

Petroleum Systems Analysis to Refine New and Existing Play: A Case Study of Mahu Sag, Junggar Basin, China

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ABSTRACT

One of the important aims of petroleum systems analysis is to try to establish the spatial and quantitative genetic relationship between discovered petroleum accumulations and generated hydrocarbons from source kitchens. The scale and phase of residual petroleum resources can be inferred through the comparison of the amount and phase changes between generated and expelled hydrocarbons from the source kitchen and discovered oil accumulations. This can refine new and existing play concepts.

Mahu Sag, located in the Northwestern area of Junggar Basin, is the most petroliferous sag in China. It contains about 10.5 billion BBL oil of proved reserves in the northwestern margin. Oil-source correlation confirmed these oils originated from world class Permian lacustrine source rocks (mainly in the lower Permian Fengchen Fm, P1f) with the iconic high carotane content. Permian lacustrines sourced the beginning of Xinjing's mid-20th century oil boom with conventional Karamayi oilfield discoveries in the northwestern margin. In the early 21st century, the Permian lacustrine Formation once again spurs exploration and development activity, yet in an unconventional way by targeting the source rock itself and overlying tight reservoirs in the Mahu sag.

Geochemical data and petroleum systems analysis indicate Permian lacustrine source rocks present high heterogeneity, including organofacies C, D/E and F. Maturity of the Fengchen Fm lacustrine source rocks range from mature to highly mature in Mahu sag, about 1.6-1.8% VRo in the deepest area of the Mahu sag, at a depth of 7000-7300 m. However, the oil in the northwestern margin play present low maturity with low GOR (mainly less than 30 m³/m³) and API, which reflects that these oils were generated from the early phase of the oil window (0.60-0.85% VRo) within organofacies C of the source kitchen, and experienced lateral migration and accumulation. Refined petroleum systems analysis can delineate three new plays, which are related to the Permian lacustrine source kitchen evolution. Firstly, the lower Triassic Baikouquan Formation alluvial fan play, charged from expelled petroleum in late phase of oil windows (0.90-1.30% VRo) of the Permian lacustrine source kitchen, with relatively high GOR, ranging from 50-200m³/m³ and vertical migration and accumulation in the Mahu sag; Secondly, the Permian-Carboniferous lower assemblage play with condensate and wet gas, charged from expelled petroleum from organofacies D/E and F of the Permian lacustrine source kitchen in the highly mature stage; Thirdly, Fengchen Formation tight oil and gas play, we delineated the sweet depth with maturity ranging 0.9-1.1% for tight oil play.

The orderly spatial distribution of API, GOR, gas carbon isotope and molecular geochemical data in whole Mahu Sag denote the various front expelled hydrocarbons in different mature stages from organic facies C, D/E and F, which reflect the dynamic scenario of petroleum migration and accumulation from the kitchen to shallow accumulations, and imply possible new plays for exploration.