

Devonian Shale Basin Characterization in the Central Northwest Territories – Results of Outcrop and Well Sampling

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Summary

As part of the Shale Basin Evolution Project, the Northwest Territories Geological Survey (NTGS) sampled six outcrops and four industry wells during summers 2016 and 2018. The study included strategically selected outcrops and stratal intervals based on their location, in order to fill areal (horizontal) and stratal (vertical) data gaps in the regional database. This effort resulted in the creation of a more detailed regional dataset covering the Devonian Horn River Group in the Central Mackenzie Valley, southern Peel Plain and Peel Plateau areas of the Northwest Territories. This presentation highlights the scientific results from the 2016 and 2018 field seasons and the 2018 well chip sampling in a regional context, and incorporates legacy data from several outcrops and industry cores.

Introduction

In 2014, the NTGS initiated a continuation of their source-rock characterization studies of Devonian black shales (the Bluefish Member of the Hare Indian Formation and Canol Formation; Figure 1) under a new name, termed Shale Basin Evolution Project. The new initiative expands the project boundaries from the Central Mackenzie Plain to include the southern Peel Plain and Peel Plateau and the northeastern Mackenzie Mountains (Figure 2). As of 2016, the project includes a rigorous scientific assessment of the entire stratigraphy of the Devonian aged Horn River Group (Hare Indian, Ramparts, and Canol formations) and preliminary scoping of the Imperial Formation (Figure 1).

Methodology

The outcrops studied in 2016 and 2018 include – in an approximately south-east to north-west transect – Carcajou River, Dodo Canyon, Powell Creek, Arctic Red River East, Rumbly Creek, and Flyaway Creek (Figure 2). Data for these outcrops include legacy data acquired during previous source-rock characterization studies, and new data acquired during the 2016 and 2018 field seasons. At each outcrop spectral gamma-ray measurements and samples for geochemical, mineralogical, and isotope analysis were taken at one-metre intervals. Carbonate samples were taken for conodont biostratigraphic dating. The TOC content and source-rock quality were determined with a HAWK source-rock analyser through pyrolysis. Thermal maturity of the rocks was assessed through T_{max} data obtained from the source-rock analyser in addition to vitrinite reflectance analysis. Whole-rock litho-geochemical analysis (ICP-MS) of major, minor and trace elements was used to provide proxies for various palaeoenvironmental indicators (terrestrial input, silica source, and palaeoredox conditions). X-ray diffraction (XRD) was used to determine the mineral make-up of the rocks. For the Arctic Red River East outcrop stable-isotope analysis of carbon in organic matter was used as a palaeoclimate proxy and then combined with conodont biostratigraphy as a chronostratigraphic dating tool.

The well cuttings included in this study include samples from MGM East Mackay I-78, COPRC Loon Creek O-06, COPRC Mirror Lake N-20, and Husky Little Bear N-09 and H-64 wells. Publicly available industry data and new sampling by NTGS in this study include XRD, lithochem and source-rock analysis for these wells.

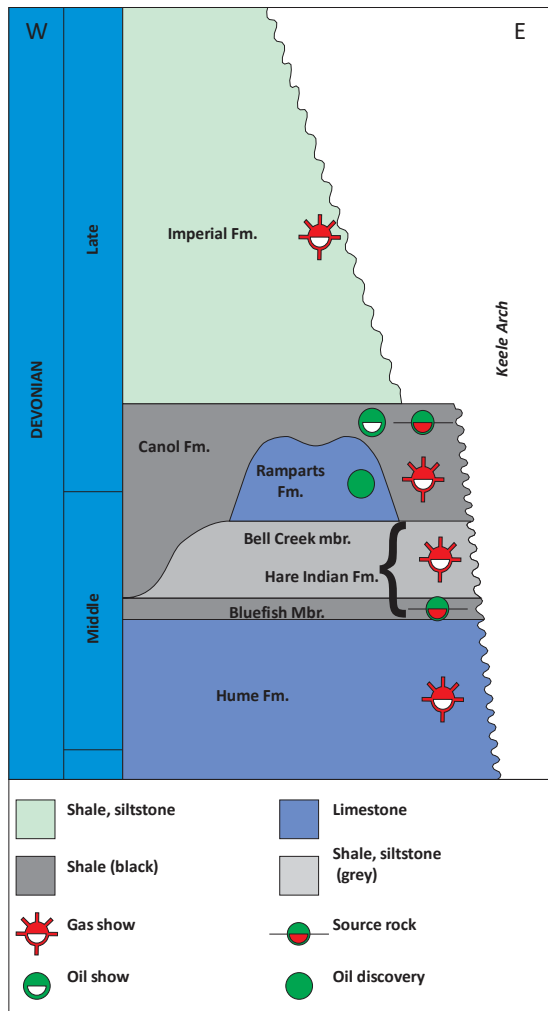


Figure 1: Regional Middle-Late Devonian stratigraphy of the Mackenzie Plain to Peel Plateau and Peel Plain areas of the Northwest Territories (modified from Rocheleau and Fiess, 2014).

