THE ROLE OF PERENNIAL SNOW AND ICE DEPOSITS IN MCMURDO DRY VALLEY GULLIES FROM HIGH-FREQUENCY, LONG-DURATION TIME-LAPSE PHOTOGRAPHY: LESSONS FOR MARS. J. L. Dickson and J. W. Head. Brown U., Dept. of Geo. Sci., Providence, RI. jdickson@brown.edu.

Introduction: Gullies on Mars [1] appear to be the result of melting of atmospherically-emplaced ice [2-6] in the last several million years, possibly forming at present [7-10]. The amount of ice necessary to form and modify gullies is not well constrained, and arguments have been made that it could be in the form of anything from seasonal frost [11] to residual ice from a recent glacial period [12]. To help understand how these various degrees of ice content manifest themselves under small amounts of melting, we have studied similar features in the one place on Earth that has gullies on steep slopes in the absence of pluvial activity: the McMurdo Dry Valleys of Antarctica.

The polar desert classification of the Dry Valleys has made it a popular analog for Mars for decades. While the entire region exhibits polar desert conditions, small variations in properties like soil moisture, temperature and relative humidity cause dramatic differences in landscape evolution [13]. To provide a framework to study these micro-climates, *Marchant and Head* [13] partitioned the Dry Valleys into three zones: The Coastal Thaw Zone, the Inland Mixed Zone, and the Upland Stable Zone. Most analogous to the majority of contemporary Mars is the Upland Stable Zone, while the boundary between the Upland Stable Zone and the Inland Mixed Zone is analogous to regions on Mars where conditions are such that liquid water can exist on the surface for short periods of time. This is where gullies are found on each planet.

In the South Fork of Upper Wright Valley, gullies incise the equator-facing wall [14-16]. In four seasons of field work and dozens of orbital observations, no evidence for input from deep aquifers has been observed. Melting of trapped wind-blown snow in channel floors has been documented as an erosive agent during spring conditions [14], particularly in the westernmost gully, but supply is generally exhausted by early December. Of greater volume, however, are perennial sheltered snowbanks found within gully alcoves that appear to persist for decades (Fig. 1). To decipher their contribution to channel erosion and fan emplacement over the course of a full summer season, we installed multiple high-resolution, long-duration time-lapse cameras overlooking this site. Observations were made during the 2009-2010 austral summer field season, and are currently being undertaken in the 2010-2011 season.

Specifications: For the 2009-2010 field season, a Canon A590 camera was installed on the southern crest of the Dais, a ~600-700 m mesa separating South Fork from North Fork, overlooking the two gullies on the equator-facing wall of South Fork (Fig. 1). Camera firmware was modified to allow for automated image acquisition every 5 minutes for 2 months (Nov. 27, 2009 – Jan. 22, 2010), providing > 16,000 images for analysis during peak summer insolation conditions (Fig. 2). The camera was then reprogrammed to acquire one image every hour during austral winter, until the camera became disabled.

For the 2010-2011 season, two Canon SX1 cameras with modified firmware were installed on the floor of South Fork: one on the northern wall of the valley, providing an overview of the two gullies, and one directly on one of the gully fans at a location known to experience fluvial activity from previous field seasons and orbital observations (Fig. 1). This camera also provides a view of the perennial snowbank in the alcove of the gully that sources the fan upon which the camera is installed (Fig. 3). The cameras are currently acquiring images every 2 minutes, providing ~5000 observations per week from each station.

2009-2010 Observations: Melting of perennial alcove snowbanks produced daily pulses of flow at the channel/fan transition beginning in early January of 2010, corresponding with peak summer temperature and insolation conditions. On warm days, these pulses would laterally expand the hyporheic zone (the region where water infiltrates the banks of the channel, darkening the surface) so as to be visible by the time-lapse camera (Fig. 2). Specular reflections from early-morning images showed that water in the channel would freeze at night when the sun set below the Asgard range to the south, then remelt in the morning, extending the surface pulse down-channel each day. This cycle continued through the warm summer months, yielding small interconnected ponds (Fig. 2c) that froze as shadows cast from the Dais to the north began to cover the floor of the valley late in the austral summer. These ponds persisted until the spring, when field work at the site continued.

