"WATER TRACKS" IN THE MCMURDO DRY VALLEYS, ANTARCTICA: A PERMAFROST-BASED HYDROLOGICAL SYSTEM SUPPORTING COMPLEX BIOLOGICAL AND GEOCHEMICAL PROCESSES IN A MARS-ANALOG ENVIRONMENT.

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Introduction: The analysis of martian hydrogeological landforms has focused largely on the measurement and modeling of large, readily discernable geomorphic features: valley networks from the Noachian, outflow channels from the Hesperian, and gullies from the recent Amazonian [1-2]. In a parallel development, analysis of the hydrogeology of the McMurdo Dry Valleys, Antarctica has focused on major volumetric water reservoirs (glaciers, streams, and ice-covered lakes) [3], megafloods recorded in the geological record [4], and recent, microclimate-related gully evolution [5-6].

Here we report on "water tracks" in Taylor Valley, McMurdo Dry Valleys, Antarctica [7]. Water tracks are zones of enhanced soil moisture that route water downslope over the ice table in polar permafrost environments [7-8]. Although only geomorphically recognizable as subtle, sub-linear depressions, or, during peak flow conditions, as damp, darkened, patches of soil, these largely unexplored Antarctic water tracks are a significant component of the cold desert hydrosystem. Water tracks occur on gullied slopes, as well as on featureless slopes [7], and, in the Arctic, represent the widely distributed 0-order tributaries of large fluvial systems [8]. *Water tracks are typical of permafrost-dominated hydrological systems, and may represent a major water transport pathway that has been active in association with more recognizable fluvial processes throughout martian history.*

Taylor Valley Water Tracks. Numerous water tracks are present in Taylor Valley. These darkened soil surfaces extend downslope, typically oriented along the steepest local gradient, over lengths of ~200-1900 m. (Fig. 1). The dark soil surfaces range from ~1-3 m in width and are commonly observed in sub-linear depressions, or in local low ground between knobby terrain. Dark surface discoloration vanishes in frozen water tracks during winter, rendering them nearly undetectable. In-situ measurements were collected along the length of several water tracks, and from adjacent, light-toned soils, as summarized in Table 1.

	On-Track	Off-Track	N
VWC (%)	15±2	5±2	34,20
EC (dS/m)	0.53±10%	0.05±10%	31,16
DTR (cm)	45±1	19±1	28, 20

Table 1. Permafrost properties on and off water tracks. VWC is volumetric water content, EC is electrical conductivity (salinity), and DTR is the depth to refusal (a measure of ice table depth). N is the number of samples measured in Taylor Valley during 2009-2010.

Excavations into the water tracks revealed increasing soil moisture with increasing depth, typical of active-layer soils in Taylor Valley. Water-saturated soil is typically present above the ice table in water tracks. Saturated layer thicknesses ranged from <1 mm (surface dampness) to ~20 cm [7]. Water track fluids are typically high-salinity, ranging in composition from <10 mg/L TDS (fresh snowmelt contributions) to briny solutions in excess of 40 g/L TDS. Downslope flow of brines occurs through the active layer along the water track, as water percolates downslope through soils with a mean hydraulic conductivity of 0.02 cm/s (Fig. 2) [7]. Organic matter is 5-10 times more abundant in water track soils than in adjacent dry soils.

Taylor Valley water tracks are generated by a combination of infiltration from melting snow packs, pore ice and massive ice melted from the ice table, and the melting of buried segregation ice formed during winter freezing. The water tracks are enriched in solutes derived from chemical weathering of sediments as well as from dissolution of soil salts, resulting in local ecological optimums in the lower-salinity portions of the water tracks (Fig. 3). Water track flow is sufficient to produce ponds and ephemeral channels, to dissect knobby terrain through enhanced soil creep, and to drive in-situ chemical weathering in polar soils [7].

Water Tracks on Mars. Water tracks have not been specifically described on Mars, however, their morphological and spectroscopic similarity to martian slope streaks has been noted [7, 9-10]. High soil matric and osmotic potential in Antarctic water tracks suggests the possibility of water track-related barriers to sublimation/evaporation under more extreme martian conditions. We will present preliminary analyses of candidate water track sites on Mars associated with geologically recent gully activity.

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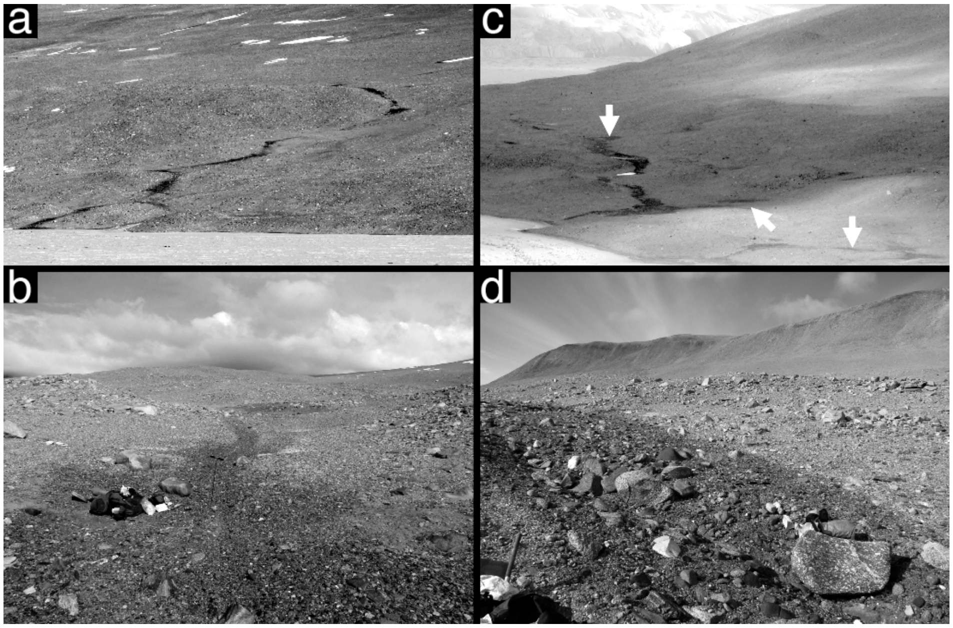

Fig. 1. Water tracks in Taylor Valley, Antarctica. a) A water track (identified by dark surface discoloration associated with damp soil) extends hundreds of meters down an ice-cemented permafrost slope. b) Close view of water track in a. Note backpack for scale. c) Branching water tracks (white arrows) dissect a low-angle permafrost slope. d) Close view of water track in c. Note backpack for scale.

Fig. 2 (Left). Saturated soil flowing in the active (thawed) layer in a Taylor Valley water track. Water flow is nearly undetectable beneath 15-20 cm of regolith. A strong desiccation gradient reduces surface soil moisture from 30-35% at the ice table to <15% at the surface.

Fig. 3 (Right). Moss (dark material) concentrated in a thermal contraction crack that locally routes water-track related brines. Note 1 cm diameter steel rod in foreground for scale.