The Mineralogy Of Lithic Sediments Within The North And South Polar Layered Deposits, Mars. P. Sinha and B. Horgan, Purdue University (sinha37@purdue.edu).

Introduction: The south polar layered deposits (SPLD), nearly the size of Alaska [1], is part of the plateau Planum Australe which consists of stacks of ice-rich sedimentary layers over 3 km thick. Based on crater statistics, the SPLD preserves pre-modern but still geologically recent (<100 Myr) climate records [2]. Total accumulation time calculated independent of crater ages suggests that these deposits preserve climate records due to orbital forcing spanning up to 15 Myr [3]. The SPLD, being older than its northern polar deposits provides a deeper look into Amazonian Mars.

Characterizing the bulk composition of the sediments in the PLD is essential to interpret the nature of the layered deposits and associated climate signals. Radar based studies have estimated the bulk dust content of the PLD to be under 15% [4-5] where individual layers can contain up to 50% of dust [6]. However, the composition of silicate dust/sediment in the PLD remains unknown. Therefore, this study aims to constrain the primary composition of lithic sediments present in both the N/SPLD using the technique of visible and near-infrared (VNIR) spectroscopy from orbit.

Method: High-resolution (~18-40 m/pixel) hyperspectral data (~6.55 nm spectral sampling) from Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboard Mars Reconnaissance Orbiter (MRO) is examined in VNIR wavelengths (0.35-2.65 μm) to detect mineralogy of sediments within the SPLD. CRISM TRR3 Full Resolution Targeted (FRT) and Half Resolution Long (HRL) images are analyzed using the ENVI CRISM Analysis Toolkit (CAT). Images are corrected for photometric and atmospheric effects before analyzing for spectral signatures to detect Fe-bearing minerals which cause a broad absorption near 1 μm and often also near 2 μm [7-9], and the position and shapes of the bands can be used to differentiate minerals like olivine, pyroxene, and glass. Glass absorption bands are resolvable only when present in high abundances (>~70%) but can be detected as a distortion on other mineral bands at moderate abundances (>~50%) [7]. Most previous glass detections in the north polar region are associated with a strong blue and concave up slope, interpreted as weathering of the glass surface [10]. Spectral summary parameters are used to generate RGB maps showing spectral variations which aid in identifying regions for spectral analysis [11]. The corrected albedo (I/F) spectra contain contributions from dust, and atmospheric residuals. To suppress these effects, we calculate a reference spectrum from an average of pixels from the same detector column in the scene with high values of BD530 (ferric dust), low values for BDI1000VIS and HCPINDEX2 (mafics). To clearly see the broad iron bands near 1 and 2 μm, the continuum of each spectrum is suppressed by dividing the ratio spectrum by a linear convex hull [6,9,11].

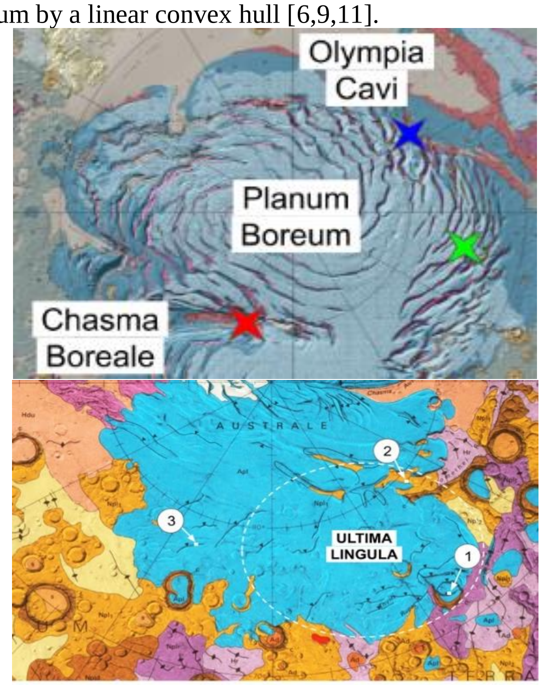

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Figure 1: Locations of CRISM images in this study*, shown on (top) geologic map for NPLD, and (bottom) SPLD (in blue).*

NPLD Mineralogy: Although the layered deposits appear dusty and icy, applying this spectral analysis technique at Chasma Boreale and Olympia Cavi in NPLD reveals a variety of mafic signatures arising from mixtures of high-Ca pyroxene (HCP) and glass of various grain sizes (Fig. 2). However, the detection of olivine in unit PB1 at a trough on top of Planum Boreum is of special interest as olivine is not found nearby in the surrounding plains (over at least a 1000 km away) [12].

SPLD Mineralogy: Three CRISM images poleward of 72°S in the Ultima Lingula region within the SPLD (Fig. 1) were chosen for preliminary study as accumulation models suggested Ultima Lingula to contain the most consistent record suitable for paleoclimate analysis [3]. These images were captured during summer in the southern hemisphere of Mars at L_S ~320°, during which the seasonal ice cap retreats poleward. Hence, the spectral data in the analyzed images are not contaminated by the presence of CO_2 and water ice on the surface. The images studied show wind-blasted surface on top of steep scarps and expose numerous continuous layers with varying degrees of degradation (i.e., fracture and collapse of layers) causing sediments to erode and deposit at the bottom of the scarp (Fig. 3).