2010-2011 Observations: Warmer conditions in early December yielded earlier and more intense melting of perennial alcove snowbanks than had been seen in previous seasons (Fig. 3). Both gullies underwent significant erosion in early/mid-December. Major pulses from mid-day maximum insolation eroded channels through fan material further downslope daily at ~1800, continuing until ~0100 the following morning. Water remaining in channels would refreeze, then produce small amounts of melting in the morning, followed by another massive pulse of activity at ~1800 the following evening. This cycle was able to erode channels to the depth of a meter in some places, producing fine-scale terracing, streamlined islands and the emplacement of new fan material over the course of just several days. In the western of the two gullies, flow resulted in ponding in the same regions observed in 2009-2010, but much earlier and in greater volume.

Field work at the source region itself revealed relatively high-energy meltwater streams emanating from the perennial snowbanks. Snowbanks had become densely incised with dendritic channels, and flow was seen to be steady over the southern wall of South Fork.

Discussion: Flow from the perennial snowbanks that characterize the alcove regions of Dry Valley gullies appears to be a significant contributor to the erosion/deposition cycle observed downslope, with peak insolation/temperature driving activity, as opposed to average conditions, which would not predict significant melting. Qualitatively, this activity appears to be of greater consequence than the contributions from wind-blown seasonal snow [14-16] or melting of the ice-cement table, though those sources are being similarly assessed.

More broadly, if a similar suite of sources were available for gullies on Mars at times when deposition and accumulation at the surface were favorable, then activity would be predicted to be at the locations of the greatest accumulation and when peak climate conditions, not average conditions, permitted the melting of that accumulated ice.

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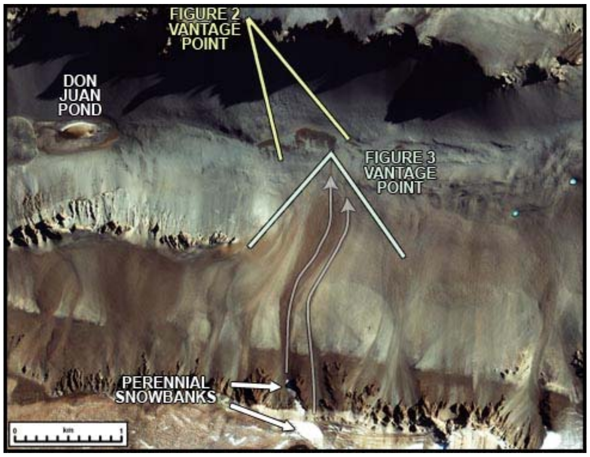

Figure 1. IKONOS image of South Fork. February 1, 2009.

