HYDROCARBON SOURCE ROCKS IN PALEOZOIC STRATA OF THE FRANKLINIAN BASIN, CANADIAN ARCTIC ARCHIPELAGO

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The occurrence of potential hydrocarbon source rocks in Lower Paleozoic strata in the Canadian Arctic has been investigated using common organic geochemical techniques such as Rock-Eval pyrolysis, organic solvent extraction, fractionation, and saturate biomarker analysis. In contrast to Mesozoic strata, where most of the proven oil and gas reserves occur in the Canadian Arctic, only one small oil field was discovered in Devonian strata at Bent Horn on Cameron Island. As a result, few studies have documented organic geochemistry and petroleum characteristics of the Franklinian Basin sedimentary sequences (Powell, 1978; Fowler et al., 1991; Stasiuk and Fowler, 1994; Obermajer et at., 2010). In this study, several Paleozoic stratigraphic assemblages were sampled and geochemically assessed including: (1) Cambrian to Ordovician shallow water carbonates; (2) Silurian shelf margin carbonates; (3) widespread Silurian deep-water shale deposited after step-back of the shelf margin; (4) Early Devonian deep-water clastics from around the Boothia Uplift; (5) Early Devonian shallow water carbonates; (6) Middle to Late Devonian clastics deposited in front of the advancing orogenic belt.

The Rock-Eval data indicate that the best potential source intervals occur in the (3) Silurian basinal succession (Cape Phillips, Devon Island, Eids, Ibbett Bay and Kitson formations). While 80% of the analysed samples have total organic carbon (TOC) contents greater than 1%, about half of these samples display TOC values of >2%, sometimes continuously within stratigraphic intervals of up to 300 m (Cape Phillips Formation). Thermally immature samples have hydrogen indices (HI) of up to 600 indicating Type II-I kerogen. The (4) Late Silurian to Early Devonian Boothia-related clastics (siltstone, shale, sandstone) also contain several organic-rich intervals, typically near the base of the Bathurst Island and Stuart Bay formations for which average TOC values are 1% and 2%, respectively. TOC values of 4-8% and HI greater than 500 observed in several Stuart Bay Formation samples indicate potential presence of oil-prone Type II kerogen. Only small amounts of organic carbon were found in the (1) Cambro-Ordovician carbonate samples (85% of samples have less than 1% TOC), although two organic-rich occurrences were also noted (an outcrop of Cambrian Cape Woods Formation on southern Ellesmere Island with TOC of 17.6% and HI of 710, and in Ordovician Thumb Mountain Formation near the Polaris Mine on Cornwallis Island with TOC varying between 2 and 10% and HI values of >700). Data for the remaining samples of the (2) Silurian and (5) Devonian carbonates, and (6) Devonian clastic wedge are similar to the (1) Cambro-Ordovician carbonate succession as most of these assemblages generally exhibit low TOC (70%, 75%, 85% of analysed samples with TOC<1%, respectively). Exceptions include the Silurian shaley Douro Formation which locally has TOC of over 2% but very low HI values, geographically restricted Devonian carbonates of the Disappointment Bay on Truro Island with up to 3% TOC and hydrogen indices of 500- 600 known to contain filamentous and coccoidal algae (Stasiuk and Fowler, 1994), and Beverly Inlet and Hecla Bay liptinite-rich discontinuous coals on Melville Island (Fowler et al., 1991).

Extract yields although quite variable, are frequently above 100 mg total extract/g TOC. This is particularly common in (6) Devonian clastic wedge samples (75% of the extracted samples), more than half of which also yielded hydrocarbon (HC) extracts of more than 50 mg HC/g TOC. However, high proportions of hydrocarbons in these extracts, often greater than 60%, indicate hydrocarbon staining rather than good source rock potential. In fact, almost a half of extracted samples from all investigated assemblages appear to be stained, especially within the Silurian (2) carbonate and (3) basinal clastics (75% and 54% samples, respectively). In contract, (4) Late Silurian to Early Devonian Boothia-related clastics, which similarly to (6) Devonian clastic wedge samples are characterized by high total and HC extract amounts, show the lowest number of stained samples (26%). Furthermore, the amounts of saturated hydrocarbons are greater than the amounts of aromatic hydrocarbons in almost 90% of the extracts, with saturated/aromatic hydrocarbons ratios commonly within a 2.0-4.0 range.

Preliminary biomarker analyses indicate that about 30% of the extracted samples show characteristics of mild biodegradation that affected only normal alkanes distribution. The pristane/phytane ratios are typically more than 1.0 except for the (1) Cambro-Ordovician carbonates in which this ratio is below 1.0 in almost all extracts. Terpane biomarker signatures are typical for marine derived organic matter with a large C_{30} hopane peak and C_{31}-C_{35} homohopane abundances decreasing with increasing carbon number. Some extracts from Silurian (2) carbonate and (3) basinal successions, as well as (4) Late Silurian to Early Devonian Boothia-related clastics, show more mature terpane profiles with high abundances of tricyclic terpanes and Ts/Tm ratios greater than 1.0. Moreover, distributions of regular steranes, with S/(S+R) ratio within and $\alpha\beta\beta/(\alpha\alpha\alpha+\alpha\beta\beta)$ approaching equilibrium values, further confirm that organic matter in most of these samples is thermally mature with respect to hydrocarbon generation. Despite the overall similarities in biomarker compositions more detailed analyses, integrated with regional geology are needed to suggest a common source for hydrocarbons occurring within the Lower Paleozoic strata.

References

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