CONSTRAINING SOURCES & SINKS OF HYDRATED MINERALS IN THE UZBOI-LANDON-MORAVA OUTFLOW SYSTEM, MARS.

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Introduction: Stretching >5,000 km along the surface of Mars, the Uzboi-Landon-Morava (ULM) outflow system (Fig. 1) is a mesoscale drainage system comprised of interconnected ancient crater lakes, outflow channels, valley networks, and chaos terrains [1-4]. Water in the ancient ULM system may have been provided in part by basal melting of the south polar cap [1,4-5], transporting water from the Argyre basin to Margaritifer Terra and the northern lowlands primarily during the Noachian (~4.1-3.7 Gya). Current understanding of the ULM system's evolution suggests it was eventually disrupted by an impact event, possibly around the late Noachian/ early Hesperian [3] when Mars may have experienced a global transition from a climate conducive to clay formation to one with limited surface water and sulfate formation.

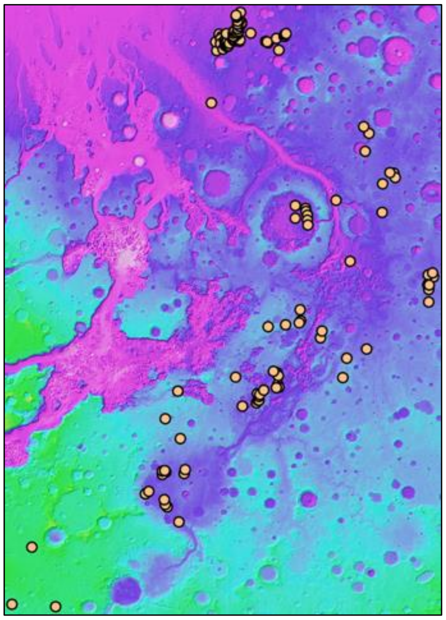

Figure 1. Topography map (MOLA) in shaded relief overlain with points indicating potential clay and sulfate deposits in the ULM and downstream. Orange dots indicate strong signals in the CRISM MRDR (mapping tile) D2300 spectral summary parameter typically associated with Fe/Mg-rich clay minerals.

Sedimentary strata within the ULM system, and its basins in particular, may record this climatic shift and changes in depositional environments. Indeed, both clay minerals and sulfate salts are detected throughout the ULM system and the downstream terrains of Margaritifer Terra [6-7]. How do clay minerals in the ULM watershed and adjacent crust relate to clays in the basins and channels? Is there evidence of clay transport throughout the ULM system? Do clay minerals vary in composition/type with transport distance? Is there evidence for possible authigenic clay formation in the ancient Holden and Ladon basins? What are the stratigraphic relationships between clays and sulfates within the ULM and adjacent Margaritifer Terra regions? In this project, we plan to integrate multiple orbital datasets to investigate the ULM system in a source-to-sink framework to better understand how strata within this extensive channel and basin system may record ancient aqueous processes on Mars. This type of large-scale analysis is aided by the recent release of new CRISM global spectral mapping tiles.

Previous studies on the mineralogy of the ULM system suggest clay minerals within the channels may be sourced from the surrounding highlands. Weitz et al. (2022) and Wilson et al. (2018) conducted detailed analyses of deposits in the southern part of the ULM, using full-resolution targeted CRISM observations. Wilson investigated the composition and origin of the Uzboi Vallis and Nirgal Vallis floor material. They proposed a provisional geologic timeline to account for the lack of obvious layering, which suggests material from Nigral Vallis was transported northward before the Holden impact blocked the ULM system. Weitz proposed that the same fluvial activity which formed the ULM's valleys also eroded highland bedrock smectites, transporting them downstream until they were deposited in small basins. Our study aims to supply further context for these hypotheses and evaluate if an authigenic origin of some clay deposits in the basins is permissible.

Mineral Mapping: Previously, near-infrared reflectance spectra acquired by the OMEGA and CRISM spectrometers have demonstrated the presence of hydrous minerals in select locations of the ULM system [1-4]. However, many deposits observed in the high spatial resolution (but limited spatial coverage) CRISM targeted observations are too small to be reliably detected at the lower spatial resolution (but generally broader coverage) OMEGA data. Until recently, this gap in spatial-spectral coverage has limited a holistic analysis of the hydrous mineralogy of the ULM system and surrounding watershed. The CRISM team has recently released updated versions of global mapping tiles that have more limited spectral resolution than targeted observations, but with the advantage of providing significantly more surface coverage at spatial scales of ~200 m/pixel. We use these new mapping tiles in conjunction with high-resolution visible images to identify and map potential sources and sinks of hydrous minerals in the ULM system and surrounding terrains, with a focus on identifying sections that may be of the highest interest for future orbital observations or landed exploration.