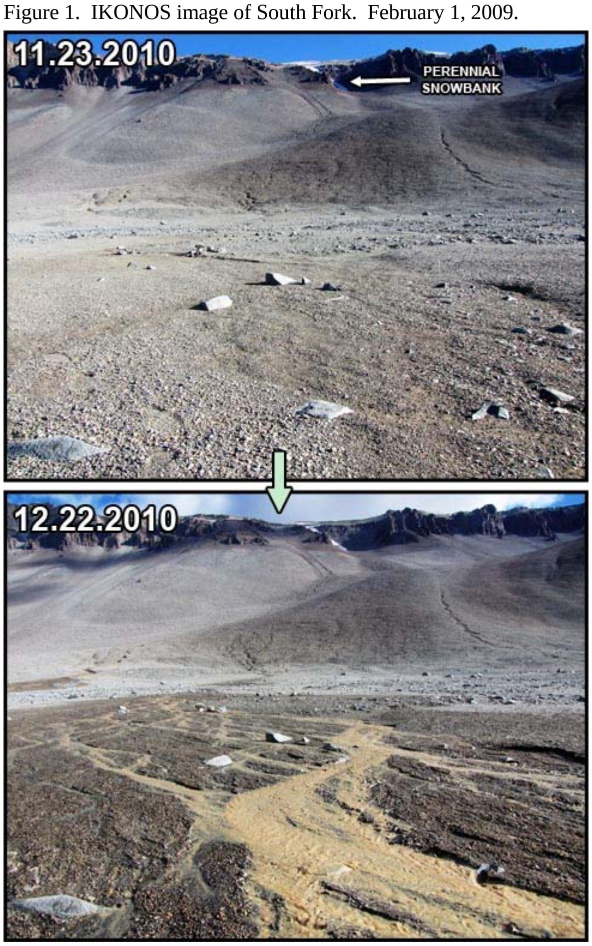

Figure 3. Increased flow through gully system through austral spring in 2010. Both gully systems (Fig. 1) experienced significant activity, with erosion of meter-deep channels in places.

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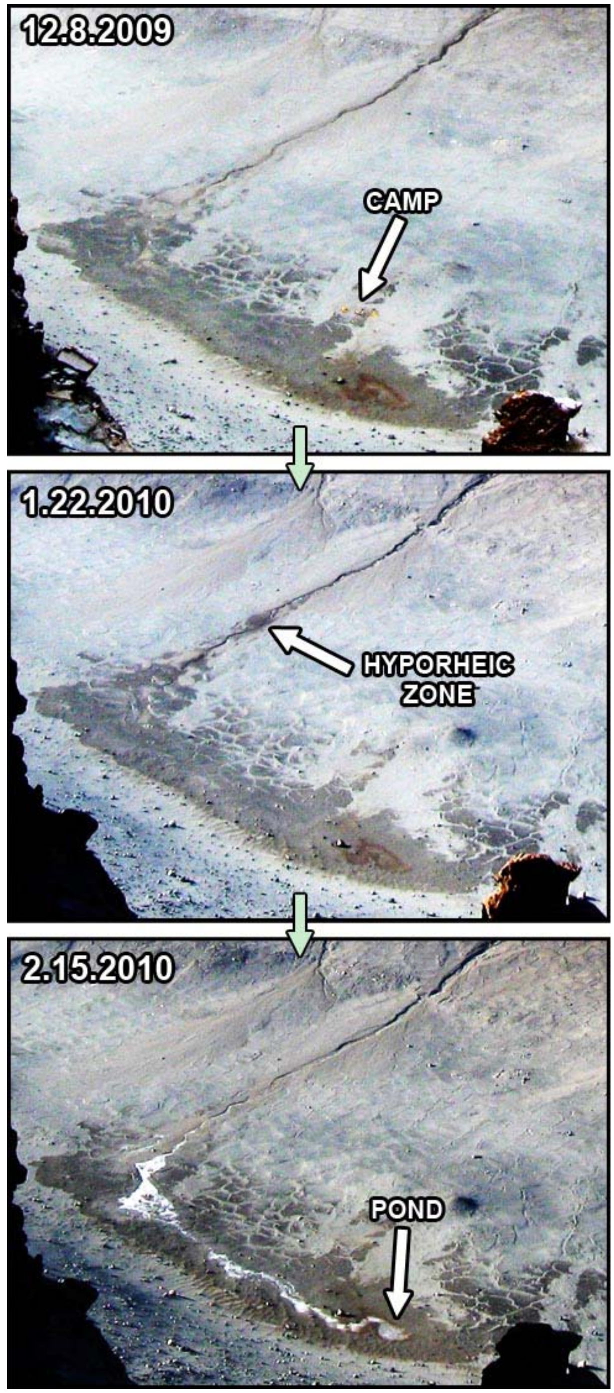

Figure 2. Samples of activity during the 2009-2010 austral summer. Daily pulses from alcove snowbanks (Fig. 1) reach the floor of the vally in January, leading to ponding in Februrary.