COLOUR AND MULTI-ANGULAR OBSERVATIONS OF MARTIAN SLOPE STREAKS. A.Valantinas[1], P. Becerra[1], L.L. Tornabene[2], A. Pommerol[1], E. Hauber[3], A.S. McEwen[4], G. Munaretto[5], V.G. Rangarajan[2], N. Schorghofer[6], N. Thomas[1], G. Cremonese[5] and the CaSSIS Team[1]. [1]Physikalisches Institut, Universität Bern, Sidlerstrasse 5, 3012 Bern, Switzerland (adomas.valantinas@space.unibe.ch). [2]CPSX, Western University, London, Canada. [3]DLR, Berlin, Germany. [4]LPL, University of Arizona, Tucson, USA. [5]INAF, Padova, Italy. [6]PSI, Tucson, USA.

Introduction: Down-slope mass-wasting features known as slope streaks were discovered in the Viking orbiter era, in images of the Olympus Mons aureole [1], and were one of the first active surface processes observed by Mars Global Surveyor [2]. Most slope streaks are darker than their surroundings by up to 10% but streaks that are up to 2% brighter also occur [2]. These bright streaks have been suggested to be a later evolutionary stage of dark streaks [3]. A transitioning stage was predicted to exist but only one case is currently known [e.g. 2, 4]. Knowledge about the global extent and formation mechanisms for slope streaks was considerably expanded with the Mars Orbiter Camera (MOC) [2,3]. Although later analyses of ultra-high-resolution images (0.35 m/pixel) taken by the High Resolution Imaging Experiment (HiRISE) revealed new information about slope streak morphology and surface evolution [5], 40 years of orbital observations have yielded several contradictory hypotheses for their origin. For example, slope streaks are found in equatorial, high-albedo, low-thermal inertia regions, which suggests that the top surface layer is composed of fine particles [6]. These observations led to models evoking both dry and wet formation mechanisms. Initially proposed to be debris weathered from dark pyroclastic materials [1], the dry-origin model invokes avalanching surface dust [2,7,8]. However, the combination of equatorial temperatures [9], a fine particle layer that protects the soil from desiccation [10] and allows capillarity [11]; and regional salt-rich chemistry [12], all point to wet-based models.

Little is known about the physical parameters of slope streaks that would affect their photometry, e.g., surface texture, roughness and grain size. One study compared CRISM to laboratory hematite spectra and suggested that amalgamation of nanophase FeOx grains into larger particles could explain dark slope streak spectral properties [13]. Similarly to the latter study, we fully characterize the brightness contrasts of dark, transitioning, and bright slope streaks in Arabia Terra, plus one site in Tractus Fossae. We use multi-angular observations by the Colour and Stereo Surface Imaging System (CaSSIS) [14] onboard the ExoMars Trace Gas Orbiter (TGO). When compared with simulated and laboratory-measured spectral reflectances of Martian analog soils [15], these observations can reveal whether the existence of slope streaks is due to a grain size difference with the surrounding regions.

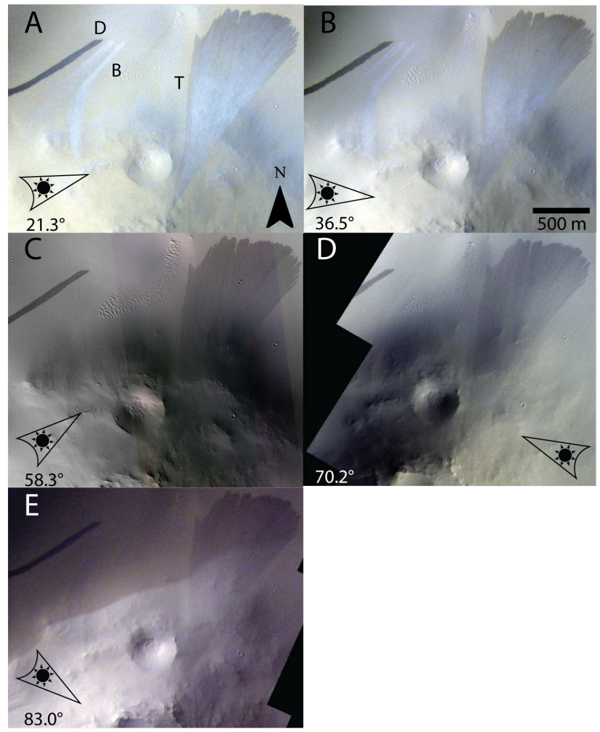

Figure 1. Multi angular observations of a site in Arabia Terra exhibiting the three types of Martian slope streaks (D - dark, B - bright and T - transitioning). (A-B & D-E) CaSSIS NPB color images. (C) HiRISE merged IRB image. The numbers in the bottom left indicate phase angle. Illumination direction shown by the sun symbol. Observations taken in L_S 98-308°.

