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NOCTIS LANDING, MARS: MRO CRISM MINERALOGY AND WATER SIGNATURES AT A PROPOSED HUMAN LANDING SITE AND EXPLORATION ZONE IN WEST VALLES MARINERIS.

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Summary: Noctis Landing is a proposed Landing Site/ Exploration Zone for human missions to Mars. This study identifies several mineral and water-related spectral signatures in data from Mars Reconnaissance Orbiter (MRO)'s Compact Reconnaissance Imaging Spectrometer for Mars (CRISM).

Introduction: Noctis Landing (NL) is a proposed Landing Site / Exploration Zone for human missions to Mars [1]. It is one of 47 sites proposed to NASA at the agency's *First Landing Site (LS) / Exploration Zone (EZ) Workshop for Human Missions to the Surface of Mars* convened in Houston, TX, in October 2015.

Understanding the mineralogy and volatiles present at the NL site is important for characterizing its geology, environmental evolution, astrobiological potential, possible resources, and promise for human exploration. In this study, we seek to identify mineral and water-related spectral signatures in MRO CRISM data released in NASA's Planetary Data System (PDS). We consider two nested EZs: the Primary EZ (PEZ), a circular region within 100 km from the NL LS; and a Secondary EZ (SEZ), a ring-shaped region ranging from 100 to 200 km from the NL LS **(Fig. 1).**

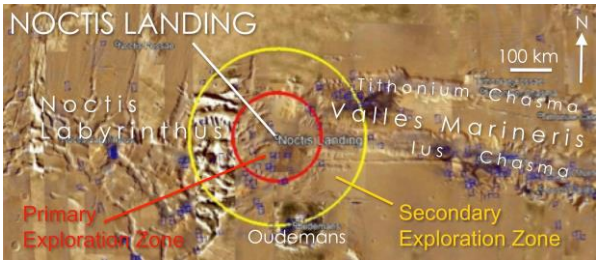

Figure 1. Noctis Landing Map. Red: Primary EZ (PEZ). **Red to Yellow:** Secondary EZ (SEZ). (Base map: Google).

The Noctis Landing PEZ is a regional depression at the western end of Valles Marineris representing a transition zone between Tithonium Chasma to the NE, Ius Chasma to the E, Noctis Labyrinthus to the W, and Oudemans Crater to the S. Our study aims to help evaluate in more detail whether the NL LS would offer access to high-value "regions of interest" (ROIs) for science and/or resources.

Previous mineral identification and mapping efforts in the region include a study of hydrated minerals in Noctis Labyrinthus and in sparse locales within the NL PEZ and SEZ [2]. The present study expands this past work, in particular to Tithonium Chasma, and also includes searches for other water-related signatures.

Methods: Areas within the Noctis Landing PEZ and SEZ covered by MRO CRISM data were located using the NASA PDS and Google Mars. CRISM images were analyzed following the standard pipeline procedure associated with the pre-processing of CRISM data, which includes a basic photometric correction for Lambertian scattering followed by division by 'Scaled Volcano Correction' to correct spectra for absorption by CO_2. To further understand the spatial distribution of candidate minerals, we considered the combination of summary parameters suggested by [3], called the 'Browse Products'.

Results: We report general results for the area, then focus on two ROIs designated "*Dragon Pit*" and "*Mirage Narrows*".

General Results: We find that, in areas covered by CRISM data, the Noctis Landing PEZ and SEZ are dominated by hydrated minerals (HYD), including mono-hydrated sulfates, poly-hydrated sulfates, and hydrated silicates (HYS). Mafic minerals (MAF) such as olivine, and low and high-calcium pyroxenes are also prevalent in both the PEZ and SEZ, with olivine being the dominant mafic phase.

The central part of the PEZ contains jarosite (a K-Fe sulfate) in addition to other hydrated sulfates. In some locations south of the NL LS, phyllosilicate signatures are observed. The NE part of the SEZ shows some of the clearest signatures of hydrated minerals.

A summary parameter, BD1500_2, which likely indicates H_2O ice in the atmosphere (*e.g.* ice fog) or at the surface (*e.g.* frost) [3], is observed in multiple locations within the Noctis Landing PEZ and SEZ. H_2O signatures may be time-variable, as they are generally observed in CRISM data acquired during early Martian summer, at areocentric solar longitudes L_s~ 90°-130°, and may become subdued or even vanish altogether at other times of year.

"Dragon Pit". A topographically depressed area located at 7°12' S, 92°30'W, ~50 km SSW of the Noctis Landing LS, presents varied mineralogy **(Fig.2).** The depressed area, informally referred to as "*Dragon Pit*", includes two main depressions with sloping walls, each ~10 km in scale: the "*Head Pit*" to the W, and the "*Tail Pit*" to the E. Hydrated minerals, including mono- and poly-hydrated sulfates, and other water signatures, are found in the "Head Pit" **(Figs 3 and 4).** Jarosite is identified in association with a central positive relief feature located inside "*Head Pit*", designated as "*Eye of the Dragon Hill*" **(Fig. 3).**

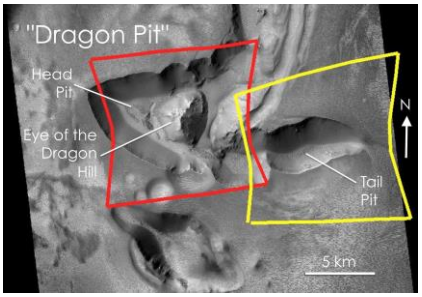

Figure 2: The "Dragon Pit" in the Noctis Landing PEZ. Red: CRISM image footprint encompassing "Head Pit" and "Eye of the Dragon Hill". **Yellow:** CRISM footprint covering "Tail Pit". (Background image: NASA MRO CTX).