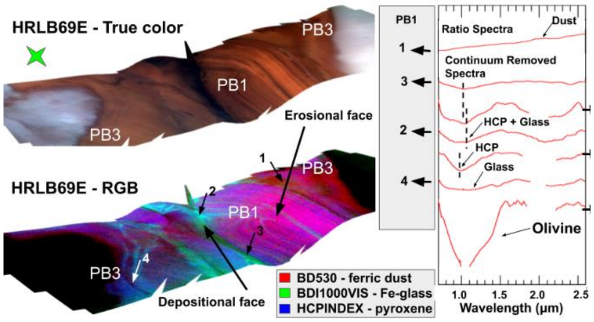

Figure 2: True color image (top), RGB composite (bottom), and extracted spectra from NPLD.

Spectrally, the layers within the SPLD appear to be dominated by ferric dust resulting in higher absorption band depth at 0.53 μm as indicated by the region in red on the RGB composite maps. But, the sediments on the floor display a strong mafic signature. Overall, the band centers at 1 μm absorption vary between 0.95 – 1.09 μm and band centers at 2 μm absorption lie between 2.12 – 2.18 μm consistent with varying mixtures of HCP and iron-bearing glass. Mafic sediments are indicated by green and blue on the parameter map which display stronger absorption at 1 and 2 μm, respectively. The maximum observed band asymmetry at 1 μm <0.35 which suggests that olivine, which displays higher band asymmetry is mostly absent at these sites. The ratio of absorption band areas at 1 and 2 μm classifies the analyzed spectra into two groups with band area ratios close to 1 and between 2 – 3. Further investigation is necessary in order to associate the these spectral groups to specific lithic units within SPLD.

Discussion: Although the majority of both the N/S PLD appear to be spectrally dominated by ferric dust, clear mafic signatures confirm the presence of primary lithics in and around the PLD. The surficial sediments at the base of scarps appear to be enriched in mafics relative to the dusty layered deposits exposed at the scarp. We interpret the difference in bulk composition of lithics in scarp and sediments on the floor due to erosion and deposition of material by katabatic winds blowing away from poles. The enrichment in mafics indicates that the ferrous silicates has a larger grain size and gets segregated from the mixture of dust made of relatively finer particles, which are blown away by the wind. Further, the absence of dust on eroded sediment at the foot of the scarp suggests that they are being transported actively to prevent settlement of airfall martian dust.

In comparison to the north polar layered deposits (NPLD) where the sedimentary layers in the northern summer displayed spectral signature of water ice [12], but the spectral signature of water or CO_2 ice is completely absent from the spectral data captured during the southern summer season. Also, the SPLD appears to be less dusty in comparison to its northern counterpart. It is also very distinct that the volume of sediment as sand sheets or dunes around SPLD is very small compared to the massive sand seas around NPLD. The cause of these difference at the two polar layer deposits (PLD) may be due to differences in its bulk composition, variation in intensity of its seasons, the contrast in their elevation, and associated wind regime. Detection of mafics at NPLD means that sediments are dateable and the age of the deposits can be constrained through radiometric age dating. This makes NPLD suitable for a future landed mission at age date ice cores and correlate to climate records.

References: [1] Cook, T. (2018) *Eos, 99.* [2] Landis et al., (2018) Amazonian Climate Workshop, #4017. [3] Bacerra et al., (2019) 9th Intl. Conf. on Mars, #6273. [4] Zuber, M. T. (2007) Science, 317(5845). [5] Plaut J.J. (2007) Science 316, 92–95. [6] Lalich et al. (2017) GRL,44,657-664 [7] Horgan et al. (2014) Icarus 234, 132-154. [8] Minitti et al. (2007) JGR 112, 1-24. [9] Cloutis et al. (1990) Icarus 86, 383. [10] Horgan et al. (2012) Geology, 40, 391-394. [11] Viviano-Beck, et al., (2014) J. Geo. Res.: Planets, 119, 1403, [11] Bennett, K.A. (2016). Icarus, 273, 297, [12] Sinha et al., (2019), LPSC 50, #2027.

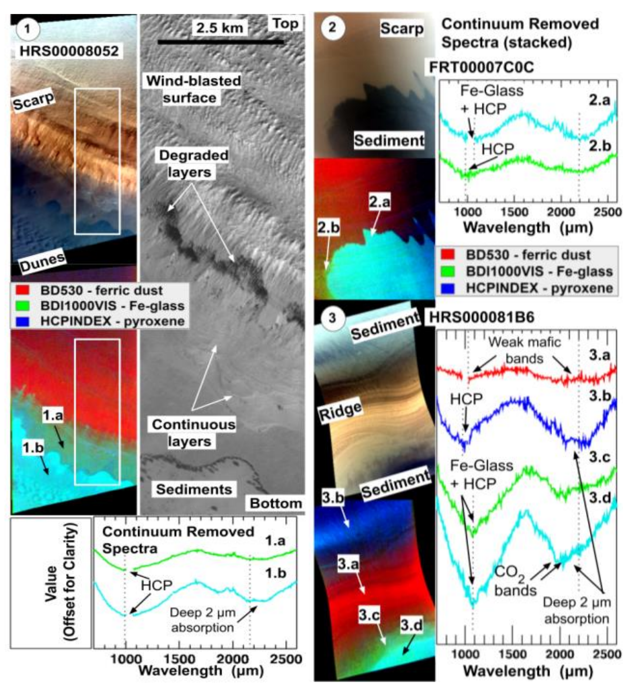

Figure 3: Results from the SPLD. *At each location (SPLD sites 1, 2, and 3), a true color image (top left), CRISM RGB composite of spectral parameters BD530/ BDI1000VIS/ HCPINDEX (middle left), and CTX image of the region within the white box, along with spectra extracted.*