RECURRING SLOPE LINEAE AND THE PRESENCE OF CHLORIDES ON MARS. J. Mitchell[1] and P. Christensen[1], [1]Arizona State University (201 E. Orange Mall, Tempe, AZ 85281, julie.l.mitchell@asu.edu)

Introduction: The presence of liquid water on the surface of Mars has substantial geologic and astrobiological implications. Potential sources of liquid water are therefore high-priority targets of study. The most likely candidates for liquid water on the surface of Mars are Recurring Slope Lineae (RSL). RSL are seen on steep slopes in both equatorial and southern mid-latitudes of Mars, appearing as streaks that extend down-slope. In the southern hemisphere, RSL appear, grow, and fade in HiRISE high-resolution imagery during the summer only, while equatorial RSL are active for larger parts of the martian year. RSL reach lengths of 10s to 100s of meters and a single linea is generally less than 10m wide. Previous studies have classified RSL according to their annual growth patterns; "confirmed" RSL have been observed to grow in the same locations over multiple years. [1]

Thermal infrared (TIR) data from the Thermal Emission Imaging System (THEMIS) [2] have allowed the temperature conditions under which RSL form to be constrained. While a small number of RSL are visible at temperatures above the freezing point of water, many are not, appearing at temperatures as low as 230K [3]. Under these cold conditions, a brine of $Fe_2(SO4)_3$, perchlorate, or $CaCl_2$ is the most likely mode of RSL formation [4]. Because chlorides lack distinct absorption features, they must be identified by their effect on spectral slope. Osterloo et al. (2008) developed a chloride-detection method using THEMIS TIR decorrelation stretch (DCS) products [5]. Their global map of chlorides on Mars shows strong parallels between the latitudes of southern hemisphere RSL and large-scale chloride deposits. The purpose of this study is to assess the colocation of small-scale chloride deposits and confirmed RSL. If a positive correlation is detected, it will provide strong evidence for $CaCl_2$ brine flow as the mechanism behind RSL formation. This work is the completion of a previously reported effort that included only southern hemisphere RSL and now includes equatorial RSL.

Methods: Ojha et al. reported the most recent catalog of confirmed RSL in early 2014, which included a list of the associated HiRISE imagery and THEMIS products used for RSL temperature estimates [3]. Using the Java Mission Analysis and Remote Sensing (JMARS) software [6], regions where RSL have been confirmed were mapped in representative HiRISE images from the Ojha et al. catalog. All RSL on a given slope were mapped as a single unit, with multiple RSL units typically appearing within a single HiRISE image (**Figure 1**).

Three DCS products, including THEMIS bands 8, 7, and 5, bands 9, 6, and 4, and bands 6, 4, and 2 are required for chloride detection. Chloride deposits appear blue in 875, turquoise in 964, and yellow-orange in 642; the RSL unit outlines were then overlain on each DCS product. Because THEMIS' highest spatial resolution is 100 m/px, most individual RSL fall within a single THEMIS pixel. The focus of this study was not to pinpoint specific RSL, therefore, but to search RSL slopes for both local- (100s of m) and regional-scale (up to 1 km) evidence of RSL colocated with chlorides. Isolated RSL clusters that were smaller than 10m in length and net width were not mapped.

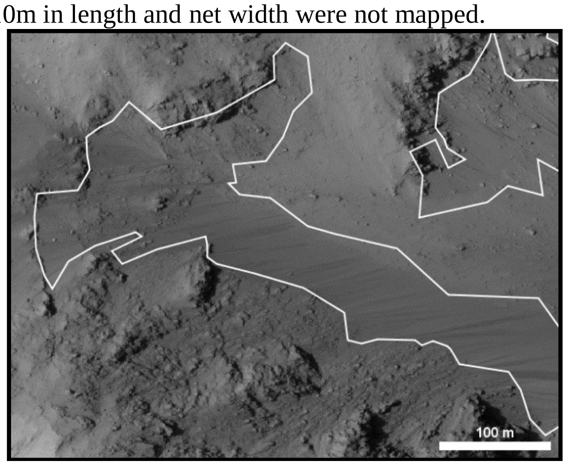

Figure 1. RSL (outlined in white) mapped on HiRISE image of Horowitz Crater.

Results: Three sites showed evidence of chlorides: Palikir Crater, Lohse Crater, and between Melas and Coprates Chasma. Palikir Crater was the most distinct locale, showing local evidence of chlorides in areas where RSL were most densely located (**Figure 2**). Indications of chlorides at RSL in Lohse and in Valles Marineris were very weak and diffuse. Because DCS is based on radiance, an emissivity spectrum must be produced to account for possible topographic effects. Emissivity spectra such as that seen in **Figure 3** show that the effects are topographic; the emissivity spectra does not have a slope and is indicative of basalt. In most cases, neither local- nor regional-scale evidence of chlorides was observed.

