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Organic matter characterization for unconventional reservoir potential assessment of the Murray Harbour Formation in the Sverdrup Basin, Arctic Canada

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Summary

This study focuses on organic matter characterization of the Middle Triassic Murray Harbour Formation. Preliminary Rock Eval 6 analysis and organic petrologic results have been obtained from closely-spaced samples (every 20 cm) of three cores taken from the west-central Sverdrup Basin in the Canadian Arctic islands. Each core is from a different stratigraphic level of the Murray Harbour Formation, and from wells located in progressively deeper parts of the basin. Total organic carbon (TOC) ranges from 0 to 4.8 wt. % for all the wells, with two of the intervals having a median TOC value of greater than 3 wt. %. Samples from two of the wells are within the oil generation window and samples from the third well are at the beginning of the oil generation window.

Organic petrologic results from each of the three cores highlight both similarities and differences in the character of the organic matter. Significant degraded, reworked organic matter is present in most samples, including vitrinite, inertinite and microfossil fragments. For this reason, the thermal maturity of organic matter was determined using reflectance of in-situ bitumen as opposed to vitrinite. Liptinitic algal material and bitumen dispersed within matrix clay fluoresce under ultraviolet light, indicating remaining hydrocarbon generation potential. Pore-filling bitumen is present in varying quantities, and in one core, has higher reflectance values than those derived from T_{max} values. These variable bitumen reflectance values suggest oxidation of organic matter and early generated hydrocarbons via bacterial sulphate reduction. Bacterial sulphate reduction likely began at deposition and continued throughout burial, resulting in a wide range of reflectance values.

Introduction

Advances in technology and greater demands for energy will eventually result in hydrocarbon exploration and development of unconventional sources in Canada's Arctic. The Murray Harbour Formation is an organic-rich, Middle Triassic, marine mud and siltstone succession located in the Sverdrup Basin in the Canadian Arctic Islands. It has a maximum thickness of 300 m and extends over the majority of the 300 000 km² basin (Embry and Beauchamp, 2008). Previous studies have

identified it as one of the major source rocks for the discovered conventional oil and gas fields of the Sverdrup Basin as well as established good regional constraints on thermal maturity (e.g. Brooks et al., 1992; Gentzis et al., 1996; Mukhopadyay et al., 1997). If the Murray Harbour Formation is proven to be a potential unconventional hydrocarbon reservoir, it could serve as a significant energy source for Canada.

Results and Discussion

This study examines core samples from three wells intersecting the Murray Harbour Formation. The cored wells, in order of increasing depth within the basin and distance from the main sediment source include: Collingwood K-33, Skybattle Bay M-11 and Pollux G-60. The Collingwood K-33 core is taken from the top of the Murray Harbour Formation, the Pollux G-60 core is taken near the bottom, and the Skybattle Bay M-11 core intersects a submarine maximum flooding surface within the formation. Median values from Rock Eval 6 analysis for each core are listed in Table 1. The lithology varies from shale to siltstone macroscopically, and as resolved from microscopic examination, the clay to silt-sized clasts are very poorly sorted.

The most organic rich samples are from the Pollux G-60 core and above the maximum flooding surface in the Skybattle Bay M-11 core (Figure 1). The Collingwood K-33 core is organically lean, as is the core from below the maximum flooding surface in Skybattle Bay M-11. The wide range of Rock Eval 6 parameters observed between the different core samples illustrates the importance of identification of organic-rich zones within the formation as production targets.

Preliminary organic petrology results show abundant reworked, oxidized organic matter in both the Skybattle Bay M-11 and Pollux G-60 core samples. Pollux G-60 samples contain abundant fluorescing algal material and bituminite, indicating further hydrocarbon generation potential. Skybattle Bay M-11 samples from above the maximum flooding surface show pore-filling bitumen with a continuum of reflectance values. This suggests bacterial sulphate reduction, leading to oxidization of organic matter and early generated hydrocarbons, occurred from deposition throughout burial. Clay-rich areas within the Skybattle Bay M-11 samples contain dispersed bitumen that generates free hydrocarbons when exposed to ultraviolet light. This population of bitumen likely represents the true thermal maturity of the rock. Pore-filling bitumen accumulates in pore spaces between clay-rich matrix and assorted silt-sized mineral grains and organic fragments.

