MINERALOGY AND STRATIGRAPHY OF SULFATES AND FERRIC OXIDES IN OPHIR CHASMA, MARS. L. Wendt[1], C. Gross[1], T. Kneissl[1], M. Sowe[1], J.-Ph. Combe[2], L. LeDeit[3], P. C. McGuire[1] and G. Neukum[1]. [1]Freie Universität Berlin, Inst. of Geosciences, Malteserstr. 74-100, 12249 Berlin, Germany, lorenz.wendt@fu-berlin.de. [2]The Bear Fight Institute, P.O. Box 667, Winthrop WA 98862, USA, [3]German Aerospace Center (DLR), Rutherfordstr. 2, 12489 Berlin, Germany.

Introduction: We present results of our detailed study of the mineralogy, geomorphology and layering attitude of sulfates and iron oxides in Ophir Chasma, Mars, using visible to short wave infrared data (SWIR) from the imaging spectrometers OMEGA and CRISM in conjunction with panchromatic and color imagery, digital elevation models and anaglyphs from HRSC, Themis, CTX, MOC and HiRISE. The mineralogy of the light-toned deposits (LTD) in Valles Marineris on Mars has been studied on a regional scale by [1] and [2] based on SWIR data from OMEGA, CRISM and thermal Infrared data from TES [3] or a combination of both [4]. Similar studies encompassing light-toned deposits (LTD) in selected individual chasmata have been presented by [i. e., 5-12].

Datasets and Methods: OMEGA is an imaging spectrometer operating in the visible to near infrared and in the SWIR onboard Mars Express. The spatial resolution of its observations varies between 2-4 km and 300 m per pixel. CRISM is an imaging spectrometer similar to OMEGA operating at wavelengths between 0.38 and 4 µm, but provides a better spatial resolution. In its multispectral (MSP) mode, CRISM acquires data in 72 selected spectral channels at a resolution of 100 or 200 m per pixel. In the targeted mode, data is acquired in all 544 channels at a spatial resolution of 18 to 40 m, at the expense of a much smaller spatial coverage. The data from CRISM was converted to atmospherically corrected reflectance values and artifacts and bad bands were removed using the algorithms described in [13, 14]. We used data between 1 and 2.6 µm over the entire study area, where available, and combined these with data in the visible range on selected observations.

We mostly used the spectral indices described by [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. To provide the best possible coverage of Ophir Chasma, we combined data at all available resolutions but analyzed only the best resolved data at each spot. The spectral index maps were overlain on georeferenced image data using a geographic information system.

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, shows kieserite and partly polyhydrated sulfates (PHS). The slope is heavily eroded, which suggests that the sulfates are found within Ophir Mensa LTD rather than being a superficial deposit. The upper boundary of detection of the sulfatic signature is not horizontal, but follows a prominent horizon that bends up and down the slope of Ophir Mensa's southern flank. This might suggest that (1) the sulfates in Ophir Mensa did not form in an open water body, as this would have left horzontal layering behind, and that (2) the upper section of Ophir Mensa is sulfate-free, which is supported by the observation that 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 mono-, and polyhydrated sulfates and iron oxides. Monohydrated sulfates (MHS) are found as rough-textured deposits that overlay the basaltic rocks of the southern chasma wall. This material 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, partly consistent with ferric oxy-hydroxides or mixtures containing amorphous silica found elsewhere on Mars [e. g. 10,11]. The stratigraphy and location of these deposits on isolated ridges is inconsistent with an open water body or ground water circulation or discharge (springs), and suggests meteoric water as the source for the hydration. Iron oxides are found as 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. This sulfate-rich material 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 chasmata [7,9-12], as the result of a changing brine chemistry, which would be consistent with evaporation in an open water body. Locally, unidentified material with absorption bands at 1.4, 1.93 and 2.21 µm as in the "mineral bowl" are found associated to the PHS-rich deposits.

Discussion and conclusions: Our observation of MHS-dominated sulfates within Ophir Mensa, apparently sulfate-free LTDs in Ophir Mensa, and deposits containing MHS, PHS, jarosite and other hydrated mineral phases stratigraphically above Ophir Mensa deposits implies that at least two sulfate-forming events have to be considered: One forming the sulfates within Ophir Mensa, and a second one forming those in the central valley after the excavation of the valley itself, and those 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 observed today. A similar formation model has been suggested for nearby western Candor Chasma deposits [7]. The similar mineralogy observed in the central valley and in Meridiani Planum [16] suggests a geochemically similar environment. The suggested interdune playa-like facies caused by ground water upwelling of Merdiani Planum in a second sulfate-forming phase is consistent with the low-lying, approximately flat deposits in the central valley. Alternatively, an open lake or sulfate formation underneath a glacier [e. g. 17, 18] might be considered. 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 suggests 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.

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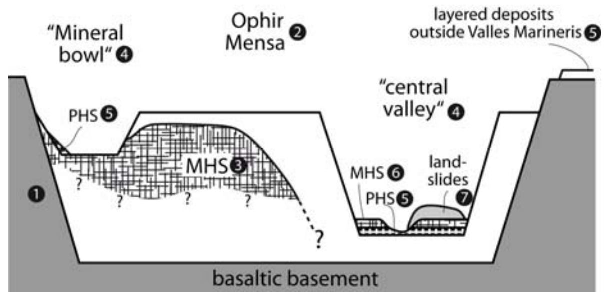

Figure 1
Suggested succession of events in Ophir Chasma. (1): Opening of Valles Marineris. (2): Deposition of the LTDs such as Ophir Mensa, possibly as airfall deposits or ash. (3): Formation of kieserite in Ophir Mensa by intruding groundwater. (4): Excavation of the "mineral bowl", "central valley" and "northern moat". (5): Deposition and/or alteration to form polyhydrated sulfates and other phases in "mineral bowl", possibly by precipitation 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. It could coincide with deposition of layered deposits with similar mineralogy on the plateau above Valles Marineris. (7): Landslides enlarge the chasm and partly cover the floor. They played no role in the sulfate formation.

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