FROTHY LAVA AT HIGHWAY FLOW, CRATERS OF THE MOON E. Sandmeyer[1], S.E.K. Nawotniak[1], S.S. Hughes[1], R.C. Elphic[2], D.S.S. Lim[2], J. Heldmann[2] [1]Department of Geosciences, Idaho State University, Pocatello, Idaho (kobsshan@isu.edu), [2]NASA Ames Research Center, Moffett Field, CA.

Introduction: Lava texture can have profound impacts on the microbial habitability of the rock, with potentially rich habitats below the scale of current detection. The BASALT (Biologic Analog Science Associated with Lava Terrains) and FINESSE (Field Investigations to Enable Solar System Science and Exploration) projects use Highway Flow at Craters of the Moon (COTM) National Monument and Preserve, Idaho, as an analog for lava flows on the moon and Mars [see work by Mallonee, Tolometti, Sehlke, Hughes, Nawotniak, and others at this meeting, 1-4]. At Highway Flow, a high-relief, rough latite lava, FINESSE is interested in the scalability of roughness and the connection between surface morphology and emplacement conditions [e.g., 5,6], while BASALT focuses on how variation in host rock, including alteration and vesiculation, impact microbial habitability [2]. Of particular interest in this work, Highway Flow is characterized by bimodal rock density, alternating between dense and frothy material with almost no gradation between physical properties. We report here on a survey of frothy textures conducted at Highway Flow in order to identify textural types, identify spatial trends, and determine the processes involved in creating the frothy patches, answers to which will aid in understanding scales of texture and potential microbial habitability.

Highway flow: Highway Flow, located at the northern limit of the Great Rift in the eastern Snake River Plain, was erupted as two lobes ~2ka [7]. The west-flowing lobe is characterized by a relatively flat. circular shape cut by radial cracks, while the south-flowing lobe has a more elongate, channel-shape with minor levees and extension cracks [4]. The latitic composition is more evolved than the basalts-to-hawaiites that dominate COTM [7]. As such, while most of the COTM lavas display transitional textures (e.g., slabby, hummocky, or rubbly pahoehoe), Highway Flow is notable for its blocky to high-relief a'a morphology, with jagged spires and deep extension cracks. The majority of the lava flow is dense (~2800 kg/m^3), with frothy lava only making up an estimated ~1-2% of *in situ* surface exposure. The froth tends to be exposed in vertical walls and overhangs. Between the limited surface area and often vertical orientation of the froth, the bimodal texture of Highway Flow is not visible in aerial imagery.

Froth types: Frothy lava is distinguished as having around 40-50% void space within the rock. Three types of frothy texture are observed in the Highway Flow: treelike, crumbly, and surficial.

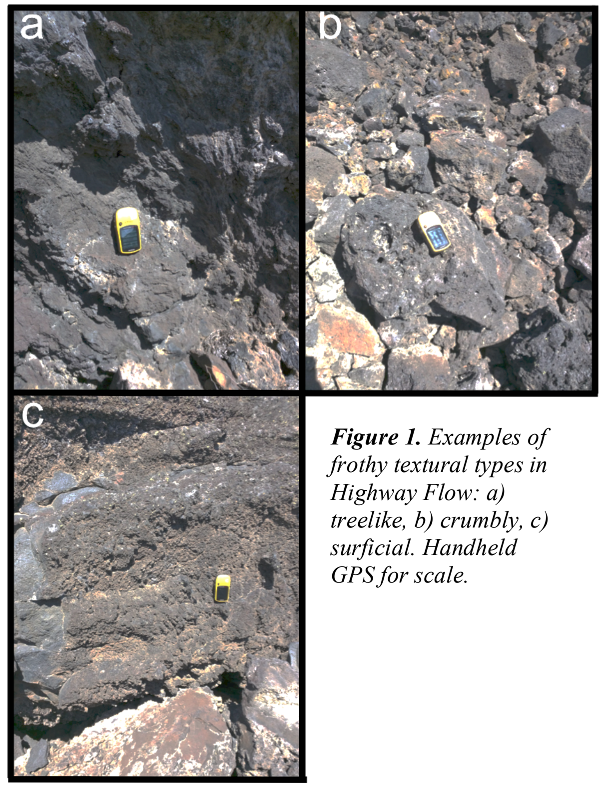

Figure 1. *Examples of frothy textural types in Highway Flow: a) treelike, b) crumbly, c) surficial. Handheld GPS for scale.*

Treelike texture is the most common. It is distinguished by elongate vesicles up to 4 cm long (1:3 aspect ratio) oriented horizontally, with void space making up the majority of the rock (~300-1000 kg/m^3). It is typically dark black and glassy, often exposed in elongate patches 10-20 cm wide and up to two meters long, oriented horizontally. In outcrop, the treelike froth frequently resembles charred logs embedded in the lava.

The second most common texture is crumbly, defined here as frothy lava texture that has appeared to have been broken, or crumbled, into loose "tephra." The size of crumbly froth clasts varies greatly, from ~1-10 cm, with an average diameter of ~3 cm. Crumbly froth accumulates in local topographic lows, where it strongly resembles fall deposits.

