Natural Resources Canada | Ressources naturelles Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8332

Report of activities for the GEM-2 Mackenzie project: Devonian litho- and biostratigraphy in the Northern Mackenzie Mountains, NWT

S. A. Gouwy, L. M. Tingley, C. Deblonde, and W. C. Chan

2017

Celebrating 175 yrs

Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8332

Report of activities for the GEM-2 Mackenzie project: Devonian litho- and biostratigraphy in the Northern Mackenzie Mountains, NWT

S. A. Gouwy[1], L. M. Tingley[1], C. Deblonde[1], and W. C. Chan[1]

[1] Geological Survey of Canada (Calgary)

2017

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2017

Information contained in this publication or product may be reproduced, in part or in whole, and by any means, for personal or public non-commercial purposes, without charge or further permission, unless otherwise specified.
You are asked to:
- exercise due diligence in ensuring the accuracy of the materials reproduced;
- indicate the complete title of the materials reproduced, and the name of the author organization; and
- indicate that the reproduction is a copy of an official work that is published by Natural Resources Canada (NRCan) and that the reproduction has not been produced in affiliation with, or with the endorsement of, NRCan.

Commercial reproduction and distribution is prohibited except with written permission from NRCan. For more information, contact NRCan at nrcan.copyrightdroitdauteur.rncan@canada.ca.

Permanent link: https://doi.org/10.4095/306213

This publication is available for free download through GEOSCAN (http://geoscan.nrcan.gc.ca/).

Recommended citation
Gouwy, S. A., Tingley, L. M., Deblonde, C., and Chan, W. C., 2017. Report of activities for the GEM-2 Mackenzie project: Devonian litho- and biostratigraphy in the Northern Mackenzie Mountains, NWT; Geological Survey of Canada, Open File 8332, 11 p. https://doi.org/10.4095/306213

Publications in this series have not been edited; they are released as submitted by the author.

FOREWORD (supplied by GEM Coordination Office)

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 responsible land-use and 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 2017 field season, research scientists from the GEM program successfully carried out 27 research activities, 26 of which will produce an activity report and 12 of which included fieldwork. Each activity included 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 partners as the program advances.

PROJECT SUMMARY

Northern Mackenzie Mountains bedrock mapping and stratigraphic studies are a component of the Mackenzie-Selwyn geo-transect: studying the evolution of sedimentary rocks of the northern mainland NWT to improve exploration success for petroleum resources and base metal deposits (Figure 1). This activity will initiate the first regional integrated effort to place Proterozoic to Cenozoic strata of the Mackenzie Platform, Selwyn Basin, and adjacent regions into a modern tectono-stratigraphic and metallogenic framework, and will better enable industry and Northerners to responsibly find and develop energy and mineral natural resources, maximizing their economic and societal impact.

This report provides a short account of the field activities in the Bonnet Plume map area (NTS 106B) of the Mackenzie Mountains (NWT). Fieldwork was conducted by the Devonian paleontology team, as part of the Arctic Red field party (MacNaughton et al., 2017), between July 4 and July 20, 2017. Information presented in this report concerns the biostratigraphic and lithostratigraphic characterization of Devonian units related to the geological mapping of the area.

