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New Observations on Oil-Source Rock Correlations in Arctic Alaska

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ABSTRACT

The USGS has initiated research to develop a better understanding of Arctic Alaska petroleum systems. The main objectives of this effort are to establish a set of advanced geochemical criteria for a) conducting oil-source rock and oil-oil correlations, b) distinguishing sources of mixed provenance, c) evaluating compositionally-altered oils (i.e., biodegraded, highly mature), and d) reconstructing migration pathways from source rock to reservoir by incorporating seismic and other subsurface data. Initial work involved geochemical analyses of bitumen extracts from whole cores of known source rocks and oils from producing fields and well tests. Samples have been analyzed by quantitative whole oil gas chromatography-flame ionization detection (GC-FID), GC-mass spectrometry (GC-MS) and GC-tandem mass spectrometry (GC-MS/MS) of biomarkers, and quantitative diamondoid analysis (QDA). Bitumen has been extracted and analyzed from multiple samples throughout three source-rock cores to evaluate vertical and facies-related variability: the Amerada Hess Northstar 1 and Tenneco OCS YO338 Phoenix 1 from the Triassic Shublik Formation, and the USGS North Kalikpik 1 from the Lower Cretaceous pebble shale unit (PSU) and gamma-ray zone (GRZ) of the Hue Shale. Bitumen extracted from the Phoenix core displays an unusually wide variation in geochemical character, suggesting the presence of both indigenous bitumen and migrated oil. In contrast, bitumen extracted from the Northstar core displays uniform geochemical character indicative of a more clay-rich facies than the widely recognized calcareous facies. This result helps delineate a clay-rich Shublik source-rock, the presence of which has previously been suggested based on geochemistry of produced oil from Northstar, NW Milne Point, and Sandpiper accumulations. Bitumen extracted from the North Kalikpik core displays a distinct vertical change in organic facies reflecting the gradation from the PSU into the GRZ. This result suggests the potential for developing criteria for distinguishing oils sourced from these units. Oils have been analyzed from seeps and wells in the National Petroleum Reserve in Alaska (NPRA), and from multiple reservoirs in producing fields and new discoveries east of NPRA. Representative source-related and taxon-specific biomarker parameters have successfully constrained depositional environment, age, and source organic matter input for most oil samples in this study. These results indicate a positive correlation between several of the oils and the calcareous facies of the Shublik Formation as the primary source. Still, many of the oils appear to be mixed, with both high- and low-maturity source contributions. Thus far, it is unclear whether the secondary contributions are from a different source formation, facies, or thermal-maturity setting. Initial QDA results and GC-FID profiles have identified the presence of multiple sources and provided evidence in support of a secondary gas charge into the producing reservoir for most of the oils. Although a certain amount of ambiguity exists in our preliminary data, we are encouraged that advanced geochemical analyses will enable us to distinguish oil-groupings, reveal end-member sources and/or co-sources, and evaluate the proportion of each contributing source. Our goal is to integrate these results with other subsurface data to interpret oil source to sink relationships, including likely migration pathways.