Abstract

Hyperspectral studies have shown that a variety of water-related minerals is present on the Martian surface. Analyzing these minerals can shed light on prevailing past and ongoing environmental conditions. We identified and mapped hydrated minerals in Aureum Chaos to understand their stratigraphy and geological context based on high resolution short wave infrared data from CRISM, imagery and elevation data. Differently from most sulfate-rich regions on Mars, we could identify phyllosilicate indicating that local conditions could have allowed clay formation after the well-accepted global “phyllosian” era that is assumed for Early Mars. We will present sulfate formation models and relative timing of mineral formation.

1. Datasets

For our spectral analysis, targeted CRISM observations of both full and half resolution (FRT, HRL) were used. Data were processed with the CRISM Analysis Tool (CAT) including atmospheric correction into I/F [1] and mapping of spectral indices [2]. Spectra were ratioed and compared to CRISM library spectra.

2. Results

Based on CRISM and HRSC DTMs, we found hydrated minerals at 3600 m below datum. Detected mineral groups are monohydrated sulfate (MHS; best matching kieserite), hydroxylated ferric sulfate (HFS; best matching jarosite), polyhydrated sulfate (PHS), ferric oxides and phyllosilicate (best matching nontronite, Fig. 1, 2).

Sulfates are associated with Interior Layered Deposits (ILDs). The nontronite is attributed to chaotic terrain as light toned fractured exposure (Fig. 2E) and to dark, smooth, and indurated mantling. It was identified by its narrow and deep absorptions at 2.29-2.3 µm, 1.42-1.44 µm, 1.93, and 2.4-2.43 µm (Fig. 1B). HFS was identified by absorptions at 2.23 µm, 1.42-1.45 µm and weak 1.93 µm and 2.4 µm bands (Fig. 2B). Kieserite has absorptions at 2.12 µm and a deep absorption at 2.4 µm. Absorptions at 1.42-1.44 µm and at 1.92-1.93 µm identified PHS. The spectral slope between 1 and 1.3 µm displayed ferric oxide-rich regions [3,4]. These regions are present in sulfate-rich materials and on chaotic terrain mounds. Confirmed by spectral absorptions at 0.5 and 0.9 µm, we detected ferric phases in regions that appear MHS-bearing.

The ILD display three stratigraphic units: The lowest unit (1) shows massive, light-toned MHS (20-650 m thick, Fig. 2C) with intercalated knobby HFS and ferric oxides. The overlying PHS (2) is commonly layered (20-40 m thick, Fig. 2D), smooth to heavily fractured, and partially contains ferric oxides (Fig. 2C-D). Spectrally neutral, distinctly layered, and bumpy cap rock forms the top ((3), 40-300 m thick). Unconformities between the units indicate periods of erosion.

3. Conclusions

Previous polyhydrated sulfate and ferric oxide detections by [5, 6] were confirmed by higher resolution data; further water-related minerals have been identified. ILD stratigraphy is slightly different to observations by [7] for Aram Chaos (different MHS, HFS-signature), but morphology is comparable. Our HFS spectra are similar to spectra of [8] for Juventae Chasma deposits that have been interpreted as dehydrated PHS.

Facies and relative timing of sulfate formation remains undefined. However, a coeval formation of ILD and one sulfate (e.g. PHS), as proposed by [9] for ILDs in Valles Marineris, and its conversion into lower hydrates later on, is conceivable here when considering evaporation in a lake. Overburden pressure could have formed secondary MHS and ferric oxides. Post-ILD sulfate formation by rock alteration through groundwater as proposed by [10] passing through pre-existing sulfate-free ILD material. Water, either as liquid or solid phase, must have reached the maximum elevation at which we see hydration (3600 m below datum).

Since, phyllosilicate is associated with chaotic terrain (Late Hesperian [11]) and with mantling deposits, it could have formed in-situ or is allochthonous, the latter would be conceivable for mantling deposits. Assuming its in-situ formation for those deposits associated with chaotic terrain, would mean local conditions could have allowed clay formation after the Noachian. According to [12], the conservation of HFS and MHS assumes dry conditions with at most short-lived wetting events, hence the preserved HFS and MHS must have formed after the potential in-situ formed clays (requires water for prolonged periods).
Acknowledgements

This research was supported by the Helmholtz Association through the research alliance "Planetary Evolution and Life" and the German Space Agency (DLR Bonn) grant 50QM0301 (HRSC on Mars Express), on behalf of the German Federal Ministry of Economics and Technology. P.C.M. was supported by a fellowship from the Alexander von Humboldt Foundation and by the CRISM Science Team.

References