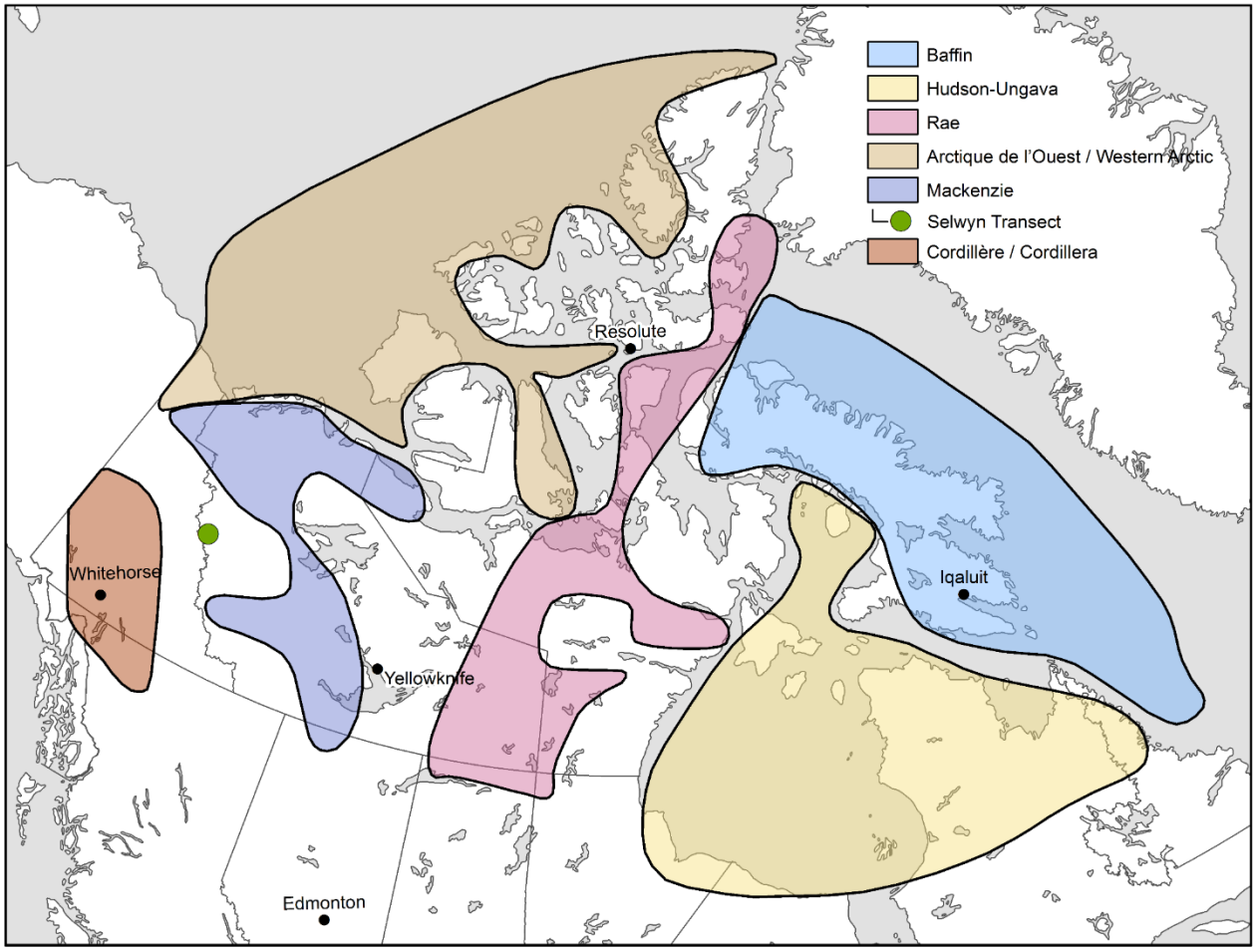

Figure 1. Location of the GEM-2 Mackenzie project area (green circle).

INTRODUCTION

The Devonian Stratigraphic Framework study is part of the GEM-2 Mackenzie Project. The main goal of the study is to upgrade the multifaceted knowledge of the region's economically important Devonian strata. The **Devonian stratigraphic framework study** focuses on the improvement of stratigraphic subdivision in support of bedrock mapping and frontier petroleum exploration.

The Devonian paleontology team conducted this year's fieldwork from July 4 – July 20, 2017, in the Bonnet Plume map area (NTS 106B) of the Mackenzie Mountains. This interval consisted of five travel days to fly in and out of the remote base camp at Goober Lake, two camp days (due to helicopter failure) that were used for traversing and exploring the geology near base camp, four camp days due to mist, rain and smoke from the Fort Good Hope wild fire and six successful field days.

The team measured, described and sampled three outcrop sections: 1GUA17 ("Tic Mountain" section), 2GUA17 (Keyhole section), and 3GUA17 ("Messed Mountain" section) (Fig. 2). These sections cover the

Middle Devonian Frasnian succession from the upper part of the Hume Formation to the basal part of the Imperial Formation. All three sections were sampled for conodont biostratigraphy, two were sampled for palynology biostratigraphy and one section was surveyed with a spectral gamma-ray scintillometer for correlation with outcrop sections in the Mackenzie Mountain front and subsurface sections in the Peel and Mackenzie plains (Kabanov *et al.*, 2016; Kabanov and Gouwy, 2017).

The purpose of this fieldwork is to strengthen the biostratigraphic framework, therefore 42 conodont samples and 180 palynology samples were collected from the studied formations.

