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The extent of oil-based drilling mud (OBM) penetration in full-diameter core samples: Implication for geochemical analysis

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Summary

Programmed pyrolysis analysis is widely used in the energy industry as the initial geochemical screening methodology for source-rock evaluation of conventional and unconventional hydrocarbon resources as well as reservoir characterization of unconventional reservoirs. Core samples are generally a better option than drill-cutting samples for source and reservoir quality evaluation of unconventional resources due to their lower degree of invasion by oil-based drilling mud (OBM) and lack of contamination by up-hole cavings. However, core samples also can be subject to contamination if drilled with OBM.

To evaluate the extent of OBM penetration in cores, six core plugs were extracted from three fresh full-diameter cores obtained from the Montney Formation. These core plugs were cut with liquid nitrogen to preserve the volatile martial in the core as much as possible before analysis. Core plug samples were sealed and kept frozen throughout the shipment and handling. Each core plug was then cut into five pieces along the axis of the core plug. The resulting samples were analyzed using extended slow heating (ESH) Rock-Eval analysis and online thermal desorption/pyrolysis–gas chromatography–mass spectrometry/flame ionization detection (TD/Py–GC–MS/FID). Full organic geochemistry analysis also was carried out on the OBM sample obtained from the same well.

The ESH cycle pyrolysis starts at initial temperature of 150°C to ensure that only the lightest fraction of free hydrocarbons/contamination is volatilized and measured as $S1_{ESH}$ (mg HC/g rock). The slower ramping temperature (10°C per/minute) than standard Rock-Eval cycle (25°C per minute) up to 650°C results in the distinction of hydrocarbon peaks from desorption of medium to heavy hydrocarbons (S2a) and thermal cracking of kerogen and solid bitumen (S2b). The S2a peak occurs between 150 and 380°C, and the S2b peak occurs between 380 and 650°C. To characterize the composition of the ESH peaks, the samples were subjected to online TD/Py–GC–MS/FID analysis. The Py–GC–MS analysis was carried out at 150°C and 380°C to fingerprint $S1_{ESH}$ and S2a, respectively.

In all samples, $S1_{ESH}$ has the highest amount at both ends of the core plugs and gradually decreases to an approximate base level in the center of the plug. A similar trend, but with less increase was observed for the S2a peak. The Py–GC–MS/FID data also show a clear trend of shifting in the carbon number distribution from the center of the core plugs to their periphery. While the center of

the core displays relatively higher abundance of hydrocarbons heavier than nC_{20}, the periphery of the core is more concentrated with hydrocarbons lighter than nC_{20} that is closer to the composition of OBM.

The results of this study indicate that core samples are subject to contamination by OBM. The extent of OBM penetration in core samples may be controlled by petrophysical and textural properties of the rock. This contamination can potentially compromise the quantification of organic matter fractions and has significance for evaluation of reservoir quality in unconventional resources. In addition, compromised S1 values that represent the free hydrocarbons in the rock, may cause inaccurate oil in-place estimation and resource assessments of hydrocarbon resources. Sampling from the center of cores drilled with OBM can significantly reduce the chance of contamination by OBM in geochemical analysis.