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Report of activities for integrated Devonian to Cretaceous studies of the northern Mackenzie Corridor GEM2 Mackenzie Project

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Abstract

The Geo-mapping for Energy and Minerals (GEM) program lays the foundation for sustainable economic development in the North. The Mackenzie region of interest contains a producing oil field at Norman Wells. Our research seeks to better understand the Norman Wells oil field in order to develop petroleum models for the broader region. We propose a new model of thrust-related exhumation and natural fracture-induced oil migration from the Canol Formation source rock to the carbonate reservoir. Ongoing research will test this hypothesis and explore the implications of this model for the hydrocarbon potential of the region.

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Foreword

The Geo-mapping for Energy and Minerals (GEM) program is laying the foundation for sustainable economic development in the North. The Program provides modern public geoscience that will set the stage for long-term decision making related to investment in responsible resource development. Geoscience knowledge produced by GEM supports evidence-based exploration for new energy and mineral resources and enables northern communities to make informed decisions about their land, economy and society. Building upon the success of its first five-years, GEM has been renewed until 2020 to continue producing new, publically available, regional-scale geoscience knowledge in Canada's North.

During the summer 2015, GEM program has successfully carried out 14 research activities that include geological, geochemical and geophysical surveying. These activities have been undertaken in collaboration with provincial and territorial governments, northerners and their institutions, academia and the private sector. GEM will continue to work with these key collaborators as the program advances.

Introduction

The Mackenzie Corridor region of interest (Figure 1) encompasses a substantial producing oil field at Norman Wells and significant unconventional resource potential. The unconventional resource potential is primarily due to Devonian mudstones (e.g., Pyle et al., 2015), quite notably including the Canol Formation which is the source rock for the Norman Wells oil field (e.g., Snowdon et al., 1987; Yose et al., 2001).

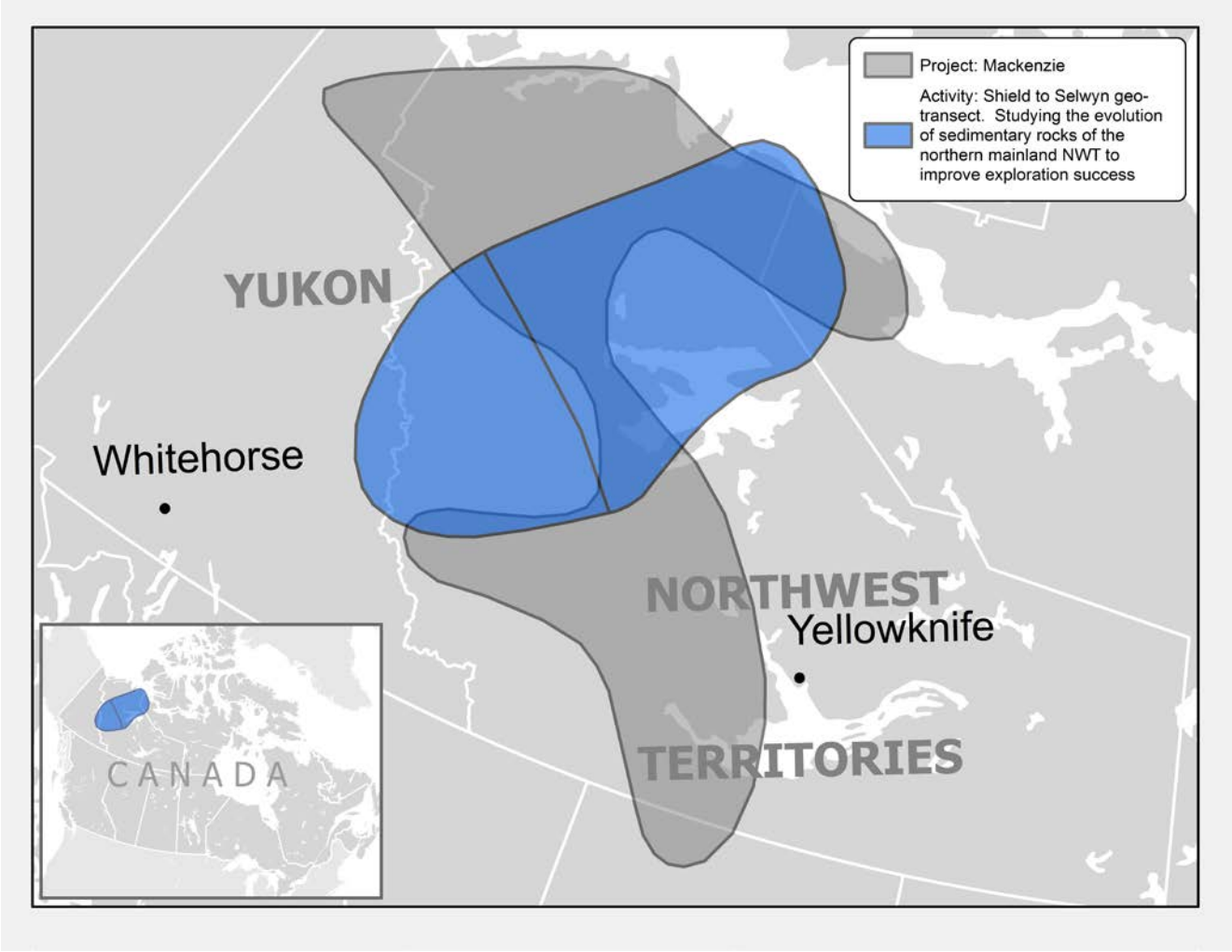

Figure 1. Location of GEM2 Mackenzie Project area.

