COMPOSITIONAL MAPPING OF THE MARTIAN SOUTH POLAR RESIDUAL CAP USING CRISM INFRARED SPECTRA.

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Introduction: The Martian South Polar Residual Cap (SPRC) is a dynamic CO_2 ice cap that exhibits unique sublimation features known colloquially as Swiss Cheese Terrain (SCT); these flat floored, quasi-circular depressions have observed scarp retreat rates of ~4m per Martian year [1].

Seasonal sublimation cycles may expose dust particles previously trapped within the SPRC [2] allowing a window of opportunity to analyse the composition of mixtures of ice and dust, and attempt to detect fragile organic molecules afforded protection within the ice from the deleterious effects of ultra-violet radiation at the Martian surface [3]. Polycyclic Aromatic Hydrocarbons (PAHs) are one such type of organic compound that have yet to be detected on Mars, but have been previously identified on icy Saturnian moons [4].

In this work, we show the first examples of compositional mapping of regions of SCT using data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on board NASA's Mars Reconnaissance Orbiter (MRO), and the results of analysis of the the mineralogy of dust content in the feature rims.

Background: Mars has both North and South Polar ice caps made up of CO_2 ice and water (H_2O) ice; while the warmer, lower altitude northern cap loses its CO_2 layer completely in northern hemisphere summer, the South Pole retains a permanent 400km diameter layer of CO_2 ice known as the South Polar Residual Cap (SPRC) throughout its warmest season [5]. Surface pressures and temperatures on Mars result in the sublimation of CO_2 as temperatures increases, with the CO_2 transitioning from solid ice to its vapour phase without becoming liquid; this process results in the formation of sublimation features unique to the SPRC, referred to as Swiss Cheese Terrain (SCT) [6]. Examples of the various morphologies are shown in Fig. 1.

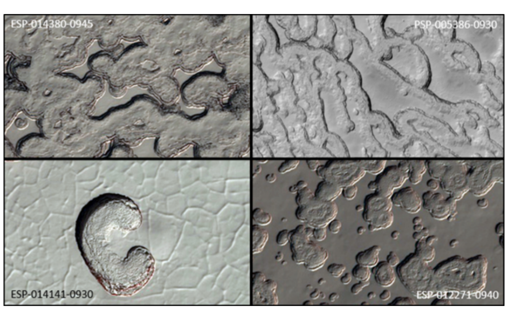

Fig.1: HiRISE imagery of SCT feature morphology

Seasonal scarp retreat of SCT features and down-wasting into the SPRC may result in the excavation of dust particles previously encased within the ice.

Polycyclic Aromatic Hydrocarbons: Polycyclic Aromatic Hydrocarbons (PAHs) are a group of chemical compounds that have not yet been detected on Mars, but are abundant throughout the universe, having been found to coalesce in space within interstellar dust clouds [7]. Organic molecules are rapidly broken down at the Martian surface due to the high flux of ultra-violet radiation as well as effects of the solar wind.

To date, the the presence of PAHs has not been systematically examined in the SPRC.

Methods: Using the targeted mode of CRISM in order to utilize the instrument's maximum spatial resolution of ~20m/pixel, 55 CRISM scenes taken over 4 Martian years, divided into 13 groups, were selected covering a range of different SCT morphologies observed using imagery from HiRISE and CTX imaging cameras on board MRO (see Fig.2).

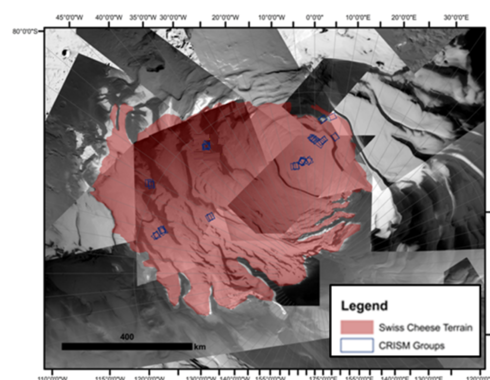

Fig.2: Base map comprised of HRSC images. Area outlined in rose covers regions where SCT is visible at HRSC image resolution (12.5m/pixel). Outlined in blue are the 55 CRISM scenes selected for further analysis

Five CRISM scenes were initially selected for further analysis, and were processed using the CRISM analysis tool for ENVI software in order to carry out photometric, atmospheric and artefact correction; in addition, 44 summary products were generated based on multispectral parameters derived from reflectances that can be used to identify regions of mineralogical interest [8].

