HiRISE OBSERVATIONS OF MARS' SOUTHERN SEASONAL FROST SUBLIMATION

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Numerous enigmatic features have been imaged as Mars' southern seasonal CO_2 cap sublimated in past Mars years, by the Mars Global Surveyor (MGS) Mars Observer Camera (MOC). As the seasonal frost sublimates, spots, fans, cracks, "caterpillars" and other odd features with no earthly counterparts form. We now have new detail from Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) images to study the processes that form these exotic features. MRO has the ability to point off-nadir to target locations of interest, which enables frequent monitoring of seasonal changes at high spatial resolution. HiRISE's high signal to noise ratio facilitates imaging at low light levels, allowing us to start imaging the sublimation process just as the sun rises at latitudes equivalent to Mars' arctic circle.

One of the primary goals for HiRISE study of seasonal processes is to test the "geyser" or "cold gas jet" hypothesis [1,2]. It has been postulated that the CO_2 seasonal cap anneals into translucent slab ice over the course of a Martian winter. In the spring, sunlight penetrates the slab to the underlying surface and heats the bottom of the cap [3]. The cap sublimates from below, and gas is trapped under the ice. This gas is released through vents, entraining the loose dust below and lofting the dust up onto the surface, forming the spots and fans imaged first by MOC and now by HiRISE. Over many years the escaping gases carve shallow troughs into the surface leading to the vents, which look like "spiders" [2].

HiRISE studies of the seasonal sublimation of the southern cap began in December 2006, winter in the southern hemisphere. Southern spring starts February 8, however sublimation of the seasonal cap begins even before sunrise. The HiRISE team planned three major observational campaigns. The first campaign was to image a variety of locations repeatedly to study the evolution of the spots and fans that develop as the cap sublimates on a variety of terrains. The second campaign was to image the locations of "spiders" at angles with good stereo convergence at numerous times and locations. Any geyser-like activity should be detectable in stereo viewing as a plume rising above the surface. The hypothesis that every spot is a site of gas jets implies that the probability of catching a geyser in action is very high. A new result, the association of seasonal volatiles with gullies, inspired our third campaign: to image high latitude gullies repeatedly, to look for changes. In particular we have seen dark inner channels in many southern hemisphere pole-facing gullies where it appears that seasonal frost and dust have been removed. CRISM has detected CO_2 frost in a shadowed region with gullies and H_2O frost just outside the shadow [4], suggesting that there is also H_2O frost in the shadows but covered by CO_2 frost.

HiRISE has 10 red CCDs in a row, to image a swath 6 km wide at 300 km altitude. Two blue-green (~536 nm) and two near-IR (~874 nm) CCDs are offset just above and below the two center red (~692 nm) CCDs. (See McEwen [5] for a detailed description of the camera.) High resolution color images give a unique new insight into the role of volatiles in gully formation.

Color images of Russell Crater dunes show a clear association of seasonal spots with gullies. The spots are similar in color and morphology to the seasonal spots postulated to be the sites of geyser-like gas release, implying that energetic "fizzing" of CO_2 as it sublimates plays a role in the initiation of the material movement that creates the gullies on dunes. Spots occur at the top of many of the channels, and are found preferentially along the channels, perhaps initiated by the removal of overlying material during gully formation. Progressive release of CO_2 in this way may help to mobilize the dune material and facilitate continued down-slope propagation of the gully. Ejection of dune material out of the channel during gas release may account for the lack of debris aprons at the foot of these gullies. Multiple images of the dunes as the seasonal frost disappears show the same color of material on the bottom of the channels. An alternative hypothesis is that the gully topography traps greater amounts of CO_2, leading to the observed association between gullies and dark spots surrounded by frost. These hypotheses of gully formation are testable with repeated HiRISE observations.

References: [1] Kieffer, H., (2000) LPI Contribution #1057. [2] Piqueux, S., S. Byrne, and M. Richardson, (2003) JGR 108(E8):3-1. [3] Kieffer, H., (2006) accepted for publication in JGR. [4] Murchie, S., *et al*, (2006) AGU abstract P33A-04. [5] McEwen, A., *et al*, (2006) JGR, in press.

Figure 1. Richardson Dunes in process of defrosting, showing development of seasonal spots with fans. The fan direction is indicative of the local wind direction. Small spots show a single fan, while larger spots have dust deposited in multiple directions, showing how wind direction has changed with time.

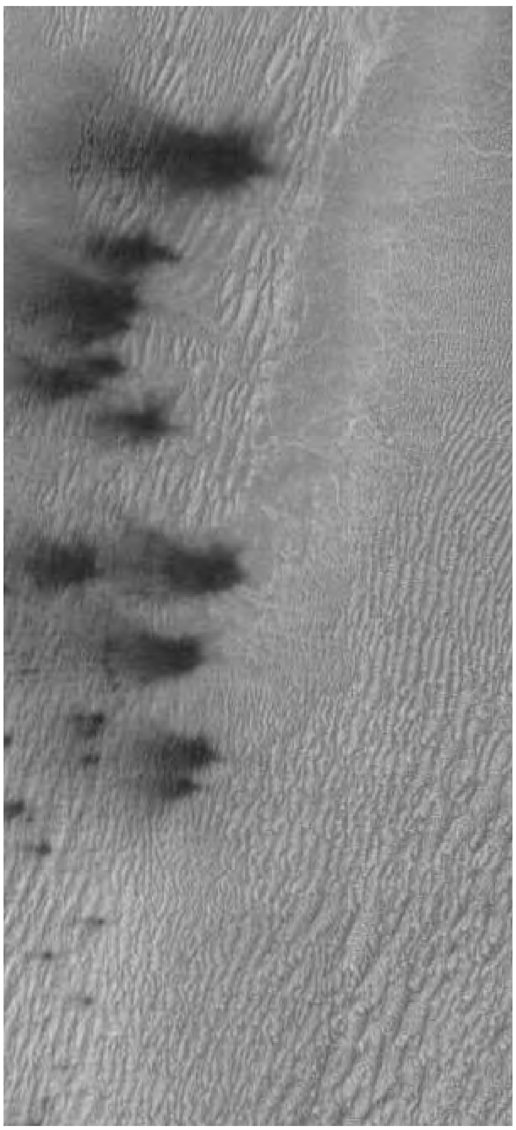

Figure 2. Russell crater dunes show an association of spots with tops of gully-like channels and preferentially along the channels.