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OVERVIEW OF SURFICIAL GEOLOGY ACTIVITIES IN THE TEHERY - WAGER GEM-2 RAE PROJECT AREA, NUNAVUT

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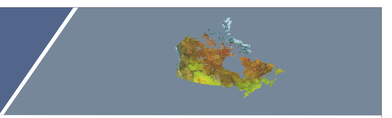


Introduction

Targeted field work during the summer of 2015 in the eastern part of the Tehery-Wager GEM-2 Rae Project area (Fig. 1), mainland Nunavut, has provided an opportunity to gather data on the history and pattern of glacial flow and ice margin retreat, collect till and stream sediment samples for provenance and evaluation of mineral potential, and test preliminary remote predictive mapping (RPM) surficial materials classification maps with field observations. The work was undertaken to provide new geological knowledge on the nature and composition of surficial sediments deposited during previous glaciation(s), successive marine inundation and emergence (McMartin et al., 2015).

The key scientific questions addressed in these studies include: 1) what is the nature of glacial transport in proximity and distal to the Keewatin Ice Divide; 2) what is the age of the weathered bedrock terrain under the ice divide and potential for preservation of an older, relict landscape under a cold-based glacier regime; 3) what is the limit of post-glacial marine inundation, glacial retreat pattern and rate, and influence on surficial sediment composition and redistribution; and 4) how can we improve on current remote predictive mapping methods to enhance surficial geology mapping and field methods.

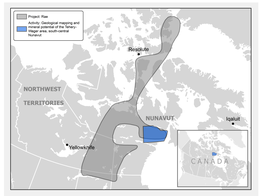


Figure 1. Location of the GEM-2 Tehery-Wager activity within the Rae project area.

Rationale

Reconnaissance scale till and stream sediment surveys completed under GEM-1 in the Tehery-Cape Dobbs region in 2012 identified areas with potential for base- and precious metal mineralization in supracrustal strands and for ultramafic/mafic and kimberlite sources outside the known kimberlite field (Day et al., 2013; McMartin et al., 2013). As a follow-up, surficial geology studies and targeted surface sediment sampling were initiated in 2015 in a large area extending between Wager Bay and Chesterfield Inlet east of 92° longitude (Fig. 2). Apart from the Wager Bay map sheet (NTS 56G), the area has not been mapped or mapped only at a reconnaissance scale for surficial geology, with little or no ground truthing.

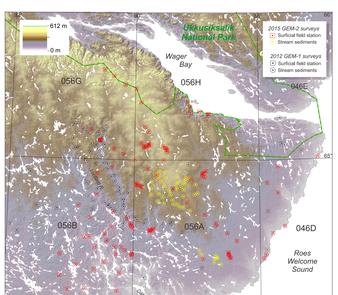


Figure 2. Location map of surficial geology observations and stream sediment samples collected in 2015 and 2012. DEM generated from CDED 1:250 000 topography.

Regional surficial geology mapping and Quaternary history framework

Regional surficial mapping indicates the area is characterized by swaths of streamlined, thin and thick till (A and B) extending southeast from the Keewatin Ice Divide (KID) zone centered in the uplands southwest of Wager Bay (Fig. 3), which are dominated by a mixture of till deposits, felsenmeer and weathered bedrock (C and D).

Till deposits are interspersed by a complex system of south-east trending sub-glacial meltwater corridors and pro-glacial channels. These corridors vary in width from 0.5 to 4 km and comprise large eskers, outwash plains, small irregular hummocks (E), short streamlined landforms, eroded till remnants (F), boulder lags, and scoured bedrock. Between the corridors, till surfaces show no sign of glaciofluvial erosion or reworking.

Extensive areas of bedrock outcrop extend far inland along the coast between Chesterfield Inlet and the outer part of Wager Bay. Folds and faults as well as small glacially scoured basins occupied by a myriad of shallow lakes are prominent features of the bedrock topography in these areas (G).

