NORTHWEST TERRITORIES
GEOLOGICAL SURVEY

Description of the Horn River Group shales from one outcrop in the southern Peel Plateau, NWT

Viktor Terlaky, Kathryn M. Fiess, and Jonathan Rocheleau
Northwest Territories Geological Survey, Yellowknife, Northwest Territories, Canada
email: viktor_terlaky@gov.nt.ca

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

Introduction

The Bluefish Member of the Hare Indian Formation and, the Canol Formation, both of the Middle to Upper Devonian Horn River Group (Figure 1), are organic-rich shales present over large areas of the Northwest Territories (NWT). In the Mackenzie Plain (Figure 2), these shales are good to excellent source rocks for hydrocarbons, and are thermally mature over large areas. Not only has the Canol Formation sourced the oil pool at Norman Wells, but the shales may be self-sourcing unconventional reservoirs with excellent economic potential. Both stratal units are present across the Mackenzie Plain, Peel Plain and Peel Plateau areas of the Northwest Territories. Their thermal maturity and hydrocarbon potential have, however, not been adequately studied in the latter two regions. To better understand the thermal maturity and hydrocarbon potential of the Bluefish and Canol shales in the Peel Plateau, a subsurface Rock–Eval/TOC sampling program was initiated by the Northwest Territories Geological Survey (NTGS) in 2015. In the summer of 2016, two outcrops were strategically selected for field examination and sampling based on their location and accessibility to fill areal gaps in the subsurface Bluefish and Canol source rock and thermal maturity dataset for the Peel Plateau. The outcrops are termed Arctic Red River East and Flyaway Creek, based on the nearest geographical feature (Figure 2); this poster focuses on the results from the Arctic Red River East outcrop.

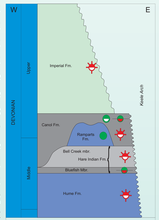


Figure 1: Regional Middle and Late Devonian Stratigraphy of the Mackenzie Plain and Peel areas of the Northwest Territories (modified from Maclean and Cook, 1999). This study focuses on the Horn River group in the Peel Plateau. The Horn River Group, comprising the Hare Indian, Ramparts, and Canol formations, overlies the Hume Formation in all physiographic regions, but its internal stratigraphy varies. The Ramparts Formation rapidly thins toward the West in the northern Mackenzie Plain and southern Peel Plain, and was not observed in either outcrop in this study. The upper member of the Hare Indian Formation, informally termed the Bell Creek member, has variable thickness. In the study area it thins and eventually pinches out toward the West; at the Arctic Red River East section it is approximately 15 m thick, but is absent at Flyaway Creek, where the Bluefish Member is directly overlain by the Canol Formation.

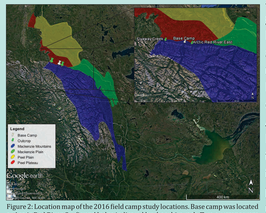


Figure 2: Location map of the 2016 field camp study locations. Base camp was located at Arctic Red River Outfitters' lodge indicated by the white tack. Two outcrops were examined: Arctic Red River East and Flyaway Creek, both indicated by green tacks. This poster focuses on the results from the Arctic Red River East outcrop.

Methods and Outcrop Description

In total, 70 m of section was measured and logged at the Arctic Red River East locality (Figure 3). The section was photographed and described with a focus on lithostratigraphic divisions. Shales were described based on their friability, hardness, weathered and fresh colours, odour, and any other macroscopic features observed. Carbonate pack- and grainstones were additionally described with the aid of a grain size comparator. Samples for geochemical and mineralogical analysis along with spectrometer data were collected at one metre intervals. Select laboratory analyses for the Arctic Red River East outcrop completed to date and their results presented here include: thin-section analysis and photomicrographs to complement facies descriptions by determining grain size and fossil content; major, minor, and trace element analysis to determine elemental abundance and ratios and used as proxies for paleoenvironmental interpretation; source-rock analysis to determine total organic carbon (TOC) content and rock maturity; and X-ray diffraction analysis to determine mineralogy.