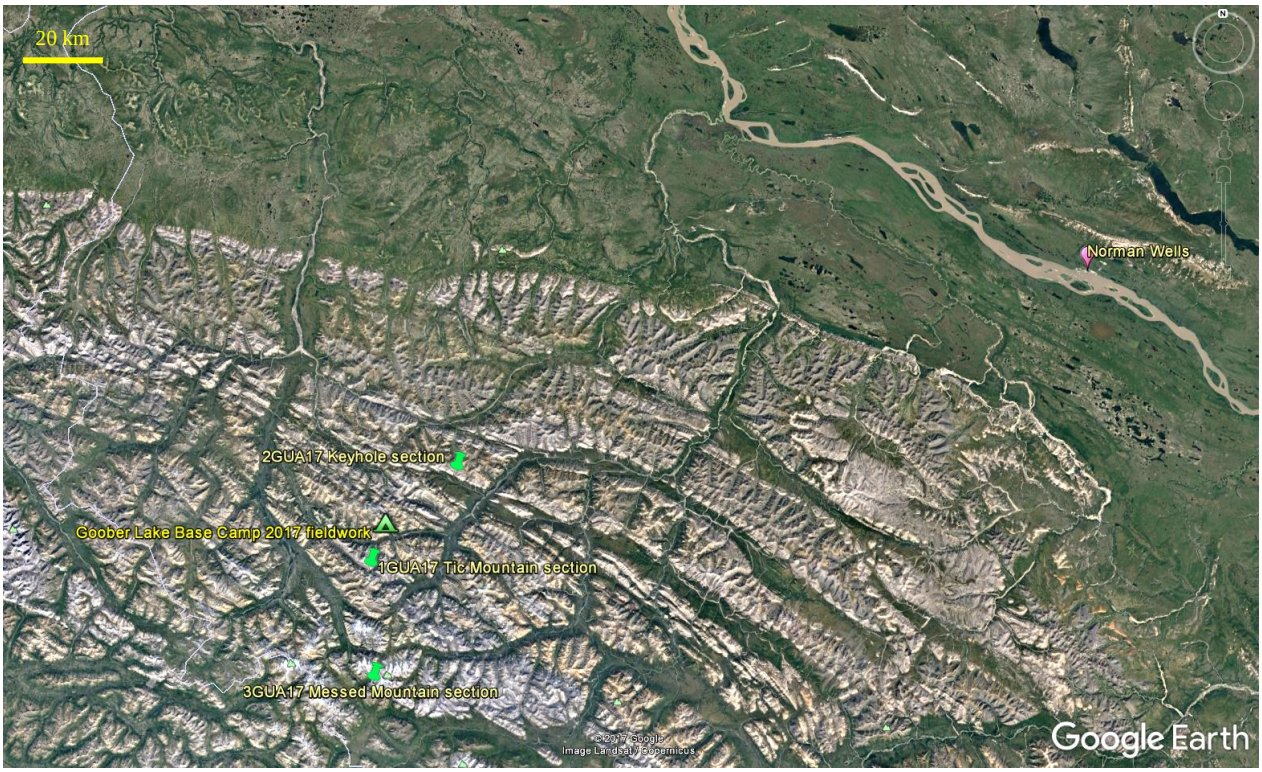

Figure 2. Location of the studied sections in the Northern Mackenzie Mountains, NWT (modified from Google Earth).

This year's fieldwork study concentrated on the Middle Devonian – Frasnian organic-rich shale deposits of the Horn River Group (Hare Indian and Canol formations) in the eastern part of the Bonnet Plume map sheet area and their biostratigraphic correlation to the equivalent formations in the mountain front of the Mackenzie Mountains (2016 Fieldwork, Kabanov *et al.*, 2016).

These thick basinal deposits follow the deposition of the Hume Formation platform carbonates and precede the deposition of the Imperial Formation sandstones. The black Hare Indian and Canol formations shales of the Horn River Group host the giant, unconventional prospect of gas and light oil. The Canol Formation shale is also known to be the source rock for the Norman Wells conventional oil play. This prospect constitutes the research focus of the multiproxy characterization of this stratal package (Pyle and Gal, 2016; Kabanov and Gouwy, 2017). The biostratigraphic and chronostratigraphic constraints on

formations and members are essential for detailed correlation, with the most significant results achieved to date in the Hare Indian and Ramparts formations (Fig. 3, Kabanov and Gouwy, 2017). In the northern Mackenzie Mountain front and in the Mackenzie Plain, the organic-rich shales of the Horn River Group enclose the platform and reefal limestone of the Ramparts Formation. In this area the Horn River Group has been studied intensively during the last five decades. The construction of the conodont biostratigraphic framework of the Horn River Group was started by Uyeno (Uyeno, 1978, 1986 & 1991) and continued by Pyle (Pyle *et al*., 2014; Pyle and Gal, 2016) and Gouwy (Kabanov and Gouwy, 2017).

In the Bonnet Plume Map area, the Ramparts Formation is not present and black Canol Formation shale is deposited directly onto the black Hare Indian Formation shale. A detailed study of Devonian outcrops in this area was done by Morrow (1991) describing mostly Lower Devonian outcrops (sometimes including the lower part of the Hume Formation). The Middle Devonian and Frasnian Horn River Group has not been studied yet in the area and no conodont/palynology biostratigraphic data are available. Dating and correlating the Hume-Hare Indian and the Hare Indian-Canol contacts in this biostratigraphic study contributes to addressing the data and knowledge gap in the Horn River Group.

