NIRB application: Project Description

Geological study and mapping of hydrothermal deposits and gossans near Expedition Fiord, Axel Heiberg Island, Nunavut, as analogues for Mars

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Gossans are geological deposits that can form through the chemical and physical weathering of metal-rich bedrock. The outcrops are generally quite small (a few hundred metres in length) and they form highly visible, rust-coloured patches on the landscape. A variety of gossans have been detected in the Expedition Fiord area, on Axel Heiberg Island, Nunavut, which is our study area. A network of mineral veins (hydrothermal deposit) is also present in the same area. The way these gossans formed is still poorly understood. Our main scientific objective is to determine if there is a geological connection deep in the ground between the network of mineral veins in the hydrothermal system and the gossans. It is possible that these gossans have been formed through the interaction between the metal-rich bedrock and the hydrothermal system. If that is the case, there are important implications in the search for life on Mars, as hydrothermal systems on Earth invariably host active and diverse microbial communities. The scientific rationale is that ancient hydrothermal systems on Mars are key places to look for signs of ancient bacterial life. Previous studies of these systems have shown that they contain minerals that provide clues on how life evolved in ancient lakes, rivers and oceans. However, the detection and mapping of hydrothermal systems on Mars is challenging. If gossans were present in the vicinity however, it would be easier to locate them because of those orange-yellow caps that are visible on satellite images. Gossans could thus be used as tracers to search for life nearby. During the past decade of research on Arctic gossans at the Geological Survey of Canada, there has been significant progress in understanding how they vary in morphology, stratigraphy, mineralogy and geochemistry according to the type of host rocks, their interaction with permafrost, and other factors. This project will build on those results, and advance the knowledge regarding planetary exploration, innovative space technologies, and Earth sciences. The detailed project objectives are as follows: 1. Map the Expedition Fiord area and detect gossans using satellite imagery. 2. Investigate the spectral signature, composition, and potential biosignatures in the gossans and the hydrothermal deposit during fieldwork using portable scientific instruments. 3. Conduct detailed spectroscopic, compositional, and biological studies on the returned samples in our laboratories. Our methodology includes steps to be conducted prior to (Objective #1), during (Objectives 1 and 2) and after (Objective 3) the field campaign. Objective 1 is currently underway at the Université de Sherbrooke as part of two MSc research projects. A geologic map of the field area was produced using satellite imagery

and gossans have been detected and added to the map. The map guided in the selection of the base camp illustrated on the location map included in this application. To meet objectives 2 and 3, we will map and sample a variety of gossans in our field area and acquire different datasets using portable scientific instruments on site, and through sample return. The data generated during the lifetime of the project will be released in three MSc academic theses, open access reports (GSC open files) and in peer-reviewed articles published in scientific journals. The equipment we use to carry out surveys in the field consists of: portable digital tablets to plot each outcrop during foot traverses, and take notes; portable GPS and cameras to take multiple photographs of outcrops; geological hammers to sample the outcrop; scoops to pick up soils around the gossans and portable pH meters to measure their acidity; measuring tapes to record the thickness of geological units; and sample bags. We will bring a Field Portable Spectroradiometer to measure the spectral reflectance of different parts of the gossans and hydrothermal deposit located near the base camp. This instrument has a wand that captures a 'spectral signature' of the rocks. The data are stored inside the instrument and compared to what is observed on satellite images. This process is referred to as ground truthing. The portable instrument allows the students to process the data in real time, allowing more precise measurements if required. It is an essential step to check the accuracy of the maps generated in advance of fieldwork using satellite imagery.

The T-MARS project involves one field season in July 2022 on Axel Heiberg Island, Nunavut. To maximize our engagement with northern communities (Grise Fiord, Resolute, Arctic Bay and Iqaluit), we are planning an ambitious outreach program that includes four activities: (1) a web page which includes regular updates on the results of field and laboratory activities as well as a web-based Geographical Information System (GIS) of the Expedition fiord area; (2) Earth Sciences modules intended for high school and college students that will be prepared by a team member who is a science teacher; (3) a space science simulation that consists of an immersive learning experience carried out in collaboration with Mission Control Space Services; and (4) an initiative led by our NRCan team members to identify science activities that require and/or intersect with local Traditional Knowledge. Prior to the field season, we will initiate Activity 1 by communicating directly with Nunavut educators to share the project web page (tmars.igeomedia.com) and present our goals. During fieldwork, we will produce material for Activity 2 based on video footage, digital stills and text modules to generate curiosity and excitement amongst northern students. Once fieldwork is completed, we will engage students in Activity 3 to demonstrate the similarities between space exploration missions and our field campaign. Students will be able to select an analogue environment, find regions of interest, and simulate driving a rover as if they were searching for geological formations on Mars. Lastly, Activity 4 will use the results of field mapping and communications

to engage the communities of Grise Fiord and Resolute in sharing traditional knowledge and science results. All these activities will be highlighted on the project website as they unfold. We will notify educators and students from our northern communities to inspire them, and provide them with more knowledge obtained directly from the land. Our engagement with northern communities before, during and after the field season will ensure that the project carries a lasting legacy and impact in the future.

