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Analysis of Clay Deposits in and around Ladon Basin

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Abstract

We have identified, mapped, and analyzed sedimentary deposits in and around Ladon basin. The study region has sediments and clays that likely formed from multiple aqueous processes, including fluvial, lacustrine, hydrothermal, and in situ alteration. A search through all HiRISE and CTX images for light-toned, possibly layered, deposits in our study region shows numerous locations where we have identified them. CRISM analysis of the light-toned deposits indicates the presence of Fe/Mg-phyllosilicates. Smectite appears to be dominant for deposits having bands near 1.9 and 2.3 µm; however, the spectral character is more consistent with nontronite (2.29 µm) in some regions and saponite (2.31 µm) in other regions. Some deposits have the 2.3 µm absorption but no 1.9 µm hydration band. We divide the light-toned clay deposits into three categories: (1) Uplands around Ladon basin; (2) Ladon Valles; and (3) Ladon basin.

1. Introduction

Light-toned layered outcrops in Holden and Eberswalde craters, near the mouth of Ladon Valles, Ladon basin, and in several of the small upland basins west of Ladon are all characterized by broadly similar morphology [1-8], suggesting that their sedimentary depositional settings were perhaps similar. The deposits are mostly confined within topographic basins and do not drape exterior surfaces, thereby favoring deposition by low-energy alluvial or lacustrine rather than airfall or volcanic (flows or ash) processes. Despite similarities in appearance and occurrence, it is uncertain whether the light-toned layered deposits in Holden crater, Eberswalde crater, Ladon basin, and other depressions are linked in time or process. Some of the phyllosilicate-bearing sediments may be sourced from weathered upland rocks later transported into the basins whereas others may be the result of alteration after the deposits were emplaced [4]. Still other phyllosilicates could relate to laterally extensive phyllosilicate-bearing terrains identified to the west in Margaritifer Terra [9], Xanthe Terra and in the walls and plains surrounding Valles Marineris [10], and northwest Noachis Terra to the south [11]. Nevertheless, while the origin of clays in the deposits is currently ambiguous, it almost certainly reflects past environments characterized by prolonged chemical weathering. Understanding the source-to-sink sedimentary pathways on Mars is key to determining the origin of alteration minerals as they reflect the ancient environmental conditions.

2. Results

2.1 Uplands around Ladon basin

The light-toned layered sediments we have identified along the western uplands of Ladon basin are associated with valley networks that eroded Noachian and Early Hesperian geologic units and deposited these sediments within small basins, likely similar to the valley networks that deposited the delta in the larger Eberswalde basin. One deposit includes an inverted channel (Fig. 1) that lies in a shallow east-west valley that may have been blocked by topography associated with two craters. Spectra from the deposit are consistent with nontronite-type clays as well as additional clay signatures that appear to be saponite, although the phyllosilicate signatures are weak in these deposits. Valleys sourcing many of these deposits head along an ancient ridge to the west forming one of the eroded rings of the ancient Holden impact basin [12,13] that likely exposes rocks weathered during an early wetter period of the Noachian [14]. Drainage from the ridge into the valleys and deposition of the layered sediments likely continued until an outlet was established to the east, thereby enabling incision of the deposits and drainage onto the lower-lying floor of Ladon basin. Such a “source-to-sink” setting on Mars where clay-bearing sediments could be traced to specific source outcrops is rare and provides critical information about understanding the origin and environmental conditions that produced alteration minerals.

2.2 Ladon Valles

The utility of combined CRISM and HiRISE analyses is shown using an example of the deposits located at the mouth of Ladon Valles (Fig. 2). CRISM results include spectral features consistent with multiple types of OH-bearing materials, like Fe/Mg-rich clays, whereas HiRISE images indicate numerous beds with variable lithologies, including color and brightness variations (Fig. 2). Strike and dips for bedding planes on a HiRISE-derived DTM are shallow, between 1-4°, and their fine-scale layering is traceable across tens of kms, consistent with a lacustrine setting or perhaps distal alluvial.

