CONSTRAINTS ON OIL PHYSICAL STATUS IN LACUSTRINE SHALE RESERVOIRS − A CASE STUDY FROM DONGYING SUB-DEPRESSION, EAST CHINA

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Introduction

Shale oil exploration in Dongying Sub-basin, east China was initiated in 2013 and three exploration boreholes were drilled targeting at the Eocene Shahejie Formation shale which had been proved as an excellent major source rock. Nevertheless, the production of the three boreholes turned out to be not ideal. A contradiction exists between the proven quality and shale oil producibility. Extensive researches have been performed on the characterization of pore microstructure features, whereas the fluid characterization within shale reservoir has rarely been performed.

Sequential extraction is normally applied in conventional oil-bearing reservoir studies. Compositional heterogeneities in free, adsorbed, residual oils and fluid inclusions have been applied for oil charge history reconstruction and petroleum system appraisal (Wilhelms et al., 1996; Schwark et al., 1997; Leythaeuser et al., 2007; Pan and Liu, 2009). While the increasing-polarity solvent suite in previous studies does recover more extractable organic matter (EOM) and help to understand kerogen thermal evolution process, the nature of each fraction from different solvents has little practical implication in terms of shale reservoir assessment. The present study adopts the same solvent suite to recover EOM sequentially from variable particle sizes under cold and Soxhlet extractions and try to investigate the constraints on the oil physical status by using the control variable method. Thus, the aim of the present study is to help to understand shale oil generation and accumulation mechanisms by quantifying the proportion of different physical status of oil in shale reservoir and shed light on constraints of shale oil producibilty.

Results

Rock-Eval pyrolysis on a suite of 24 lacustrine shale core samples indicates that majority of samples are organic-rich with total organic carbon (TOC) contents greater than 1.44 wt.% (averaged 3.69 wt.%), dominated by Type II_1 kerogen and at the early to peak oil stage. In the present study, shale oil physical statuses were roughly termed as free, adsorbed and residual oil by sequential extraction with dichloromethane: methanol (9:1 v/v) from different particle size (5-10 mm, 2-5mm and 60-80 mesh) under twice cold and a final Soxhlet extractions, respectively. Quantitative data illustrated that free, adsorbed and residual oil account for approximately 66%, 16% and 17% of total extract yield, respectively (Figure. 1). Bulk compositions of extractable organic matter (EOM) revealed that saturated hydrocarbons are the dominant fraction in EOM, which decrease sequentially from free to residual statuses, corresponding to the increment of polar fraction.

Various factors may affect the proportions of free, adsorbed and residual oil in shale reservoirs, including TOC content, brittleness index, clay mineral content, thermal maturity and also the expulsion efficiency, were investigated in the present study. Among them, thermal maturity and clay mineral content exert critical influences on shale retaining ability.

Variation on the biomarker parameters and their absolute concentration was investigated to reveal the fractionation effect at the molecular level. Particularly, distinct change of maturity parameters (e.g. Methyl-phenanthrene indexes, Tri-methylnaphthalenes ratios and Ts/(Ts+Tm) ratios) on certain samples was observed, which may indicate higher maturity oil mixing from deeper source or suggest that the source rock is highly mature but with low oil-expulsion.

Conclusions

The present study may demonstrate compositional fractionation during primary migration within shale reservoirs both in bulk and molecular scales. The relatively-low maturity was considered as the main cause of low production in study area, since hydrocarbon generated with minor or no cracking may be the primary heavy oil with relatively high viscosity and polars component content.

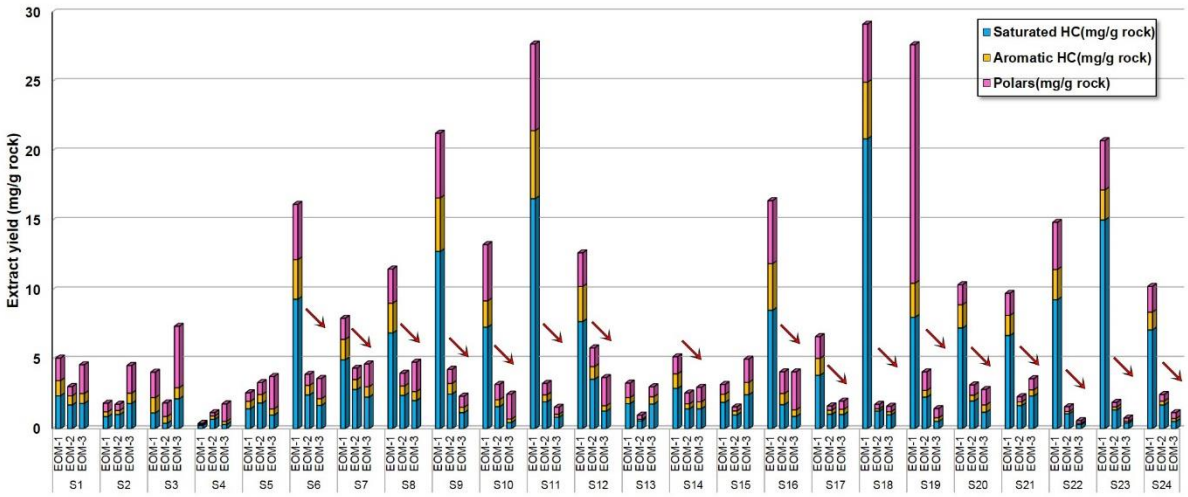

Figure 1 *Sequential extract yields and their respective gross composition.*

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