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Role of organic matter fractions in the Montney tight gas reservoir quality

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This study presents a new approach in Rock-Eval analysis to quantify various organic matter fractions in unconventional reservoirs. The results of study on core samples from the Triassic Montney Formation tight gas reservoir in the Western Canadian Sedimentary Basin show that operationally-defined S1 and S2 hydrocarbon peaks from conventional Rock-Eval analysis may not adequately characterize the organic constituents of unconventional reservoir rocks. Modification of the thermal recipe for Rock-Eval analysis, in conjunction with manual peak integration, provides important information with significance for the evaluation of reservoir quality. An adapted Rock-Eval method, herein called the extended slow heating (ESH) cycle, was developed in which the heating rate was slowed to 10°C per minute over an extended temperature range (150 to 650°C). For Montney core samples from the wet gas window, this method provided quantitative distinctions between major organic matter components of the rock. We show that the traditional S1 and S2 peaks can now be quantitatively divided into three components: (S1ESH) free light oil, (S2a ESH) condensed hydrocarbon residue (CHCR), and (S2b ESH + residual carbon) solid bitumen (refractory, consolidated bitumen/pyrobitumen).

The majority of the total organic carbon (TOC) in the studied Montney core samples consists of solid bitumen that represents a former liquid oil phase which migrated into the larger paleo-intergranular pore spaces. Subsequent physicochemical changes to the oil environment led to the precipitation of asphaltene aggregates. Further diagenetic and thermal maturity processes consolidated these asphaltene aggregates into “lumps” of solid bitumen (or pyrobitumen at higher thermal maturity). Solid bitumen obstructs porosity and hinders fluid flow, and thus shows strong negative correlations with reservoir qualities such as porosity and pore throat size. We also find a strong positive correlation between the quantities of solid bitumen and pyrite, a relationship confirmed by petrographic evidence showing a close spatial association of bacterially-derived framboidal pyrite with solid bitumen accumulations in the intergranular paleo-pore spaces. These relationships suggest that solid bitumen and framboidal pyrite were both early products of bacterial sulphate reduction of liquid hydrocarbons following initial oil charging of the Montney Formation.

Although the CHCR fraction constitutes a small portion of the mass and volume of TOC in Montney samples it has important implications for reservoir quality. This fraction represents a thin film of condensed, heavy molecular hydrocarbon adsorbed onto mineral surfaces and may represent the lighter component of the paleo-oil that migrated into the Montney reservoir. The CHCR fraction potentially plays an important role in wettability alteration by creating hydrophobic matrix pore networks in portions of the reservoir that were not already filled with solid bitumen.