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Detailed spectral analysis of chloride salt deposits in Terra Sirenum, Mars

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Daytime infrared images from the 2001 Mars Odyssey Thermal Emission Imaging System (THEMIS) have been used to detect ∼600 occurrences of chloride salt deposits dispersed throughout the southern highlands of Mars. These deposits are identified in THEMIS and Thermal Emission Spectrometer (TES) data by the presence of a distinctive blue slope over the 8-12 m spectral range. The blue slope in THEMIS and TES data is due to the low emissivity and relative transparency of anhydrous chloride salts over much of the middle infrared (MIR) spectral region. The chloride salt deposits have also been investigated at visible to near infrared (VNIR) wavelengths using data from the Mars Reconnaissance Orbiter Compact Reconnaissance Imaging Spectrometer (CRISM) and the Mars Express Observatoire pour la Mineralogie, I'Eau, les Glaces et I'Activite (OMEGA) instruments. Over the VNIR wavelength region, the chloride salt deposits display spectra that are relatively featureless and have a red slope relative to the surrounding terrain over the ∼1 to 2.6 m range. Additionally the deposits display a weak 3 m feature, suggesting relatively lower hydration than the surrounding regolith.

A perplexing aspect of the martian chloride deposits is the lack of other alteration or additional evaporite phases associated with most of the deposits. On Earth, evaporative settings are often characterized by a multitude of evaporate and phyllosilicate phases including carbonates, sulfates, and in some cases, nitrates and perchlorates. Chemical evolution and brine pathways predicted for Mars include late-stage brines that favor chloride salt precipitation in multiple scenarios. In all cases, the pathway to the formation of these late-stage brines and precipitates include the precipitation of carbonates and sulfates. However, to date, no additional evaporite minerals have been identified in association with the chloride salt-bearing deposits on Mars.

The presence or absence of minor phases has important implications for the origin and evolution of these deposits as well as the past habitability and astrobiological preservation potential of these environments. In order to investigate the presence or lack thereof of associated minor phases, we are undertaking a detailed spectral analysis of chloride salt deposits within Terra Sirenum. Specifically, we use factor analysis and target transformation on CRISM long wavelength (L) spectrometer images that have been atmospherically corrected using the Discrete Ordinates Radiative Transfer (DISORT) model for reduced atmospheric contributions and improved spectral interpretations. This technique allows for a direct comparison of martian chloride salt deposits to laboratory spectra of carbonates, sulfates, clays, nitrates, perchlorates and other alteration phases. This study is the first to undertake a comprehensive spectral analysis to definitively determine if any other alteration phases are geochemically associated with the chloride salt deposits.