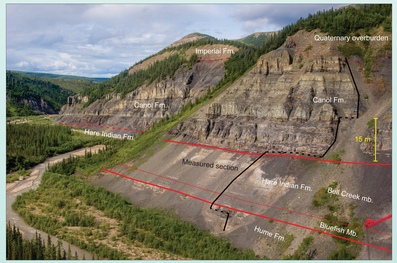


Figure 3: Overview image of the Arctic Red River East outcrop taken during a helicopter fly-by. The outcrop is ~ 75 m high; the scale bar is approximate due to the perspective distortion of the photograph. Stratigraphic up is toward the top of the outcrop. Contacts are indicated by solid red lines, dashed where inferred. The black line indicates the measured and sampled section, dashed black line indicates measurement and sampling shifts along-strike. Strata are near-horizontal with a gentle dip to the northeast. Arctic Red River East is located at N65°21.045, W130°45.339, or approximately 20 km east of Arctic Red River Outfitters base camp, and is in the Upper Ramparts River map area (NTS 106G; Aitken et al., 1982). The outcrop is located on the eastern bank of a deep river cut of a tributary of the Arctic Red River. The outcrop can be approached by helicopter with suitable landing on a boulder-rich point bar of the river. At this locality an exposure of the Hume Formation is overlain by the Hare Indian and Canol formations. The top of the Canol Formation is covered at the measured outcrop, but the contact with the overlying Imperial Formation was observed in the next outcrop exposure toward the North (upward in the photograph).

Facies Descriptions

Six distinct lithofacies are recognized at the Arctic Red River East outcrop (Figures 4-10).

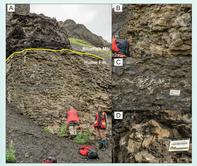


Figure 4: Field photographs of Facies 1, nodular limestone. A) Overview of the Hume Formation at the Arctic Red River East outcrop. B) Closer view of the nodular limestone facies. C) Possible crinoid arms and disarticulated ossicles, and laminar stromatoporoid fragments in a bed of Facies 1. D) Large tabulate coral fragments in a bed of Facies 1. Stratigraphic up is toward the top in all photographs. Photomicrographs of facies 1 are shown in Figure 6A and 6B.

Figure 5: Field photographs of Facies 2, bedded limestone. A) an ~ 10 cm thick matrix-supported limestone bed containing large intact brachiopods (floatstone; basal contact at scale card). Stratigraphic up is toward the top. Thin section photomicrographs of this bed are shown in Figure 6C and 6D. B) well-bedded grain- and packstone beds (at the level of the scale card) containing abundant tentaculitids and/or stylolinids. Stratigraphic up is toward the top. Photomicrographs of one of these beds is shown in Figure 6E and 6F.

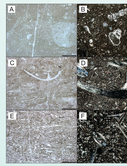


Figure 6: Thin section photomicrograph of Facies 1 and 2; photographs at different magnifications of the same thin section are paired next to each other. A) and B) photomicrograph of Facies 1 shows a matrix-supported fossiliferous limestone containing limestone, brachiopod, gastropod, crinoid, and stromatoporoid fragments. C) and D) photomicrograph of Facies 2 "matrix supported end-member" floatstone show matrix supported fossiliferous limestone containing large intact brachiopod body fossils and fragments. E) and F) photomicrograph of Facies 2 "grain supported end-member" packstone/grainstone shows fine-grained, grain-supported limestone with abundant tentaculitid and/or stylolinid body fossils.

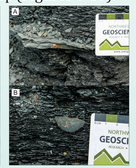


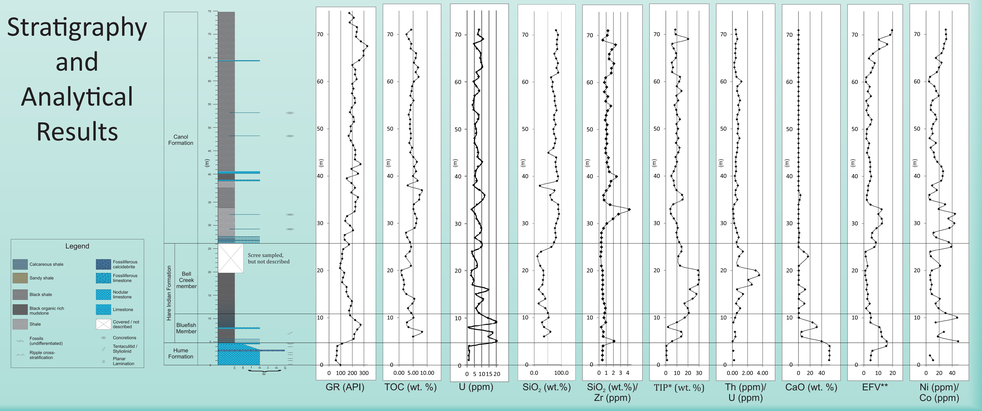
Figure 7: Field photographs of Facies 3, friable black shale containing abundant tentaculitids. A) black, friable, papery mudstone typical of Facies 3 is intercalated with thin packstone beds (at bottom of scale card). Stratigraphic up is toward the top. B) Tentaculitids and/or stylolinids are the characteristic feature of Facies 3, and where well preserved, are readily apparent on bedding planes. Stratigraphic up is toward the top.

