LACUSTRINE PETROLEUM GENERATION AND ITS IMPLICATIONS IN THE QINGSHANKOU SHALE OIL EXPLORATION, NORTHERN SONGLIAO BASIN

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Introduction

As the most proliferous source rock of the Songliao Basin, the Qingshankou formation lacustrine shale has played a key role in the forming of Daqing oilfield, of which after 60 years of mass exploitation, the conventional petroleum resources start to decline gradually. Therefore in recent years, the possibility of exploiting shale oil from the shale has intrigued more and more geologists and geochemists. It is estimated by statistics that the shale oil resources in the Qingshankou 1st member of northern Songliao Basin is about 78 Gbbl, nearly as more as its conventional oil resources (Liu et al, 2014). In order to better understand shale oil formation and occurrence, previously established petroleum generation profile needs to be reviewed, especially when it is based on traditional programmed pyrolysis, in which the overlap of pyrolysis S1 to S2 has complicated our understanding of shale oil formation (King et al., 2005).

Methods and results

In this study, both un-extracted and extracted by chloroform, 40 shales from the Qingshankou 1st member with different maturity were analyzed by standard Rock-Eval method. The results are shown in Fig. 1, in which all S_2 value is normalized to TOC of un-extracted samples (denoted by as-is) and the estimated S2 values are calculated from as-is samples by formula S2-(A-S1) where A denotes extractable organic matter by chloroform (EOM). The S2 of extracted samples refers to solid organic matter or kerogen. As shown in Fig. 1, at lower transformation ratio (early maturation), the extracted S2 is close to as-is S2, whereas at greater transformation ratio the extracted S2 is much lower than as-is S2 and the difference is as high as 379mg/gC, indicating that a greater part of generated hydrocarbons are retained in source rocks than previously assumed using traditional pyrolysis method.

Another interesting finding deduced from Fig. 1 is that the estimated S2 is roughly the same as the extracted S2. Therefore, for practical usage in this study, organic matters in a source rock are divided into three components: reactive kerogen defined by S2-(A-S1), free oil defined by S1, and adsorbed oil defined by A-S1 which is mainly composed of heavy hydrocarbons. Based on such component definitions, in order to attain natural petroleum generation profiles, a total of 311 shales dominated by type I kerogen from the Qingshankou formation were analyzed for TOC, Rock-Eval and chloroform EOM. As shown in Fig. 2, mass kerogen cracking occurs at maturity (Ro) between 0.9-1.1%, while both free oil and adsorbed oil increase with maturity. At Ro greater than 1.1%, the free oil is expected to increase with maturity, whereas the adsorbed oil decreases. Noted that the free oil of most samples decreases at Ro>1.1%, except the SYY1 well, of which the S1 was analyzed immediately after the cores were drilled out of subsurface, indicating that the decrease is actually due to light hydrocarbon (LHC) loss as suggested by other researchers worldwide and that the decrease of adsorbed oil is due to oil cracking at high maturity. The free oil ratio as shown in Fig. 2 is evaluated by S1 complemented

by LHC versus total retained oil in a source rock and increases significantly at Ro>1.0. It is therefore suggested that shales with Ro>1.0% is the best for shale oil exploration in the Qingshankou formation of northern Songliao Basin.

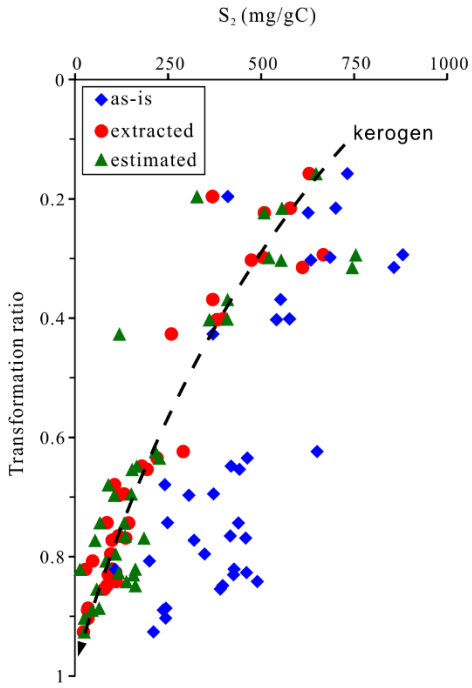

Figure 1 *Pyrolysis S2 varies with transformation ratio in the Qingshankou shale, northern Songliao Basin.*

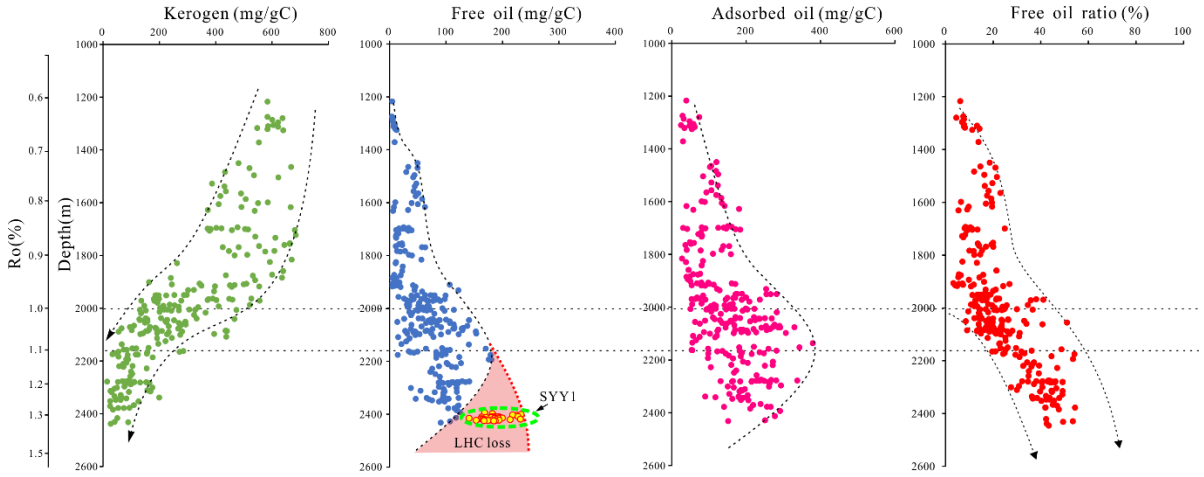

Figure 2 *Organic matters and free oil ratio vary with increasing maturity and depth in the Qingshankou shale, northern Songliao Basin*

References

King, R.R., Smith, T.R., Jarvie, D., Cannon, D., Weldon, D., Maende, A., 2015. Addressing the Caveats of Source Rock Pyrolysis in the Unconventional World: Modified Methods and Interpretative Ideas, Unconventional Resources Technology Conference, San Antonio, Texas, USA, p. 19.

Liu B., Lu Y., Ran Q., Dai C., Li M., Wang M., 2014. Geological conditions and exploration potential of shale oil in Qingshankou Formation, Northern Songliao Basin. Oil & Gas Geology, 280-285.