The petroleum geology of the central and northern Mackenzie regions presents numerous conundrums. First and foremost, what makes the Norman Wells oil field unique (location is shown in Fig. 2)? There are other Devonian reefs in the region, but they do not contain commercial oil resources. In fact, many exploration wells have been drilled in the region and the vast majority were unsuccessful.

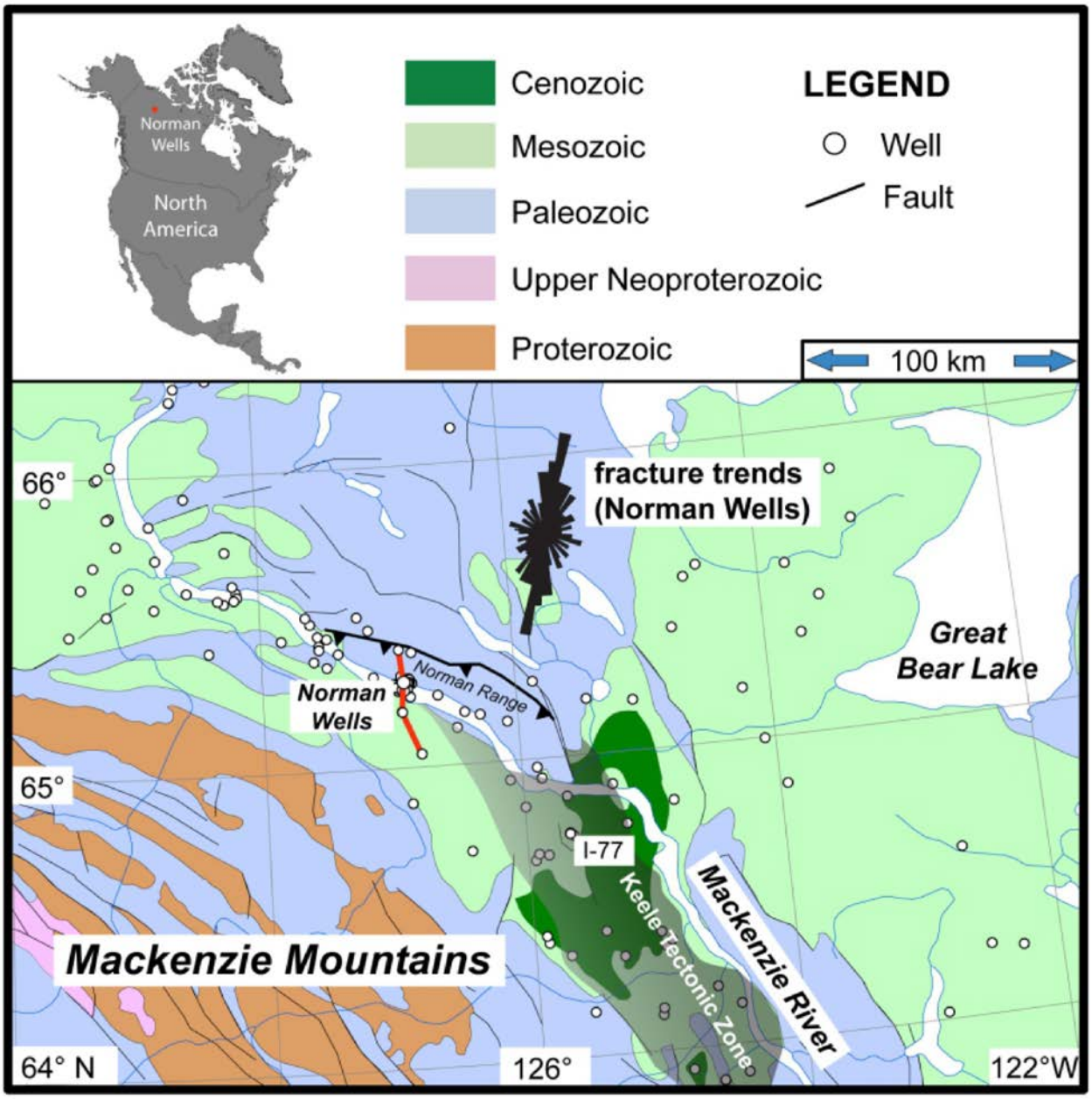

Figure 2. Location of the Norman Well oil field, the Norman Range thrust fault, and orientation of fractures in the reservoir.