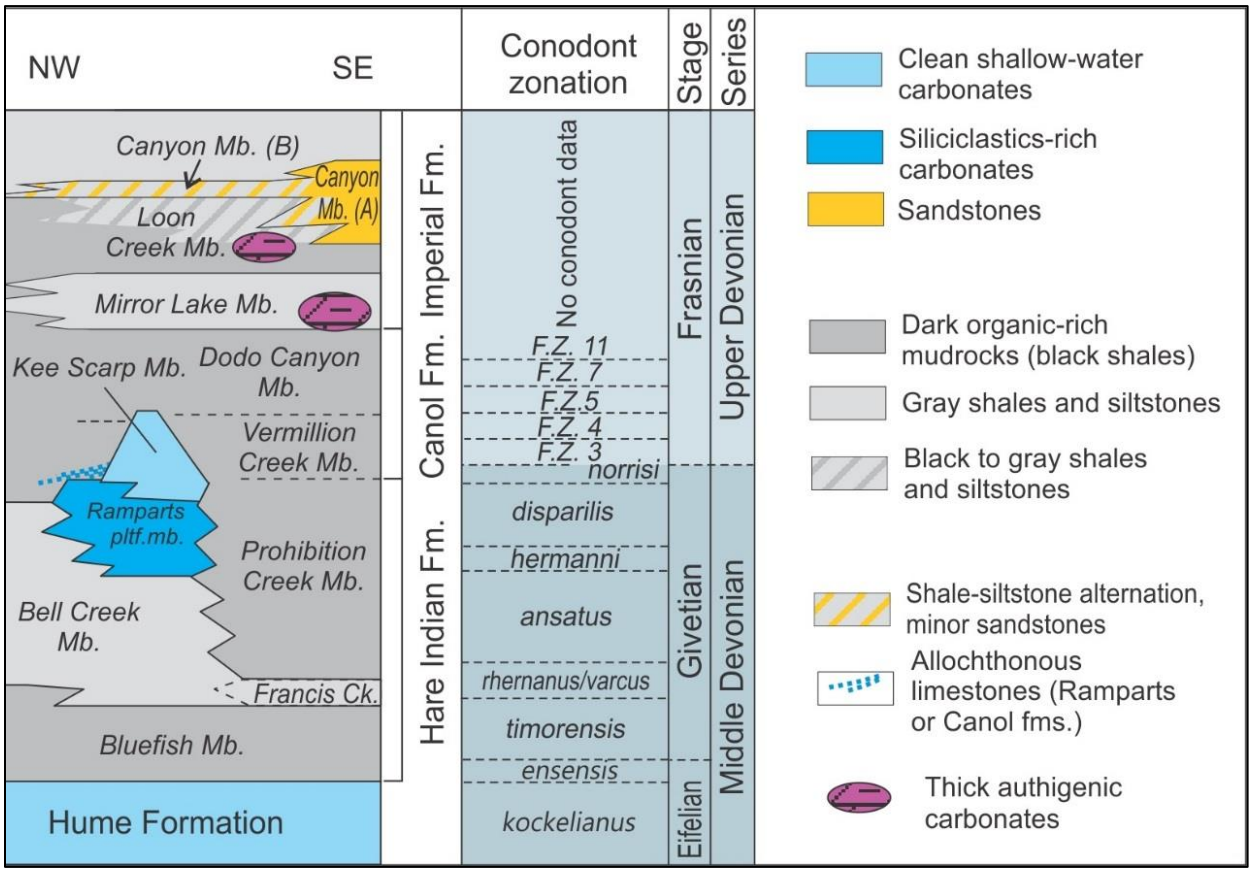

Figure 3. Litho- and biostratigraphy of the Horn River Group in the Northern Mackenzie Mountains and Mackenzie Plain (modified from Kabanov & Gouwy, 2017).

METHODOLOGY

- *Microfossil biostratigraphy (conodonts and palynology)*

An important part of the Devonian study involves producing detailed biostratigraphic information allowing regional and global correlation of the Horn River Group. The most detailed biostratigraphic framework for the Devonian is based on conodonts, an extinct group of marine protochordates with phosphatic teeth-like elements (Blieck *et al*., 2010). The fast morphologic evolution of these conodont elements through geologic time allows for a detailed subdivision of the studied time interval into conodont biozones that has seen most success in high-resolution correlations of Paleozoic marine rocks (Fig. 3). Earlier publications on the local conodont biostratigraphy (Kabanov and Gouwy, 2017 and references therein) provide a good basis for correlation (Fig. 3), but also indicate the need for further investigation to complete the framework where no data were available.

