Refined Petroleum Systems Characterization and Application to New Play Assessment: A Case Study of Raoyang Sag, Bohai Bay Basin, China

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Abstract

Raoyang Sag, located in the middle area of Jizhong Depression, is one of the most petroliferous sags in the Bohai Bay Basin. The exploration area is about 6,300 km^2 with about 5.10 billion BBL oil of proved reserves. Most discovered oil accumulations were located above a depth of 3,500 m. The mid-deep Renqiu buried hill reservoir, with 2.97 billion BBL oil of proved reserves, contributes most among various reservoirs. How to assess residual petroleum resources and to delineate the next play are urgent issues for further exploration.

Refined source kitchen analysis indicated that Es1 and Es3 lacustrine source rocks developed in Raoyang Sag present high heterogeneity, including organofacies C, D/E and F, and a maturity range from the oil window to over-mature stage in the deep area of the sag. The scale and phase of residual petroleum resources can be inferred through the comparison of amount and phase between expelled hydrocarbons from source kitchen and discovered oil accumulations. Oil-source correlation confirmed that oil accumulations above 3,500 m depth were mainly derived from organofacies C source rocks in the early phase (0.60-0.90% VRo) of oil window, mainly with API ranges from 26 to 30, and GOR ranges from 2 to 30 m^3/m^3. Most hydrocarbons expelled from organofacies C in the late phase (0.90-1.20% VRo) of oil window, and organofacies D/E and F source rocks have not be found.

The spatial orderly distribution of API GOR, gas carbon isotope and molecular geochemical data denote the various front expelled hydrocarbon in different mature stages from organic facies C, D/E and F, which reflects the dynamic scenario of petroleum migration and accumulation from kitchen to the shallow accumulations. Therefore, the deep buried hills charged with high GOR hydrocarbon from the late phase (0.90-1.20% VRo) of oil window, condensate and wet gas are recommended for further exploration. Recently Ninggu-1 deep buried hill with the bottom depth about 5100 m found high GOR hydrocarbon (157 m^3/m^3) accumulation, which prove our model of the high GOR hydrocarbon, condensate and wet gas efficiently accumulates in the deeper buried hill prospect.