Methods: Our image analysis consisted of measuring the I/F (detected irradiance (I) over the solar irradiance at zero incidence (F), such that I/F = 1 for a normally illuminated, perfectly diffuse reflector) of regions of interest (ROIs) in the apex and talus of all three types of streaks in 29 selected sites. We define an ROI as a rectangular area containing 30-100 pixels , depending on the available area of a slope streak. The I/F of the ROIs in the slope streaks' apex and talus are then divided by the I/F of ROIs in the surrounding terrain to obtain a representative brightness ratio. These relative photometry methods are widely used [e.g. 16], and have the benefit of avoiding the dependence of reflectance on slope and illumination geometry. When necessary and available, we complement CaSSIS with higher-resolution images and Digital Terrain Models (DTM) of our study sites taken by HiRISE [17].

Observations: We found 25 new locations of transitioning slope streaks (i.e. include areas that are darker and areas that are brighter than the surroundings) in our global mapping campaign of Arabia Terra [18]. We targeted several of these with CaSSIS and HiRISE (e.g. Fig. 1). Since CaSSIS is not in a sun-synchronous orbit, it can observe a selected site in various illumination geometries. The example in Fig. 1 also features both bright and dark slope streaks, which are visible on the left side of each panel. Interestingly, under low phase angles in (A) and (B) the bright streak and the transitioning streak appear brighter than in high phase. In the transitioning streak, the apex begins to darken towards the middle, and at the distal end appears darker than the surrounding surface. This relative brightness difference is not apparent under higher phase angles (>58.34° phase). However, we have observed other locations where multi-angular observations do not affect the relative brightness reversal of transitioning slope streaks, and there is no phase angle effect, suggesting that some streaks are intrinsically bright.

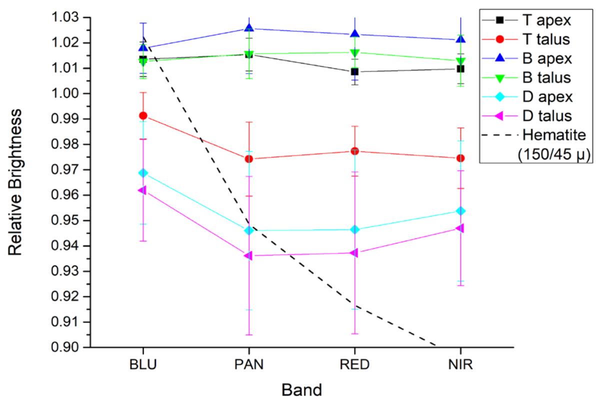

Figure 2. Average relative brightness plot for all slope streaks (dark, bright and transitioning) studied in this work. Each measurement shown in 4 CaSSIS filters: BLU, PAN, RED and NIR (in ascending wavelength order). Ratioed lab hematite spectra for coarse (150-500µ) and fine (45-150µ) particles, convolved with CaSSIS filter response functions.

We calculated the averages of the relative brightness of all three types of slope streaks in this study (~60 in total). For each type we included one measurement at the apex and one at the talus, to quantify potential differences related to fading. Fig. 2, shows these average relative albedo measurements for each CaSSIS color band (BLU, PAN, RED and NIR [14]), which are compared to lab spectra of ratioed coarse and fine hematite. On average, all 3 types of streaks are brighter at the apex and darker at the talus. However, the largest difference between apex and talus occurs in transitioning slope streaks. Also, both transitioning talus and dark streak talus points exhibit a similar spectral shape. Another interesting result shows that all slope streaks are darker at the talus and brighter at the apex than the surrounding terrain (Fig. 2). This implies either: 1) a fading process from top to bottom affecting all streaks, 2) thinning of the removed layer, or 3) very different particle size distributions.

Discussion and Future Work: Multi-angular observations shown in Fig. 1 suggest that viewing angle effects need to be considered when interpreting the reflectance of slope streaks. In general, low phase observations result in higher signal to noise ratio, allowing a sharper contrast between streak and surroundings to be visible. Another intriguing possibility is that as the phase angle approaches 0, there could be opposition surge effects (e.g. lunar regolith) . If so, the slope streak surface could be composed of very fine, porous, and interconnected particles. This is partially supported by the relative brightness averages in Fig. 2. However, the most important observation from these measurements is that the three types of slope streaks have distinct spectral slopes and observable differences in brightness. The cause behind these brightness contrasts can be understood through comparisons with reflectance models and lab measurements of dust of different grain sizes. We will thus contrast our observations with a Hapke-based model of the spectral reflectance of Martian dust of different grain sizes based on that of [19], and with spectrometry and photogoniometry measurements [20] of different grain size distributions of a high-fidelity Martian soil analog [15]. Preliminary results of these comparisons will be presented at the conference.

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