Fig.3 shows an RGB image (top) of an area of SCT, with a false colour composite (bottom) of the same region created from three summary products layers in order to highlight areas with spectral features indicative of CO_2 ice, H_2O ice and carbonates.

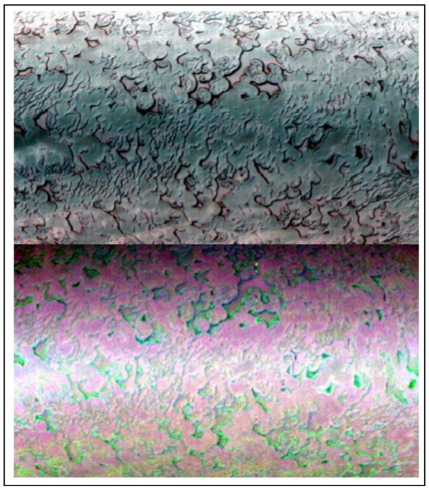

Fig.3: CRISM scene FRT00005D24 (Top) RGB visualization of region of SCT (Bottom) False colour visualistion using summary products Red: CO_2 ice; Green: H_2O ice; Blue: Carbonates

The false colour images were then used to select smaller regions of interest along SCT feature rims for more detailed examination and comparison to areas of featureless ice, by taking averages of 20-50 pixels to reduce noise. The resulting spectra were then subject to further correction by removing spectral effects of CO_2 and H_2O ice and Gaussian decomposition in order to compare to known mineralogy on Mars and signatures indicative of PAH mixtures of astrobiological interest [9].

Results: CO_2 ice spectral features have an overwhelming effect on CRISM spectra from the SPRC (Fig.4)

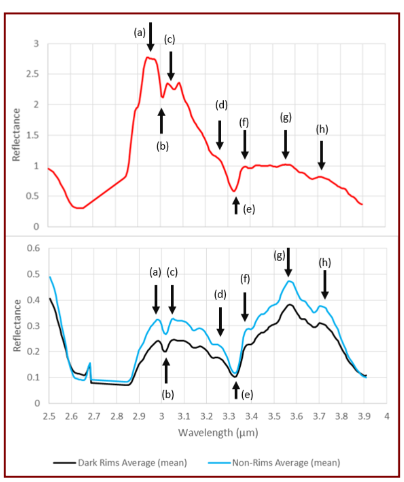

Fig.4: Comparison of spectral features (a-h) visible in both pure CO_2 (Top)and CRISM SPRC spectra (Bottom)

SCT scarp walls exhibit more spectral variation over a similar spatial area than areas of featureless ice, such as depression floors and mesas. Spectral mapping has revealed that there are distinct compositional differences between rim features and the rest of the SPRC; these differences are further highlighted when the effects of ice are removed from spectra. Signatures suggestive of PAHs have not been observed, but there are indications of some magnesium carbonate content within rim features.

Work is now being undertaken to establish the effects of CO_2 frosts on CRISM spectra, to further isolate sub-pixel spectral features from the data, and to produce spectral maps of changes in SCT in a given region over time, using a wider range of summary products.

References:

[1] Thomas et al., (2009) *Icarus, 203.2,* 352-375. [2] Kieffer et al., (2006) *Nature, 443,* 45-49. [3] Dartnell et al., (2012) *Meteorics and Planetary Sci., 47.5,* 806-819. [4] Cruikshank et al., (2008) *Icarus. 193.* 334-343. [5] Byrne, S. (2009) *Ann.Rev. of Earth and Planetary Sci., 37.* 535-560 [6] Byrne and Ingersoll. (2002) *Science, 299. 1051-1053* [7] Allamandola, L.J (2011) *EAS Publication Series, 46.* 305-317 [8] Pelkey et al., (2007) *JGR, 112.* E08S14 [9] *Colangeli et al.,* (1992) *Astrophysics Journal 396.* 369-377.

Acknowledgements: The research leading to these results has received partial funding from the STFC "MSSL Consolidated Grant" ST/K000977/1 and partial support from the European Unions' Seventh Framework Programme (FP7/2007-2013) under iMars grant agreement no. 607379. The first author is supported by STFC studentship number 526993