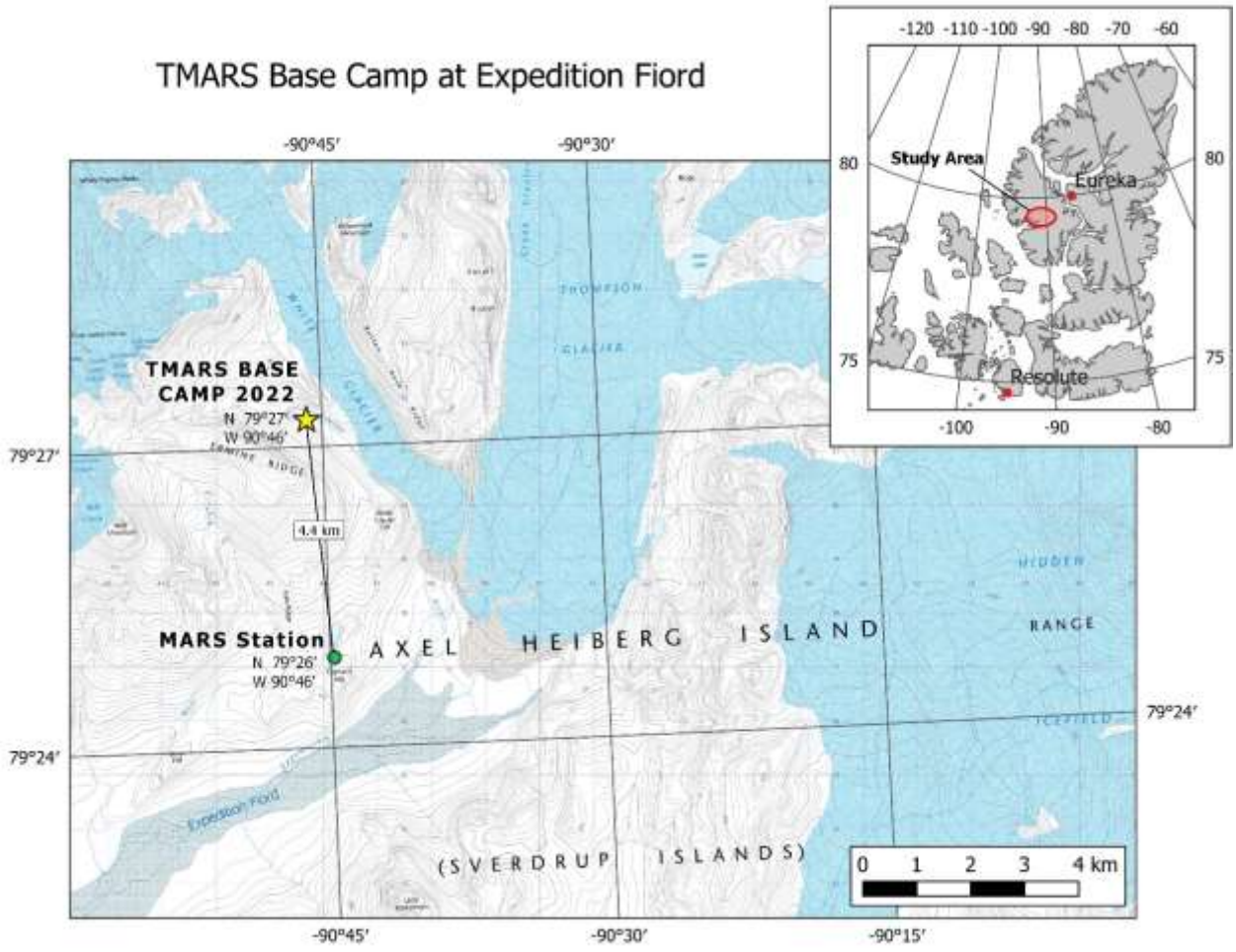

Figure 1. Topographic map of the Expedition Fiord area showing the location of the McGill Arctic Research Station (MARS Station) and of the TMARS base camp.