For conodont studies, about 2.5kg of limestone or dolostone is sampled in the field and shipped back to GSC laboratories for processing. Sampling density was higher below and above the contact of the Hume/Hare Indian formations with the intention of precisely locating the base of the Givetian Stage (Fig. 6). In the basinal mudrocks of the Horn River Group (Hare Indian and Canol formations), the total number of stratigraphic levels that can be sampled for conodonts is limited since the processing techniques require dissolution of calcareous or dolomitic rock matrixes using acetic acid. In those black shale formations, the sampling was restricted to the few dolomitic beds and dolomitic or calcareous nodule levels that can be processed using standard techniques and might yield the necessary biostratigraphic information.

For palynology (study of pollen and spores), about 200g of shale is sampled in the field and shipped back to GSC laboratories for processing. Sampling at the 1GUA17 Tic Mountain Section (Fig. 2) was done at 0.5m intervals from the top of the Hume Formation for the entirety of the exposed Canol Formation (approximately 46 m with some covered sections). At the 2GUA17 Keyhole Section (Fig. 2), samples were taken at 0.5m intervals from the top of the Hume Formation to the base of the Imperial Formation. The goal of sampling for palynology is to fill in gaps in biostratigraphy within the Horn River Group shales where the possibility of sampling for conodonts is lacking within large siliceous shale packages of substantial thickness (up to 9 m in some cases).

The combination of results from the conodonts sampled in the calcareous units and the palynomorphs sampled in the shale units will give us a more complete data set to create a strong biostratigraphic framework correlating the new shale dominated sections with the regional and global stratigraphy.

- *Gamma ray spectrometry*

The gamma ray signature was measured in one outcrop using a RS-230 BGO scintillometer (Radiation Solutions Inc.). Standard gamma ray logs were made in 0.5 m increments in the organic shale-dominated part of the outcrop. Decomposition of gamma radiation into U, Th and K spectra is widely used to interpret

lithology and depositional environments. Potassium and thorium are relatively stable and mostly bound in detrital siliciclastics, whereas uranium is more soluble and tends to be trapped by organic matter.

The gamma ray logs are an additional correlation aid alongside the biostratigraphic data and are especially useful in the short distance correlation of organic-rich argillaceous/siliciclastic deposits.

RESULTS

1GUA17 – "**Tic Mountain" section** (Trilobit section) (64°38'18.39"N; 130°50'18.11"W)

