SPECTRAL ANALYSES OF GULLY-ASSOCIATED LIGHT-TONED MATERIALS FROM TGO/CASSIS AND MRO/HIRISE OBSERVATIONS: IMPLICATIONS FOR MARTIAN GULLY FORMATION MECHANISMS.

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Introduction: Since the first discovery of gully-like features on Mars by [1], there have been series of global gully surveys [2-5] directed to understand their distribution and potential formation mechanisms. Observations of seasonal activity coupled with frost deposition, through strategic time-series monitoring campaigns from imaging instruments like the High Resolution Imaging Science Experiment (HiRISE) [6] and the Colour and Stereo Surface Imaging System (CaSSIS) [7], continue to test a variety of dry and wet-based models for gully formation and evolution. Presently, no single model completely explains the variety of gully activity observed on the surface of Mars [8].

One particular approach that has drawn interest is the H_2O ice melt model [9], where snow deposition during high obliquity periods followed by subsequent melting is proposed as a gully formation mechanism. A protective dust cover builds up after every active phase preventing further melting [10], until future slumping re-exposes the ice layer. While evidence of mantle dust-ice layering is seen in different geologic settings both on Mars [11] and Earth [12,13], snowmelt as a process is harder to distinguish from that due to near-surface water flows, by morphology alone [8].

Recent work by [14] employs VNIR spectral characteristics of ices from HiRISE images to comment on light-toned materials (LTMs) observed in some Martian gullies, interpreting them as possible re-exposed water-ice deposits. Their results, however, highlight some difficulties with validating these interpretations, including the lack of water-ice spectral characteristics over HiRISE bandwidths. Importantly, their spectral results remain ambiguous due to lack of a correction for atmospheric dust-scattering contributions to HiRISE I/F, which is heavily represented by a ferric signature in the VNIR [15]. Alternatively, the additional NIR channel in CaSSIS [7] coupled with the application of a dark subtraction (DS) correction to mitigate atmospheric scattering, may allow for more comprehensive and confident detection of surface water-ice features [16-18]. This work presents a preliminary analysis of the LTMs of [14], with HiRISE and CaSSIS DS-corrected I/F spectra with attempts to provide less ambiguous spectral results that better isolate surface signatures, validate if H_2O ice is consistent with these LTMs, and by extension, comment on the plausibility of the H_2O ice-melt gully formation model.

Methods: A new database of ~23 gully-associated LTMs observed by HiRISE has been generated. This was initially based off previously identified deposits by [14] and was further expanded to include a larger subset of HiRISE gully observations with recently reported activity [5]. Simultaneous requests for 4-band CaSSIS images were made to cover the LTMs. HiRISE RDR and CaSSIS images were radiometrically calibrated to I/F [7,19,20]. An empirical DS correction [21] was then applied to the datasets to reduce effects of atmospheric contributions. In cases where band minima pixels did

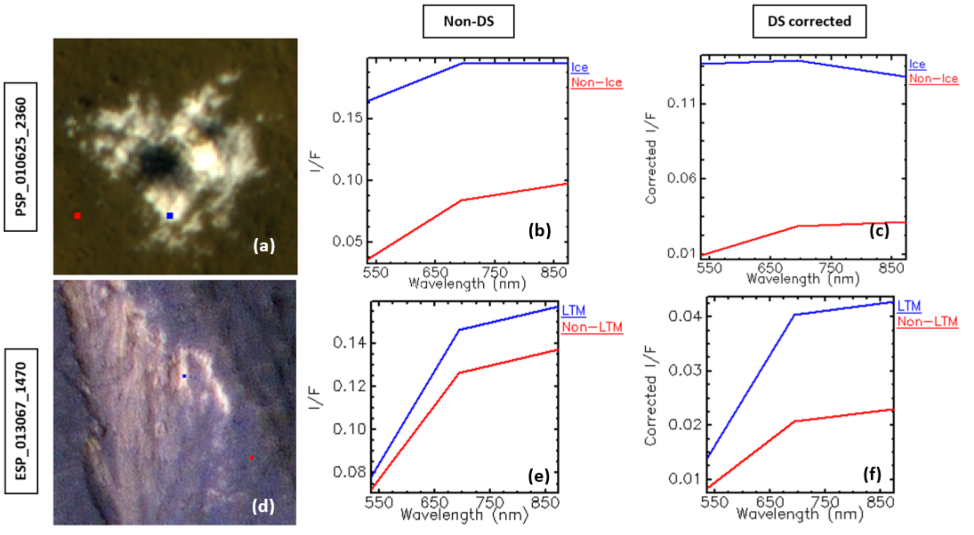

Figure 1 (a) HiRISE IRB image of an icy impact. Blue and Red ROIs represent icy and non-icy regions respectively. **Figs. (b)** and **(c)** show non-DS and DS-corrected spectral comparisons of the two ROIs. **Fig. (d)** is a HiRISE IRB image of a LTM; Blue and Red ROIs in this image represent a LTM and a non-LTM region. **Figs. (e)** and **(f)** are corresponding non-DS and DS spectral comparisons of the two ROIs.

