

DO BOULDER HALOS REFLECT SHALLOW BEDROCK STRENGTH OR CLIMATE PROCESSES?: SUBSTRATE IMPACTS ON BOULDER FORMATION AND PRESERVATION. J.S. Levy¹ C.I. Fassett², M. Tebalt¹, ¹Colgate University, 13 Oak Ave., Hamilton, NY, jlevy@colgate.edu, ²NASA Marshall Space Flight Center, Huntsville, AL.

Introduction: Boulder halos concentric rings or annuli of boulder-sized (>0.5 m diameter) clasts present on largely flat-lying surfaces at middle latitudes on Mars. Because they are associated with circular fracture and trough patterns or wide, low-relief depressions similar to impact craters, they have been inferred to form as a result of excavation of boulders from beneath an overlying fine-grained and/or ice-rich regolith (Fig. 1) [1-6]. Global surveys of HiRISE image data have shown that boulder halo clasts are much older than the surfaces they are found upon (boulders outlast the craters that form or eject them) and boulder halos are about three times more common in the northern hemisphere than in the southern hemisphere (19% versus 6% of images) [6]. The origin of this hemispheric mismatch is mysterious; [6] inferred that because the necessary conditions for boulder halo formation are present in both hemispheres (impacts, bedrock, and overlying ice-rich mantles), a modern (Amazonian) climate process such as soil column inflation was most likely leading to either the preservation of boulder halos in the northern hemisphere or the destruction of boulder halos in the southern hemisphere.

One potential solution to this mystery is that the bedrock beneath sediment covers does not have uniform boulder-producing characteristics. Recent mapping in an important recent paper by Rogers et al. [7] has shown that high thermal inertia surfaces that had been interpreted as lava flows and/or mechanically strong bedrock are largely devoid of thick regolith covers. Instead, they are pitted, scoured, and sculpted, suggesting these are instead weak bedrock materials easily modified by the wind. Evidence suggests that these are thus low-strength clastic rocks, rather than Hesperian lava flows such as those found around and beneath Vastitas Borealis sediments [8-10].

Hypothesis & Questions: In order to evaluate possible bedrock strength control on boulder halo formation

and/or preservation, we pose three questions: 1) are boulder halos associated with one or more specific mapped geomorphological unit(s) on Mars (e.g., Hesperian Ridged Plains)? 2) Do boulder halos on different geological units have different clast sizes? 3) Do boulder halos on different surfaces persist for different lengths of time? We predict that if boulder halo presence is dictated in part by boulderogenic bedrock properties, then 1) boulder halos should be associated with mechanically strong bedrock units (e.g., Hr) not mechanically weak units such as southern hemisphere “bedrock plains” [7]; 2) boulder halos should have larger clasts atop strong substrates (i.e., less fragmentation during impacts); and 3) boulder halos should persist longer and have older apparent crater retention ages if the clasts are composed of mechanically strong material than mechanically material.

Methods: We extracted geological unit data [11] for a catalog of 554 boulder halos detected in 4,188 HiRISE images [6]. Boulder halo size and clast size was measured directly from 25 cm/px HiRISE images along four transects (cardinal directions).

Results: Preliminary results indicate that boulder halos are largely clustered in specific geomorphologic units. Over 80% of northern hemisphere boulder halos are associated with Amazonian or Hesperian lowlands units—ice-rich sediments that in many locations cap older lavas [9] Similarly, in the southern hemisphere a majority of boulder halos are found within Noachian-aged plateau units and/or directly within Hesperian Ridged Plains lavas (Fig. 2). Boulder halos are nearly absent in both hemispheres on the ejecta of large, fresh craters (e.g., Lyot), except for at the margins of the ejecta deposits—perhaps where ejecta thins sufficiently to allow access to underlying bedrock during halo for-

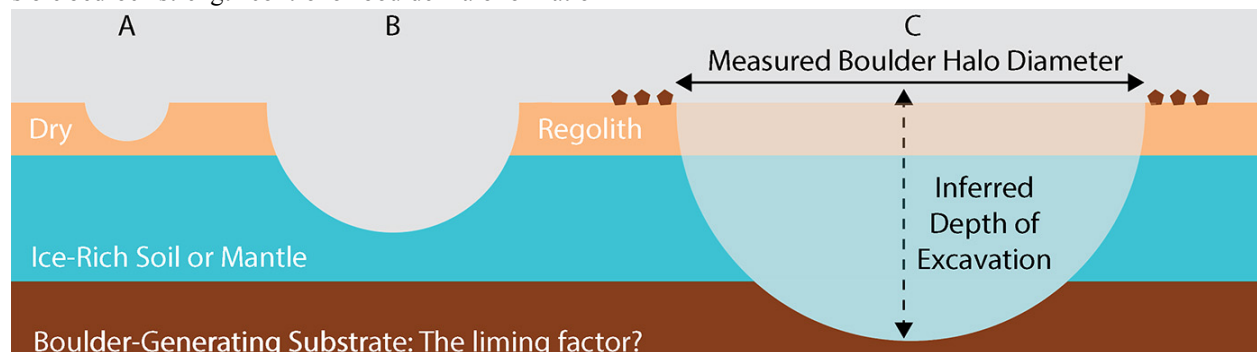


Figure 1. Schematic illustration of boulder halo excavation.