The least common texture, surficial, occurs on the underside of overhangs and extends into the outcrop only a few centimeters. It appears as spackle on the otherwise dense lava surface, and may cover areas up to ~2 m^2. Surficial froth, unlike the treelike texture, has approximately spherical vesicles and thick bubble walls, with a bulk density greater than 1000 kg/m^3.

Froth distribution and interpretation: All three frothy textures are located throughout Highway Flow, though with unequal distribution (Fig. 2).

Treelike: The treelike froth is pervasive throughout the flow, with no apparent preference for flow lobe or local surface morphology. The treelike froth is often capped by layers of dense lava 0.5-2 m thick, with more pristine example showing the frothy material appear to extrude ~3-10 cm from the outcrop face. We interpret the treelike froth as the result of late-stage, low viscosity lava exposed and allowed to depressurize during cracking of the dense carapace.

Crumbly: Most of the crumbly texture occurs in local depressions in areas of relatively flat topography, although we identified three instances where it appears in association with lava spires. It accumulates up to over a meter in thickness over areas of several square meters, often mixed with eolian dust and tiny lava fragments. Due to this, it provides opportunities for vegetation growth and incipient soil formation. We are confident that the crumbly froth is *not* produced by tephra fall based on age relationships between Highway and proximal scoria cones, maximum clast sizes inconsistent with grain size distributions from local explosive vents, and the frequent occurrence of topographic lows devoid of crumbly froth while similar nearby low areas contain over a meter of accumulation. There is often no apparent source for the crumbly clasts, though in many places it occurs along with treelike froth outcrops, and we interpret the crumbly froth in those locations to be a byproduct of the treelike material. We expect that it forms from weathering-driven breakup of the solidified treelike froth, as opposed to local decompression explosions during emplacement, based on our inability to identify explosion scars; these scars could be, however, buried beneath accumulated deposits.

Surficial: The most restricted distribution pattern is exhibited by the surficial froth, which is concentrated in the central portions of the southern lobe. These textural zones are frequently found in overhangs and extension cracks that reach depths down to 20 m. In several cases, surficial froth appears to be associated with the interior of m-scale flow folds. We hypothesize that these surfaces may represent an area where volatiles accumulated in the hinges of stiff folding lava or as localized depressurization in extension cracks.

Implications for planetary lava flows: Increased vesicle space in the rock influences microbial habitat by contributing to pathways for fluid and microbe transport; increased presence of glassy material, which is more accessible for energy than stony material; and potential for water retention. Visual inspection and textural analyses of aerial imagery only indicate blocky, high relief textures typical of high density lava at Highway Flow, hiding the potentially rich habitats in the frothy lava; this effect would be compounded for lower-resolution satellite imagery of Mars. Ongoing microbial and organic geochemistry analysis will indicate whether these hidden zones represent habitat hotspots. In that case, we will need to develop new ways to identify areas with likely hidden froth in imagery too coarse to allow detailed observation, thereby enabling better interpretation of complex lava emplacement and identification of targets in the search for life on Mars.

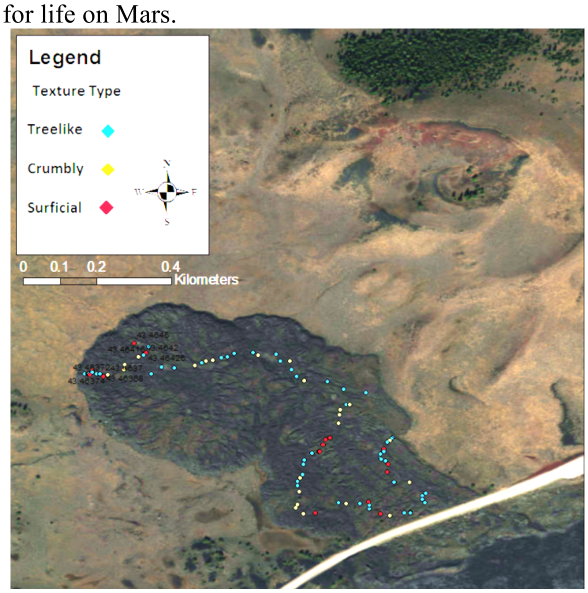

Figure 2. *Map of frothy textures identified during traverses of Highway Flow. Red = treelike; Yellow = crumbly; Green = surficial. Basemap from Esri ®.*

References: [1] Neish et al. (2017) *Icarus* 281: 73-89. [2] Kobs-Nawotniak et al. (2016) *AGU Fall meeting.* [3] Sehlke et al. (2016) *AGU Fall meeting.* [4] Hughes et al. (2016) *AGU Fall meeting.* [5] Sehlke et al. (2014) *Bull Volc* 76: 876. [6] Sehlke and Whittington (2015) *JGR: Planets* 120(11): 1924-1955. [7] Kuntz et al. (1994) *USGS OFR* 94-659.

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