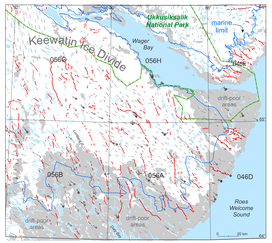
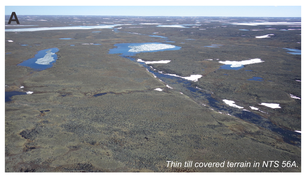
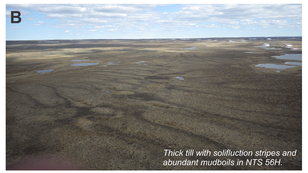
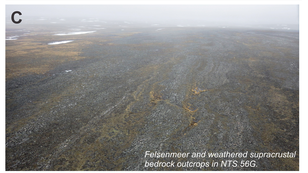
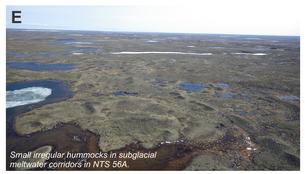


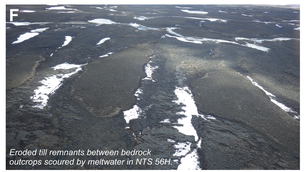
Figure 3. Generalized landform and striation map (see legend in McMartin et al., 2015).

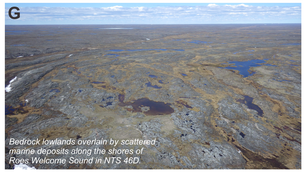


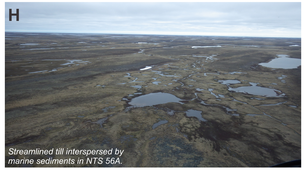












Glacial flow sequence

The predominant regional trend of streamlined till landforms indicates ice flow to the southeast from the KID, parallel to major 1st generation eskers, meltwater corridors and main striae direction (Fig. 3). Along the central Wager Bay shores, early and late ice flows into and parallel to the bay are observed in the landform and striation record and suggest the ice divide extended in a narrow zone inland south of the bay. No evidence for an early flow inland from Roes Welcome Sound/Southampton Island was found in the striation record; furthermore, Paleozoic carbonate clasts were only observed at the surface below marine limit suggesting these erratics were transported by icebergs and not reworked from till derived from the east.

Post-glacial marine invasion

The limit of marine submergence increases from 119-125 m asl south of Wager Bay, to about 145-160 m west of Roes Welcome Sound, and 138-152 m asl northwest of Daly Bay (Fig. 3), as revealed by well-defined wave-washed surfaces, wave-cut notches, boulderry deltas, high shorelines developed along esker flanks, and circular trimlines around small topographic highs (Fig. 4). Lowlands that skirt the coasts of Roes Welcome Sound and Chesterfield Inlet show evidence for post-glacial marine erosion and reworking of thin glacial and glaciofluvial sediments; marine veneers are sandy and occur as scattered deposits between rock ridges or glacial landforms (G&H).

Geochronology

Three different types of landforms were sampled for cosmogenic nuclide dating (see Fig. 7 for location). Four bedrock samples were collected in weathered upland terrain under the Keewatin Ice Divide to constrain the relative age of potentially preserved (older) surfaces under a cold-based dome; these outcrops are characterized by the absence of glacially polished surfaces or ice flow indicators (D). Six bedrock samples were collected at or slightly below the post-glacial marine limit to date the timing of marine incursion and subsequent retreat. These sites are characterized by intensively wave-washed surfaces surrounded by boulderey beaches forming a distinct trimline with unmodified till-covered surfaces on higher ground (Fig. 4).

Marine shells were found at only two sites near the Connery River that flows into Hudson Bay northeast of Chesterfield Inlet (see Fig. 7 for location). They were collected at the surface of frost boils developed in till mixed with marine sediments. Single shells of *Hiatella arctica* from each of the two 2015 samples were submitted for radiocarbon age determinations. The new radiocarbon dates will provide information when sea level stood near the respective elevations, and also give minimum deglaciation ages for the outer part of Chesterfield Inlet.

