LAVA CHANNEL TEXTURES IN TARTARUS COLLES, ELYSIUM PLANITIA, MARS.

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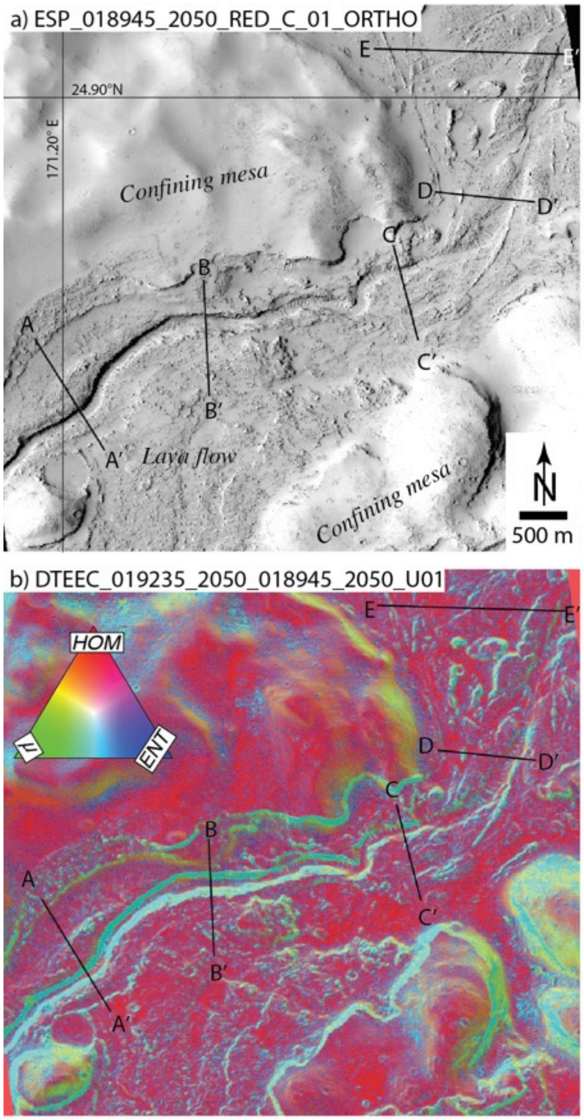
Introduction: Basaltic lava flow textures, (e.g., ‘a‘ā and pāhoehoe end-members) are related to the parent flow’s composition and emplacement dynamics. If other factors, such as viscosity and slope are equal, then ‘a‘ā lava texture is generally indicative of high volumetric flow rate, whereas pāhoehoe is indicative of lower volumetric flow rate [1]. Reliable methods for distinguishing lava texture in remote sensing data would aid planetary mapping by providing a method for inferring flow conditions of ancient lavas by measuring their present day deposits. However, such a method (using terrestrial or planetary data) remains elusive. For instance, ‘a‘ā can be confused with slabby and rubbly lava, as they are all rough at the decimeter to meter-scale [2] even though ‘a‘ā forms by viscous tearing of a cooling crust, whereas slabby and rubbly lavas form when pāhoehoe is disrupted by subsequent flow emplacement processes (i.e., effusion rate changes or the release of ponded lava). Consequently, inferences drawn from roughness alone, in remote sensing data, can lead to inaccurate interpretations about emplacement styles and flow rate.

Co-occurrence roughness patterns and lava textures: Patterns in topographic roughness illuminate differences in volcanic deposits that are more subtle than roughness alone [3]. These co-occurrence measures use topographic data to evaluate changes in surface roughness by comparing surface roughness measured in two adjacent (11 × 11 pixel) neighborhoods. In locations with a random distribution of roughness one neighborhood is an ineffective predictor for its neighbor and the location has high Entropy (ENT). Locations with predictable distributions of roughness have high Homogeneity (HOM). Locations where both neighborhoods are particularly rough have high mean roughness (μ) [4].

Recent work in Hawaii found that, lava within the Muliwai a Pele Lava Channel on Muna Ulu, had high ENT and low HOM, while the lava that made up the levees (i.e., channel walls) was high in HOM and low in ENT [5]. Furthermore, pāhoehoe lava was shown to have high HOM, low μ, and low ENT while ‘a‘ā lava has high ENT, high μ, and low HOM. This work suggests that co-occurrence roughness patterns can be used to differentiate lava textures but does not attempt to do so on Mars. Here, we use a digital terrain model (DTM) DTEEC_019235_2050_018945_2050_U01 derived from a High Resolution Imaging Science Experiment (HiRISE) stereo pair to evaluate lava textures associated with the Tartarus Colles lava flow **[Fig. 1]** in Elysium Planitia, Mars.


a) ESP_018945_2050_RED_C_01_ORTHO

b) DTEEC_019235_2050_018945_2050_U01

Figure 1: The Tartarus Colles lava flow in **(a)** HiRISE orthophoto ESP_018945_2050_RED_C_01_ORTHO and **(b)** a RGB composite of three co-occurrence roughness patterns; HOM-Red, μ-Green and ENT-Blue. Flow is from west to east then to the north around a confining mesa. Displaying the above flow with separate roughness metrics discriminates areas where lava has different textures.

