

The Formation Mechanism of the Multi-Phase Reservoirs in the Ordovician of Tarim Basin, NW China

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Introduction

The fore-bulge of the Northern Tarim Basin is the most important exploration area of the marine craton. In this area, enriched petroleum sources and multilayered reservoirs have been determined to be developed. The hydrocarbon phases are quite diversified and complex, and include condensates, normal oils, heavy oils, and dry asphalt. According to the systematic analysis of the formation, evolution, and conservation of the marine reservoirs in the fore-bulge of the Northern Tarim Basin, as well as the geochemistry characteristics of the petroleum and fluid inclusions, it is believed that the Ordovician marine reservoirs in the eastern fore-bulge experienced three important hydrocarbons charging stages.

Results

The Cambrian-Lower Ordovician and Middle-Upper Ordovician are the two main sets of source rock in the Northern Tarim Basin. The deposition environments and formation modes of the source rock were different, and thus the biomarkers were also obviously different. The biomarkers of the Cambrian-Lower Ordovician source rock contained large contents of C₂₈ $\alpha\alpha\alpha$ 20Rsterane, Gammacerane, Dinosterane, Triaromatic dinosterane, 4-methyl sterane, C₂₆-4-norcholestane, and Tricyclic terpane, as well as small contents of Diasterane, and the heavy carbon isotope of individual n-alkanes. The geochemical characteristics of the Middle-Upper Ordovician source rock were the opposite of those of the Cambrian-Lower Ordovician source rock. These indexes could therefore be used for the qualitative distinction of the hydrocarbons which have originated from the two sets of source rock. The distinction of Dinosterane and Triaromatic dinosterane, which originated from dinoflagellate, easily indicated the hydrocarbons which had been generated from the Cambrian-Lower Ordovician source rock. In regard to the hydrocarbons from the Cambrian-Lower Ordovician, the contents of methyl triaromatic sterane (m/z 245) and triaromatic sterane (m/z 231) were found to be quite high [1]. According to the oil-source correlation of the marine reservoirs in the Northern Tarim Basin, it had been demonstrated that over 90% of the oil samples were derived from Middle-Upper Ordovician source rock. Also, the oil which was mixed with hydrocarbons from the Cambrian-Lower Ordovician source rock was mainly distributed in the eastern fore-bulge, including the condensate of well LG-39. The petroleum in the Yingmaili, Halahatang, Tahe, and western Lungu oil fields was determined to have originated from the Middle-Upper Ordovician source rock.

Discussion

We have developed models to reconstruct the mixing process in the deeper and more mature reservoirs based on isotope fractionation and kinetic parameters of alkane gases for the generation and cracking processes. In consideration of the maturity of hydrocarbon kitchen in

the Tarim Basin, the over-mature kerogen cracking gas with R_o around 3% and oil cracking gas with various maturities were selected to estimate the extent of mixing. In this model, the relative content of oil-cracking gases varies from 42 to 98%, which is considered the main source for the condensate gases in the basin. The mixture of kerogen and oil cracking gas with various maturities could also lead to the carbon isotope reversal of methane and ethane in the marine gases. This is further corroborative evidence indicating the condensate reservoirs represent a secondary mixture rather than primordial ones.

Except from the genetic characteristics, the potential source of the condensate gases is another important issue for deep exploration in the Tarim Basin. Given that the maturity of condensates exceed 1.1% (VR^E_o), the concentration of sterans and hopanes are scarce in most samples collected. Hence, the special aromatic biomarkers such as dino-triaromaticsterane (Dino-TAS) and 3-methyl-24-ethyl- triaromaticsterane (3-M, 24-E-TAS) can be used to pinpoint the source kitchen. Although the main source of the hydrocarbons in the Tarim Basin is still not unequivocally, the unique identification of Dino-TAS indicate that the source rocks are Cambrian [2]. However, the concentration of 3-M,24-E-TAS is negligible in the Cambrian units. Therefore, the ratio of Dino-TAS/(Dino+3-M, 24-E-TAS) could be used to indicate the proportion of the contribution from the Cambrian rocks in individual reservoirs. Through the comparison of oils and condensate reservoirs in the Tabei and Tazhong Uplifts, the values of $\delta^{13}C_2$ - $\delta^{13}C_1$ show a notable negative correlation with the Dino-TAS/(Dino+3-M, 24-E-TAS) ratio (Fig. 1). This shows that the relative content of Dino-TAS in most condensates is much higher than that of oils, and the hydrocarbons in the condensate reservoirs could have been generated from the Cambrian units. Furthermore, the proportion of hydrocarbons derived from the Cambrian units distinctly rises with the increasing of thermal maturity in the condensate reservoirs [3]. These observations indicate that the Cambrian hydrocarbon kitchen is the main source of condensate gases.

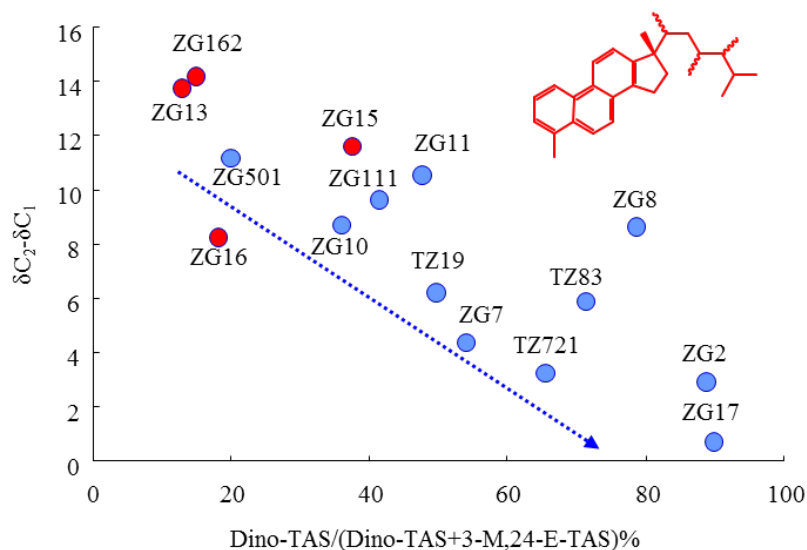


Figure 1 Correlation of the $\delta^{13}C_2$ - $\delta^{13}C_1$ with the contribution of Cambrian source rocks in the Tazhong area. Abbreviation TAS = Triaromaticsterane

References

- [1] Hanson, A. D., Zhang, S. C., Moldowan, J. M., Liang, D. G., Zhang, B. M., 2000. Molecular organic geochemistry of the Tarim Basin, Northwest China. AAPG Bulletin, 84, 1109-1128.
- [2] Zhang, S., Huang, H., Xiao, Z., Liang, D., 2005. Geochemistry of Palaeozoic marine petroleum from the Tarim Basin, NW China. Part 2: Maturity assessment. Organic Geochemistry 36, 1215-1225.
- [3] Thompson, K.F.M. 2016. Hybrid gas condensates and the evolution of their volatile light hydrocarbons. Organic Geochemistry 93: 32-50.