CHARACTERISTICS AND SIGNIFICANCE OF COMPOUND SPECIFIC SULFUR ISOTOPE IN TYPICAL SALINE LACUSTRINE OILS FROM BOHAI BAY BASIN

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Gas chromatography (GC) with multicollector inductively coupled plasma mass spectrometry (MC-ICP-MS) enables precise and accurate δ34S analysis of trace organic sulfur compounds (OSCs) in petroleum, trace gases and organic sediments. This technology has been applied in thermochemical sulfate reduction (TSR) identification, oil-oil and source rock-oil correlation, hydrocarbons migration and solid asphalt investigation (e.g., Amrani et al., 2012; Greenwood et al., 2018). A suite of 18 saline lacustrine oils from the Pucheng, Weicheng, Liutun and Wenliu oilfields in the north and 2 freshwater lacustrine oils from the Shanchunji oilfield in the south of the Dongpu Depression were selected for compound specific sulfur isotope characterisation.

Sulfur isotope of a series of alkyl dibenzoanthiophenes were measured from all 18 samples, and alkyl benzoanthiophenes were additionally analysed in 3 samples. The δ34S values of these OSCs ranged widely from +10.9‰ to +47.8‰. At least four oil groups were identified on the basis of their δ34S distributions: 1) Pucheng oil showed a wide range of δ34SDBT values extending to quite heavy values (Fig.1 a, b, e); 2) Weicheng oil had a similar range of δ34S values but were generally lighter (Fig.1 a, b, c); 3) Wenliu oils had intermediate δ34SDBT values spanning a relatively narrow range. 4) Fresh-water lacustrial oil in the Shanchunji Oilfield featured relatively low δ34SDBT values. The δ34S values of the oils increase in the order of Pucheng-Weicheng> Liutun-Wenliu > Shanchunji oilfields, which coincided with their general salinity variation (decreasing from the north to the south). The δ34SDBT values showed a positive relationship with C35-/C34-hopanes ratios, and the values of δ34S1-mDBT-δ34S4-mDBT has negative correlation with the C35-/C34-hopanes ratios. These relationships suggest the sedimentary paleo-environment can influence the δ34S composition of petroleum OSCs.

The general δ34SDBT values of the Donpu oils and the specific relationship of δ34S1-mDBT-δ34S4-mDBT values (nb. 4-mDBT is more thermally stable than 1-mDBT) also showed a good correlation with several maturity related parameters including C29 sterane αααα20S/(S+R), C29 sterane αββ/αααα+αββ), 4-/1-DBT, diasteranes/regular steranes and percentage of “resin+asphaltene” for the Wenliu oils (Fig.1c–f) of similar origins, suggesting a thermal maturity control on sulfur isotopic values and distribution. Previous studies have similarly reported that the δ34S values of OSCs increase and homogenise with maturity, such that the value range between different compounds decreases (Ellis et al., 2017). The presently observed δ34S data, including the δ34S differential between the 1-mDBT and 4-mDBT isomers, might also be influenced by TSR which can be supported by multiple gypsum deposits and has been recognised to impact several oils in the Dongpu Depression (Ji et al., 2018). Additionally, TSR might have occurred before secondary hydrocarbons migration (an issue we are further investigating). The deviation of the Pucheng and Weicheng oils from the trend of the Wenliu-Liutun oils (Fig. 1) suggests they derive from different source rocks.

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which give rise to different $\delta^{34}$SOSC values.

Our results suggest the $\delta^{34}$S value of the Dongpu oils are controlled by several factors including source, paleo-environment, thermal maturity and TSR. The relative significance of these controls on specific oil reservoirs may sometimes be distinguished from their respective $\delta^{34}$S values. For instance, the $\delta^{34}$S values of south fresh-water lacustrine oils (+17.05–+19.64‰) are reflective of their depositional environment, the Wenliu oils (+20.46–27.27‰+) were significantly impacted by thermal maturity and the distinctly $^{34}$S enriched OSCs of several deep oils (e.g., + 22.16–+37.49‰: PS18, Wen203-58 and W42-21) by TSR. This study indicates that compound specific sulfur isotope could be used in oil-oil and oil-source rock correlation as well as thermal maturity evaluation and TSR identification.

Figure 1 The relationship between depositional and thermal maturity biomarker parameters and compound specific sulfur isotope data.

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References