

2013 Nunavut Research Licence Renewal Application: Wayne Pollard

Scientific Research #02 014 12R-M (multi-year)

Project Title: The permafrost hydrology and environmental significance of perennial springs in the Expedition Fiord area, Axel Heiberg Island (Year 3)

Project Leader: Wayne Pollard, McGill University.

2013 Research Team: Wayne Pollard, Chris Omelon, Melissa Ward, Dale Andersen, Miles Ecclestone and 1 student field assistant.

2013 Fieldwork: Planned fieldwork includes April 5-17, and June 28-July 10.

2013 Field sites: Sites on Axel Heiberg Island, including Expedition Fiord area (79° 25'N; 90° 45'W), Strand Fiord (79° 05'N; 90° 00'W), Whitsunday Bay (79°05'N; 87°00'W) same as previous years

Funding source: Natural Science and Engineering Research Council of Canada (NSERC)

Overview: This is an ongoing university-based research project concerned with the study of the hydrology and geomorphology of cold saline groundwater flow on Axel Heiberg Island in the Canadian High Arctic. These springs are very unusual because they flow year-round, even under the extreme cold of winter. Because they flow through the winter our studies provide valuable information about permafrost hydrology. The primary goal of this research remains unchanged – it is to study and understand how cold (~0°C) saline groundwater interacts with (a) thick permafrost and (b) high Arctic polar desert ecosystems. Specific research questions include: (1) What is the distribution and geographic extent of this type of groundwater system? (2) What is the source and age of the groundwater? (3) Are there unique and unusual landforms and processes related to the interaction between groundwater and permafrost? And (4) can these springs support life? Our research has provided new information about the chemical and physical processes associated with freezing depression of saline groundwater and conditions of water and microbial life related to cold temperatures. Because of the remote locations where these springs occur and the need to study them during cold winter condition (late March-early April) we tend to approach these questions one at a time. The current focus is on the very unusual landforms related to groundwater. This is the only research on cold perennial springs being conducted in the high Arctic. These springs have no commercial value and our research is driven entirely by scientific questions. A long term benefit of this research is a better understanding about the behaviour of saline water under cold conditions which may have useful applications to the understanding of contaminants.

Progress Report – 2012 fieldwork. Between April 5-17, 2012 we undertook a series of salinity measurements for springs at Strand Fiord and Whitsunday Bay. Due to logistical challenges associated with getting to these sites (we are supported by PCSP and rely on their coordination of helicopters) this was the first year since 2010 that we have been able to visit these sites. In both cases we were able to spend 1 day at each site. However, I was able to collect water and salt

samples for ongoing monitoring of chemistry and environmental isotopes. We also were able to collect water samples at 2 ongoing study sites close to the McGill station at Expedition Fiord (Colour Peak and Gypsum Hill). We also completed annual mapping of the surface icings and mound formations around the springs at Gypsum Hill. We returned to this area in Late June to collect data from 2 automatic weather stations as well as completing summer sampling of spring discharge. Summer water characteristics provide basic information on water chemistry and permafrost conditions. The Met station data form the core of environmental monitoring and climate change studies for this and other research being conducted on permafrost and glaciers. These climate data indicate that 2012 was a normal snow year and even though winter temperatures were slightly above average the summer temperatures were normal (with a July maximum of + 12C and winter minimum of -53C). Again we experienced a heavy late winter snow fall. In July we continued fieldwork at a site very close to the McGill station next to the White glacier where we have evidence of an inactive spring (old no longer flowing). This site is important because it will provide information about the geology that controls their occurrence.

2013 Proposed Research: Proposed fieldwork in 2013 includes 10 days in April and another 10 days in late June based at the McGill Field Station at Expedition Fiord. In 2013 a major priority is collecting data for Melissa Ward's M.Sc. thesis. April fieldwork is extremely important because it allows me to observe the nature and pattern of groundwater flow under cold conditions as well as allowing Melissa to evaluate processes that occurred during the dark season. Research will focus on understanding the interaction between saline groundwater and cold air temperatures and in particular the formation of tufa-like structures composed of hydrohalite. We are also interested in annual observations of icing deposits, frost mound structures and gypsum precipitates. Melissa will collect water samples (~1 litre) for hydrochemical analyses and for freezing experiments back at McGill. These analyses document changes underground flow systems and the importance of chemistry on both physical and biological processes. These studies improve our understanding about the physical, chemical and biological processes associated with these spring systems. Fieldwork will also include ground penetrating radar mapping of ice and spring deposits, snow surveys and the collection of data from automatic weather stations. June fieldwork will focus will include sampling relic spring sites and mineral precipitates. June field work will also involve (a) measurement outflow temperatures, flow rates and chemistry of these spring systems, (b) sampling for microbial activity, (c) climate monitoring and (d) sampling and analysis of mineral samples. We will visit springs at Expedition Fiord, Strand Fiord and Whitsunday Bay. We will map the location of spring outlets, flow paths and structures. I will repair and replace sensors on our network of automatic weather stations. This work will be based as the McGill field station at Expedition Fiord.

Significance: I wish to emphasize the scientific value of this research, our results are providing new and valuable information about the behaviour of saline water in cold permafrost. Together with my students and colleagues we have identified important geological characteristics related to perennial spring occurrence as well as new and unusual biological features. The results of this work have lead to partnerships with NASA who believe that these springs may help in the planning for the exploration of Mars. I am the only person in Canada doing this type of research.

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