Oil-Source Rock Correlation Studies in the Shallow Berea Sandstone, Northeastern Kentucky

Paul C. Hackley[1], T. Marty Parris[2], Stephen F. Greb[2], Cortland F. Eble[2], and David C. Harris[2]

[1]U.S. Geological Survey
[2]Kentucky Geological Survey, University of Kentucky

ABSTRACT

Light sweet oil is produced from the Upper Devonian Berea Sandstone in northeastern Kentucky at shallow depths (~2,200 ft and less) where the postulated source rocks (underlying Upper Devonian Ohio Shale and overlying Mississippian Sunbury Shale) appear to be immature for oil generation. To determine if local source rocks were indeed the source of produced oils, geochemical data from source rock bitumen extracts (n=20) and Berea oils (n=6) were compared. Results show Berea oils are of one family and from a similar source rock based on API gravity (35-42), sulfur (0.17-0.21%), SARA fractions (1.2-1.4 sat/arom), n-alkane envelopes, C isotopic compositions (δ13C, -30.2 to -30.5‰ whole oil), normal sterane distributions (e.g., 45.3-47.1% C29 ααα R), correlations between individual sterane and hopane concentrations and similarity in extended hopane concentrations. Berea oils are identical in δ13C composition to Berea-reservoired crude oils in eastern Ohio, likely originating from the same source rocks, and are dissimilar to oils reservoired in lower Paleozoic eastern Ohio strata. Berea oils and organic matter in the postulated source rocks are from a marine source based on multiple proxies including Pr/Ph (>1) and terrestrial-aquatic (0.06-0.20) ratios, CPI values (~1), n-alkane maxima (centered at C15-17), δ13C compositions, and presence of tricyclic terpanes (from Tasmanites and/or bacterial biomass). The data cannot resolve whether the Ohio Shale or Sunbury Shale is the primary source of oils because of similar bitumen extract Pr/n-C17 and Ph/n-C18 ratios, sterane distributions, δ13C values, and sterane/hopane and tricyclic terpane ratios. Sterane isomer ratios and C27 (Ts/Ts+Tm) hopanes are poor predictors of thermal maturity in the Berea system when compared to measured Ro values, possibly due to open-system behavior or analytical issues, e.g., co-elution. Sulfurization of organic matter may explain high S (up to 7.5 wt.%) concentrations in some bitumen extracts and suggests generation of low S Berea oils occurred in the mid- to late oil window. Ro equivalent values from the methylphenanthrene index suggest generation of Berea oils occurred at 0.7-0.9% Ro and require updip migration of 5-20 mi at a minimum and 40-50 mi at a maximum, explaining production of shallow light sweet oil in an area of immature source rocks.