BASALT LAVA FLOW TEXTURE IDENTIFICATION AT DIFFERENT DATA RESOLUTIONS. H. C. Mallonee[1], S. E. Kobs Nawotniak[1], S. S. Hughes[1], C. Neish[2], M. Downs[3], D. Delparte[1], D. S. S. Lim[4, 5], J. Heldmann[4], and the FINESSE team [1]Dept. of Geosciences, Stop 8072, Idaho State University, Pocatello, ID, 83209, [2]Dept. of Earth Sciences, University of Western Ontario, London, ON, Canada, [3]NASA Kennedy Space Center, Merritt Island, FL., [4]NASA Ames Research Center, Moffett Field, CA, [5]BAER Institute, NASA Ames Research Center, Moffett Field, CA.

Introduction: Mapping lava flow textures and interpreting their emplacement conditions is crucial to understanding the eruptive history of a basaltic volcano. The diversity of lava flow textures is the result of differing compositions and dynamics within the flow. A higher viscosity or shear will result in a rugged flow texture, as will disruption of the rapidly cooled outer crust [1-7]. The differences in roughness are commonly used for qualitative identification of flow textures. This study investigates the horizontal scales at which one form of surface roughness calculation (2D-3D surface area ratio) can differentiate flow types, suggesting data resolution limits to be considered in planetary lava flow identification.

The wide variety of lava flow textures found at Craters of the Moon National Monument, Idaho, United States, makes it an ideal location for this study. The volcanism in this area is the result of a rift that stretches approximately 85 km across the eastern Snake River Plain [9], the type location for plains-style volcanism [8]. Basaltic flows in the associated lava fields include textures ranging from smooth pāhoehoe to slabby pāhoehoe, rubbly pāhoehoe, and blocky pāhoehoe, with some areas bordering on ‘a‘ā.

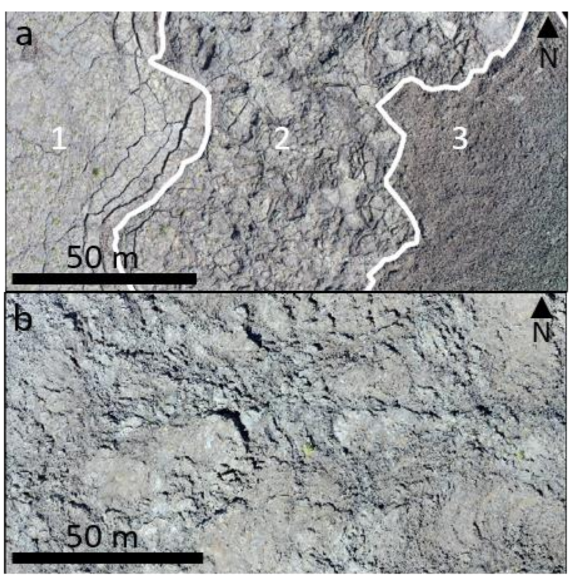

Figure 1. Flow textures examined in this study.a) smooth pāhoehoe (1), hummocky pāhoehoe (2), and rubbly pāhoehoe (3). b) Blocky pāhoehoe.

Methods: Unmanned Aerial Vehicles (UAVs) were used to collect aerial imagery (Fig. 1) over the North Crater, Highway, and Kings Bowl flows, all formed during the most recent eruptive period 2.1 - 2.3 ka [5]. The data collected on these flights was used to create Digital Terrain Models (DTMs) with resolutions between 1.30 cm and 2.33 cm (Fig. 2a.)

Different textures were classified by hand using the aerial imagery and field notes. These areas were downsampled to a range of resolutions (0.5 m, 1 m, 2.5 m, 5 m, 10 m; Fig. 2) to simulate lower resolution datasets. Roughness for each area and resolution was calculated using a simple ratio of the two-dimensional map area to the three-dimensional surface area, using the ArcGIS Surface Volume tool.

Results:

Textures have distinct 2D:3D ratios. Textures with a greater amount of total elevation change (i.e., rougher textures) have lower 2D:3D surface area ratios. For higher data resolutions, the ratios could be used to broadly identify lava texture type. In order from highest (smoothest) to lowest (roughest), the flows are: smooth pāhoehoe, rubbly pāhoehoe, hummocky pāhoehoe, and blocky pāhoehoe (Fig. 3).

Identification of flow textures is dependent on data resolution. The large spread of roughness values seen at high-resolution decreases with sequentially lower resolution DTMs. At high resolutions, the rubbly and hummocky pāhoehoe form two clusters of points with overlapping outliers. At lower resolutions (2.5 m) the smooth pāhoehoe becomes undistinguishable from the rubbly and hummocky pāhoehoe. At resolutions greater than 10 m, flow textures cannot be identified.

Discussion: Rubbly pāhoehoe has the 2D:3D area ratio most similar to smooth pāhoehoe. Genetically speaking, rubbly pāhoehoe is the most similar texture to ‘a‘ā, an endmember texture diametrically opposed to smooth pāhoehoe. This oppositional association may be due to the influence of many small-amplitude elevation changes in the rubbly pāhoehoe. In contrast, the hummocky and blocky flows have many large elevation changes that decrease the 2D:3D ratio and result in a rougher texture at these scales.