The lack of chloride detection does not necessarily mean a lack of chlorides on the surface. Berger et al. [7] observed a decrease in maximum emissivity with continuous chloride layers down to 29 μm thick. Taking this value as the detection limit for chlorides, the mass of chloride needed to produce a detectable deposit over the area of an RSL was determined to be 1.5×10^{8} kg. This quantity of chloride would consume the large chloride deposit studied by [8] in Miyamoto Crater (**Figure 4**) in less than 1Kyr.

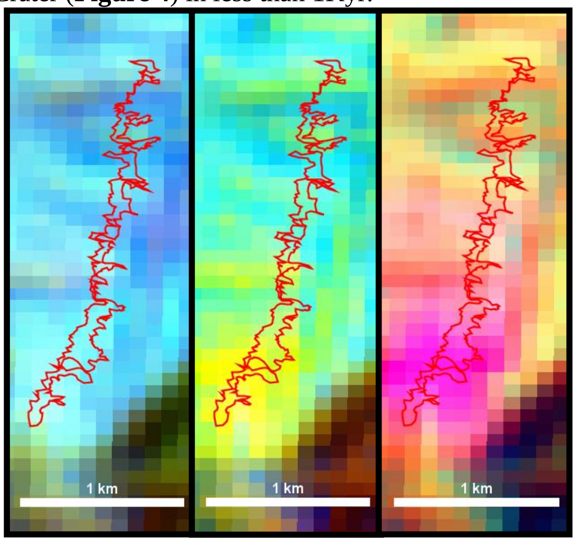

Figure 2. Outline (red) of RSL region of study in Palikir Crater. From left to right: DCS 875, 964, and 642 basemaps.

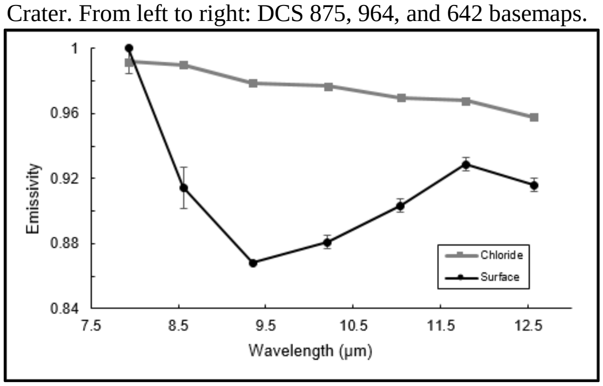

Figure 3. Emissivity spectrum of RSL in Valles Marineris (black circles) and a chloride deposit from [5] (grey squares).

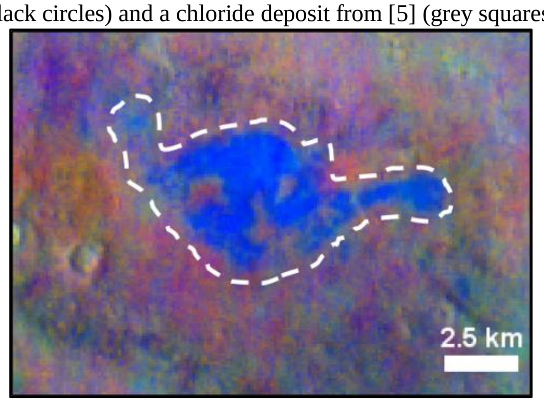

Figure 4. Chloride deposit (blue, in dotted lines) in Miyamoto Crater – THEMIS DCS.

Discussion: The lack of chloride signatures could be the result of one of three scenarios. First, RSL may not contain chlorides, either because they a) are not aqueous flow features or b) are not chloride-based brines. This scenario has the greatest astrobiological implications, especially if RSL are water-lubricated granular versus liquid water flows, as some have hypothesized [9]. Second, steep slopes (where all RSL are located) could affect the appearance of RSL in THEMIS DCS. Several locales are dominated by the distinct steep-slope anisothermality signature identified by Bandfield [10]. Third, the concentration of chlorides could be non-zero, but below the detection limits of THEMIS. If this is indeed the case, any chlorides present at or near the RSL are masked by the TIR properties of the surrounding terrain.

An analysis of larger (100s of meters long) RSL, such as many at equatorial latitudes, did not reveal a significant detection of chlorides. An examination of an RSL in Valles Marineris [11] large enough to be resolvable by THEMIS showed that the quantity of chloride needed to produce a positive detection would be significant. If RSL are continuous surface brine flows rather than subsurface wetting events, then the amount of chloride consumed in producing an RSL would likely result in significant mass wasting from nearby surface or subsurface chloride deposits; this mass wasting has not been observed in proximity to RSL sites [12]. The source of dissolved salts that could produce RSL remains a significant outstanding question as to how these features could be produced. A simple analysis of perchlorate shows that the quantity dissolved for a resolvable RSL would be higher than that of calcium chloride because it is more soluble when both solutions are at the same temperature. Therefore, the question of how to produce large, recurring brine flows on Mars is still outstanding for either salt because the water and salt quantities involved are substantial.

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