COMPOSITIONAL CONSTRAINTS ON MARTIAN GULLY FORMATION AS SEEN BY CRISM ON MRO. J. I. Núñez1, O. S. Barnouin1, F. P. Seelos1, and S. L. Murchie1, 1Johns Hopkins University Applied Physics Laboratory (11100 Johns Hopkins Road, Laurel, MD 20723; jorge.nunez@jhuapl.edu).

Introduction: Martian gullies are widespread on Mars, with most occurrences found in the southern hemisphere [e.g., 1-7]. Due to their resemblance to gully morphologies on Earth, their discovery was taken as evidence for recent liquid water activity on Mars [1-2]. Multiple alternative models have subsequently been proposed for their formation mechanism, including groundwater release [e.g., 1-2, 4, 8], melting of snow or near-surface ground ice [e.g., 6-7; 9-10], dry granular flows [e.g., 11-12], or alternatively different CO2-driven mechanisms, including release of liquid CO2 [e.g., 13] and CO2 frost sublimation [e.g., 14-18].

Recent studies using high resolution images obtained with the High Resolution Imaging Science Experiment (HiRISE) [19] and Context Camera (CTX) on the Mars Reconnaissance Orbiter have revealed morphological changes to gully channels and aprons over intervals as short as one Martian year [16-18; 20-22]. These studies demonstrated that active gullies are widespread and are consistent with seasonal activity [16-18; 20-22]. Some studies favor liquid water in the form of melting of H2O-ice or snow as the driving mechanism for the observed activity [20-21], while others have supported a mechanism driven primarily by CO2 frost sublimation [16-18; 22].

Investigation: We analyzed over 100+ images of gullies and their apron deposits taken with the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on the Mars Reconnaissance Orbiter (MRO) [23] over multiple Martian years to constrain gully formation and seasonal activity based on composition.

Observations: Gullies within or near high albedo regions are spectrally indistinct from their surroundings (Fig. 1). This is most likely due to mantling by martian dust (Fig. 2), which suggests a lack of gully activity (i.e. older age) or fast rate of dust accumulation.
Gullies with spectral contrast from surroundings predominate in the southern hemisphere and coincided with low albedo regions (Fig. 1). In these instances, gullies exposed and transported underlying material downslope, composed of mafic composition. In few instances, spectral signatures for phyllosilicates were detected in Noachian–early Hesperian terrains (Fig. 3). However, these occur in pre-existing layers that are exposed and transported downslope. No spectral evidence for liquid water or hydrated salts, such as perchlorates, has been observed in gully sites that would indicate present or recent liquid water activity as a result of groundwater release or melting of H2O ice.

Seasonal ice was observed in mid- to high latitude gullies. Spectral signatures were consistent with the presence of both CO2 and H2O frost (Fig. 4). However, in some cases only detections for H2O ice were observed, primarily in shadowed regions and steeper slopes with angles $>20$ degrees. Analysis of slope data suggest that at these steep slope angles, little volatile material would be needed to cause material transport [26]. The freeze/thaw cycle of seasonal frost may suffice in incising gullies on Mars.

**Summary:** Most gullies on Mars are spectrally indistinct from their surroundings, indicating older age due to inactivity or active coating by dust. In instances where mineralogic signatures are detected, they primarily reflect underlying material.

This implies ongoing activity that prevents dust accumulation from masking spectral signatures. However, gullies do not show spectral evidence for deposition of hydrated minerals or in situ alteration associated with long-lived water-rock interactions. Observations of freeze/thaw activity from seasonal CO2/H2O frost in mid- to high-latitude gullies contribute to recent gully formation and evolution. These observations combined indicate a limited role for long-lived liquid water in the recent formation and modification of martian gullies.

**References:**


**Figure 3:** Phyllosilicates transported downslope in an unnamed crater near Gorgonum Chaos in Terra Sirenum.

**Figure 4:** Seasonal Ice detected in CRISM image FRT00098BD during Solar longitude 20.21 in 2008. (a) Visible color image of high-latitude crater suggest possible ice with higher albedo. (b) Spectral parameter map targeting H2O and CO2 ices shows the distribution of these ices on gully walls and aprons. (c) CRISM spectra is consistent with both H2O and CO2 ice. (d) HiRISE image (PSP_006955_2495) of region shows gully morphology and relationship of ices to gully apron.