The influence of large elevation changes on the ratio is also thought to account for the rubbly pāhoehoe dataset whose 2D:3D area ratios overlap with the hummocky pāhoehoe ratios. The particular area of rubbly pāhoehoe associated with the lowest ratio has compressional ridges (ogives) that increase the 3D area relative to the other rubbly pāhoehoe areas. Qualitatively, hummocky pāhoehoe and rubbly pāhoehoe have very different roughnesses, highlighting the need to use more sophisticated roughness calculation techniques, such as the 2D Hurst exponent, to improve textural identification.

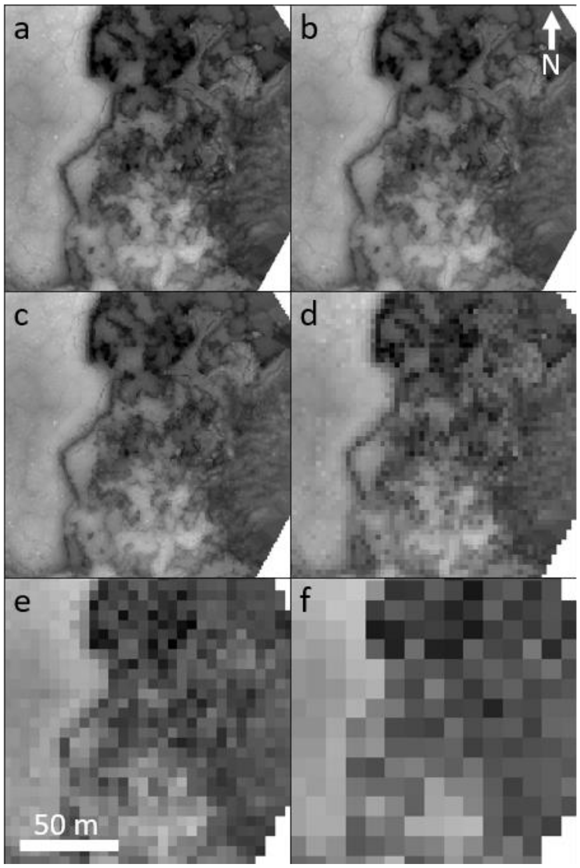

Figure 2: Downsampling of the North Crater flow to different pixel resolutions: 1.30 cm (a), 0.5 m (b), 1 m (c), 2.5 m (d), 5 m (e), and 10 m (f).

Understanding the impact of data resolution on lava flow identification is critical to building an objective texture classification tool. A 5 m resolution is sufficient to identify a rough block flow from a pāhoehoe flow. However, sub-meter resolutions are necessary to distinguish various pāhoehoe flow types. The resolution at which different flow textures can be determined is important to consider when interpreting terrestrial and planetary data. For example, the HiRISE instrument on board the Mars Reconnaissance Orbiter can produce 1m/pixel DTMs, while the LROC NAC instrument on board the Lunar Reconnaissance Orbiter can produce 2 m/pixel DTMs.

Objective classification of lava flows based on roughness measurements at various scales will allow rapid and consistent mapping of planetary bodies. This is of particular interest for terrestrial planetary bodies like the moon and Mars, where the lack of plate tectonics leaves volcanism and impact events as the key processes shaping surface evolution.

Conclusion: The 2D:3D area ratio can be used to distinguish between some basaltic lava flow textures. The data resolution necessary to differentiate lava flow textures is determined by how precise the textural classification must be. Future work includes the addition of several other measures of roughness, including the Hurst exponent, RMS slope, and median slope techniques previously applied to quantify roughness of impact melts [10] and the lunar surface [11]. The long term goal of this work is to create an objective tool for lava texture classification on Earth and other planetary bodies, as constrained by data resolution.

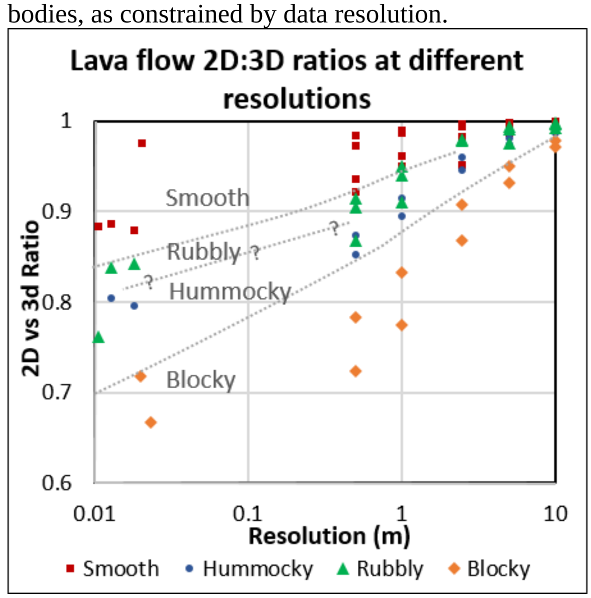

Figure 3: 2D:3D surface ratio at different data resolutions. Interpreted dashed lines divide flow types.

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