Results

Although results of the 2018 studies are forthcoming at the date of this submission, preliminary data suggest that the Bluefish Member of the Hare Indian Formation comprises organic-rich shales with generally good, but regionally variable TOC content, also indicated by consistently high uranium concentration. Silica content in the Bluefish Member is moderate and variable, resulting in lower brittleness of the rock, which was also observed in the field. Terrestrial input, based on geochemical indicators, is generally low for the Bluefish Member, but increases upward in stratigraphy. Palaeoredox indicators suggest deposition under at least partly anoxic conditions during Bluefish Member deposition. The Bell Creek member has generally low TOC content and low uranium concentration. Silica content is also low with an elevated terrestrial input signature. Palaeoredox indicators suggest sustained oxic conditions. The Canol Formation has a variable, but generally elevated TOC content. Silica content in the Canol Formation is the highest of these formations, resulting in brittle fracturing noted in the field.

Terrigenous input is low through Canol Formation deposition. Palaeoredox indicators suggest variable conditions during deposition. Source-rock and vitrinite reflectance analyses indicate a regionally variable trend of rock maturity, with generally increasing maturity toward the western part of the study area. Available conodont and stable isotope analysis results will aid in delineating the chronostratigraphy of these strata.

Existing and forthcoming data will be used to create regional correlations between surface and subsurface sites. The chronostratigraphic data will aid in elucidating the stratal relationships between the lithologic units in the Horn River Group, which to date remain a topic of debate (e.g. Pyle et al., 2014; Kabanov and Gouwy, 2017). A major focus of this study will be not only the vertical, but also the lateral variations in lithologies and transitions between stratal units. Collectively, these data will be used as input for a new, future research initiative focused on basin analysis and basin modeling of Paleozoic-Mesozoic strata in the Northwest Territories.

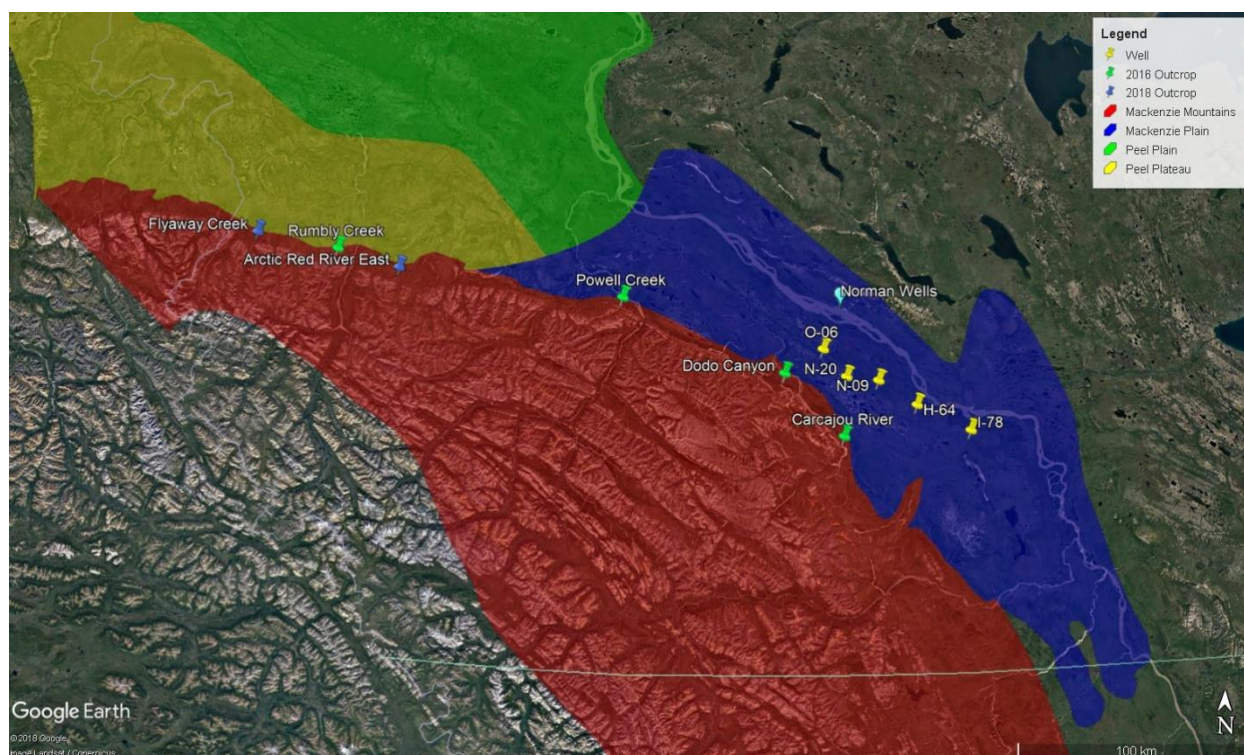


Figure 2: Exploration regions in the west-central Northwest Territories and study locations.

Conclusions

The six outcrops and five wells selected for detailed analysis in this study provide data to infill gaps in our current regional database for the Horn River Group strata. The aim is to refine regional hydrocarbon potential mapping for the Central Mackenzie Plain, southern Peel Plain and Peel Plateau, and north-eastern Mackenzie Mountain areas of the Northwest Territories. Results of this study will be used to create regional correlations between surface and subsurface sites, facilitate paleoenvironmental interpretations, refine the regional stratigraphic interpretation using high-resolution chronostratigraphic data, and aid in future basin modeling efforts by the NTGS.

Acknowledgements

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