Figure 8: Field photograph of Facies 4, heavily weathered shale. Chip samples were commonly difficult to obtain due to the extensive and deep weathering of this facies. Hammer is ~ 30 cm long; stratigraphic up is toward the top.

Figure 9: Field photograph of facies 5, black shale with a well-bedded, blocky (book-like) appearance (above the yellow arrow). Typically facies 5 is relatively hard and breaks into sharp chips. It most commonly has a greenish-blue patina and yellow surface staining, but is locally dull grey-brown to black. Stratigraphic up is toward the top.

Figure 10: Field photograph of facies 6, lenticular limestone that is typically interbedded with flaky black shale facies. In this photograph the carbonate lenses rapidly thicken and thin laterally and have a weak laminated appearance. Stratigraphic up is toward the top.

Stratigraphy and Analytical Results



Results & Summary

The **lithostratigraphy** of the outcrop consists of the carbonate-dominated Hume Formation, overlain by the tentaculitid-rich, friable black shales of the Bluefish Member, the Bell Creek member consisting of weathered shale, and the Canol Formation of blocky black shale.

Organic richness, indicated by Gamma-Ray counts (GR), TOC, and U concentration, shows that both the Bluefish Member and Canol Formation are enriched in organic materials, whereas the Hume Formation and Bell Creek member have low organic content.

Silica enrichment, shown by the SiO_2 content and SiO_2/Zr, indicates rock brittlenes. The carbonates of the Hume Formation have negligible silica content. The Bluefish Member has moderate, but variable silica content, whereas the Bell Creek member has a generally low silica content. The Canol Formation has the overall highest silica content, but is locally variable. The SiO_2 trend suggests that the Canol Formation has an increased biogenic silica input compared to the terrestrially dominated silica input for the Hare Indian Formation.

The **relative input of terrigenous material** at the time of deposition is determied by the terrigenous input profile (TIP)* and Th/U. Except for the Bluefish Member, where Th levels were below the detection limit in three samples, the profiles show good correlation between TIP and Th/U throughout the sampled stratigraphy. The Hume Formation has negligible terrigenous input. The Bluefish Member and lower Bell Creek member show an oscillating, but increasing terrigenous input trend, followed by a rapid decrease. The upper Bell Creek member and the Canol Formation show a relatively flat and low profile, indicating sustained reduced terrigenous input.

Presence of **carbonate**, indicated by CaO content, shows high values for the Hume Formation, an oscillating but decreasing trend upward in the Hare Indian Formation, and a generally low profile in the Canol Formation.

Proxies for **paleoredox conditions** include the enrichment factor of vanadium (EFV)** and Ni/Co. An EFV > 1 indicates enrichment of V under anoxic conditions; a Ni/Co < 5 indicates oxic, 5-7 dysoxic and > 7 suboxic-anoxic conditions. Note that values are highly susceptible to weathering effects, and the results are likely indicative of overall trends only, but may not represent actual depositional conditions. The values suggest that anoxic conditions did not prevail during the deposition of the Bell Creek member and most of the Canol Formation. However, for most of the Bluefish Member, the lower 10 m and increasingly in the upper 10 m of the Canol Formation both EFV and Ni/Co values are high, suggesting at least partially anoxic or hypoxic conditions.

References

Aitken, J.D., Cook, D.G. and Yorath, C.J. 1982. Upper Ramparts River (106G) and Sans Sault Rapids (106H) map areas, District of Mackenzie. Geological Survey of Canada, Memoir 388, 48 p.

MacLean, B.C., and Cook, D.G. 1999. Salt tectonism in the Fort Norman area, Northwest Territories, Canada. Bulletin of Canadian Petroleum Geology, 47: 104-135.

Wedepohl, K.H. 1971. Environmental influences on the chemical composition of shales and clays; in Physics and Chemistry of the Earth, edited by L.H. Ahrens, F. Press, S.K. Runcorn, and H.C. Urey. Pergamon, Oxford, p. 305-333.

Wedepohl, K.H. 1991. The composition of the upper Earth's crust and the natural cycles of select metals; in Metals and their Compounds in the Environment, edited by E. Merian. VCH-Verlagsgesellschaft, Weinheim, p. 3-17.

* TIP (wt. %) = Al_2O_3+Fe_2O_3+KO_2+TiO_2

** EFV = $(V_{(PPM)}/Al_2O_{3(wt.\ \%)})/(V_{(PPM)}{}^{AS}/Al_2O_{3(wt.\ \%)}{}^{AS})$, where AS = average shale composition (Wedepohl, 1971; 1991)