DIAMONDOID AND OIL-CRACKING OF ORDOVICIAN OILS FROM TAHE OILFIELD, TARIM BASIN, NW CHINA

Anlai Ma[a*], Zhijun, Jin[a], Cuishan Zhu[b]

[a] *Petroleum Exploration & Production Research Institute, SINOPEC, Beijing, China*
[b] *Yangtze University, Jinzhou, Hubei, China*

Introduction

With exploration moving to deep strata in Tarim Basin, NW China, the petroleum depth limit is becoming deeper and deeper. In the Ordovician strata greater than 6500m, a series of petroleum reservoirs have been discovered. Due to high temperature and high pressure of deep strata, the oil in the deep is liable to suffer thermal cracking, TSR and evaporative fractionation, especially thermal cracking. Two methods have been developed to explain the occurrence of the oil in the deep reservoirs. One is the chemical kinetics method. The other method is known as "diamondoid-biomarker cracking method" to estimate the degree of oil-cracking and mixing (Dahl **et** al., 1999). Although the "diamondoid-biomarker" method has been used to assess the oil-cracking (Zhang et al., 2011) in the Tarim Basin, diamondoid baseline in the Tarim Basin was referred only by Fang et al. (2013), which is about 47 ppm, much greater than that of the value of 8~10ppm for an unknown basin proposed by Dahl et al. (1999).

In this paper, 76 crude oil samples from Tahe oilfield, in which 41 oil samples from Ordovician, were selected and the biomarker, maturity and diamondoid concentrations were determined. The purpose of the study was to determine the maturity and the degree of oil-cracking of the Ordovician oils.

Result

Almost all the marine oils in the Tahe Oilfield originated from similar source rocks, Ts/(Ts+Tm) can be used as an effective maturity indicator. The Ts/(Ts+Tm) ratio shows positive relationship with C_{29}Ts/(C_{29}H+C_{29}Ts) ratio of oils from different aged reservoirs in Tahe Oilfield. The Ordovician oils show most widest Ts/(Ts+Tm) and C_{29}Ts/(C_{29}H+C_{29}Ts) ratios ranges, with 0.27~0.97 and 0.16~0.59, respectively. The MPI1 values of oils from different aged reservoirs ranges from 0.42 to 1.27 and the calculated Rc ranges from 0.65% to 1.16%. The MAI values ranged from 0.61 to 0.81 and MDI value are in range of 0.38~0.52. According to Chen et al. (1996), the maturity of oils from Tahe Oilfield, ranging from 1.1% to 1.6% Ro, which is consistent to that of oils from Tabei and Tazhong Uplifts (Zhang et al., 2005), higher than the maturity results obtained by Ts/(Ts+Tm) and MPI1. Difference in maturity calculated from different compound classes proposed that either different compound classes were generated at different maturation stages of a source rock, or the oils represent mixtures from more than one source or from different maturity segments of a source rock (Zhang et al., 2005b). Generally, diamondoid enriched at the high maturation stage, i.e. *Ro*>1.1%. The heavy oil and normal oil reservoirs from Tahe oilfield have at least two oil filling history, as revealed by the coexistence of 25-norhopane and n-alkane in most of oils. This discrepancy of maturity also reflect the Ordovician reservoir have the multiple filling history.

The main producing reservoirs of Tahe Oilfield include Ordovician, Triassic and Carboniferous. The concentration of A (adamantane) of oils from different reservoirs showed satisfied linear relationship with that of As (adamantane series), with A concentrations of oils ranging from 202 to 2709 ppm and most values below 2000 ppm. And also the D (diamantane) concentrations of oils showed satisfied linear relationship with that of 4-MD+3-MD, with the D concentrations ranging from 3 to 71 ppm and 4-MD+3-MD concentrations in the range of 4-73 ppm. The values of the 4-MD+3-MD is scatter and lower than 30 ppm when Ts/(Ts+Tm) is below 0.55. Whereas Ts/(Ts+Tm) value is greater than 0.55, the concentration of 4-MD+3-MD increased rapidly.

