Hydrocarbon heterogeneity in a Montney core: Indication of drilling mud invasion and implications

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Summary

Both bulk and molecular organic geochemical results on samples collected across three full-diameter cores from the Montney Formation in western Canadian sedimentary basin (WCSB) will be presented along with the hydrocarbon compositions of oil-based mud (OBM) samples collected during the drilling/coring of the wells. It is observed that OBM fluid invasion into the cores has resulted in contamination to the in-situ hydrocarbons originally present in the Montney Formation siltstone. Therefore, caution should be exercised when cores and cuttings samples from unconventional operations where use of OBM is common are to be used for hydrocarbon resources evaluation.

Method

Cores used in this study were sealed before plug drilling in the lab. Core plugs were extracted across the core diameters with liquid nitrogen, and then kept frozen before lab analyses to preserve the volatile material as much as possible. Six core plugs from three Montney cores have been subjected to extended slow heating (ESH) Rock-Eval analysis following the method by Sanei et al. (2015), to examine the variation of the bulk amounts of various hydrocarbon components across the diameter of the cores. Based on the Rock-Eval results, three samples from one selected core plug corresponding to the periphery, semi-periphery and center of the original core respectively were analyzed by thermal desorption-gas chromatography (TD-GC) to fingerprint their hydrocarbon compositions following the procedure reported in Jiang et al (2016). In addition, two OBM samples from the same depth intervals where the studied cores were taken have also been submitted for molecular characterization of their hydrocarbons via solvent extraction and GC analysis of the whole solvent extracts.

Results and Conclusions

The ESH Rock-Eval results show significant variation of measured free hydrocarbon and total organic carbon (TOC) contents across the diameter of the cores. Free oil represented by $S1_{ESH}$ and S2a peaks are in the highest amount at the periphery of the cores and decrease toward the center of the cores. For example, $S1_{ESH}$ is consistently higher by 34 to 1052% at the core periphery compared to the core center. All but one sample show an enrichment of 50 to 362% in their S2a at the core periphery compared with core center.

The systematic variation in the amount of thermally mobile hydrocarbons across the core diameter is also observed in their molecular compositions along the diameter cross-section of the core.

Figure 1 presents the TD-GC traces for the rock samples collected at the center, the semi-periphery and the periphery of a selected core. The whole solvent extract GC trace for the drilling mud collected at similar depth is also presented in Figure 1 for comparison. There is a clear trend of shifting in the carbon number distribution from the center of the core to the periphery of the core. While the center of the core displays relatively higher abundance of $\geq nC_{20}$ heavy hydrocarbons (Fig.1a), the periphery of the core is more enriched in $<nC_{20}$ hydrocarbons (Fig.1c). Furthermore, the hydrocarbon distribution in the periphery of the core (Fig. 1c) lies between that of the center of the core (Fig. 1a) and that of the drilling mud sample (Fig 1.d), but is closer to the latter. This suggests that drilling fluid penetration during coring has resulted in contamination of the hydrocarbons hosted in the core by the oil used for the formulation of OBM.

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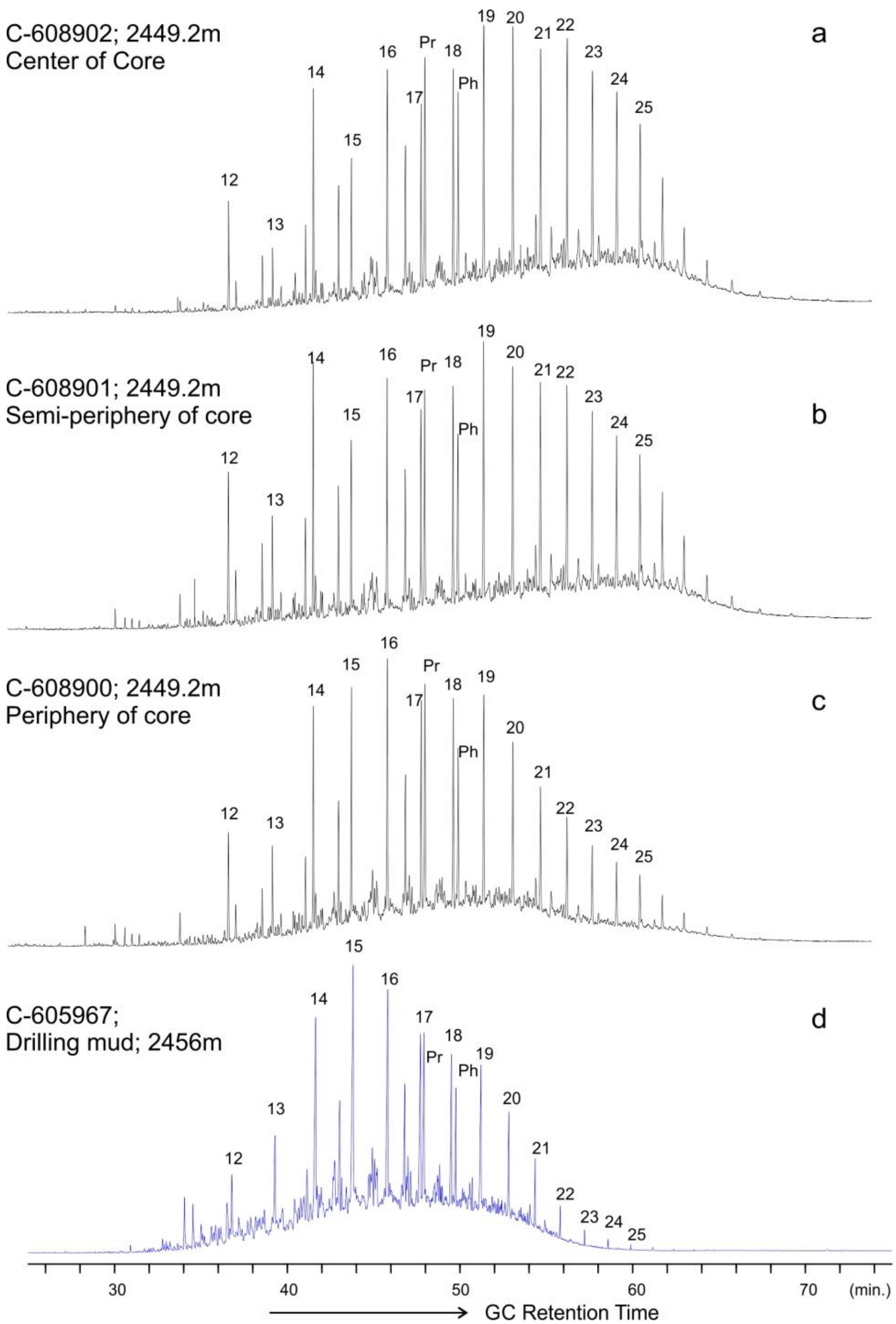

Figure 1. TD-GC traces for samples from (a) the center, (b) the semi-periphery, and (c) the periphery of a core taken from the Montney Fm. of WCSB. (d) the whole extract GC trace of a drilling mud sample from the same well for comparison. Peak labels represent the carbon number of n-alkanes.