LOCAL VARIATIONS IN LUNAR REGOLITH THICKNESS: TESTING A NEW MODEL OF REGOLITH FORMATION NEAR THE APOLLO 15 LANDING SITE.

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Introduction: The formation of regolith is a fundamental surface process on airless terrestrial bodies, yet the processes and rates of regolith formation have yet to be fully resolved. A new analytical model developed in [1] describes the growth of regolith by small, simple craters as a function of time, improving on pre-existing Monte Carlo estimates for the regolith. In addition, this model describes the expected variability in regolith thickness on a given geologic unit. In this study, we analyze the regolith thickness in the mare units exposed near Hadley Rille (~26°N, 3.6°E; **Fig. 1**) to test the regolith production model presented in [1].

The study by [1] re-examined a Monte-Carlo simulation by [2] and found that their consideration of ejecta as a source of regolith was at least 3 times higher than the observed ejecta thicknesses. The work presented in [1] alternatively proposed that regolith produced in crater interior cavities plays an important role in regolith formation.

Methodology: We have begun making preliminary measurements of regolith thicknesses using two approaches. First, we measured characteristics of fresh craters in the vicinity of Hadley Rille. These craters have high albedo ejecta, varied morphologies, and may or may not contain rocks in ejecta; those whose ejecta includes abundant rocks penetrated through the regolith layer to excavate bedrock basalt.

Crater morphology varies from normal, bowl-shaped craters, which are not influenced by inhomogeneities in the target rock, to flat-bottomed, central mound, or concentric craters, which are affected by variations in target rock properties [3-5].

Table 1: *Relationships between crater geometry and ratios of D_A/t, where t is regolith thickness [2].*

Crater Morphology		**D_A/t**
Normal Crater		10
Flat-Bottomed Crater		8 – 10
Central Mount Crater		4 – 7.5
Concentric Crater		8 – 20 [related to D(interior)]

See Table 3 of [2].

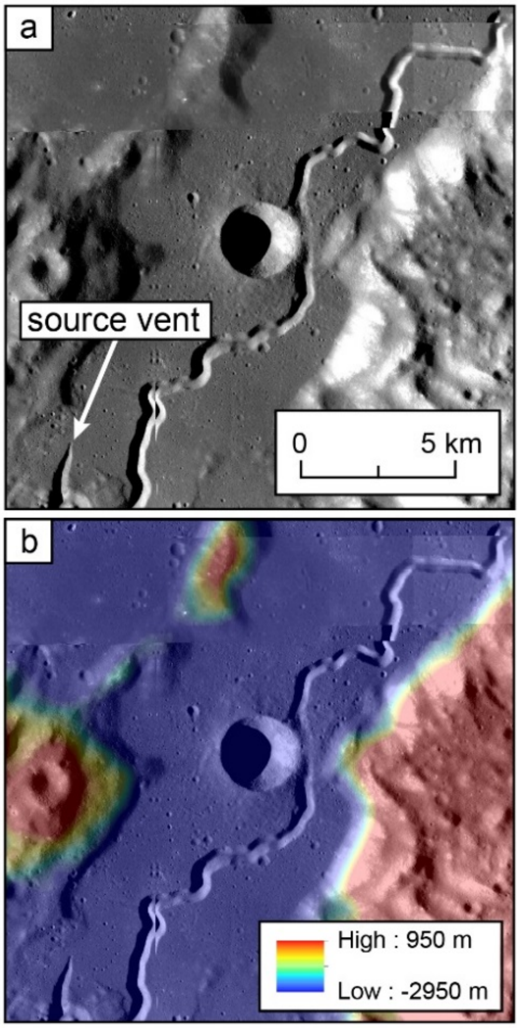

Fig. 1: Hadley Rille as shown in Kaguya Terrain Camera data (a) and Lunar Orbiter Laser Altimeter data (b). We investigate the regolith thickness in the vicinity of Hadley Rille to test the reolith production model presented in [1].

We measured the apparent diameter (D_A) of these craters and used the technique defined in [2] to determine the depth to the change in target rock properties, interpreted to be the thickness (t) of the regolith (**Table 1**). Larger craters that excavated rocks were also measured, and their excavation depth constrains the maximum regolith thickness locally.