From the concentrations of 4-MD+3-MD of unbiodegraded oils from Carboniferous and Triassic reservoirs, it is suggested that the diamondoid baselines should be 15 ppm, which is slight higher than that of Dahl et al. (1999). According to the method proposed by Dahl et al. (1999), the C_{29} stigmastane concentrations for most of the oils is greater than 20ppm, whereas the 4-MD+3-MD concentrations of most Ordovician oils is less than 35 ppm (Fig.1), suggesting cracking degree of Ordovician oil lower than 50%.

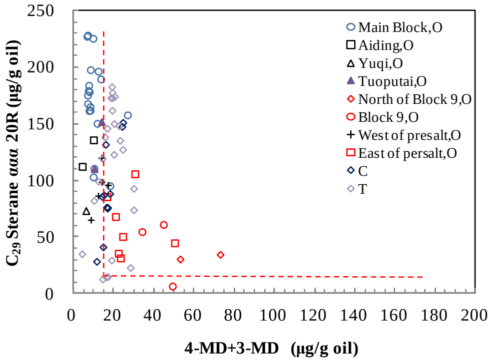

Fig.1 Correlations between 4-MD+3-MD and C_{29} stimastane concentrations in oils from different age reservoirs.

The concentration of 4-MD+3-MD of Ordovician oils in east of Tahe Oilfield is in the range of 35~60ppm, whereas in block Aiding of west, the value is about 5 ppm. Moreover, the concentration of 4-MD+3-MD of oils in the south such as oil from AT5 well is about 23 ppm, while in the main block, the values is about 7.5~10 ppm, indicating the maturity of oils from the main block are relatively uniform. According to the concentration of 4-MD+3-MD, the maturity of oils in south is higher than that of the main block and the maturity of oils in the east is higher than that of the west. Based on the distribution of concentration of 4-MD+3-MD, two main migration directions can be roughly described, one is from east to west and the other is from south to north.

Conclusions

1)The biomarker maturity parameters and MPI1 values suggested that the Ordovician oils of Tahe Oilfield is in the oil peak to condensate stage, whereas the diamondoids values such as MAI and MDI proposed that the maturity of Ordovician oils is in the range of 1.1~1.6% Ro, which is higher than that of maturity obtained by biomarker and MPI1. The discrepancy of the maturity from different parameters reflected that the Ordovician reservoirs have multiple filling histories.

2)The diamondoid baseline of oils of Tarim Basin is in the range of 15ppm. The concentration of 4MD+3-MD of most oils ranged from 4 to 35 ppm, indicating the oil cracking is lower than 50% and the deep strata has the petroleum exploration potential.

3)The distribution of 4-MD+3-MD concentration is characterized by higher in east, lower in west, higher in south and lower in north, indicating that the oil maturity of east and south is higher than west and north, respectively. The 4-MD+3-MD concentration may reflect the oil migration is from east to west, and from south to north, respectively, which is consistent with the results obtained by oil density and maturity parameters.

References

Chen, J. H., Fu, J. M., Sheng, G. Y., Liu, D. H., Zhang, J. J., 1996. Diamondoid hydrocarbon ratios: novel maturity indices for highly mature crude oils. Organic Geochemistry 25, 179-190.

Dahl, J. E. P., Moldowan, J. M., Peters, K. E., Claypool, G. E., Rooney, M. A., Michael, G. E., Mello, M.R., Kohnen, M. L., 1999. Diamondoid hydrocarbons as indicators of natural cracking. Nature 399, 54-56.

Fang, C. C., Xiong, Y. Q., Li Y., Chen, Y., Liu, J. Z., Zhang, H. Z., Adedosu, T. A., Peng, P. A., 2013. The origin and evolution of adamantanes and diamantanes in petroleum. Geochimica et Cosmichimica Acta 120: 109-120.

Zhang, S. C., Huang, H. P., Xiao, Z. Y., Liang, D. G., 2005b.Geochemistry of Paleozoic marine petroleum from the Tarim Basin, NW China. Part 2: Maturity assessment. Organic Geochemistry 36, 1215-1225.

Zhang, S. C., Su, J., Wang, X. M., Zhu, G. Y., Yang, H. J., Liu, K. Y., Li, Z. X., 2011. Geochemistry of Paleozoic marine petroleum from Tarim Basin, NW China: Part 3: Thermal cracking of liquid hydrocarbons and gas washing as the major mechanisms for deep gas condensate accumulations. Organic Geochemistry 42, 1394-1410.