Investigation of the detectability of sulfates in the 4-5 μm range of Martian remote soil spectra and application to Mars Express/PFS data

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Chemical analyses performed at Viking, Pathfinder, and, recently, at Mars Exploration Rover (MER) landing sites suggest the presence of sulfate minerals in Martian bright soils covering large areas of the planet. However, remote soil spectra have so far provided only tentative identification of sulfates in bright soil regions regarding mineral types and abundances. More detailed information on this is needed to provide new insight into weathering processes that may have formed bright soils on Mars and the environmental conditions during their formation.

We present laboratory studies on the detectability of four Ca- and Mg-sulfates (anhydrite, gypsum, kieserite, hexahydrite) in the 4-5 μm range of Martian remote soil spectra. This spectral range is important for sulfate detection as most fine-grained sulfates exhibit significant absorption bands between 4 and 5 μm independently of the texture of the host soils (e.g., loose powdered or cemented soils). Furthermore, this is the spectral range for which the Planetary Fourier Spectrometer (PFS) and the OMEGA instrument onboard ESA/Mars Express mission provide high spectral and spatial resolution data. Laboratory IR reflectance spectra of the pure sulfates and their mixtures with a terrestrial Martian soil analog were acquired. The results show that even the smallest amount of admixed sulfate ($\sim$5 wt. %) generates significant absorption features in the portion of the 4-5 μm range not covered by the saturated Martian atmospheric CO_2 absorption band between 4.2 and 4.4 μm. Model calculations of the influence of emitted surface radiation on the detectability of sulfate features show that the depth of the features decreases strongly with increasing surface temperature of an observed area resulting in the fact that all sulfates are spectrally hidden at surface temperatures around 270 K even at $\sim$14 or $\sim$25 wt. % sulfate content in the soils. Sulfates become increasingly detectable depending on the sulfate content if the surface temperature is below 260 K.

The implications of our laboratory studies for spectral sulfate detection in the 4-5 μm range is being discussed considering the first results of analyses of Martian remote spectra provided by PFS on ESA/Mars Express. PFS is collecting spectral data using two separate channels: (i) the short wavelength channel (SWC) ranging from 1.2 to

5 μm, and (ii) the long wavelength channel (LWC) ranging from 5 to 45 μm. The LWC data were used here to estimate the surface temperature of observed areas. The resulting surface temperatures combined with the outcome of our laboratory studies allow to constrain the number of SWC spectra potentially showing sulfate features in the 4-5 μm range.