractionation caused by diffusion made methane carbon isotope of the Lower Paleozoic natural gas significantly reduced.
3. The natural gas carbon isotope reversal phenomenon of southern Jingbian gas field in the Lower Paleozoic is mainly due to a large number of the Upper Paleozoic coal-derived gas downward diffusion migration and mixing with oil-type gas.
4. The Lower Paleozoic methane in the study area is mainly derived from the coal-derived methane from the Carboniferous-Permian, and the proportion of coal-derived gas in the mixed gases is high. Besides, oil-type gas in the mixed gases mainly comes from the Upper Paleozoic marine limestone.

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