Applying Quantitative Fluorescence Techniques to Characterize Mechanism of Hydrocarbon Migration and Accumulation in Thick Source Strata: A Case Study of Member 4 of the Shahejie Formation, Langgu Sag in Bohai Bay Basin

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9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

Due to the influence of heterogeneity and effective hydrocarbon expulsion thickness, the mechanism of hydrocarbon migration in thick source strata is still unclear, directly affecting the evaluation of petroleum resources quantity and the establishment of hydrocarbon accumulation model. The quantitative fluorescence analysis includes a series of techniques including quantitative grain fluorescence (QGF), quantitative grain fluorescence on extract (QGF-E), and total scanning fluorescence (TSF), which can accurately provide such important information as hydrocarbon saturation, maturity and migration path during the past and present geological periods in a fast, simple, economical and efficient way. Using the quantitative fluorescence, fluid-inclusion, biomarkers and basin simulation technique, this paper analyzes the hydrocarbon migration characteristics in the thick source strata of Member 4 of Shahejie Formation in Langgu sag, and reconstructs the hydrocarbon migration and accumulation process from thick source strata to reservoirs. The results show that the QGF index of sandstone interlayers in thick source strata is generally greater than 4.0, the QGF-E intensity is partially greater than 40, and the λmax of QGF and QGF-E are quite

different. It is indicated that paleo-oil layers once existed in the sand body were diluted and transferred in the later stage; the sand body played the role of “transfer station” during hydrocarbon migration and accumulation. The difference in quantitative fluorescence response indicates the transit capacity of sand body varies at different depths. The sand bodies with coarse lithology, moderate sand ratio (approaches to 0.25) and large thickness show higher migration efficiency and transit capacity. The hydrocarbon generation and thermal evolution history of source rocks, fluid-inclusion and quantitative fluorescence spectrum of sand strata and fault activity history demonstrate two episodic hydrocarbon transport and accumulation processes exist in the “transfer station”. The first stage is from the end stage of Member 3 of Shahejie Formation to the early stage of Dongying Formation (35-30 Ma). The sand body was mainly filled with medium-light oil and gas. With the opening of faults, oil and gas migrated upward efficiently from the end stage of Member 1 of Shahejie Formation to the early stage of Dongying Formation. When hydrocarbon generation ceased at the end stage of Dongying Formation, the oil and gas saturation in the sand body was decreased. The second stage is from the Minghuazhen Formation sedimentary period to the present (5-0 Ma). The sand body is mainly charged with a large amount of condensate oil and gas. Since the faults tend to be closed, the oil and gas in the sand body migrate upward by steady seepage; till the formation of better preservation conditions, oil and gas can be accumulated in the buried hill reservoir.