Abundance, distribution and cycling of organic carbon and nitrogen in University Valley (McMurdo Dry Valleys of Antarctica) permafrost soils with differing ground thermal and moisture conditions: analogue to C-N cycle on Mars. B. Faucher and D. Lacelle, University of Ottawa (bfauc073@uottawa.ca; dlacelle@uottawa.ca); A. Davila, SETI; W. Pollard, McGill University; C.P. McKay, NASA Ames.

Introduction: One of the key ingredients for life as we know it is the presence of water and nutrients. On Mars, there are now two direct observations of ice-rich permafrost: 1) at high latitudes at the Phoenix lander site and 2) at mid latitudes in Amazonis Plantia (near the boundary of Utopia and Arcadia). Ice-rich permafrost at mid and high latitudes on Mars is considered the place of more recent habitability [1][2]. However, orbital changes over the past 20 Myr may have warmed the surface of the regolith [3][4], and because of the low elevation, and hence higher atmospheric pressure, liquid water would have been stable at these locations (e.g. [5], [1], [2]). Evidence of life in ice-rich martian permafrost could be found in the form of molecular biomarkers. Currently, the preservation potential of molecular biomarkers in extremely cold ice-bearing permafrost is unknown. On Earth, the permafrost in the high elevation McMurdo Dry Valleys of Antarctica ranks amongst the coldest and oldest; as such, it represents a valuable terrestrial analogue to inform about ground ice conditions and abundance, distribution and cycling of key nutrtients: organic carbon and nitrogen.

Previous studies on the carbon and nitrogen cycling in the permafrost of the MDV have mainly been undertaken in the low elevation valleys. The aim of our research is to characterize organic carbon and nitrogen content and isotopes in University Valley, one of the upper elevation valleys in the MDV, and to assess effects of liquid water in soils as a limiting factor.

Study area: University Valley is a northwest facing valley (1600-1800m a.s.l., 1.5 km long and 500 wide) situated in the stable upland zone of the MDV. The mean annual air temperature and relative humidity in University Valley is –24.3°C and 48%water, respectively, and the summer air temperature are always below the freezing point [6]. The origin of ground ice in University Valley was attributed to ground surface temperature and moisture conditions that separate the valley into two distinct zones: 1) a perennially cryotic zone (PCZ) in the north-east section of the valley that is characterized by ground surface temperatures always below 0ºC and that lacks geomorphic features associated with aqueous processes; and 2) a seasonally non-cryotic zone (NCZ) characterized by ground surface temperatures that rise above 0°C for at least a few hours on clear summer days and that contains geomorphic features associated with aqueous processes, such as frozen ponds and runoff deposits [6]. Based on δD-$\delta^{18}O$ analyses, the ground ice in the PCZ was attributed a vapour-diffusion origin; whereas the ground ice in the NCZ formed by the freezing of liquid water [7, 8].

Methods: In this study, we measured the organic carbon and nitrogen content, ^{13}Corg and ^{15}N and dissolved organic carbon (DOC) in 17 ice-bearing permafrost cores collected in the polygonal terrain in University Valley: 8 from the PCZ and 9 from NCZ. All measurements were made at the G.G. Hatch Laboratory (University of Ottawa).

Preliminary results: Concentrations of total organic carbon and nitrogen in the 17 ice-bearing permafrost cores is low throughout; although average concentrations from the PCZ (C: 0.93 mg g^{-1} soils, N :0.32 mg g^{-1} soils) is lower than those from the NCZ (C: 1.8 mg g^{-1} soils, N: 0.4 mg g^{-1} soils). Results from one core with differing ground ice origin (vapour-deposited in the upper section and freezing of liquid water in the bottom section) revealed that DOC was < 4 mg L^{-1} in the upper part, but reached values > 8 mg L^{-1}) in the bottom section. This points to distinct abundance of organic carbon and nitrogen following availability of liquid water (or lack thereof). Upcoming results (i.e. $\delta^{13}C$ and $\delta^{15}N$) and additional organic carbon, nitrogen and DOC will shed further light on the nature of carbon and nitrogen cyling in such extreme environments, especially in the PCZ where little evidence of life was detected [9].

Ultimately, this research will help us to further improve our scientific knowledge on the roles that the origin of ground ice and the concentrations of organic carbon and nitrogen have on the habitability of cryotic soils. In the long run, this study will potentialy be a contribution to the refining of sampling techniques and instrumentation for the upcoming 2018 Mars Icebreaker mission.

References:

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