

ORIGIN AND ACCUMULATION OF HEAVY OILS IN THE QINGDONG SAG, BOHAI BAY BASIN, EASTERN CHINA

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Introduction

Numerous commercial oil reservoirs have been revealed in Qingdong Sag, a sub-sag of Jiyang Depression, Bohai Bay Basin (Wang Yongshi et al., 2017). Characteristics of crude oils in reservoirs of the fourth and third members of Paleogene Shahejie Formation (E_{S3} and E_{S4}) in the Qingdong Sag are complex, with co-existence of conventional and heavy oil (Ma Lichi, 2014). Maturity of the major source rocks including dark mudstones of the E_{S3} and E_{S4} members of Shahejie Formation is mostly low in the study area except for the deep zone of the middle-northern sag (Ge Haixia et al., 2016a; Ge Haixia et al., 2017). Heavy oils are important unconventional resources in the study area. However, the origin and accumulation processes of heavy oils in the study area remain unclear at present. It is of great significance to reveal the origin and accumulation processes of heavy oils in this area. In this paper, a set of source rock and crude oil samples were geochemically analyzed to study the hydrocarbon generation potential, the origin of immature oil, the biodegradation of crude oil, oil-source correlation and episodes of oil charging. Some indicators with highly resistant to biodegradation together with stable carbon isotopic compositions were used for oil-source correlation. And on this basis, the main factors controlling formation and distribution of heavy oils in the study area are discussed.

Results

The results show that the heavy oils in the Qingdong Sag originated from immature source rocks and biodegradation of crude oils, which mainly occurred in the shallow reservoirs around the sag. According to some indicators with high anti-biodegradation including β -carotanes/($2\times C_{29}$ hopane), ($2\times C_{24}$ -tetracyclic terpane)/ C_{26} -tricyclic terpane and ($2\times C_{19}$ -)/($C_{28}+C_{29}$)-tricyclic terpanes, the biodegraded oils in the Qingdong-Qingnan transitional belt are mainly sourced from the source rocks of the fourth member of Shahejie Formation (E_{S4}) in the Qingnan sag. A new geochemical indicator, i.e. the ratio of 4,4,8,9,9-pentamethyl decahydronaphthalene/ 8β (H) decahydronaphthalene, has been used as an effective parameter to distinguish immature oil from mature oil in our previous studies (Ge Haixia et al., 2017; Ge Haixia et al., 2016b). This ratio together with other geochemical indicators suggest that the immature oils occurred in the study area. The immature oils in southwestern part of the sag are proved to be generated by source rocks of the upper part of the fourth member of Shahejie Formation (E_{S4}^s) in the Qingdong sag.

The heavy oil reservoirs in the Qingdong sag have experienced two oil filling events (Eocene Donging stage, Neogene Guantao to Quaternary stage), which were dominated by the later pulse. Heavy oils in the study area are mainly of biodegradation origin during the oil

migration processes. The accumulation and distribution of heavy oils in the study area is mainly controlled by occurrence of source rocks. The size of oil reservoirs is controlled by effective source rocks and the oil reservoirs mainly distribute in intervals near the source rocks. The physical properties of reservoir rocks, fault systems and preserve conditions have a great influence on the distribution of heavy oils in the study area.

Conclusions

(1)The heavy oils in the Qingdong sag originated from immature source rocks and biodegradation of crude oils. The biodegraded oils are mainly sourced from the source rocks of the fourth member of Shahejie Formation in the Qingnan sag. The immature oils derived from the source rocks of the upper part of the fourth member of Shahejie Formation in the Qingdong sag.

(2)The heavy oil reservoirs in the Qingdong sag have experienced two oil filling stages (Eocene Donging stage, Neogene Guantao to Quaternary stage). The distribution and accumulation of heavy oils in the study area is mainly controlled by occurrence of source rocks, physical property of reservoirs, fault systems and sealing conditions.

Key words: Heavy oil, Origin, Biodegradation, Immature oil, Qingdong Sag

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