Polar Cryoenvironments as Mars Analogues and the Development of a Micro Life Detection Platform I. Raymond-Bouchard[1], C. Maggiori[1], D. Touchette[1], E. Magnuson[1], J. Goordial[2], A.J. Ricco[3], and L.G. Whyte[1], [1]McGill, Macdonald Campus, 21,111 Lakeshore Dr, Ste-Anne-de-Bellevue, Qc, Canada, H9X3V9, isabelle.raymond-bouchard@mail.mcgill.ca. [2]Bigelow Laboratory for Ocean Sciences, 60 Bigelow Dr, East Boothbay, ME, 04544, jgoordial@bigelow.org. [3]NASA Ames Research Center, Moffett Fields, CA, 94035, antonio.j.ricco@nasa.gov.

Introduction: Astrobiology and the search for life on other solar system bodies is a major focus of space exploration. The primary targets for astrobiology investigations are Mars, Europa and Enceladus, which are characterized by extremely cold temperatures. As such, the best terrestrial analogues may be the Earth's polar regions. Considerable evidence has been found on Mars strongly indicating that over ~3.5 bya the planet was warmer and wetter. Based on our current knowledge of extremophile microbiology on earth, it was potentially capable of hosting microbial life and ecosystems. For example, the MSL mission has reported ample evidence of past fluvial, deltaic, and lacustrine environments within the Gale Crater [1]. As such, the search for biosignatures and life detection are key features of Mars missions on, for example, ExoMars 2020 and Mars 2020 and beyond. The very recent significant report of a subglacial, likely salty, liquid body of water on Mars [2], in addition to evidence of possible surface brine water at several reoccurring slope linaea (RSL) locations on Mars [3] now opens up the possibility that extant microbial life, most likely cold-adapted and halophilic, could be present at these sites, and will almost certainly be the targets of future missions, including potential sample return missions.

The presentation will summarize recent highlights of our research investigating the microbial biodiversity/ecology in extreme polar cryoenvironments including hypersaline cold springs, cryptoendoliths and permafrost in the Canadian high Arctic and University Valley (McMurdo Dry Valleys, Antarctica), with a focus on the cold temperature adaptations and limits of life [4-6]. Recent in-depth metagenomic analyses of Lost Hammer Spring (LHS), a perennial hypersaline (~24%) subzero spring (-5ºC) in the Canadian high Arctic, which harbors a diverse active microbial ecosystem [7], have revealed potentially ~50 draft genomes representing possible new species. Future efforts will include participation in a collaborative effort to characterize the microbial ecosystems in the newly discovered and unique Devon Island subglacial lakes which are believed to be subzero and hypersaline (8), and thus a significant analogue to the subglacial lake discovered on Mars.

Our lab is developing a prototype microbial life detection platform utilizing pre-existing, low cost instruments having low mass and energy requirements [9]. The platform includes: 1) a Microbial Microactivity MicroAssay (μMAMA), which can detect and characterize active microbial ecosystems, based on detection of their metabolic activity; 2) An instrument capable of isolating, detecting, and sequencing nucleic acids (NA) based on the ultralight and ultraportable MinION (Oxford Nanopore Technologies, ONT) sequencer.

Using samples from a variety of Mars analogue samples (permafrost, desert soil, saline springs, endoliths) we have successfully tested components of the platform in the field, including the μMAMA, instruments capable of nucleic acid extraction (MP FastPrep) and sequencing preparation (VolTRAX, ONT), and the MinION sequencer. We have tentatively established a detection limit of ~100 cells/g (~0.001 ng of DNA) with the MinION. With the μMAMA, we can detect microbial activity with as low as 10^3 microbial cells, similar to the numbers we observe in extreme environments. We can also characterize substrate utilization in environmental samples, including from lithoautotrophs. With NASA Ames, we are developing an autonomous μMAMA version based on their microfluidic assay.

Our work over the past year has allowed us to increase the robustness, sensitivity and detection limits of the these instruments. Eventually, we hope to have a fully developed and optimized platform for microbial life detection system that could be robotized and integrated into future planetary exploration space missions attached to surface rovers or micro-penetrators.

References:

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