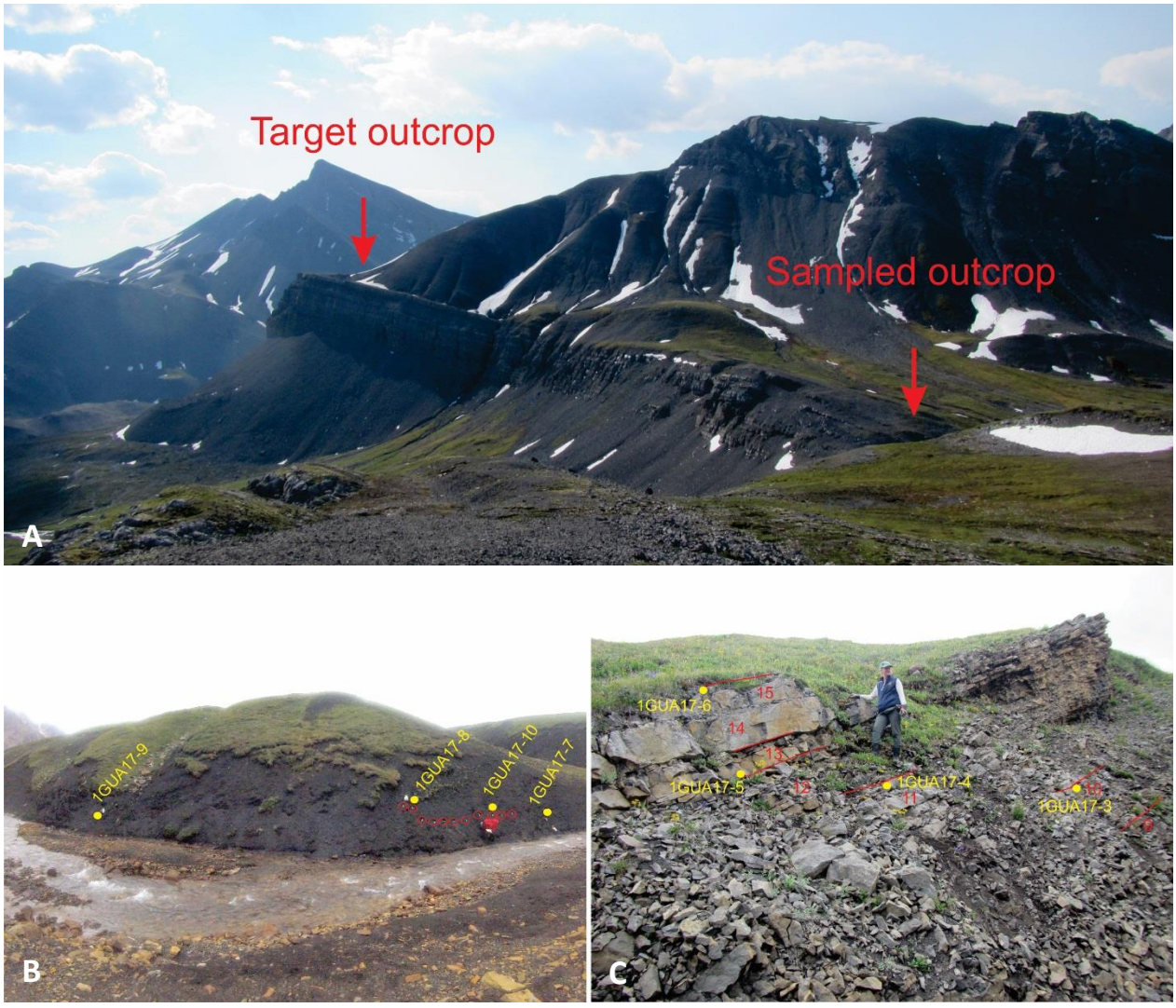

Figure 4. "Tic Mountain" section. A: View on the target section and the sampled section; B: Lower part of the Canol Formation with position of conodont samples (yellow) and some of the palynology samples (red); C: Uppermost part of the Hume Formation with indication of the units and position of samples (Geologist Leanne for scale).

The exposure of black shales on the flank of the mountain was suggested to us by Beth Fisher (Project Geologist at NTGS, Yellowknife) who surveyed the area of Tic Mountain for mapping purposes. The initial target section proved not to be suitable (steep limestone cliff, weathered scree-covered shales). A section exposing the same lithological succession was found in a small creek cut, about 800 m west of the target section (Fig. 4A). The outcrop along the side of the creek allowed sampling of the upper 10.6m of the Hume Formation (platform limestone) and the lower 46m of the Canol Formation (recessive black shales with several thin limestone beds). Unfortunately, the contact between the Hume and Canol formations was covered (3m) by rock debris in a small gully. Ten samples were taken for conodont biostratigraphy (6 in the Hume Formation and 4 in the Canol Formation) and 35 for palynology studies in the Canol Formation.

2GUA17 – **Keyhole section** (64°51'37.02"N; 130°22'4.70"W)