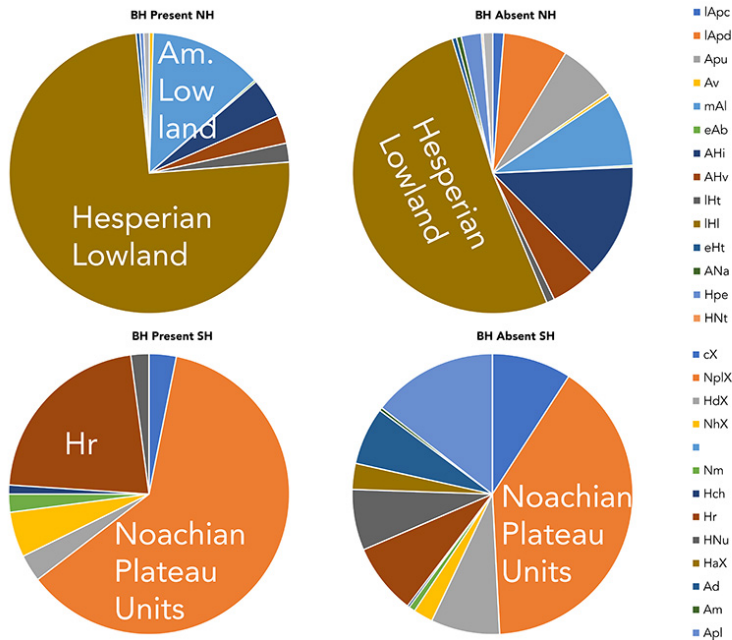


Figure 3. Geomorphic units in which boulder halos are present or are absent in the northern (NH) and southern (SH) hemispheres.

mation. Boulder halos are found to have diffuse and spatially inhomogeneous clusters of clasts decrease in size with distance from the halo centroid (Fig. 3).

Discussion: The preliminary observations presented here are consistent with the idea that substrate properties are critically important in where boulder halos are observed versus absent. If correct, this may explain the difference in the northern and southern hemispheres' boulder halo populations.

Ongoing Work: Next steps for this project include determinations of relative apparent crater retention age between northern and southern hemisphere boulder halo populations, and comparison of boulder size between potential bedrock source populations.

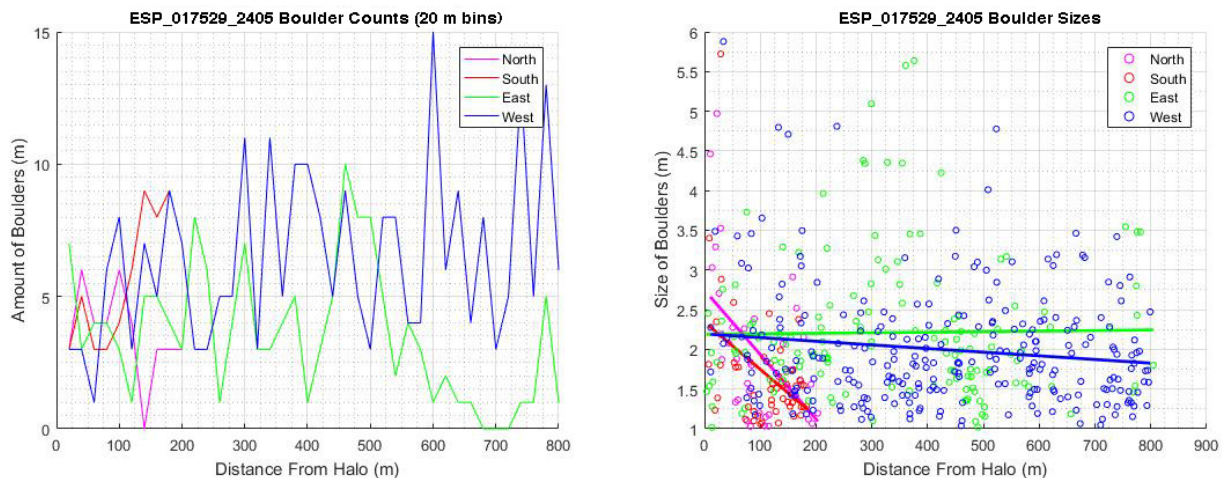


Figure 2. Boulder spatial density and size for one northern hemisphere halo.

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