UNDERSTANDING MARS AT THE MICROSCALE BY IMAGING TERRESTRIAL ANALOGS: THE HANDLENS ATLAS.

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Background: On Earth, understanding the origin of a geologic material as the summed history of its constituent grains is a proven and powerful strategy to maximize the information that can be gleaned from limited samples. Multiple properties, such as size, sorting, roundness, and texture may reveal clues to transport regime (e.g. fluvial, glacial, eolian), transport distance and diagenesis, eruptive patterns and processes, and differentiation of primary or recycled (by surface processes) grains. This strategy is important for Mars, where the available information is especially limited.

Applying handlens scale imaging to martian surface materials through the Mars Exploration Rover Microscopic Imagers (MI) has revolutionized our understanding of past and present surface processes (e.g. [1-4]), and will be equally critical for future Mars missions, such as Phoenix and Mars Science Laboratory (MSL). The ability to directly compare martian and terrestrial microscale textures and fabric elements is the first step in revealing those similarities diagnostic of various origin, transport and weathering regimes. However, terrestrial image atlases provide images either at the outcrop scale, or as processed microsamples (e.g. thin sections). A library of terrestrial analog images at the handlens scale bridges this gap, providing a crucial resource for comparative studies. Here we report on preliminary efforts to create the first Mars-focused handlens image atlas by imaging, documenting and classifing the microscale characteristics of a variety of terrestrial materials as potential Mars analogs.

Equipment: In choosing a camera to serve as a proxy for present and future Mars microscale imagers we considered several factors: resolution, lighting, and practicality for conducting fieldwork. In terms of resolution, MI resolution is ~31 μm/pxl [5], and MSL MAHLI [6] as currently designed can achieve high spatial resolutions approaching 9 microns/pixel (on the low resolution end, it can focus at infinity). We chose a camera that could match this resolution. For illumination, we chose a light source that provides consistent illumination under all conditions. In this way, images in the atlas are not affected by variations in sun angle, atmospheric opacity or other variables. This lighting choice also mimics the microscale imager set-up on both Phoenix and MSL. The final factor of field practicality necessitated a lightweight camera and tripod system to provide stability regardless of shooting geometry. Ultimately, we utilized a Canon Rebel XT, a digital SLR with an 8.0 Mpxl sensor. For most images, a 100mm f/2.8 macro lens was threaded into the lens adaptor and a twin-tube ring light was mounted on the extended lens. A tripod with a three-way head provided stability during high-resolution imaging.

Field Testing: We conducted a week-long field excursion in the volcanic country of central Oregon. Our goals were twofold: 1. Test whether the chosen camera would provide images comparable to MI and MAHLI and would also allow for rapid, efficient imaging; and 2. Compare the resulting images with volcanic deposits on Mars that poentially have a similar origin or depositional/weathering history. We imaged microscale features and textures of several outcrops of the Columbia River Flood Basalts, the Deschutes Formation (pyroclastic and lahar flows), the Tumalo Tuff formation, Fort Rock tuff ring, Hole-in-the-Ground Maar, China Hat (rhyolitic flow), the basaltic andesite flow fields of Lava Butte and the rhyolitic flows of Paulina Peak and Big Obsidian Flow.

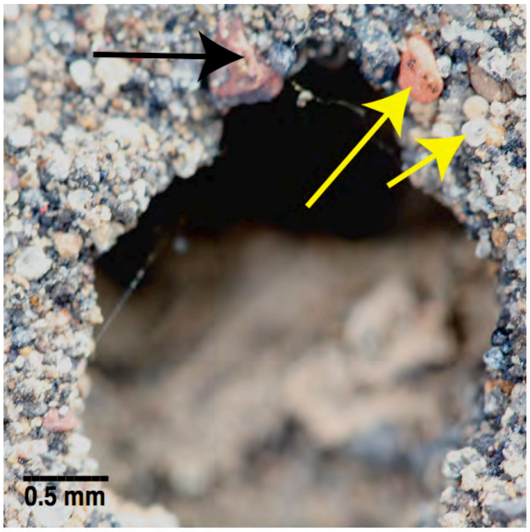

Figure 1. Coarse grained clast-supported vesicle in lahar deposit from the Deschutes Formation, Crooked River Grade, OR. Note the more rounded grains previously mobilized by the Deschutes River (yellow arrows) and the divet at the top (black arrow).

