OIL CRACKING EXPERIMENT AND ITS APPLICATION IN OIL-SOURCE CORRELATION: A CASE STUDY FROM EASTERN TARIM BASIN

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Introduction

Oil cracking experiment has been conducted by many researchers and they mainly focused on cracking kinetics, while oil properties change and resulting pyrobitumen evolution were less discussed. In an exploration area such as eastern Tarim Basin, which has experienced over-maturity, oil-source correlation is hard, causing long debate on the oil origin in this area. In this paper we conducted a series of oil cracking experiments and, evolution of both cracked oil and pyrobitumen were discussed. The result were then used in oil-source correlation and other geologic problem interpretation in eastern Tarim Basin.

Experiment

The oil sample was from an Ordovician marine oil of the Hade oilfield, Tarim Basin. About 0.5g oil was sealed in a quartz tube with the volume of ca. 37ml, and was heated at a constant temperature (350-550°C) for 24h in an autoclave. After the reaction, the tube was loaded to a sealed device, which injected the tube and collected gas product. The cracked oil and yielding pyrobitumen were separated through a filter system. All reactants and products were quantified as possible and geochemically analysed.

Results and discussion

As the increase of temperature, more pyrobitumen was yielded and the result shows that the total pyrobitumen (or coke) yield is about 45*wt*% for our oil sample, depending on chemical composition as suggested by Ungerer et al. (1988). As shown in Fig.1a, carbon isotopic ratios of both cracked oil and pyrobitumen increase as the increase of thermal stress. The carbon isotopic ratio of cracked oil increases more quickly than that of pyrobitumen. The maximum carbon isotopic variation of pyrobitumen is about 2‰ with respect to the primitive oil, while that of the cracked oil is ca. 4‰. It is suggest that the isotopic composition of kerogen has no significant change during hydrocarbon generation especially for marine type I kerogen (Buchardt et al., 1986; Lewan, 1983), while the resulting oil generally has lighter carbon isotope than the source kerogen by 1-2‰, indicating that the carbon isotope of pyrobitumen is similar to the source kerogen. Therefore, the carbon isotopic ratio of pyrobitumen can be used as an oil-source correlation indicator where there is no oil presence due to cracking and/or conventional biomarker technology is unavailable due to over maturity.

As shown in Fig. 1b, random reflectance of pyrobitumen increases with the increase of thermal stress as expected. What is interesting is that at higher thermal stress, the reflectance distribution shows bimodal, which was also seen in geologic samples in the Cambrian-Ordovician carbonate reservoirs of eastern Tarim Basin. Microscopic review shows that there are two distinct types of pyrobitumen at higher thermal stress, one of which has fine-grained texture with lower reflectance and the other has coarse-grained texture with higher reflectance

(Fig. 1c). We propose that the optically different pyrobitumens at the same thermal stress are yielded by different components of oil. The cracking experiment shows that the oil cracking began with components with high molecular weight. Therefore, it can be expected that pyrobitumen yielded at lower thermal stress will be different to some extent from those yielded at higher thermal stress. Further experiment will be needed to get more details about the process of oil cracking.

Application

Available pyrobitumen samples from pre-Cambrian to lower Ordovician carbonate reservoirs of eastern Tarim Basin have carbon isotopic value of -31.98 ~ -30.26‰, which is close to the isotopic ratios of kerogen in the lower Cambrian and mid Ordovician (the Heituwa member) source rocks, indicating that oils (now only pyrobitumen) in these reservoirs are mainly from such two sets of source rocks.
Some researchers have proposed that pyrobitumens with different reflectance at the same interval indicated that there were multiple oil charging events, which according to our result, possibly be misguiding. We suggest that they are from cracking of different components.

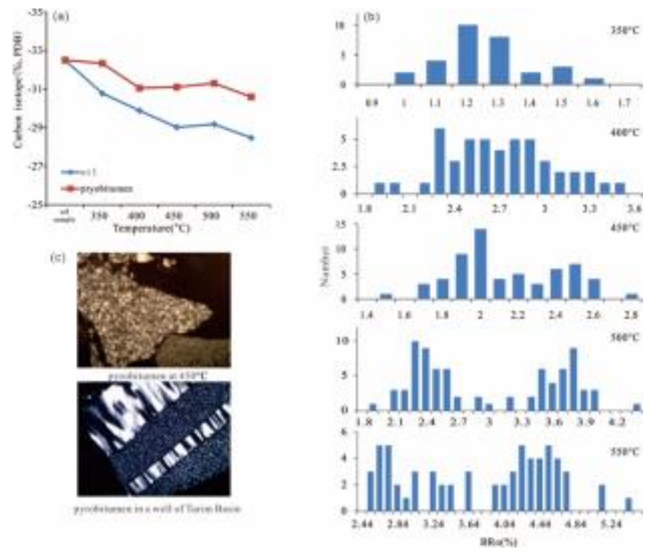

Figure 1 *(a) Carbon isotopic ratios of cracked oil and yielding pyrobitumen increase with temperature. (b)Reflectance distribution of yielding pyrobitumen by different temperature. (3)Microscopic view of pyrobitumen with different texture, under white reflected light equipped with polar filter.*

References

Buchardt, B., Clausen, J., Thomsen, E., 1986. Carbon isotope composition of lower palaeozoic kerogen: Effects of maturation. Organic Geochemistry 10, 127–134.
Clayton, C., 1991. Carbon isotope fractionation during natural gas generation from kerogen. Marine and Petroleum Geology 8, 232–240.
Lewan, M.., 1983. Effects of thermal maturation on stable organic carbon isotopes as determined by hydrous pyrolysis of Woodford Shale. Geochimica et Cosmochimica Acta 47, 1471–1479.
Ungerer, P., Behar, F., Villalba, M., Heum, O.R., Audibert, A., 1988. Kinetic modelling of oil cracking. Organic Geochemistry, Proceedings of the 13th International Meeting on Organic Geochemistry 13, 857–868.