Conclusions

Preliminary results from Rock Eval 6 analysis indicate the Murray Harbour Formation core samples from the Pollux G-60 and Skybattle Bay M-11 wells are within the oil generation window. Samples from the Collingwood K-33 core are just below the oil generation window. TOC values range from fair to excellent in both the Pollux G-60 and the upper portion of the Skybattle Bay M-11 core samples. The poor sorting of silt-sized grains provides accumulation space for bitumen and free hydrocarbons within the rock. These results suggest that certain zones within the Murray Harbour Formation may be considered potential unconventional reservoirs.

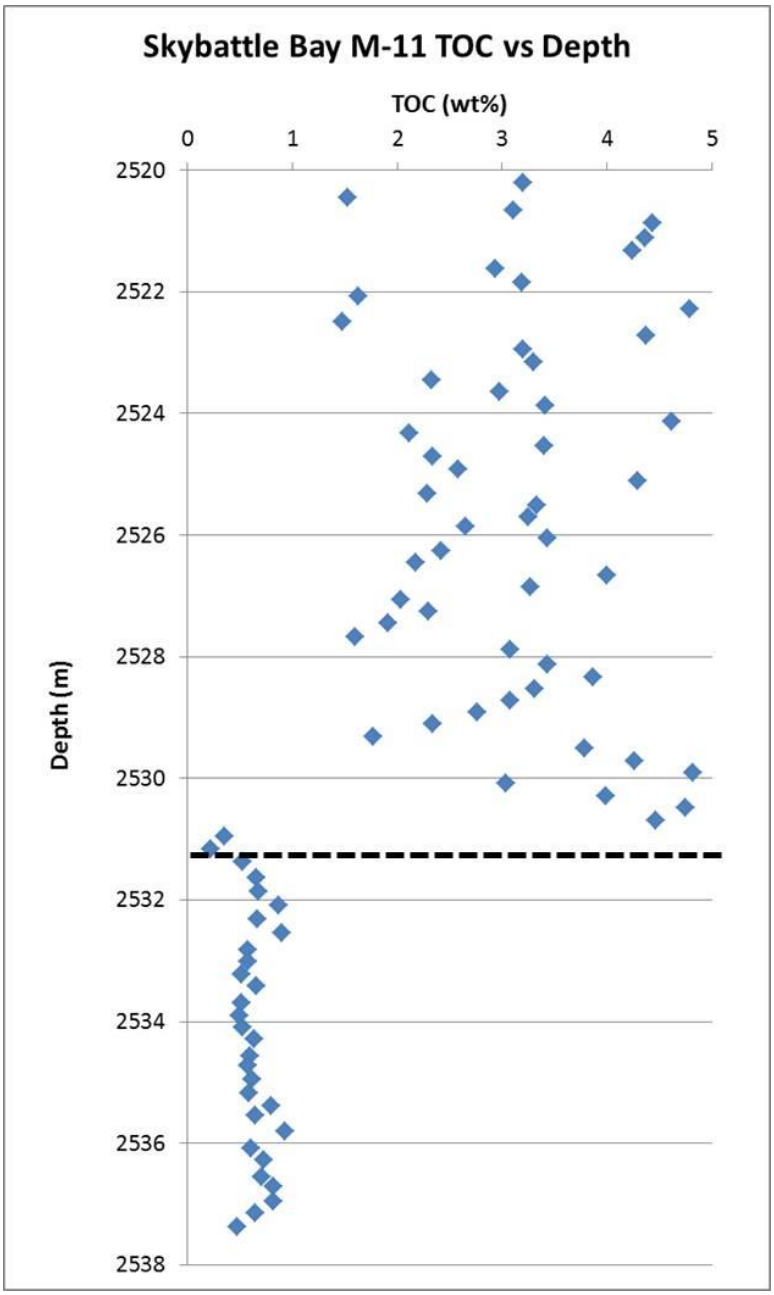

Figure 1: Plot of total organic carbon (TOC) versus depth for core samples taken from Skybattle Bay M-11. The dashed black line marks a submarine unconformity with organically lean siltstone below, a thin, starved basal lag deposit immediately above and overlying organically-rich shale.

Table 1: Median Rock Eval 6 parameters for studied core samples.

Well	Median TOC (wt. %)	Median S2 (mg HC/g rock)	Tmax (°C)
Collingwood K-33	0.4	1.0	434
Skybattle Bay M-11 (Upper core)	3.2	6.2	443
Skybattle Bay M-11 (Lower core)	0.6	0.4	438
Pollux G-60	1.4	5.7	441

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