Regional Geologic Framework for Appraising Continuous Petroleum Resources in Source-Rock Systems of Arctic Alaska

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The North Slope of Alaska is a prolific petroleum province due in part to the presence of world-class source rocks. The demonstrated viability of petroleum production from source-rock systems in the lower-48 suggests that similar potential may exist in Arctic Alaska. As a first step in constructing a regional framework for appraising continuous (unconventional) petroleum resources, we have mapped geological parameters of two source-rock systems across Arctic Alaska (North Slope, Chukchi shelf, and Beaufort shelf) using seismic and exploration-well data. The "Brookian source-rock system" is defined to include the transgressive systems tract overlying the Lower Cretaceous unconformity (LCU) plus distal facies of Cretaceous clinoform depositional sequences. This succession includes the Hauterivian-Barremian pebble shale unit and the Aptian-Campanian Hue Shale. The Triassic Shublik Formation is the second source-rock system we have mapped.

Based on the well documented relationship between total organic carbon (TOC) and total gamma-ray response in shale, and following a technique developed by the U.S. Geological Survey for use in lower-48 shale-gas assessments, we use digital gamma-ray logs to define two mapping parameters involving "high gamma-ray" (HGR; total gamma-ray response greater than 150 API units) response: (1) Gross HGR is the total thickness of strata between the top of the shallowest HGR response and the base of the deepest HGR response within each study interval. (2) Net HGR is the sum of thickness of beds displaying HGR response within the gross interval. These parameters have been shown in lower-48 basins to be reliable proxies for shale-reservoir thickness and shale-source-rock thickness, respectively. Well productivity in lower-48 shale-gas plays commonly is correlated positively with these parameters, particularly with net HGR. We also incorporate maps of structure, drilling depth, and thermal maturity into the analysis, as these factors influence fracture orientation and density, reservoir pressure, well productivity, and hydrocarbon phase (oil versus gas).

Maps of the Brookian source-rock system reveal background patterns of both southward- and eastward thickening of gross HGR and mostly eastward thickening of net HGR. Significantly, a series of irregularly shaped pods of very thick HGR occurs beneath the northern part of the North Slope between Harrison Bay and the Canning River. Maximum thicknesses of 400-1,200 ft of gross HGR and 200-700 of net HGR occur in these pods, the localization of which appears to have been controlled by depositional and erosional processes within a sequence stratigraphic framework. These pods are located mostly within the oil window as defined by vitrinite reflectance, although they extend northward into an area where they are immature.

The HGR mapping technique is less effective in the carbonate-rich Shublik source-rock system. Throughout much of the Shublik succession, there is little or no correlation between HGR response and source-rock richness as defined by TOC, hydrogen index (HI), and other

geochemical parameters. An alternative approach for mapping areas of optimal continuous-resource potential may be provided by the observation that elevated values of TOC and HI occur within one or more transgressive systems tracts in the lower part of the Shublik Formation.