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Araneiform terrain formation in Angustus Labyrinthus, Mars

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The sublimation and condensation of CO_2 ice cap drives seasonal changes of south polar area that is among the most active regions of Mars. The south pole hosts an abundance of exotic sublimation landforms, one of which is araneiform terrain, colloquially called "spiders" [1]. It is carved into the substrate and usually exhibits dendritic or radially-organized troughs. Its origin is generally thought to involve basal sublimation of seasonal CO_2 ice layer and consequent gas jetting activities [1-4]. However, the detailed erosion mechanism is still an open question. In our work, we performed an in-depth study in Angustus Labyrinthus (81°S, 63°W) dubbed "Inca City", suggesting a new spider formation mechanism based on our HiRISE observations, which could provide implications for polar surface processes.

The Inca City region hosts substantial numbers of spiders [1-4] offering adequate samples to study in details. As high as 0.25m/pix spatial resolution, HiRISE [5] allows an intensive study of small features like spiders (spatial scale 45m-1km). By means of repeated coverage of HiRISE images over the Inca City region for nearly five Martian years, a detailed spatial distribution mapping of spiders was conducted. In order to investigate spider′s spatial distribution characteristics, the Crater Tool [6] and Crater statistics tool (Craterstats2) [7] were repurposed for a spatial randomness analysis.

Based on geomorphologic features, we identified two undocumented spider species (elongated and half spiders) related to pre-existing cracks and ridges which play key roles for spider initiations. We suggest a new spider formation mechanism with detailed large-scale erosion mode. In previous researches, sunlight is thought to penetrate through the overlying CO_2 ice slab resulting in basal sublimation, the sublimating gas is thought to trapped between the ice layer and the substrate [1-4]. We propose the pressurized gas is trapped inside the substrate. It diffuses through the substrate towards one rupture resulting from the accumulating pressure, accelerating as it passes out of the substrate into free air and entraining particles from the substrate-air boundary. A pit forms after many repetitions. Here, the flow to be diverted towards any prominence in the evolving eroded depression, and this will cause enhanced erosion in the prominence. We propose that this is the mechanism which leads to the growth of spider 'legs' or troughs. In the vicinity of one spider, the weakening and dispersing of the pressure and the consequent reduction of scouring force to the substrate inhibit the initiation of a new spider. This is consistent with the results of our spatial randomness analysis revealing that spatial locations of spiders are not random, which agrees with our hypothesis of this formation mode.

The work presented here could help improve the understanding of sublimation as an essential agent of modifications for Martian surface.

[1]Hansen et al. (2010) Icarus 205(1). [2] Kieffer et al. (2000) JGR 105 (E4). [3]Kieffer (2007) JGR 442 (E8). [4]Piqueux et al. (2003) JGR, 108 (E8).[5] McEwen et al. (2007) JGR 112. [6]Kneissl et al (2011) PSS, 59(11-12). [7]Michael et al. (2012) Icarus 218.