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## 2018



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## Forward

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 2018 field season, research scientists from the GEM program successfully carried out 18 research activities, 17 of which will produce an activity report and 14 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

Extensive Cretaceous-Paleogene sedimentary basins are known along the western side of Baffin Bay from southern Davis Strait to southern Nares Strait and it is hypothesized that the region may contain significant hydrocarbon deposits, particularly within the vast basin at the mouth of Lancaster Sound (Harrison et al., 2011) and along the continental shelf of eastern Baffin Island Moir et al. (2012). A persistent oil seep offshore of Scott Inlet, Baffin Island, demonstrates that petroleum systems are present in the region. Limited geological data exist for the offshore region in this area, with only a few shallow drill holes and dredge samples, and an ODP well near the Baffin Shelf. Understanding the correlative onshore sequences can serve as a ready analogue for the offshore deposits. Such onshore sequences are limited to only a few localities, however, including Bylot Island and adjacent areas of northern Baffin Island (Fig. 1).

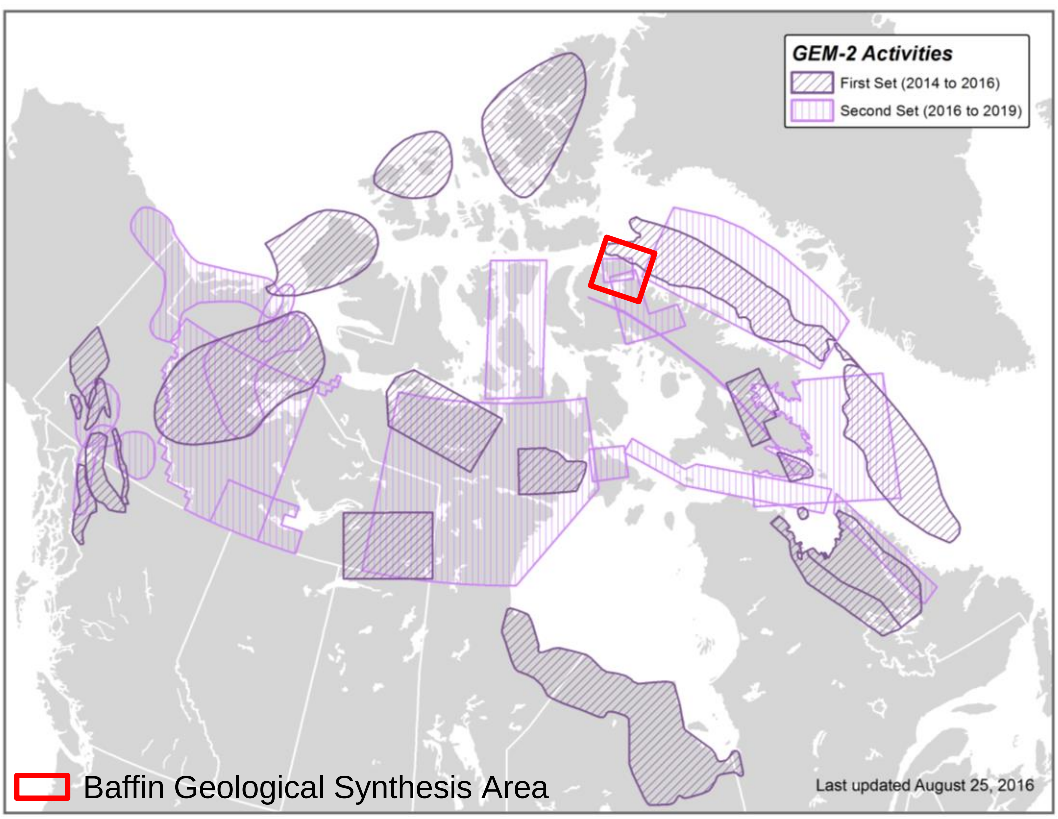


**Figure 1.** Map of past and current GEM-2 activities with Onshore Cretaceous-Paleogene Stratigraphy area highlighted in red.

