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Detection and stratigraphic mapping of spectrally distinct hydrated layers in equatorial regions of Mars

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1. Introduction

Minerals detected from orbit by imaging spectrometers may be assigned to geologic units on Mars. Where topographic information is also available at an appropriate resolution, layers with characteristic spectral features can be correlated with stratigraphic positions. Characterization of the position of a spectrally distinct unit allows for comparison with similar sequences elsewhere. Similarly, the detection of known sequences elsewhere can allow us to infer the presence of units that are known to occupy a particular stratigraphic position. We demonstrate the use of spectral and topographic data to map spectrally distinct rock units spatially, in elevation and in stratigraphy. Using hyperspectral data from NASA's CRISM and stereo-derived topographic data from ESA's HRSC we present the first results of a project to map geologic units containing hydrated minerals in equatorial regions of Mars (e.g. Valles Marineris, Xanthe Terra and Margaritifer Terra) and to correlate their stratigraphic position with existing formation theories.

2. Methods

For regions of interest we identify CRISM hyperspectral data products and process them to correct for atmospheric effects and noise. Spectral features are parameterized as spectral summary indicators [3]. These are 'flattened' (to correct for spectral smile) and map-projected. Stereo-derived HRSC topography is retrieved and re-projected at the resolution of CRISM data, as is the nadir-pointing 12.5m/pixel image from the same HRSC observation, (although any other visible or infrared images may be used).

Plotting three CRISM spectral summary parameters as the red, green and blue color channels to form a composite layer allows the grouping of related spectral characteristics. In Figs. 1 and 2 we explore the association of the sulphate signature (a drop in reflectance at 2.4μm) with band depths at 1.9μm and 2.1μm (derived to indicate poly- and mono-hydrated minerals, respec-

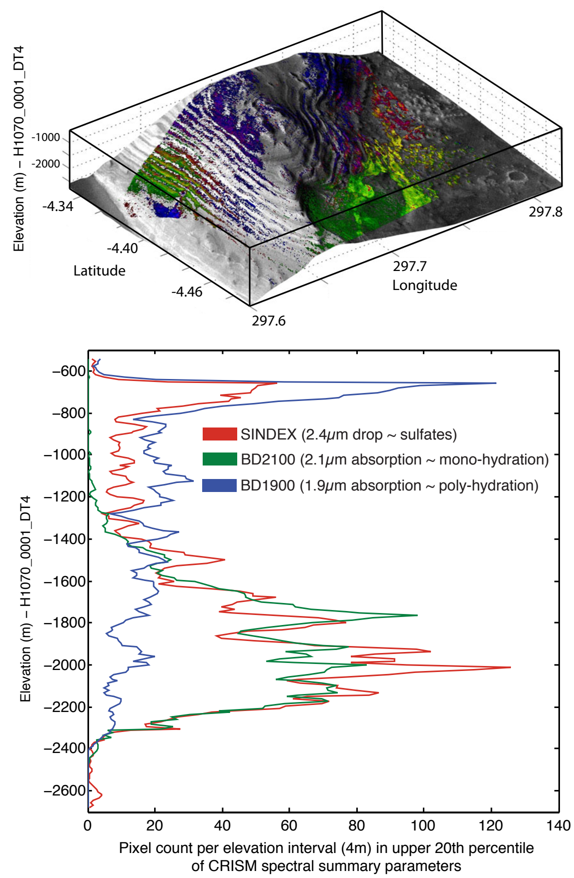

Figure 1: Sulphate mound in Juventae Chasma. Top: Plot of CRISM spectral summary parameters BD1900 (blue), BD2100 (green) and SINDEX (red) (obs. 9C0A) overlaid on HRSC stereo-derived topography (H1070_0001_DT4). Background image is nadir imagery from same HRSC observation. Lower: Histogram of CRISM spectral summary parameters as a function of elevation. Elevation class width = 4m.

tively). We plot histograms of the spectrally 'bright' pixels (upper 20th percentile), binning them into elevation classes of 4m (Figs. 1 & 2, lower panels). This positions spectrally distinct layers with respect to elevation/stratigraphy. Mapping in this manner is most straightforward where dip = 0°. While identification of individual phases is desirable, classification of layers according to broad spectral characteristics, e.g. their general level of hydration, is sufficient to perform stratigraphic mapping at local scales.

