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Global properties of Martian Recurring Slope Lineae

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Abstract

Recurring Slope Lineae (RSL) are narrow (0.5 – 5 m wide) dark features that source from bedrock outcrops and incrementally lengthen down warm, low albedo and low dust steep slopes [1]. Their activity starts in early local spring, when mid-afternoon temperatures are warm ($\approx$ 250 K), ends in cold seasons, as temperatures drop, and recur every year in the same locations [1]. After their discovery by [1], the subsequent monitoring of Martian steep slopes has led to an increasing number of candidate and confirmed number of RSL sites, amounting to ~500 to date.

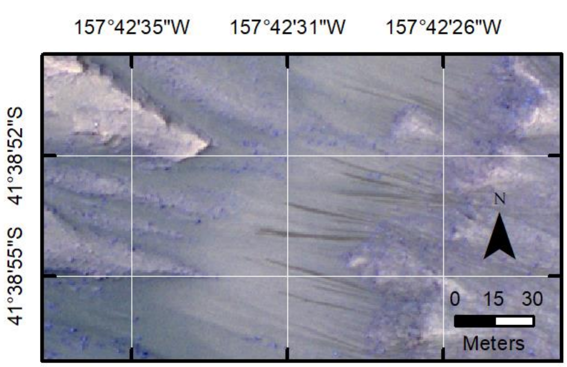

Fig. 1: RSL (dark lines) located in Palikir crater.

Most RSL have been identified in Valles Marineris (VM RSL, [1-4]), but they are also present in the southern mid latitudes (SML RSL) [5-7], in the equatorial highlands (EQ RSL) [1,2], as well as in Chryse and Acidalia Planitiae (CAP RSL) [8]. Multiple models have been proposed to explain their formation: the temperature dependence of RSL and their recurring darkening and fading suggested that a volatile may be involved in the process, such as freshwater or brines [1,5,8-11] although a distinct water spectral feature has not been observed yet [12,13]. Instead, the analysis of CRISM spectra at four sites showed a correlation between RSL activity and absorptions at 1.4, 1.9 and 3.0 μm wavelenghts attributed to the presence of hydrated salts, suggesting that a briny flow model is more likely [13]. According to such ''wet models'', RSL would form by melting of (briny) water ice during early spring that then would flow downslope darkening the regolith. Eventually, RSL would fade due to evaporation and decrease in temperatures. The main issue with these models is that the necessary volume of water required to supply RSL would be significant [3,14], while a clear water source has not been identified yet. To overcome this conundrum, other studies have proposed a formation mechanism based on dry granular flows [15], whose angle of repose is consistent with RSL slopes at many different sites. This scenario would imply a limited role for volatiles, but it hardly explains the annual recurrence and fading of RSL.

The aim of this work is to study the distributions of the global properties of all candidate and confirmed RSL, in order to provide a general picture of this phenomenon, hence framing the results from the detailed analysis of each single site. To do so, we collected all candidate and confirmed RSL sites present in literature [1-8] in a unique dataset. For each RSL location we extracted the MOLA elevation [16] and computed the local slope [17], TES thermal inertia [18], dust cover index [19], albedo [20] and IRTM rock abundance [21]. We then studied the distributions of such variables, identifying that the confirmed RSL sites occur in regions with MOLA elevation ranging from −5002 to 5088 meters, local slopes ranging from 0.09 to 36.66 degrees, daytime thermal inertia from 52 to 469 TIU (TIU is thermal inertia units, i.e. J m^{-2} $s^{-0.5}$ K^{-1}), nighttime thermal inertia from 171 to 2057 TIU, IRTM rock abundance from 2% to 25%, albedo from 0.09 to 0.24 and dust cover index from 0.95 to 0.99; the latter meaning that they have been found in almost dust-free regions of Mars.

As an example of the dataset we have, the daytime thermal inertia distribution of all confirmed and candidate RSL sites is presented in Fig. 2A. The confirmed RSL sites have a thermal inertia ranging from 52 to 469 TIU, with a median of 224 TIU. When we extract both the VM RSL subset and the SML one we note that the VM RSL have a higher thermal inertia (median 268 TIU) with respect to those of the SML RSL (median 185 TIU), Fig. 2B and 2C; this behaviour is preserved even if we consider a larger sample with candidate RSL. Independently from the locations, all thermal inertia medians are above the dust thermophysical limit of 150 TIU [22], suggesting that most of the RSL do not generally occur on dusty surfaces.

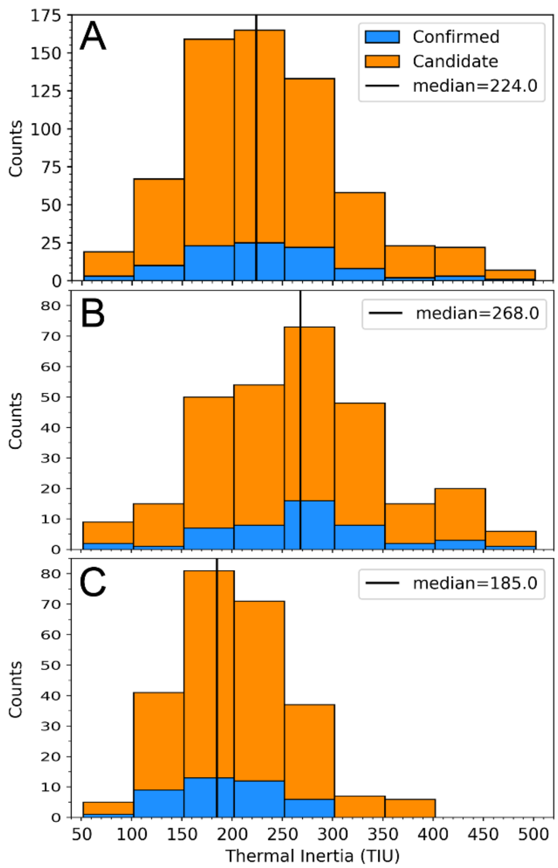

Fig. 2: A) Daytime Thermal Inertia (TI) distribution for all candidate (orange) and confirmed (blue) RSL and median of the *confirmed* distribution B) TI distribution for candidate and confirmed RSL in Valles Marines. C) TI distribution for candidate and confirmed RSL in southern mid latitudes.

By correlating all the considered variables, we propose new areas on Mars where RSLs have not been identified yet, but that have great potentiality to be discovered on HiRISE images in the near future.

Acknowledgments

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