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Mineralogy and Stratigraphy of Light Toned Deposits in Ophir Chasma, Mars

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1. Introduction

We studied the mineralogy, geomorphology and layering attitude of Light Toned Deposits (LTD) in Ophir Chasma, Mars, using visible and short wave infrared data (SWIR) from the imaging spectrometers OMEGA and CRISM together with panchromatic and color imagery, digital elevation models and anaglyphs from HRSC, Themis, CTX, MOC and HiRISE. Previous investigations of the light-toned deposits (LTD) in Valles Marineris on the regional scale based SWIR data from OMEGA or CRISM include [1,2]. Thermal infrared data from TES [3] was used by [4]. LTDs in other chasms have been investigated in detail by [5-12].

2. Datasets and Methods

OMEGA and CRISM are both imaging spectrometers operating in the visible to near infrared and in the SWIR. OMEGA observations have a spatial resolution between 4 km and 300 m per pixel. CRISM observations are acquired in various modes. In multispectral (MSP) mode, data is collected in 72 selected spectral channels at a resolution of 100 or 200 m per pixel. while in targeted mode, all 544 channels are used, and a spatial resolution of 18 to 40 m is reached at the expense of a much smaller spatial coverage. All data were converted to atmospherically corrected reflectance values and artifacts and bad bands were removed [13, 14].

We mostly used the spectral indices from [15] to identify individual minerals or mineral groups in CRISM and OMEGA data, but mapped the presence of iron oxides by the spectral slope between 1 and 1.3 µm as in [5, 6], and confirmed their presence using continuum-removed data from the visible wavelength range. We combined all data in a geographical information system (GIS).

3. Results

Sulfates were observed in the valleys north, east and south of Ophir Mensa and partly within Ophir Mensa itself. The southern slope of Ophir Mensa, exposed in the informally named "mineral bowl" valley [4], shows spectra of monohydrated sulfates (MHS) and partly polyhydrated sulfates (PHS). The slope is heavily eroded, suggesting that the sulfates are found within Ophir Mensa LTD rather than being a superficial deposit. The upper boundary of detection of the sulfate signature is not horizontal, but follows a prominent horizon that bends up and down the slope of Ophir Mensa's southern flank. The upper section of Ophir Mensa is apparently sulfate-free, as even spots with elevated thermal inertia and conditions unfavorable for dust accumulation (erosional rills, steep slopes) show no spectral sulfate signature.

The southern wall of the "mineral bowl" valley shows a complex juxtaposition of MHS, PHS and iron oxides. (MHS) are found as rough-textured deposits that overlay the basaltic rocks of the southern chasm wall. It is interpreted as remnants of Ophir Mensa, which once extended further towards the south. It is discordantly overlain by smooth layers of redeposited MHS material, PHS, and thin deposits of jarosite and mineral phases with absorptions at 1.4, 1.93 and 2.21 or 2.23 µm, possibly ferric oxy-hydroxides or mixtures containing amorphous silica as found elsewhere on Mars [e.g. 10,11]. Iron oxides form lag deposits on the floor of the mineral bowl and on the southern slope, and are often associated with polyhydrated sulfates.

The chasm floor north of Ophir Mensa is mostly hidden underneath landslide deposits, but a few locations have remained uncovered. The LTD material in some of these locations shows a sulfate signature, which appears to stratigraphically overlay the sulfate-free LTDs on the northern side of Ophir Mensa.

In the flat central valley east of Ophir Mensa, MHS and PHS are found. PHS are constrained to topographically low regions below -4400 m, MHS is found between -4400 m and -4300 m. The transition between the two mineral groups is not a sharp boundary, and no evidence is found for a discordance between the two groups. We therefore interpret the succession of MHS on top of PHS, which is "inverted" compared to sulfate occurrences in other chasms [7,9-12]. Locally, unidentified material with absorption bands at 1.4, 1.93 and 2.21 µm (possibly jarosite) as in the "mineral bowl" are found associated to the PHS-rich deposits.

4. Discussion and conclusions

We observe MHS-dominated sulfates and apparently sulfate-free LTDs *within* Ophir Mensa, and deposits containing MHS, PHS, jarosite and other hydrated mineral phases stratigraphically *above* Ophir Mensa. This implies at least two sulfate-forming events: One forming the sulfates within Ophir Mensa, and a second one forming those in the central valley and on the southern wall of the "mineral bowl". The first event might have been the intrusion of groundwater into previously deposited LTD material of unknown origin. Variations in permeability would have controlled the water transport within the deposits, leading to the non-horizontal upper limit of sulfates, as also suggested for nearby western Candor Chasma deposits [7]. In the nearly horizontal central valley, an interdune playa-like facies caused by ground water upwelling, as suggested for Meridiani Planum [16] is conceivable. In contrast, the sulfate deposits in the "mineral bowl" valley south of Ophir Mensa with their varying, but high topographic elevation compared to the central valley and a steep inclination of layering down the slope suggest a drape deposit, which is neither formed by a standing body of water, nor by groundwater upwelling, but might indicate the presence of meteoric water in the form of rain, frost or snow. Our suggested succession of events is summarized in figure 1.

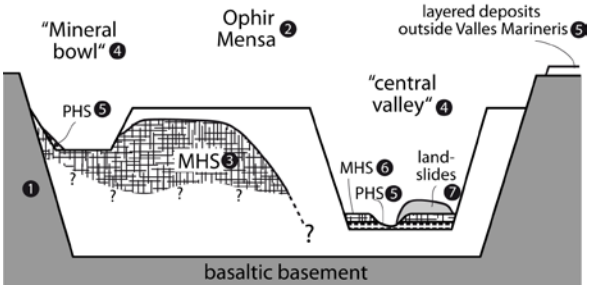

Figure 1. Suggested succession of events in Ophir Chasma. (1): Opening of Valles Marineris. (2): Deposition of the LTDs such as Ophir Mensa, possibly as airfall deposits or ash. (3): Formation of kieserite in Ophir Mensa by intruding groundwater. (4): Excavation of the "mineral bowl", "central valley" and "northern moat". (5): Deposition and/or alteration to form polyhydrated sulfates and other phases in "mineral bowl", possibly by meteoric water. Deposition of PHS and MHS (6) in "central valley", possibly in lake or underneath a glacier. The relative timing of the events (5) and (6) is not constrained. and might be related to layered deposits outside Valles Marineris. (7): Landslides enlarge chasm and partly cover floor. They played no role in the sulfate formation.

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