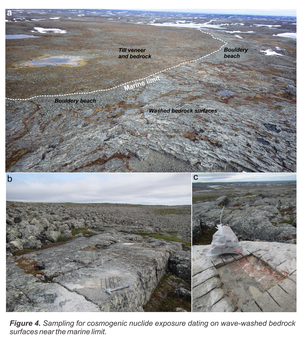
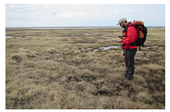


Figure 4. Sampling for cosmogenic nuclide exposure dating on wave-washed bedrock surfaces near the marine limit.

Remote predictive surficial materials mapping

Remote interpretation of surficial materials can provide first-order assessment of the unconsolidated sediments covering the study area, guide field geological mapping activities (both surficial and bedrock), assist in interpretation of the surficial geology between field sites, and provide a regional context for the surficial materials. A preliminary surficial materials map with 15 classes was produced from a combination of satellite imageries with a digital elevation model and slope data. Field observations collected in 2015 (Fig. 5) will be used as control points to validate the map.



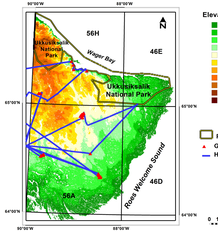


Figure 5. Location of the ground stations and the helicopter tracks along which photographs were taken at short intervals, southern Wager Bay area, Nunavut (from Byatt et al., 2015). Background image was generated using a Canadian digital elevation model mosaic (scale 1:50 000).

Methods and results

Representative training areas of each of the 15 material classes were delineated from air photo interpretation of the orthorectified Landsat-8 and RADARSAT-2 imagery. The classifier used in this study is a nonparametric decision-tree–type classifier, Random Forests (RF). A preliminary surficial materials map with 15 classes was produced from a combination of images from RADARSAT-2 in the C-band (HH and HV polarization) and from Landsat-8 Operational Land Imager (OLI) with a digital elevation model and slope data (Fig. 6).

Two types of field data were collected during a five-day period in the summer of 2015: field observations at 45 visited sites, and photographs of the terrain taken from the helicopter between visited sites (Fig. 5). The visited sites were located in 10 areas of interest that represent the surficial material diversity of the study area. The surficial material and landform features at each visited site were described, with an attempt to assign the site to one of the 15 surficial material classes of the map. For each visited site, additional recorded observations included the geographic co-ordinates, photos of the site (surface and material) and photos of the area surrounding the site.

The data collected during the fieldwork is still being processed. The photographs taken from the helicopter have all been georeferenced and sorted by time and date of capture. Both the GPS field observations and field photographs will be used to further refine the preliminary RPM map and to assess its mapping accuracy by determining the percentage of GPS sites correctly mapped over the RPM map per surficial material class.

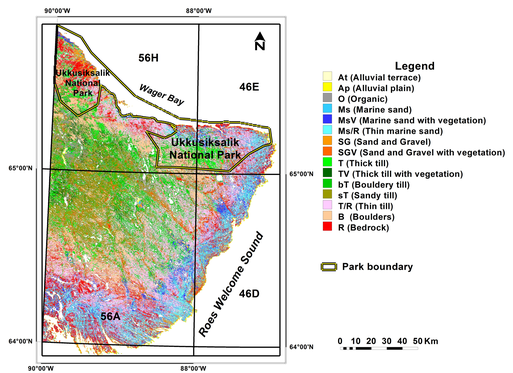


Figure 6. Preliminary remote predictive surficial materials map for the southern Wager Bay area produced by the Random Forests classifier (from Byatt et al., 2015).