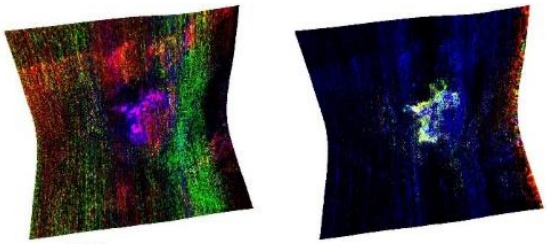

Figure 3. Sulfates at "Head Pit" & "Eye of the Dragon Hill". Left: CRISM Browse product HYD. Magenta: Poly-hydrated sulfates; Green: Mono-hydrated sulfates; Blue: Other hydrated minerals. **Right:** CRISM Browse product HYS. Yellow: Jarosite; Blue: Other hydrated minerals.

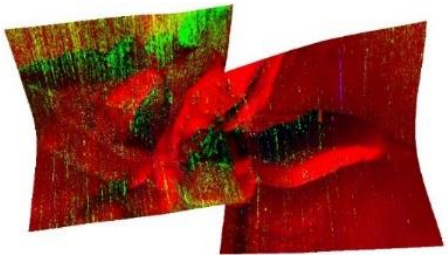

Figure 4. Water at "Dragon Pit". Green: CRISM summary parameter BD1500_2 indicating likely H_2O ice. Red: CRISM summary parameter R3920, a proxy for silicates.

"Mirage Narrows". A section of the floor of Tithonium Chasma, located at 4°50'S, 89°57'W, ~175 km NE of the Noctis Landing LS, illustrates the time-variability that H_2O detections may present in the region. The location, a topographic low and one of the narrowest sections of the canyon floor, is informally referred to as "*Mirage Narrows"* **(Fig. 5).** Three CRISM images acquired at this location and at similar incidence angles but at different times of year are shown in **Fig. 6**. H_2O is detected in the two CRISM images acquired in early summer (at Ls = 126.26° and 134.17°), while the third CRISM image acquired in early winter (at Ls = 271.99°) shows almost none.

It remains unclear what form these transient occurrences of H_2O take. Hypotheses include ice fog [4] and/or surface ice deposits such as frost [3].

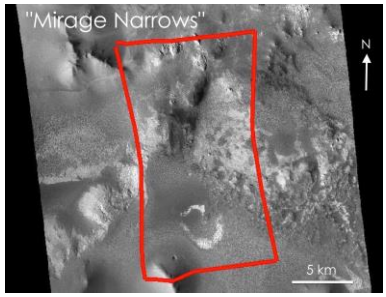

Figure 5. "Mirage Narrows" in the Noctis Landing SEZ. Red: CRISM image footprint. (Background image: NASA MRO CTX).

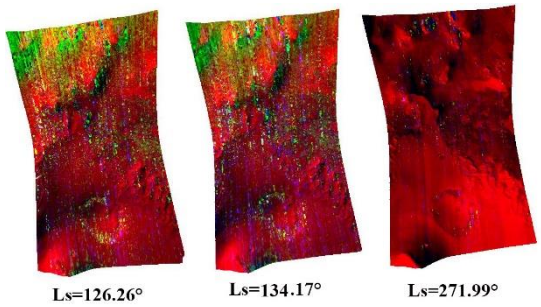

Figure 6. Transient Water at "Mirage Narrows". CRISM images of same location acquired at similar incidence angles but at different Ls. Same color coding as in Fig. 4.

Conclusion: The presence of hydrated minerals (in particular of poly-hydrated sulfates) in the Noctis Landing PEZ and SEZ is scientifically interesting and also important in the assessment of potential resources for the human exploration of Mars [5]. Our spectral analysis also indicates the possible presence of actual H_2O in the area, although in some locations at least, H_2O occurrences are time-variable on seasonal timescales [6]. Our study strengthens the appeal of the NL site for astrobiology and human exploration.

Future Work: Acquisition and analysis of additional CRISM data to expand the spatial and temporal coverage for the Noctis Landing PEZ and SEZ, are needed and recommended.

References: [1] Lee, P. *et al.* (2015) *1st LS / EZ Workshop for Human Missions to the Surface of Mars*, Abst. #1050. [2] Weitz, C. *et al.* (2014) *8th Int'l Conf. on Mars*; [3] Viviano-Beck, C. *et al* (2014) *JGR: Planets* 119(6), 1403-1431. [4] Esteban, S. & P. Lee (2018). *LPSC-2018*, Abst. #2770. [5] Lee, P. *et al.* (2017). *NASA ESF-2017*, Abst. #117. [6] Rodriguez, J. *et al.*, *Planet. Space Sci. 124*, 1-14.

Acknowledgements: This study was carried out as part of the Mars Institute's Global Research Internship Program (MI-GRIP). Use of Google Mars, ENVI, and NASA's CRISM Analysis Tool is acknowledged. P. Lee was supported via NASA Cooperative Agreement NNX14AT27A.