Study site: The Tartarus Colles lava flow is a part of the Cerberus Fossae 2 unit, which embays the Nepenthes Mensae and Elysium Rise units more than 1,000 km East of Elysium Mons [6]. In the study area **[Fig. 1]**, the lava flow is confined between a collection of mesas that caused the flow to over-thicken, producing lava benches. Subsequent flow formed a ~40-m-deep lava channel [6]. Down flow from the constriction the flow widens and is locally unconfined. This change in flow geometry, from confined to unconfined, provides an opportunity to investigate associated changes in lava texture.

To investigate lava textures we calculated surface roughness (the largest inter-pixel difference of a central pixel and its surrounding pixels [7]) and the co-occurrence patterns (ENT, μ, and HOM) from a 1 m resolution HiRISE DTM. We then evaluated five cross sections across the lava channel. Two cross sections (A and B) cover a confined segment of the flow, while D and E cover an unconfined portion. Profile C covers a transition zone between the two regimes **[Fig. 2]**. The analysis is sensitive to changes in topography (roughness) between 1 m (the scale of the DTM) and 3 m (the longest distance between pixels in the roughness calculation).

Results: In the confined portion of the flow the most prominent feature in the co-occurrence patterns is the channel itself and it can be identified (topography is the black line) as the deepest valley in the profiles (A and B). The channel walls have the highest μ (green line) and the highest ENT (blue line). In profiles B and C the region outside the channel to the north has lower ENT than within the channel. HOM is nearly featureless except at the channel walls where it is depressed. In the unconfined portion of the flow (Profiles D and E) the lack of topographic organization (i.e., a lava channel) is reflected in the chaotic and noisy co-occurrence patterns where topographic features do not seem to correlate with ENT, μ, or HOM features.

Discussion and Conclusions: The high ENT and μ walls of the Tartarus Colles lava channel and High HOM, low ENT, low μ surrounding plains is consistent with a lava flow that ponded to form smooth plain then slowly drained to form a channel, as [6] suggested. The preserved lava textures do not suggest the volumetric flow rate was high enough to produce ‘a‘ā lava in contrast to textures found at the Muliwai a Pele Lava Channel [5]. Rather, both the confined and the unconfined portions of the flow have roughness patterns consistent with pāhoehoe lava.

A caveat to this analysis is that the lava flows are indeed covered in a mantle of dust that likely obscures some roughness features. However, ~1-m-diameter features (e.g., boulders) can be seen throughout **Figure 1a** indicating that the lava flow features, at the suitable scale, show through.

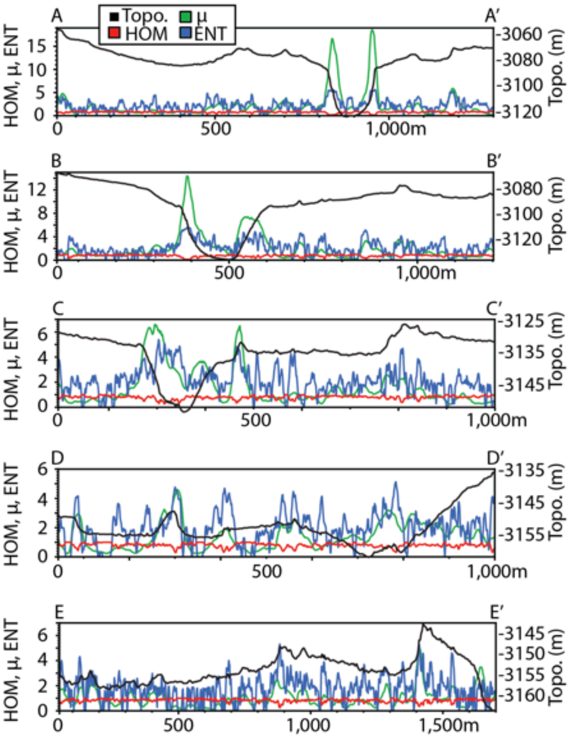


Figure 2: Topographic and co-occurrence pattern profiles across the Tartarus Colles lava flow. All of the data are derived from the HiRISE DTM in Fig. 1. This set of profiles shows changes in lava flow morphology and roughness patterns as it transitions from confined (A and B) to locally un-confined (D and E).

Roughness patterns, derived from HiRISE DTMs, can be used to infer lava flow emplacement dynamics on Mars. Future study will evaluate a larger set of lava textures and volcanic settings.

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