Formations of interest were imaged for context at outcrop scale, and then specific features were imaged at ~10 μm/pxl, as shown in Figure 1. Approximately

150 images were produced for each location, and 3-5 locations were visited each day. Because of the set-up time required, we were unable to produce a large number of image stacks (sequences of images of a single feature where the depth of focus has been adjusted) of each individual feature. Instead, we strove to summarize as completely as possible the unique or diagnostic microscale details of each feature or unit. This necessitated sacrificing depth of imaging many images of a few features) for overall imaging coverage (~5 images of each feature, but 10-15 features imaged per location). Samples were taken of each imaged formation for further analysis in the laboratory. Stratigraphic columns were also created of each location, to place images in context and facilitate subsequent analysis.

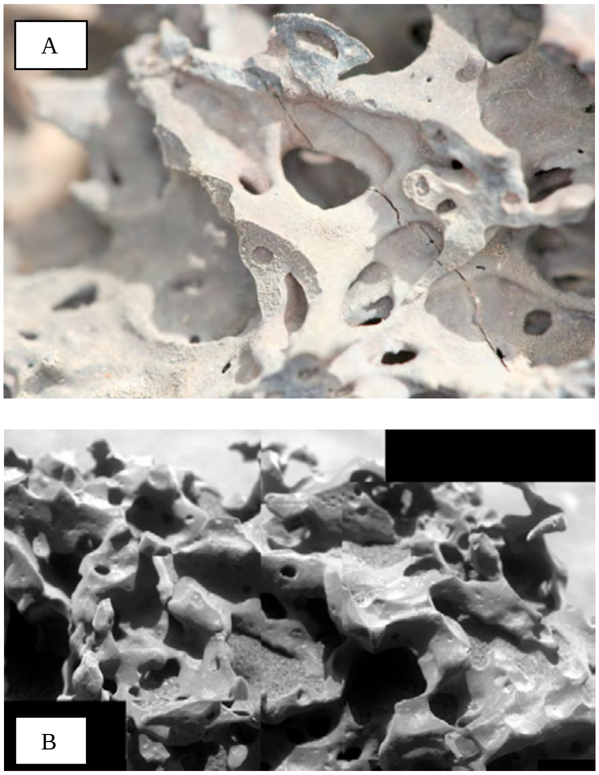

Figure 2. Scoria at the microscale. (a) Basaltic andesite scoria, Lava Butte, Oregon; (b) GongGong, sol 736, Gusev Crater, Mars. Images are ~50 mm across. The faceted edges on GongGong imply wind abrasion, while at Lava Butte the edges are primary breaking points from the high shear stress and fragmentation during eruption.

Results and Discussion: Images returned were comparable to or better than current MI images in terms of resolution and illumination. Figure 2 compares images of vesicular basalts taken for this study (a) and by the Spirit MI (b). Figure 2b has been coarsened to match the 31 μm/pxl resolution of Figure 2a. Details such as frosted texture and complex networks of septia can be seen in both images. These images also demonstrate that volcanically-derived voids have specific diagnostic features at this scale. Concave shapes and outward bloom, easily discerned rims (Figure 2a), and occasional divets (Figure 1) appear regardless of the state of weathering or the composition of the rock and appear to be typical of volcanic vesicles. Such features can be compared to voids imaged at Home Plate (shown in Figure 3), which have been interpreted to be possible vesicles [8]. The texture and morphology of the voids in Figure 3 do not resemble any of the volcanically-derived voids imaged at any of the locations visited for this study, suggesting that these Home Plate voids are not volcanic in origin.

Figure 3. Microscale voids (black arrows) imaged by the MI, sol 753, Home Plate region, Gusev Crater, Mars. Image is 30 mm across.

This method of image collection has proven to yield a representative summary of the microscale features and textures of the volcanic deposits examined. However, for features with significant microtopography, only a fraction of the image is typically in focus, which is unsatisfactory. A way must be found to efficiently and clearly image larger portions of such features. A method of automatically mosaicking a significant number of high-resolution images would provide a larger effective field of view to examine, greatly improving the usefulness of the resulting atlas.

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