AAPG Datapages/Search and Discovery Article #90302 ©2017 AAPG Pacific Section Annual Meeting, Anchorage, Alaska, May 21-24, 2017

A New Methodology for Determining Source Rock Quality and Quantity with Applications to the Alaska North Slope

Allegra Hosford Scheirer[1], Leslie B. Magoon[1], Kenneth J. Bird[2], and Edward Duncan[3]

[1]Stanford University
[2]Consultant
[3]Duncan Petroleum Advisors

ABSTRACT

The values of total organic carbon (TOC) and hydrogen index (HI) before a source rock generates petroleum determine the quantity and quality, respectively, of that petroleum. These so-called 'original values' can be challenging to obtain because pyrolysis experiments (in which the immature sample is heated to generate petroleum) require a thermally immature sample. This is problematic for at least three reasons. First, it can be difficult to find truly thermally immature samples from core or cuttings because exploration wells are usually drilled near where the source rock has already generated oil and/or gas. Second, outcrop samples often are thermally immature, but they may be altered due to weathering so may not be representative of the organic facies in the subsurface. Third, original TOC and HI can be calculated via a fractional conversion equation, which is based on mass balance, present-day values of TOC and HI, and several assumptions. Because original TOC and HI are key inputs to basin and petroleum system models, an observation-based approach is warranted. We present a new method for obtaining the original TOC and HI of organic-rich source rocks. The methodology depends on a rich catalog of geochemical analyses, which is available on Alaska North Slope, and statistical analyses of the data. This statistical method organizes the geochemistry data in three thermal maturity classes: immature, defined as vitrinite reflectance (Ro) less than 0.6% or Tmax from Rock-Eval of less than 435Â°C; early to peak oil, defined as Ro between 0.6 and 0.9 or Tmax between 435Â° and 450Â°C; and late oil, defined as Ro greater than 0.9 or Tmax greater than 450Â°C. Distribution functions calculated for the two datasets (TOC and HI) in each of the maturity classes reconstruct original TOC and HI at each level of thermal maturation. Although we report mean values here, this analysis can be easily extended to different geographic regions where organic facies differ. We applied this method to five source rocks: the Hue Shale above its basal Highly Radioactive Zone (HRZ), the HRZ itself, the pebble shale unit (Kalubik Formation), the Kingak Shale, and the Shublik Formation. Where thermally immature, all five source rocks exhibit TOC values ranging from 2 wt. %, our minimum for consideration, to as high as 10 wt. %, with a mean of about 2 to 3 wt. %. The original HI values, on the other hand, exhibit large variability due to different kerogen types in the source rocks. The pebble shale unit has the lowest mean original HI (165 mg HC/g TOC) whereas the Shublik Formation has the highest (550 mg HC/g TOC). Our results are generally consistent with earlier values determined with the fractional conversion method, although the original HI for the Shublik Formation in this study is considerably higher (550 mg HC/g TOC for this study vs. 300 to 400 mg HC/g TOC with fractional conversion method). A new insight gained from this method is the ability to examine the relative behavior of carbon and hydrogen depletion with thermal maturation. The hydrogen index precipitously decreases with maturation as expected but the total organic carbon does not; rather it drops off slowly through the oil window. In summary, this new method for determining source rock quality and quantity is easy to implement, provides needed input for basin and petroleum system modeling, and serves as an independent check on established methods.