2.3 Ladon Basin

Clays within Ladon basin are associated both with light-toned layered deposits and also medium-toned fractured materials that exhibit no layering. Alteration through burial/diagenesis, pedogenesis, or hydrothermal activity can take place across multiple elevations or conform to topography, and may have produced layering as chemical conditions changed over time. If hydrothermal alteration of a precursor material occurred, then the spectral properties of the phyllosilicates could vary as a function of distance from the heat source. Spectra from several of the clays within Ladon basin exhibit a 2.3 µm absorption but no hydration band at 1.9 µm, which could reflect dehydration from high temperatures that drove out the water in the clays [15].

3. Figures

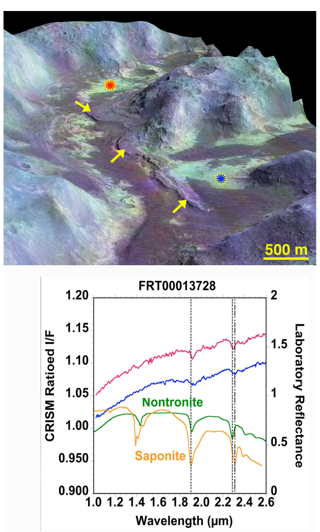

Figure 1. HiRISE DTM perspective view (5X vertical exaggeration) merged with CRISM spectral parameters in color. Red and blue asterisks show the locations where CRISM spectra were extracted and are plotted below. Yellow arrows identify a 15-m high inverted channel.

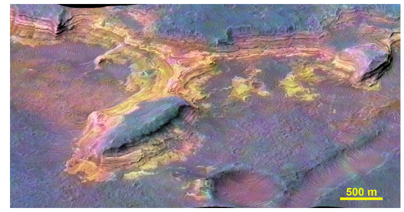

Figure 2. HiRISE DTM (5X vertical exaggeration) showing light-toned layered deposits near the mouth of Ladon Valles. Overlain on the HiRISE DTM is color derived from CRISM FRT00008076 (red is olivine index, green is 1.9 µm band depth, and blue is sulfate index).

4. Summary and Conclusions

The layered clay-bearing deposits in several upland basins identified in our preliminary investigation all occur between 0.5-2 km above similar-appearing deposits on the floor of Ladon basin and near the mouth of Ladon Valles [8]. These results are consistent with local trapping of water and sediment in topographic depressions on the upland flank of Ladon basin. The study of Ladon basin may constrain the number of layers/units on the basin floor (as exposed to in the walls of craters and fractures) and explore reasons why there is no obvious constructional delta or fan near the mouth of Ladon Valles. Our results are providing critical new constraints on the role and timing of aqueous activity in this region.

References

[1] Pondrelli, M., et al. (2005), *J. Geophys. Res.*, *110*, 2004JE002335; [2] Pondrelli, M. A. et al. (2008), *Icarus*, *197*, 429-451, doi:10.1016/j.icarus.2008.05.018. [3] Grant, J. A. et al. (2008), *Geology*, *36*, 195-198, doi: 10.1130/G24340A. [4] Milliken, R. E., and D. L. Bish (2010), *Philosophical Magazine*, 1478-6443, DOI: 10.1080/14786430903575132. [5] Rice, M. S., et al. (2011), *Geophys. Res. Letts.*, 38, doi:10.1029/2011GL048149. [6] Rice, M.S., et al. (2013) *MARS 8*, 15-57, doi:10.1555/mars.2013.0002. [7] Weitz, C. M., and J. L. Bishop (2012), *Lunar Planet. Sci. Conf., XXXXIII*, Abstract 1243. [8] Weitz, C.M., et al. (2013) *Lunar Planet. Sci. Conf. 44th*, Abstract 2081. [9] Buczkowski, D. L. et al. (2013), *44th LPSC,* The Woodlands, TX, Abstract 2331. [10] LeDeit, L., et al. (2012), *Journal of Geophysical Research*, *117*(E00J05). [11] Buczkowski, D. L., et al.. (2010), *Geol. Soc. of America Abstracts with Programs*, *42*(5), 645. [12] Schultz, P. H., et al. (1982), *J. Geophys. Res.,* 87, 9803-9820. [13] Grant, J. A. (1987), in *Advances in planetary geology*, NASA Technical Memorandum 89871, p. 1-268. [14] Bibring, J.-P., et al. (2006), *Science 312*, 400-404, DOI: 10.1126/science.1122659. [15] Morris, R.V., et al. (2010) *LPSC 41*, Abstract 2156.