Anatomy of a Petroleum Source Rock

Barry Jay Katz
Chevron, Houston, TX
BarryKatz@Chevron.com

Abstract

With the growing global attention in shale gas and shale oil plays there has been a renewed interest in source rock geochemistry. This has resulted in a number of key questions concerning source characterization, including: 1) how much internal variability might be anticipated; 2) what is the potential impact of the variability on resource assessment; and 3) how best may a source be sampled to "fully" understand its variability?

These questions were examined, in part, through the detailed sampling of the Kimmeridge Clay at the type locality. A representation of variability was obtained from basic source rock data collected on fresh outcrop samples. Total organic carbon contents, for this world-class source rock, varied between 0.88 and 21.35 wt.%, with a mean of 9.13 wt.%. Samples with greater than 1.0 wt.% TOC had total pyrolysis yields ranging between 6.31 and 126.65 mg HC/g rock, with a mean of 54.16 mg HC/g rock. Hydrogen index values ranged from 240 to 611 mg HC/g TOC, with a mean of 516 mg HC/g TOC.

Even these ranges do not fully capture the variability of the source, if data from elsewhere in the North Sea region are included. For example, TOC values exceeding 40 wt% have been measured. Although the hydrogen index values suggested similar liquid hydrocarbon products at Kimmeridge Bay across the outcrop the variability across the North Sea suggests that there are regions that are more gas-prone character. The differences in organic carbon content and hydrocarbon yields, which range by more than an order of magnitude, would have direct impact on estimates of both conventional and unconventional resources, if assessments were based on individual discrete samples.

Discrete sampling either from an outcrop or a core commonly results in bias. Historically, these biases have been skewed toward the more organically enriched samples. This can be overcome through an increase in the number of samples and the incorporation of lithologic information, so that weighted averages can be generated to obtain a better representation of the unit. The analysis of cuttings samples introduces a different suite of problems, associated with representativeness and positioning. Regional variation also needs to be incorporated through an examination of the depositional systems of the unit, ensuring that the key environments are sampled accounting for the impact of factors such as sedimentary dilution, influence of storms, and oxygen content of the water column.