Our second approach to measuring regolith thickness was to analyze the depth of bedrock exposures in the walls of Hadley Rille. Apollo 15 Astronauts Irwin and Scott observed layering in the

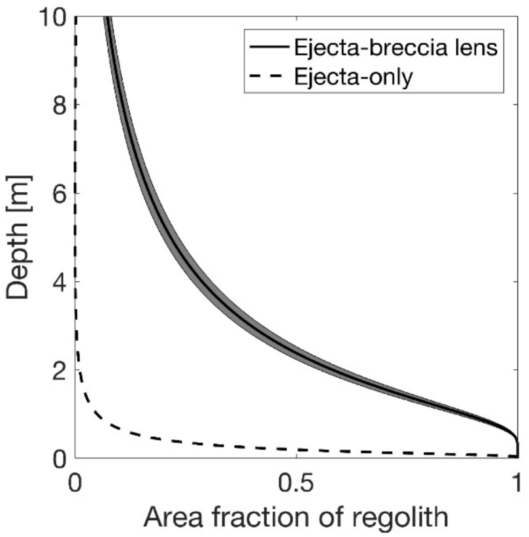

Fig. 2: Modeled regolith thicknesses (from [1]). This model is in line with previously reported mean regolith thicknesses of about 4.5 m [6,7].

walls of Hadley Rille, observations that have been confirmed through analyses of Lunar Reconnaissance Orbiter Narrow Angle Camera (LROC NAC) images. These rocky outcrop layers are observed to be capped by poorly consolidated regolith material, and we measured the depth of the bedrock with the expectation that it might correspond to the thickness of that regolith layer to compare with results from the impact crater analyses. We used the PDS-released DTM of LROC NAC images M111571816 and M111578606 (50 cm resolution) to compare the elevation of the adjacent regolith-covered mare plains to the elevation of the top of the rock outcrops in the rille walls.

Preliminary Results and Discussion: Preliminary results of the crater observations (**Fig. 2**) indicate that craters excavated only regolith material (i.e., non-rocky ejecta) to depths of ~3 m, at which depth craters began to "feel" a change in target rock characteristics. This is the point at which crater morphology changed from normal, bowl-shaped to flat-bottomed or concentric craters. The depth of this transition is interpreted to represent the thickness of the regolith. There is widely variable crater morphology that overlaps across diameter ranges, indicating that the regolith thickness varies significantly over the study area. This is consistent with the model and findings presented in [1].

Thickness measurements of the sinuous rille wall regolith layers are not consistent with those predicted from the crater technique. We interpret this to indicate that regolith drapes over mare basalt substrate on the upper part of the rille wall (**Fig. 3**), so that the depth to rocky outcrops is not an accurate measure of the actual thickness of the regolith.

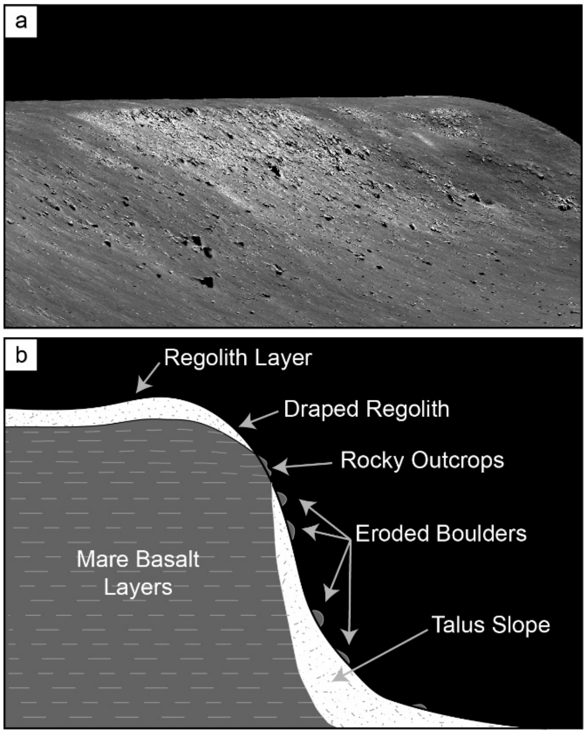

Fig. 3: The thickness of layers of regolith exposed in sinuous rille walls are not representive of regolith thicknesses in the mare plains due to regolith draping over rocky outcrops of mare basalts. This lens artificially increases the apparent thickness of the regolith.

Future Work: We will perform similar analyses at other locations to expand the coverage and verification of the model in [1]. Additionally, we will continue to assess the uppermost regolith layer as well as properties of outcrops exposed in sinuous rille walls to determine potential factors that influence the apparent thickness of the uppermost regolith layer.

References: [1] Hirabayashi, M., et al. (2017), submitted to *JGR*.; [2] Oberbeck, V. R., et al. (1973), *Icarus*, *19*(1), 87–107; [3] Quaide, W. L. and Oberbeck, V. R. (1968), *JGR*, *73*(16), 5247–5270; [4] Bart, G. D., et al. (2011), *Icarus*, *215*, 485–490; [5] Fa, W., et al. (2014), *JGR-Planets*, *119*(8), 1914–1935; [6] Fa, W. and Jin, Y.-Q. (2010) *Icarus*, *207*, 605–615; [7] Kobayashi, T., et al. (2010) *Geosci. Remote Sens. Lett.*, *IEEE*, *7*, 435–439.