not lie in shadow, a modified DS correction [17] was applied. Spectral extraction was done from two regions of interests (ROI) – one over the LTM and one just outside it, such that both were on visually similar slopes to minimize photometric effects. Spectral parameters highlighting ferrous/ferric surfaces, including possible ice exposures, were also generated [17,22] for CaSSIS images to aid spectral extraction. To help validate results obtained for the LTMs, observations with well-characterized water-ice deposits were also studied for comparison.

Results: Preliminary results from comparisons of non-DS (Figs. 1b and 2b) and DS-corrected I/F spectra (Figs. 1c and 2c) show that DS-correction greatly aids spectral detection of surface water-ice deposits in both HiRISE and CaSSIS images. Icy surfaces in the VNIR are predominantly characterized by higher overall relative reflectance in all bands, and a rapid downward slope towards 1000 nm, due to the presence of weaker asymmetric overtone absorptions near 800, 890 and 1030 nm for water-ice [16]. These characteristics are better emphasized with CaSSIS spectra, owing to its additional IR channel compared to HiRISE.

While this overall deflection towards 1000nm is distinctly observed in the DS-corrected HiRISE observation of an icy impact crater (Blue spectrum in Fig. 1c), and the DS-corrected CaSSIS image of the Korolev crater ice deposits (Blue spectrum in Fig. 2c), it is noteworthy that these characteristics are lacking in spectral observations of the LTM, either pre- (Figs. 1e and 2e) or post-DS correction (Figs. 1f and 2f).

Discussions: Preliminary results presented in this work pose important questions on previous interpretations of LTMs as re-exposed water-ice, as unambiguous spectral evidence of water-ice in the VNIR is not observed. As such, a larger detailed survey of these LTMs from a CaSSIS standpoint is warranted and would prove to be extremely useful in understanding the composition of these deposits. Our future work will expand on the gully LTM database by including the CRISM-based gully survey by [23] to provide additional examples for joint HiRISE-CaSSIS analyses.

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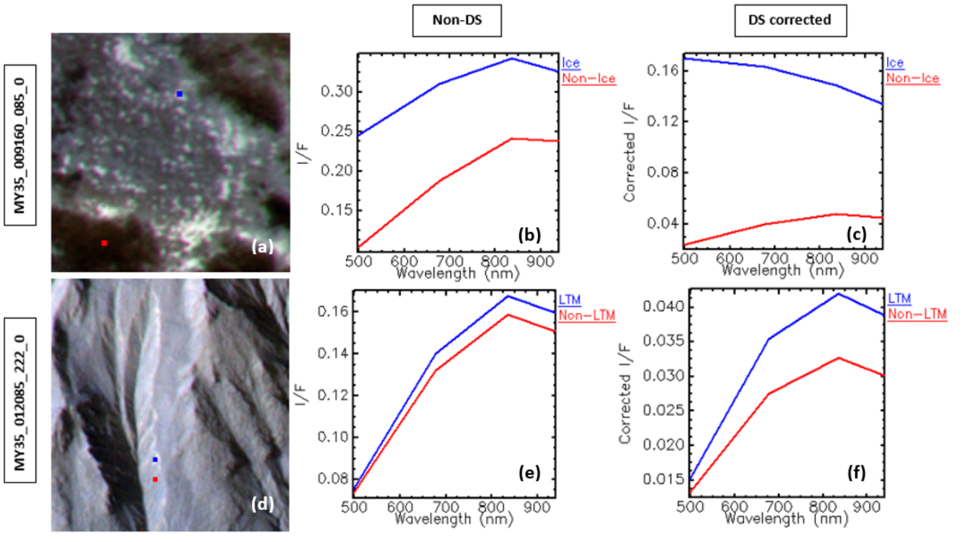

Figure 2 (a) CaSSIS NPB image of ice deposits in Korolev crater. Blue and Red ROIs represent icy and non-icy regions respectively. **Figs. (b)** and **(c)** show non-DS and DS-corrected spectral comparisons of the two ROIs. **Fig. (d)** is a CaSSIS NPB image of a LTM at Triolet crater; Blue and Red ROIs in this image represent a LTM and a non-LTM region. **Figs. (e)** and **(f)** are corresponding non-DS and DS spectral comparisons of the two ROIs.