Goal & objective

This activity aims to provide a better understanding of the broad geological context for Devonian resources and how Devonian to Cretaceous tectonic events impact the petroleum geology of the region.

Scientific question addressed

The regional framework scientific question being addressed by this research activity is, can integrated basin tectonic models improve our understanding of the petroleum resources of the region (Figure 1)?

Methodology

The overall approach is to integrate existing data and target key questions to test new hypotheses. New bedrock geological maps of the region generated by the GSC under the GEM1 program provide good structural and stratigraphic context (e.g., Fallas et al., 2013). New subsurface geological frameworks were also produced by previous GSC activities (e.g., Hadlari et al., 2013; Hadlari et al., 2014; Hadlari et al., 2015). Pre-GEM work on Norman Wells regarding organic geochemistry (Snowdon et al., 1987; Gal et al., 2009) and the overall structure of Norman Wells (e.g., Yose et al., 2001) are to be integrated with regional thermal history models (Issler et al., 2005).

Results

A new conceptual model for the Norman Wells oil field is deduced by integrating Devonian thermal maturity data, structural geometries, regional thermal history, and updated Cretaceous tectonostratigraphy (Hadlari et al., 2014). Hadlari (2015) proposes that the Canol Formation source rock is naturally "fracked" as it has been exhumed from the late Tertiary to present (Fig. 3). This model shows how Norman Wells is unique and helps to explain why there is an apparent absence of hydrocarbons in other Devonian reefs at depth and away from thrust faults.

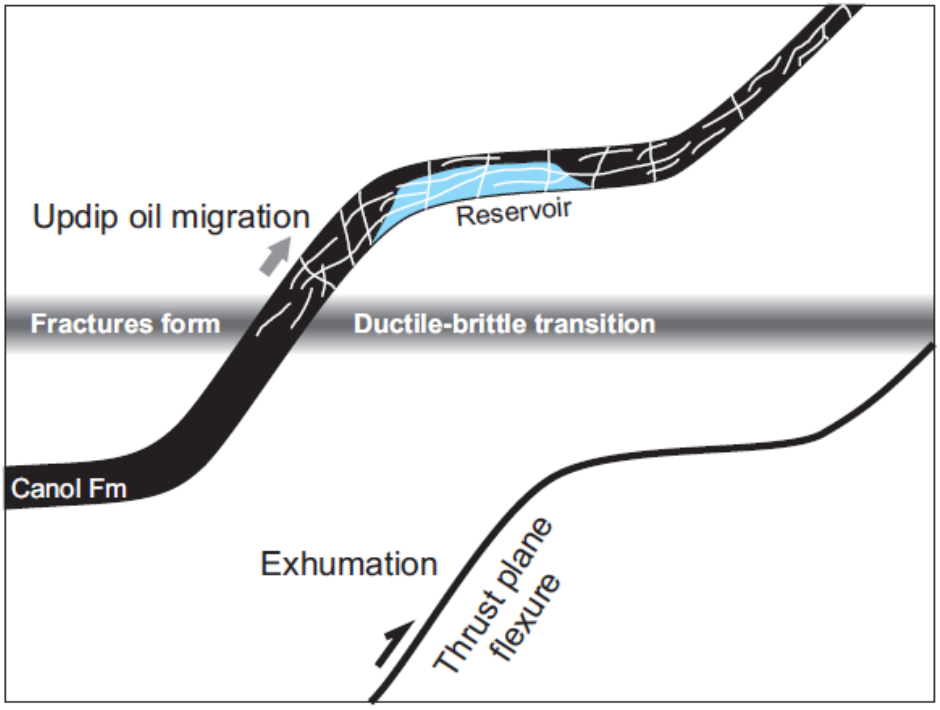

Figure 3. New conceptual model for the Norman Wells oil field after Hadlari (2015).

Conclusions

A conceptual model of exhumation and relatively shallow fracture-induced oil migration is consistent with geological data from the Norman Wells oil field and the surrounding region. The new model explains why a second version of Norman Wells has not been found by using conventional exploration models. The new model implies that Devonian mudstones contain significant amounts of hydrocarbons at depth, which impacts the unconventional resource potential of the Canol Formation, and so this aspect is a high priority topic for ongoing study.

Future work 2015-2016

Study of Rock-Eval pyrolysis data and organic petrology to better understand thermal history and maturity, both from the Devonian Canol Formation source rock and Cretaceous strata.

Future work 2016-2018

Development of updated regional tectonic models to better constrain basin events related to petroleum generation and migration. Use new methods to test the impact of organic matter recycling on Rock-Eval pyrolysis data.

Acknowledgments

This research activity is part of the GEM 2 Mackenzie Project, with GSC management support from Carl Ozyer and Paul Wozniak. The nature of this study is only possible because of previous work under GEM1 by Bernie MacLean, Karen Fallas, and Robert MacNaughton; and by Leanne Pyle, Len Gal, and Kathy Feiss.

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