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Impact of Entrained Hydrocarbon and Organic Matter Components on Reservoir Quality of Organic-Rich Shales: Implications for Sweet Spot Identification in the Duvernay Formation Canada

Amin Ghanizadeh, University of Calgary

Summary

Hydrocarbon storage capacity of organic-rich shales depends on porosity and surface area for fluid (ad)sorption, whereas pore (throat) size distribution/connectivity influences permeability. The pores in organic matter (OM) are expected to develop during thermal maturation as generated hydrocarbons are expelled from the kerogen. However, the ability of industry to identify “sweet spots” within these reservoirs is still hampered by insufficient understanding of the effect of type/content of entrained hydrocarbon/OM components on reservoir quality. The primary objective of the current study is therefore to investigate the impact of entrained hydrocarbon/OM on storage and transport properties of organic-rich shales. To accomplish this goal, a comprehensive dataset was collected for a diverse sample suite from the Duvernay Formation (a prolific Canadian organic-rich shale reservoir), before and after sequential pyrolysis utilizing a new Rock-Eval procedure (“extended slow heating” (ESH) cycle; Sanei et al., 2015). Using the ESH cycle, different hydrocarbon/OM components can be distinguished more easily during the pyrolysis process: 1) free light oil (up to 150 °C), 2) fluid-like hydrocarbon residue (FHR, 150-380 °C) and 3) solid bitumen (380-650 °C).

Method

For a sample suite differing in organic matter type/content (2.8-5 wt%), the evolution of petrophysical properties are quantified after being subjected to an ESH cycle. The characterization techniques at each stage are helium pycnometry (grain density, porosity); low-pressure gas (N2, CO2) adsorption (surface area, pore size distribution); crushed-rock gas (He, N2, CO2) permeability and rate of adsorption (ROA) analysis (N2, CO2) (Haghshenas et al., 2016). Organic petrology and scanning electron microscopy (SEM) analyses were further conducted to verify/support the petrophysical observations.

Results, Observations, Conclusions

Compared to the “as-received” state, porosity, permeability, modal pore size distribution and surface area increase with sequential pyrolysis stages, associated with expulsion and devolatilization of free light oil and fluid-like hydrocarbon residue (up to 380 °C). However, the change in petrophysical properties associated with the (possible) degradation of solid bitumen (up to 650 °C) is variable and unpredictable - petrographic/SEM analyses are used to verify possible hypotheses that could justify the latter observation.

Novel/Additive Information

The present study is a continuation of previous works (Clarke et al., 2016, 2017), aiming to elucidate the impact of different type and content of entrained hydrocarbons/OM on reservoir quality of organic-rich shales. The quantification of these effects has important implications for identifying and targeting petrophysical “sweet spots” within organic-rich shale reservoirs for the purpose of optimizing stimulation design.