Molecular and Bulk Geochemical Indicators of Early Thermal Maturation in the Mahogany Zone Oil Shale of the Green River Formation, Uinta Basin, Utah

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Abstract

Characterization of early catagenic processes in the lacustrine strata present in the Uinta Basin is key to understanding the onset of oil generation as well as the origin and extent of unconventional petroleum resources like tar sands and gilsonite. To investigate changes related to early maturation, Mahogany zone oil shale samples from the Eocene Green River Formation were examined in five wells along an east-to-central basin transect that have a maturity level of less than a vitrinite reflectance (Ro) of ~0.7%, which is below oil generation onset of type I kerogen. Samples of the Mahogany zone oil shale were analyzed for bulk organic geochemistry. Samples varied from 20 to over 100 from each individual core. A subset of samples (13) were then selected for analysis of solvent extractable hydrocarbon biomarkers to evaluate what compounds are sensitive to the early, pre-oil stage of catagenesis. These results were compared to data on oils typed to the Mahogany zone, Fischer assay data, and biomarker results for gilsonite and tar sand bitumen determined in previous studies. Bulk parameters from programmed pyrolysis analysis (e.g., Tmax and hydrogen, oil saturation, and production indices) show trends with burial depths that are consistent with previous examinations of thermal maturity in the Green River Formation in the Uinta Basin. Carotenoids like β-carotane and the acyclic isoprenoids pristane and phytane show similar sensitivity to thermal maturity to indicators like Tmax determined from programmed pyrolysis but these particular biomarkers could also have been affected by variations in depositional environment or organic matter source. However, other molecular parameters like the C29 ββ/(αα+ββ) sterane ratio, C31 hopane 17α,21β 22S/(22S + 22R) ratio, and C31 2α+β methylhopane index also show similar trends consistent with differences in thermal maturity from east to west identified in previous work. These results provide information on the subtleties of early Mahogany zone maturation that may have played a role in charging tar sand deposits in the southern basin and gilsonite veins in the east. Considering the very low porosity and high organic matter content of the Mahogany zone shale, these early stages of thermal maturation may have led to early expulsion of what would usually be considered bitumen and not “oil” based on the physical properties (high density and viscosity) of this material and may be a source of the non-crude oil petroleum resources found in the Uinta Basin.

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