SOURCE AND THERMAL MATURITY OF CRUDE OILS IN THE JUNGGAR BASIN, NORTHWEST CHINA: DETERMINED FROM THE DIAMONDOID INDICES

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Introduction

Due to the diamond-like structures, diamondoids are more thermally stable than most other hydrocarbons (Dahl et al., 1999), and are significantly more resistant to biodegradation (Grice et al., 2000). Although diamondoid ratios are considered to be a potentially useful tool in multiple aspects of petroleum geochemistry (e.g. determining the thermal maturity of source rocks and crude oils, estimating the extent of oil cracking), few systematic investigations have been undertaken on actual oil and gas fields. The Junggar Basin is an important oil-producing basin in northwest China, given that the oils in the Junggar Basin were sourced from at least six sets of source rocks, with a wide range of maturity from low-to over-mature, the basin is an ideal setting for studying diamondoid indices. Here we discuss three types of diamondoid parameters for oils from the Junggar Basin, which are: absolute concentrations, concentration ratios, and isomerization ratios.

Results

Sixty-six crude oil samples from the Junggar Basin are used in this study, comprising 12 condensates from the Kelameili gas field (eastern basin), 18 oil samples from the center of the basin, 26 oil samples from the northwestern part of the basin, and 10 oil samples from the southern margin of the basin. Fig. 1a shows that oils from the four regions have a significant variation in diamondoid concentrations of 0–7000 ppm for total adamantanes and 0–450 ppm for total diamantanes. In general, high diamondoid concentrations reflect high maturity, and thus the oils can be divided into three main areas. Data for oils plotting in area A have a relatively low concentration of diamondoids (< 100 ppm adamantanes and < 5 ppm diamantanes), indicating that the crude oils in this area are at the low-mature stage. This is supported by the low API gravity of the oils in area A (Fig. 1b), given that API gravity increases with increasing oil maturity. The oils in area B contain 100–1000 ppm adamantanes and 5–50 ppm diamantanes, and the total diamondoid concentration displays a positive relationship with the oil API gravity (Fig. 1b). This suggests that these oils have entered the mature stage. Diamondoids are enriched in oils from area C, with > 1000 ppm adamantanes and > 50 ppm diamantanes, indicating that these crude oils have entered the highly mature stage. In this stage, the oils are dominated by condensates with API gravity values of > 50° (Fig. 1b).

According to some diamondoid pairs based on adamantane concentration ratios (e.g., A/1-MA vs 1,3-DMA/1,3,5-TMA and A/MA vs DMAs/TMAs), the sources of the oils from the northwestern Basin, which are in the low-mature to mature stages, can be divided into three groups: Group I oils in the Wuxia Zone derived from Fengcheng Formation (P1f), Group II oils in the Kebai Zone sourced from Wuerhe Formation (P2w), and Group III oils in the Mahu Depression generated from more mature source rocks of Jiamuhe Formation (P1j or P1f).

Different diamondoid indices are useful only in certain thermal maturity ranges. For the mature oils from the central Junggar Basin, there appears to be a positive linear correlation in
the oils between diamondoid concentration ratios (e.g., MAs/MDs and DMAs/DMDs ratios; MAs/MDs and DMAs/MDs ratios). While, for the condensates from the eastern and southern margins of the Basin, there is a good positive correlation between diamondoid isomerization ratios (e.g., MAI vs MDI and DMAI-2 vs TMAI-2) for the oil samples.

**Figure 1** The concentration of adamantanes vs diamantanes (a) and total diamondoids vs API gravity (b) for crude oils from the Junggar Basin

**Conclusions**

(1) Oils from the Junggar Basin can be broadly divided into three maturity stages according to diamondoid concentrations, which are low-mature (0–100 ppm adamantanes; 0–5 ppm diamantanes), mature (100–1000 ppm adamantanes; 5–50 ppm diamantanes), and highly mature (> 1000 ppm adamantanes; > 50 ppm diamantanes). (2) For oils in the low-mature to mature stages, some diamondoid concentration ratios (i.e., A/1-MA, 1,3-DMA/1,3,5-TMA, A/MAs, and DMAs/TMAs) can be used for oil–oil correlations. Oils from the northwestern Junggar Basin sourced from different Permian formations can be differentiated based on these diamondoid concentration indices, as Group I, II, and III oils were derived from the P1f, P2w, and relatively more mature P31 or P1f source rocks in the Mahu Depression, respectively. (3) Different diamondoid indices are applicable at different thermal maturity ranges. Some diamondoid concentration ratios (MAs/MDs, DMAs/MDs, and DMAs/DMDs) can be used for assessing the maturity of mature oils. Diamondoid isomerization ratios (e.g., MAI, MDI, DMAI-2, and TMAI-2) are effective for determining the maturity of condensates (i.e., oils at the high- to over-mature stages).

This study shows the limitations of different diamondoid indices. Because our conclusions are based only on our field study of the Junggar Basin, more data may need to be analyzed in order to apply our conclusions to other basins.

**References**