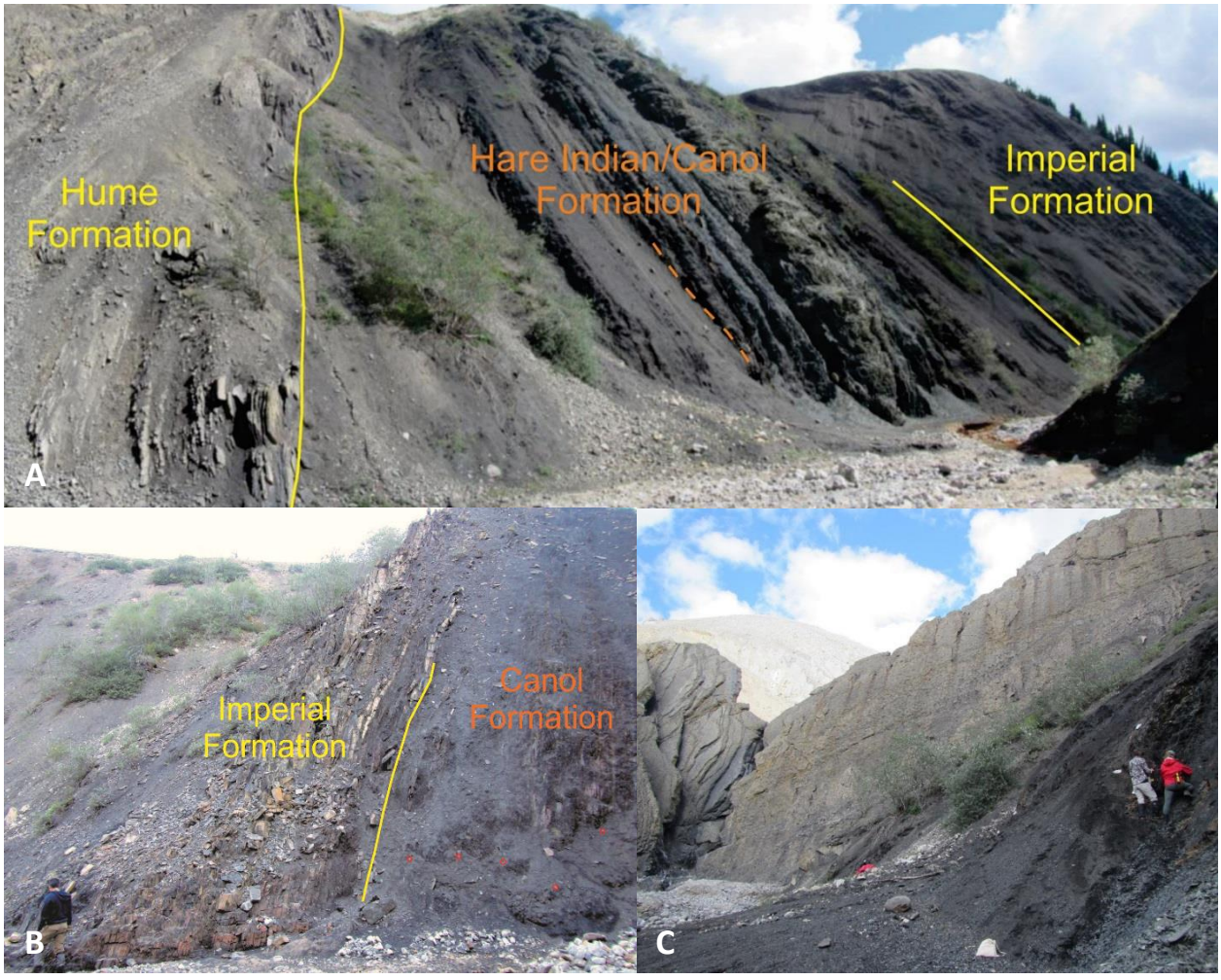

Figure 5. Keyhole section. A: Overview of the section from the top of the Hume Formation to the base of the Imperial Formation. The contact between the Hare Indian and Canol Formations is tentatively indicated by the dashed line (contact may be transitional); B: Contact between the Canol Formation (Horn River Group) and the overlying Imperial Formation. Palynology samples indicated by red circles; C. Geologists sampling for palynology research in the Hare Indian/Canol Formation, Hume Formation limestone cliffs in the background with a waterfall (not visible in photo) cutting a (key)hole in the rock.

The Keyhole section was discovered on air photos as a possible exposed contact between the Hume and the Hare Indian/Canol formations. It turned out to be a beautiful section exposing deposits from the upper part of the Hume Formation, over the Hare Indian/Canol Formation to the lower part of the Imperial Formation. The sampled interval ranges from the uppermost 16m of the Hume Formation up to the uppermost layer of the Canol Formation at the contact with the Imperial Formation. The section was sampled for conodont biostratigraphy and palynology and was scanned for gamma ray spectrometry. The contact between the Hume and the Hare Indian/Canol Formation is well exposed in this section and consists of well-bedded brachiopod wackestone followed by several thin layers of dark limestone (barren of macrofossils) and paper-thin black calcareous shales. The Hare Indian/Canol Formation contains 21 calcareous levels (limestone beds and nodules) which will give us a good conodont biostratigraphic record for this basinal deposit. One hundred sixty samples were taken for palynology in the black shales of the Hare Indian/Canol Formation.

3GUA17 – "**Messed Mountain" section** (64°22'24.38"N; 130°49'34.79"W)

The contact between the Canol Formation and the underlying strata is rather problematic on "Messed Mountain" due to tectonics (hence the informal name). In this area the underlying Hume Formation is possibly replaced by the Hailstone Formation. Although the two formations are easily distinguished based on their lithological description (the Hume Formation consists of bioclastic platform carbonates in its uppermost part; the Hailstone Formation is largely composed of black shales alternating with bioclastic limestone in its uppermost part), due to severe weathering in the field, on "Messed Mountain" it is not clear which formation is represented by the exposed limestone. Several crinoid ossicles with twin canals have been found in the limestone (Fig. 6B and inset), a characteristic that so far has only been observed in the bioclastic limestone of the Hailstone Formation.

Figure 6. "Messed Mountain" section. A: Target outcrop covered by snow and ice; B: Detail of the Hailstone (?) bioclastic limestone including twin-canal crinoid ossicles (in red circles).

Figure 7: Contact between the Hailstone? Formation and the Canol Formation on "Messed Mountain". Red dots are samples taken for conodont biostratigraphy (Geologist Wing for scale).

Another way to discriminate the uppermost part of the two formations is their age. The uppermost part of the Hailstone Formation is placed in the lowermost Eifelian, while the upper part of the Hume Formation is positioned in the upper Eifelian. To investigate this, the contact was sampled for conodont biostratigraphy (Fig. 7). The target outcrop suggested by Beth Fisher (NTGS) was unfortunately still covered by snow and ice (Fig. 6A). A new outcrop exposing the contact between the Canol Formation and the underlying limestone was found at the junction of two creeks (Fig. 7).