Limited geological and paleontological surveys of the onshore strata were undertaken by industry and university personnel in the 1970s-1980s, and a preliminary, mostly unpublished, litho- and biostratigraphic framework was established at that time. Reconnaissance fieldwork undertaken under the GEM-1 program determined that the basic elements of a petroleum system are present in the Bylot Island region (Brent et al., 2013), but subsequent field studies necessary to fully describe the succession and to provide detailed insights into the geology of the offshore region were postponed. Undertaking these activities under GEM-2 will finally provide an extended data set valuable for better understanding depositional systems of Baffin Bay.

## Introduction

Cretaceous-Paleogene rocks that crop out on Bylot Island and Baffin Island in the vicinity of Pond Inlet and Scott Inlet are being investigated in 2017-2018 to determine details of their stratigraphic succession and age. Research activities are summarized under five broad themes:

1) Geological mapping of Cretaceous-Paleogene strata to establish the overall stratigraphic succession and structural controls on rock distribution;
2) Development of a lithostratigraphic framework for the basin successions, to include local lithologic detail, biostratigraphic data, and existing and new samples summarized in measured stratigraphic sections;
3) Biostratigraphic studies to constrain the age limits of the lithostratigraphic succession and to help identify sequence stratigraphic boundaries;
4) Assessment of sedimentary environments of Cretaceous-Paleogene strata using outcrop sedimentology and analysis of trace fossil and microfossil assemblages;
5) Determination of the region's Cretaceous and younger structural history through low-temperature thermochronology studies;

Assessing stratigraphic variation across onshore basins will provide insights into basin history, and allow more accurate local and regional models of sedimentation to be developed. This knowledge will provide a basis for correlation of onshore and offshore strata, and will improve understanding of the hydrocarbon potential of the region (Brent et al., 2013).

## Results

Community engagement visits were undertaken to Pond Inlet during the winter-spring of 2018 to discuss the project's proposed field research plans and to identify any concerns about the suggested program within the community. Sensitive sites were noted and the research program formulated to avoid these. The small field team was based in Pond Inlet during July, relying on the local community for all accommodations and meals and some supplies, and a Wildlife Monitor was hired from the community of Pond Inlet. The research team travelled by helicopter each day from Pond Inlet to reach research sites.

### 1) Geologic Mapping

Field activities were focused on the principal areas of Cretaceous–Paleogene outcrop identified in Haggart et al. (2017, fig. 2). These include: 1) outcrops southwest of Pond Inlet on northeast Baffin Island (see Skipton et al., 2018); 2) the southwest coast of Bylot Island and adjacent inland areas extending to opposite Borden Peninsula; and 3) coastal and inland exposures on the north side of Bylot Island. The first two of these areas comprise the Eclipse Trough and the third is the North Bylot Trough of Miall et al. (1980); uplifted Archean to Mesoproterozoic rocks of the Byam Martin Mountains in central Bylot Island separate the two troughs (Jackson and Davidson, 1975a, b).

Important new geological observations arising from the recent mapping include:

1) A new stratigraphic section of the base of the Cretaceous transgressive succession was identified on southwest Bylot Island. This section is much thicker than any other equivalent section recognized to date.
2) Distinctive lithological marker units identified in 2017 have been traced more widely across the outcrop belt of southwest Bylot Island and are now recognized in the Maud Bight area of north Bylot Island as well.

3) Lateral facies changes between time-equivalent rock units can explain unusual lithostratigraphic relationships observed in both Eclipse Trough and North Bylot Trough.

**2) Cretaceous-Paleogene Lithostratigraphy**

The lithostratigraphic succession of the Eclipse and North Bylot trough areas of Bylot Island were the focus of interest in the 1980s, particularly highlighted by the mostly unpublished work of Sparkes (1989), Waterfield (1989), Benham and Burden (1990), Benham (1991), and Wiseman (1991). The current fieldwork aims to consolidate the lithostratigraphic framework introduced in these contributions.

In Eclipse Trough, six new stratigraphic sections were measured and described during 2018 in terms of their lithology, sedimentology, paleontology, and ichnology. These included four sections within the Paleocene sandstones and mudstones, one within the Cretaceous transition from sandstone to mudstone, and one at the upper transition from the Cretaceous mudstone to Paleocene sandstones.