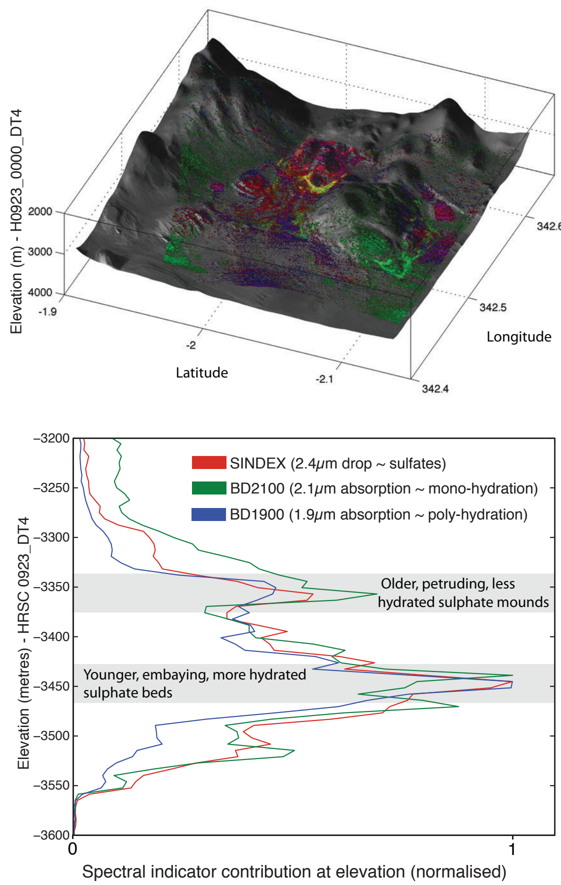

Figure 2: Light-toned layered deposits in Iani Chaos. Upper: Plot of CRISM spectral summary parameters BD1900 (blue), BD2100 (green) and SINDEX (red) from observations (obs. 7E16 & 8158) overlaid on HRSC stereo-derived topography (H0923_0000_DT4). The background image is nadir imagery from the same HRSC observation. Lower: Normalized histogram of CRISM spectral summary parameters as a function of elevation.

3. Results & Discussion

Fig. 1 shows a sulfate-rich mound in Juventae Chasma [1, 2]. Lower states of hydration are noted in layered units at the base of the mound, while its upper slopes show domination by signatures indicating mono-hydrated minerals, identified as szomolnokite and kieserite by [1]. Data from spatially adjacent CRISM cubes may be joined to show cumulative spectral associations with elevation over wider areas. We plot joined spectral data from CRISM cubes (Fig. 2) with footprints covering light-toned layered deposits in central Iani Chaos. The two hydrated layers shown have different hydration states, which could be caused by differences in surface exposure time (i.e. formed in different events) or environmental conditions (i.e. different formation mechanisms, or the same mechanism under different circumstances). Where they are thought to have formed in different events we seek to correlate their estimated epoch of formation with geologic/aqueous chronologies that are proposed for the Iani Chaos-Ares Vallis system (e.g. [4]).

4. Summary and Conclusions

We are attempting to map spectrally distinct layers in selected equatorial regions of Mars in terms of elevation, with a goal of determining their stratigraphic position. Where possible, we aim to correlate formation epochs of these layers with aqueous/geologic histories that are proposed for the region. The first results from this investigation demonstrate that the methodology provides a way of mapping spectrally distinct layers and it is hoped that correlation of these layers over broad areas will shed light on the aqueous and geologic history of equatorial regions.

Acknowledgements

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