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New Insights about Organic Matter and Petroleum Migration from co-occurence of two organic phases with contrasting properties in Lower Carboniferous Banff Formation

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Introduction

The Lower Carboniferous Banff Formation of Western Canada Sedimentary Basin (WCSB) is a widespread and up to 800 m thick succession deposited on the cratonic platform in the northwestern margin of ancestral North America. Recent work on selected cores from West-Central Alberta reveals the co-occurrence of low reflectance alginate, indicative of immature organic matter, and both solid bitumen (migrabitumen) and fluid light hydrocarbon residue (FHR) indicative of migrated oil. Furthermore geochemical (biomarker) analysis shows two distinct organic facies: marine and carbonate sourced.

Theory and/or Method

Multidisciplinary analysis of selected core samples include: (i) Core description, facies identification, and depositional environment interpretation; (ii) Petrography and EDS elemental study of thin sections and rough samples; (iii) RockEval and qualitative organic petrography (fluorescence); (iv) Hydrocarbon molecular composition analysis using gas-chromatography - mass spectrometry (GC-MS); (v) Grain and bulk density (on 1.5 x 2 inch core samples) to calculate porosity and permeabiity; (vi) Burial modeling. Data and results are integrated and interpreted in contexts of the petroleum system.

Examples

Data and observations from cores show carbonate dominant lithology with rare siliceous fragments and sporadic clays. There is also evidence of multistage dolomitization and silica precipitation, initial porosity reduction, and limited secondary nano-scale porosity development. In contrast to high organic matter concentration (1-6% TOC wt%) recorded in drill cuttings, core samples display low TOC content (~0.2 TOC wt%). Although rocks appear to be non-porous in thin sections, SEM and organic petrography shows evidence of live oil in micropores and microfractures. Bulk analysis shows about 3-7% porosity. The organic matter is present but is immature in studied samples. Biomarkers clearly show two distinct types of source rocks: marine shale (Exshaw Type) and carbonate (i.e. Madison Group Type). Although data and burial history interpretation suggests that live oil migrated from some distances, the mechanism of migration through tight rocks on larger distances remains enigmatic. Presented data suggests that invasive percolation may have played a significant role.

Conclusions

The widely accepted belief that petroleum migrates via narrow migration paths comprised of porous carrier beds or paths is challenged by the presence of Exshaw sourced oil in examined Banff Formation tight carbonates. Dispersed occurrences of migrated live oil in tight non-reservoir rock units may represent significant, yet poorly understood petroleum losses during migration. In summary, the co-existence of dispersed organic matter and migrated oil within Banff Formation tight rocks and their roles in the petroleum system needs to be better understood.

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