Cobble and boulder conglomerates within the uppermost Cretaceous-lower Paleocene part of the succession often bear strong resemblance to Quaternary alluvial fan deposits and Pleistocene glacial deposits; differentiating between these units in the field is often challenging, particularly in the north Bylot Island region. Analysis of select conglomerate packages was undertaken in 2018, to help to distinguish the older packages from their more recent counterparts. In general, clasts in the local Quaternary sediments are less rounded and fresher compared to those in the Cretaceous-lower Paleocene strata, and the latter are distinctively consolidated or semi-consolidated beneath the regolith mantle, in contrast with the Quaternary sediments.

The composition of Cretaceous–Paleogene conglomerates varies locally from 100% Rae granitic gneiss and other crystalline rocks, to 20% Mesoproterozoic sandstones and other lithologies (including mudstones) and 80% Rae crystalline rocks. These compositions reflect the nature of Precambrian rocks in the nearby uplifted areas of the Byam Martin Mountains of Bylot Island. The transport of these lithologies from their nearby source areas into the basin suggests a nearby eroding and possibly active fault scarp during conglomerate sedimentation.

**Figure 2**. Common alteration of conglomerate clasts in uppermost Cretaceous-lower Paleocene cobble to boulder conglomerates.

Associated matrix and lateral correlatives of conglomerate packages suggest three distinct modes of clastic sedimentation: 1) mature sands from continental input (i.e., more than 100 km distant); 2) sub-rounded to rounded pebbles with immature matrix, probably from rivers cut into the fault scarp (5-50 km transport distance); and 3) angular clasts likely deposited at high angle (30°?) and derived from fault scarp fans, and deposited relatively close to their source (< 5 km?). A mix of these three clastic types are observed in some sections.

Pre-exposure alteration of some conglomerate clasts is observed (see Fig. 2), but its precise timing is unknown. Alteration is assumed to have most likely taken place during the basin-bounding faulting process, however, as it affects only some clasts; unaltered clasts are presumably derived from 'fresher' sources on the Precambrian exposures, which were more distal to the bounding faults.

In the Clyde Foreland area, northwest of Scott Inlet, previous workers have visited the lowland exposures adjacent to the coastline and assigned these strata either Cretaceous–Paleogene, Cretaceous to Tertiary, or Quaternary ages (Jackson et al., 1979; Burden and Holloway, 1985; Newman, 1987; Scott and De Kamp, 1998). Additional exposures farther inland from the coast, however, have never been fully documented and plans were made to visit these exposures over three days during 2018 field season, to assess the extent and age of strata that may be present. Unfortunately, funding cutbacks precluded visitation to the area in 2018. However, additional samples collected in the early 1980s from the coastal area of Clyde Foreland are being reassessed for palynological content in an effort to more fully understand their stratigraphic extent and age.

**3) Basin Biostratigraphy**

Palynostratigraphic analysis continues on the rich sample set accumulated in the 1980s and in 2009 and 2017. Approximately 10 additional samples were collected for palynological analysis in 2018, to help identify ages of local outcrops and aid in geologic mapping. A principal objective of this study is to qualitatively and quantitatively document marine (dinoflagellates or dinocysts) and non-marine (spores and pollen) palynomorphs, which will allow recognition of sequence stratigraphic events preserved in the onshore succession, and hence facilitate inter- and intra-basinal correlations. Because of the range of paleoenvironments represented in the Eclipse Trough and North Bylot Trough successions, from non-marine to deeper water, organic-walled palynomorphs are being studied for determining both ages and environmental settings.

Ages determined from dinocyst assemblages are based on last or youngest occurrences of these microfossils, as given in Williams et al. (2004) for Northern Hemisphere high latitudes and Nøhr-Hansen et al. (2016) for the Labrador-Baffin Seaway specifically. For pollen and spores, derived ages are based on Nichols (2003) and Sweet (2015). Taxa range charts and a preliminary events plot have been compiled for several stratigraphic sections of Eclipse Trough; comparison with sections from more southerly and eastern regions of Baffin Bay (Nøhr-Hansen et al., 2016) shows some similarities. Based on assemblages present, strata of the following ages are represented: late Albian–Cenomanian, Cenomanian, Turonian, Coniacian, Santonian, Campanian, early Maastrichtian, late Maastrichtian, Danian, and Selandian. Some of the taxa are known only from higher latitudes and several are new.