CONCLUSIONS

The fieldwork in the Mackenzie Mountains allowed sampling of three sections for conodont biostratigraphy and palynology. Detailed stratigraphic sections were measured through the uppermost part of the Hume Formation, the entire Hare Indian/Canol Formation and the contact between the Hailstone? Formation and the Canol Formation. This will allow us to provide detailed biostratigraphic data on the entire black shale deposit (Hare Indian/Canol Formation), the Hume/Hare Indian contact, the Canol/Imperial contact and the Hailstone?/Canol contact in support of geological mapping in the area.

ACKNOWLEDGEMENTS

We thank first of all, Rob MacNaughton who, as the Arctic Red field party leader and leader of the organizational, informational and technical aspects, made this great field season possible. Audrey Edgi (Fort Good Hope, Sahtu settlement) provided wildlife monitoring services during our fieldwork. Sahtu helicopters (and pilot Scott and technician Adam) took care of transporting us safely and comfortably to our outcrops. Arctic Red River Outfitters set up our basecamp and provided cooks and camp managers to secure the camping site. Thanks to Beth Fisher (NTGS) for her advice during the preparation of the fieldwork and for her never-ending enthusiasm in the field. The manuscript was peer-reviewed by Robert B. MacNaughton. This is a contribution to the Mackenzie Project of GEM2 with administrational support from Carl Ozyer, Paul Wozniak, Marlene Francis, and Jordan Stenzler.

REFERENCES

Blieck, A., Turner, S., Burrow, C.J., Schultze, H.-P., Rexroad, C.B., Bultynck, P. and Nowlan, G. S., 2010. Fossils, histology, and phylogeny: Why conodonts are not vertebrates. Episodes. P. 234-241.

Kabanov, P. and Gouwy, S., 2017. The Devonian Horn River Group and the basal Imperial Formation of the central Mackenzie Plain, N.W.T., Canada: multiproxy stratigraphic framework of a black shale basin. Canadian Journal of Earth Sciences. 54, p. 409-429.

Kabanov, P., Gouwy, S.A., and Chan, W.C., 2016. Report on field activity for Devonian studies in the Mackenzie Mountains in 2016, GEM 2 Mackenzie Project, Open File 8131, 16 p. doi:10.4095/299288

MacNaughton, R.B., Fallas, K.M., Fischer, B.J., Pope, M.C., Chan, W.C, Finley, T.D., and Martell, J., 2017. Report of activities for GEM 2 Mackenzie Project:

Bonnet Plume River map area (NTS 106B) bedrock mapping, stratigraphy, and related studies Geological Survey of Canada, Open File xxxx, xxx p. https://doi.org/10.4095/xxxxxxx

Morrow, D.W.,1991. The Silurian Devonian Sequence of the northern part of the Mackenzie Shelf, NorthwestTerritories; Geological Survey of Canada, Bulletin 413, 121 p.

Pyle, L.J., Gal, L.P., and Fiess, K.M., 2014. Devonian Horn River Group: A reference section, lithogeochemical characterization, correlation of measured sections and wells, and petroleum-potential data, Mackenzie Plain area (NTS 95M, 95N, 96C, 96D, 96E, 106H, and 106I), NWT; Northwest Territories Geoscience Office, NWT Open File Report 2014-06.

Pyle, L.J. and Gal, L.P., 2016. Reference Section for the Horn River Group and Definition of the Bell Creek Member, Hare Indian Formation in central Northwest Territories. Bulletin of Canadian Petroleum Geology, 64(1), p. 67-98.

Uyeno, T.T. 1978. Devonian conodont biostratigraphy of Powell Creek and adjacent areas, western District of Mackenzie. In Western and Arctic Canadian Biostratigraphy. Edited by C.R. Stelck and B.D.E. Chatterton. Geological Association of Canada Special Paper, 18: 233–257.

Uyeno, T.T. 1986. Report on 177 conodont samples from the Hume, Hare Indian, Ramparts (Kee Scarp) and Canol formations from 12 Sections at Mountain River and Vicinity, Mackenzie Mountains, District of Mackenzie (NTS 106H), submitted by Iain Muir, Department Of Geology, University Of Ottawa. Geological Survey of Canada, Paleontological Report 1-TTU-86.

Uyeno,T.T. 1991. Pre-Famennian Devonian conodont biostratigraphy of selected intervals in the eastern Canadian Cordillera. In:M.J. Orchard & A.D.McCracken (Eds.) Ordovician to Triassic conodont paleontology of the Canadian Cordillera, Geological Survey of Canada Bulletin, 417, p. 129-161