Till and stream sediment sampling

In total, 33 till samples were collected to provide more detail on geochemical anomalies identified in 2012, or to support bedrock mapping in drift covered terrain (Fig. 7). Till samples were also collected at approximately 10 km intervals along a 140-km long transect parallel to ice-flow (SE) to characterize the regional glacial transport (provenance). Samples were carefully collected on flat till surfaces in Cy-horizon material from hand dug pits in frost boils (Fig. 8), at an average depth of 30 cm. At each site, one small sample (~3 kg) and one large sample (~10 kg) were collected. All samples will be processed for geochemistry, heavy minerals, clast analysis and texture.

Stream sediment and water samples were collected at 46 sites, predominantly from the headwaters of the Borden River (parts of NTS 56A), as well as from a small area further down river (Fig. 7). Bulk stream sediment samples were wet sieved on site to obtain ~15 kg of <2 mm sized material from relatively high-energy, gravel rich sites and will be processed for their heavy mineral content (Fig. 9). Silt sediment samples consisting of representative fine-grained material were gathered from relatively lower energy environments within the active stream bed. After being dried to completion (<40°C), the fine-grained material will be sieved to obtain the <177 µm fraction for chemical analyses. Water samples were collected from the main flowing channel, filtered (0.45 µm) in situ and will undergo chemical analyses.

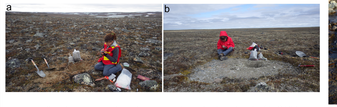


Figure 8. a) Bouldery sandy till east of Lorillard River in the NE extremity of NTS 56B. b) Silty till in streamlined landform near Mistake Creek in NTS 56A.

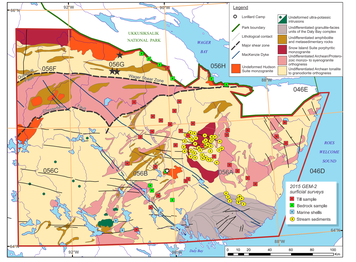


Figure 7. Location map of till and stream sediment samples collected in 2015. Bedrock and marine shell samples collected for Quaternary age dating are also shown. Simplified geological map of the Tehery-Wager area modified from Wodicka et al. (in prep., 2015) and Steenkamp et al., 2015 (and references therein). Known kimberlite bodies from Peregrine Diamonds Ltd. appear as black stars.

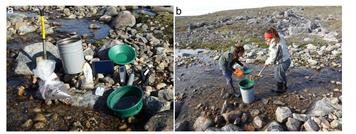


Figure 9. a) Samples collected and field equipment used at a typical bulk stream sediment and water site. b) Sieving sediments along an unnamed stream in the northwest quadrant of NTS 56A.

Conclusions and future work

Targeted field work was completed during the summer of 2015 along the northwestern shores of Hudson Bay, mainland Nunavut. The work was undertaken to provide new geological knowledge on the nature and composition of surficial materials deposited during the retreat of the Laurentide Ice Sheet, successive marine inundation and emergence, and addresses a number of scientific questions relevant to the mineral exploration industry.

Bedrock samples were collected for cosmogenic nuclide dating on wave-washed bedrock surfaces to date the timing of marine incursion and subsequent retreat, and on weathered outcrops under the ice divide zone to constrain the relative age of potentially preserved (older) surfaces under a cold-based dome. Marine shells were collected for radiocarbon age determinations to provide minimum deglaciation ages. Till and stream sediment samples were collected to help evaluate mineral potential, to characterize the regional glacial transport, and to support bedrock mapping in drift covered terrain. To support surficial geology mapping at 1:100 000 scale, a preliminary surficial materials map was produced by classifying a combination of Landsat-8, Radarsat-2 C-HH and C-HV and DEM/slope data. Future work will include data and map compilation, sample analysis, and interpretation. Additional field work is planned for 2016.

Acknowledgments

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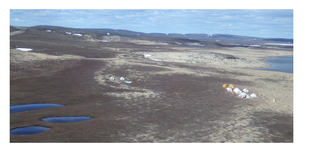

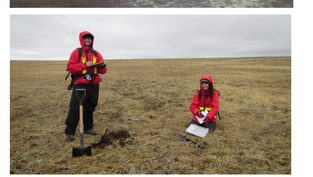

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