Biostratigraphic analysis of marine microfossils is also continuing, with focus on foraminifer and diatom assemblages preserved in samples collected in 2009 and 2017.

**4) Paleoenvironmental Analysis**

Assessment of Cretaceous–Paleogene depositional paleoenvironments is based on outcrop sedimentology, palynological and other biotic assemblages, and ichnofossil analysis. Relative percentage plots showing miospores, dinocysts, acritarchs, and other palynomorphs (such as the fresh-water *Pediastrum*) are being compiled for all sections. Such plots have shown that paleoenvironments ranging from open-ocean to non-marine are represented in the Upper Cretaceous to Paleocene strata. In addition, fluctuations in concentrations of individual dinocyst taxa can show whether a particular assemblage is indicative of a lagoonal to coastal, inner neritic, outer neritic, or open-ocean setting, and hence provides information on changing water depths and recognition of transgressive and regressive episodes.

Building on analyses from the 2017 field season (Haggart et al., 2017), additional detailed sedimentological and ichnological analyses were undertaken for both previously measured sections and newly measured sections in order to provide high-resolution interpretation of depositional paleoenvironments. This work also aids geologic mapping by providing facies control that can help differentiate lithostratigraphic intervals. A total of 21 sections were studied during the 2018 field season from both the Eclipse Trough and North Bylot Trough, with one section studied at the southeastern end of Eclipse Sound on Baffin Island. Sedimentological analysis includes the assessment of lithology, sedimentary structures, and overall facies stacking patterns. Trace fossil analysis includes identification to ichnogenera level (where possible) and overall degree of bioturbation, although some lithologies did not permit clear identification of ichnotaxa (Fig. 3). By integrating trace fossil interpretation with sedimentology and stratigraphic stacking pattern, robust depositional paleoenvironment interpretations can be developed. Key findings include a diverse set of trace fossils in the basal transgressive facies of the Cretaceous succession, some of which indicate marine conditions (Fig. 3A), and depauperate trace fossil assemblages in the Paleocene mudstones, suggesting brackish marine sedimentation (Fig. 3D). Representative lithology samples and ichnofossils were collected for further study.