Our mapping efforts utilize spectral summary products for the mapping tiles provided by the CRISM team through the PDS as well as custom-designed spectral parameter maps, with an emphasis on detecting and identifying clays and sulfates. We also use parameters to identify mafic/Fe-rich areas, as well as the BD1900_2 parameter to measure band strength of the 1.9 µm H_2O absorption feature. ArcMap Pro was used to integrate the spectral maps with MRO Context Camera (CTX) and the High-Resolution Imaging Science Experiment (HiRISE) images, where available.

Prospective clay mineral detections were identified based on the CRISM summary parameters' signal strength (Fig. 1, 2). These potential detections were then categorized by their signal strength and geologic context (e.g., bedrock vs. crater or valley floors, unit albedo, unit texture, etc.). Each potential detection was then examined using the mapping tile atmospherically corrected Lambert albedo spectra. Spectra were evaluated using ratio techniques and, when available, compared with spectra from full spectral resolution CRISM targeted mode data (e.g., Figure 2).

Results: Here, we provide an example of spectra for a potential clay detection in the western part of Ladon Basin (32.5˚W 18.4˚S). The detection was identified in the mapping tile using the D2300 parameter and was also covered in a targeted CRISM image (FRT0001B8A9). Spectra (5x5 pixel avg) from the clay-bearing region were ratioed to spectra from a spectrally bland region in the same image (Fig. 2).

Both mapping tile and full-resolution CRISM spectra generally agree for important features typical of clay minerals, including an absorption at 2.31 µm (Mg/Fe-OH) and subtle absorptions at 1.4 µm (structural OH/H_2O) and 1.9 µm (H_2O). The weak 1.9 µm feature in both datasets, along with the asymmetry of the 2.3 µm feature, may be indicative of a mixed-layer chlorite-smectite rather than pure smectite [8].

Additional regions with mapping tile spectra like those in Fig. 2 are found throughout the ULM system (Fig. 1), where the strongest detections of likely clay mineral outcrops tend to occur outside of the main channel system. Notable exceptions to this are Ladon Basin and Margaritifer Terra, which both host a variety of clay-bearing exposures. This suggests at least some of the clays within the ULM basins may have been sourced from the surrounding altered terrain, and ongoing work will focus on comparing the clay type/chemistry of these deposits. Clay-bearing outcrops in Ladon Basin suggest it may have acted as a sink for fine-grained, clay-rich sediment, though it is intriguing that clay occurrences seem relatively scarce in the bedrock adjacent to and upstream of the basin.

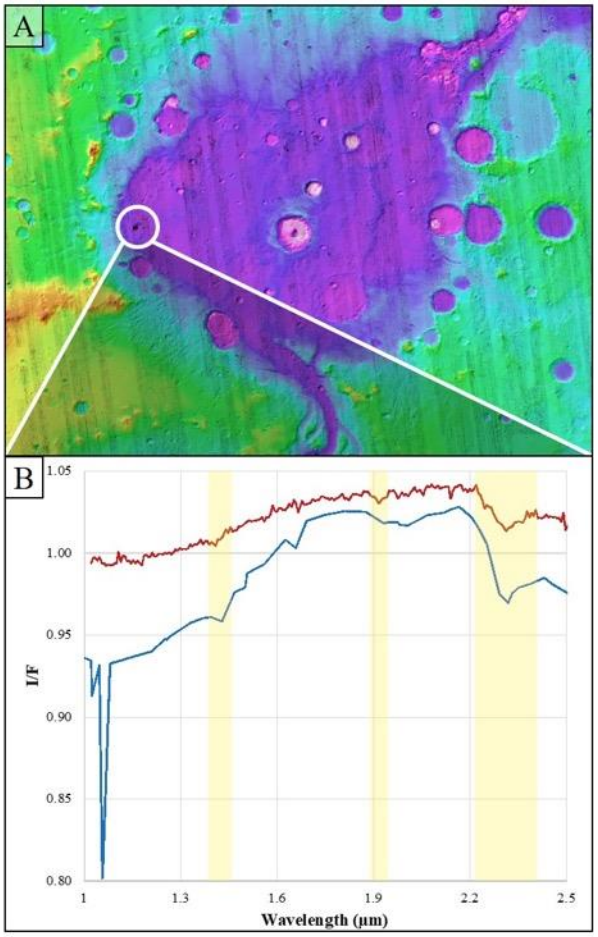

Figure 2. A) Potential clay detection, Ladon Basin, Mars. CRISM MRDR spectral summary parameter D2300 (black) overlaying MOLA terrain map. A strong signal is circled in white. B) Ratioed spectra of low-resolution (blue) and high-resolution (red) CRISM spectra of the potential clay deposit highlighted in A. Yellow bars highlight key absorptions.

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