EPSC Abstracts
Vol. 8, EPSC2013-119, 2013
European Planetary Science Congress 2013

Water tracks in the McMurdo Dry Valleys, Antarctica: Investigating habitability conditions in a terrestrial analogue to recurring slope lineae

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Abstract

Water tracks are shallow groundwater features that form seasonally in Antarctic permafrost environments and are the best known terrestrial analog to martian recurring slope lineae (RSL). Here, we detail the hydrological, geochemical, and biological structure of water tracks in order to determine how habitable conditions and biomarkers are distributed within this Mars-like landform.

1. Introduction

Water tracks (Fig. 1) are zones of enhanced soil moisture that route water downslope through the seasonally-thawed portion of the permafrost and over the ice table in polar environments [1,3]. Water tracks mapped in Taylor Valley, Antarctica, are one of the best known terrestrial analogs to martian RSL [2] and share many morphological and formation characteristics (Table 1). A key outstanding question

Table 1. Comparison of RSL and water tracks in the McMurdo Dry Valleys, Antarctica (MDV). Adapted from [1-2]

Attribute	Recurring Slope Lineae	MDV Water Tracks
Feature Width	Up to 5 m	Typically 3-5 m, wider when multiple tracks intersect
Feature Length	10s to 100s of meters	10s to 1,000s of meters
Feature observable changes	Incremental growth, slow uniform fading	Incremental growth, slow uniform fading
Contrast with background slope	Slightly darker	Slightly to much darker
Slope albedo	Low (<0.2)	Low (~0.15)
Slope thermal inertia (J m^{-2} K^{-1} $s^{-½}$)	180-340	330-1100
Slope aspect preference	Equator-facing (also E, W)	Equator-facing at high elevations, less preference at low elevations
Surface temperature during formation	240-297 K (-33˚C to +24˚C)	270-287 K (-3˚C to +15˚C)
Formation season	L_s = 260-20 (Southern Spring-Summer)	Nov-Feb (Antarctic Spring-Summer)
Feature fading timescale	Months	Months
Feature abundance on slope	Up to hundreds, concurrently	Up to dozens, concurrently
Topography	None resolved	Gentle surface troughs (below HiRISE DEM resolution)
Source Surface	Bouldery regolith or rocky outcrops	Bouldery regolith / rocky outcrops

regarding water tracks is how water, solutes, and biomarker compounds are distributed and preserved in water tracks. In particular, how does the hydrology of water tracks change the distribution of water activity and temperature in water tracks (thus, controlling the water track's habitability and biomarker preservation potential) [4]?

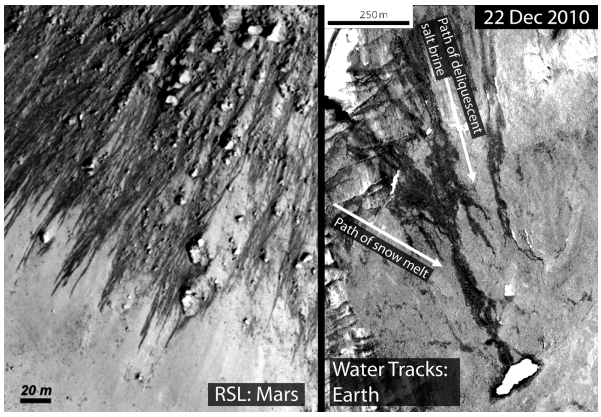

Figure 1. (Left) Recurring slope lineae on Mars. Portion of HiRISE image PSP_005787_1475 (Right) Water tracks in the Goldman Glacier basin, Taylor Valley, Antarctica1.

2. Methods

Water tracks in Taylor Valley, Antarctica (78˚S, 162˚E) were measured and sampled during austral summer, 2012-2013. Water track soil moisture content was measured with Decagon Devices 5-TE soil moisture probes at discrete locations. Water track conductivity (a measure of salinity) was determined using a Geonics EM-38 Mk.2 induction probe that was traversed over the water tracks in a tight grid pattern to produce a spatially-integrated measure of salinity. Water track fluids were extracted using standpipe piezometers, and were analyzed for major ion composition via ion chromatography. Water track soils were analyzed for total organic matter, total organic carbon, as well as C and N isotopic ratios, and microbial biomass.

3. Results and Implications.

Preliminary results indicate that, while water tracks become wetter down-slope (higher soil moisture content), they also become more saline (higher salinity) (Figure 2), which reduces the water activity (and thus, the habitability) of the wetted soil environment. This saline fluid, however, may act to

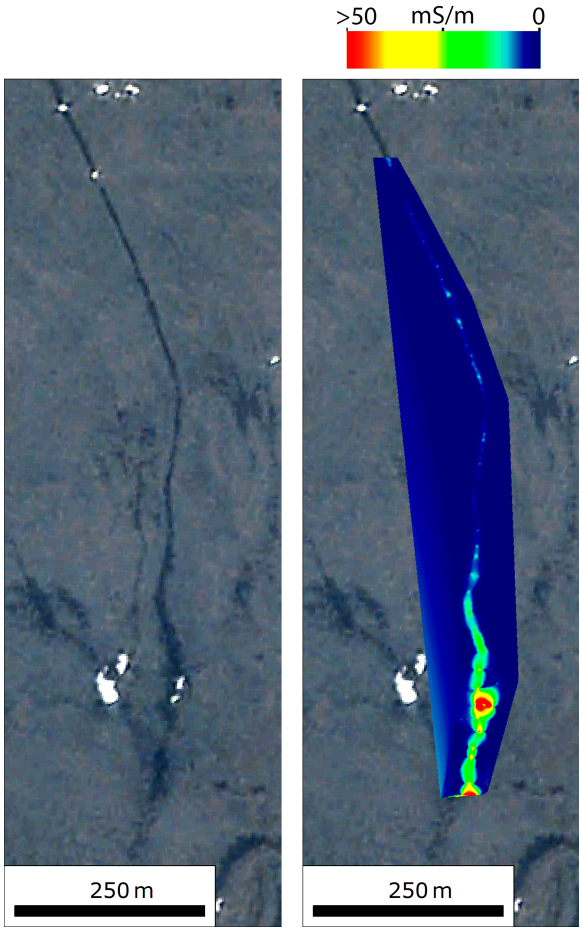

Figure 2. (Left) WV2 satellite image of a water track. (Right) measured conductivity (salinity) distribution in the water track.

prevent consumption of organic matter within the water track, making them both highly productive regolith environments for primary production as well as stable environments for biomarker preservation. Water track water activities span a wide range, from <0.5 to nearly 1. Consequently, RSL on Mars may be inferred to be potentially habitable environments on modern Mars that may be capable of preserving biomarker material in the geological record.

4. References

[1] Levy, J. et al. (2011) *GSAB,* **123,** 2295–2311. [2] McEwen, A. et al. (2011) *Science,* **333**, 740-743. [3] McNamara, J. et al. (1999) *Geomorp.* **29,** 339–353. [4] Beaty, D. et al. (2006) *Astrobio.* **6,** 677–732.