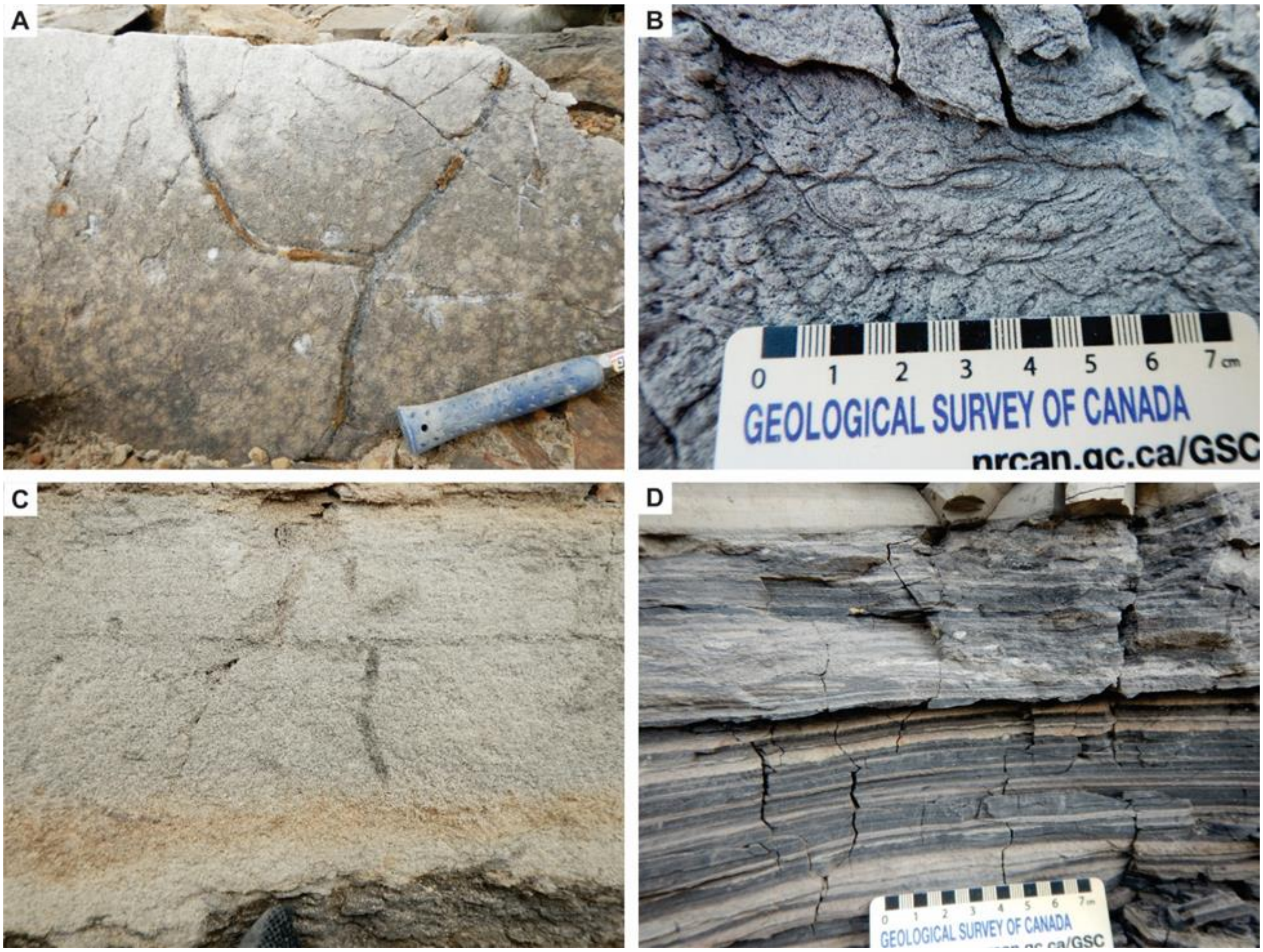


**Figure 3**. Ichnofossils and representative lithologies from the Cretaceous and Paleogene rocks of Bylot Island. A) Large, branching *Ophiomorpha* from Lower Cretaceous basal transgressive unit in northwest Eclipse Trough. B) *Rhizocorallium* in homogenized sandy siltstone concretion from Upper Cretaceous strata, North Bylot Trough. C) *Ophiomorpha* from Paleocene strata, Eclipse Trough. D) Typical laminated mudstones and very fine-grained sandstone of upper Paleocene strata, North Bylot Trough, with a few cylindrical *Planolites* trace fossils.

Finally, analysis of stable isotope stratigraphy of the Cretaceous–Paleogene succession is continuing, with at least one oceanic anoxic event possibly identified in the succession.

**5) Low Temperature Thermochronology and Structural History**

Some of the faults in the Bylot Island-northeastern Baffin Island area that were active during the Mesoproterozoic were reactivated in the Mesozoic and possibly more recently (Jackson and Davidson, 1975a). Where Mesozoic and younger sedimentary rocks are preserved, it is often possible to determine which faults were active during that time. In areas where these rocks are absent, however, low temperature thermochronology studies provide valuable insights into the timing of fault motion, and in some cases can be used to constrain fault locations.

Low temperature thermochronology results, such as apatite fission track analyses, provide the basis for the cooler portions of thermal history models (generally < 250°C). One rock sample was collected during the 2018 field season from southeast Bylot Island and has been submitted for apatite fission track analysis. It was not possible to collect this sample during the 2017 field season due to poor weather conditions.

Apatite fission track and electron microprobe analyses were obtained for 30 of the 31 samples collected in 2017 (one sample did not contain apatite), providing the basis for thermal models for this area. Preliminary thermal history models indicate that the area is divided into structural blocks with unique thermal histories by faults that were active in the Mesozoic and possibly more recently, and demonstrate the usefulness of modelled thermal histories to constrain fault locations.

## Acknowledgments

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