**DEFINING THE OPTIMAL TOPOGRAPHIC RESOLUTION FOR PROCESS-DRIVEN STUDIES.** **M. H. Bulmer[1], D. Finnegan[2], and S.W. Anderson[3,4]. [1]Geophyiscal Flow Observatory, JCET/UMBC 1000 Hilltop Circle, Baltimore, MD 21250 (mbulmer@umbc.edu), [2]Cold Regions Laboratory, USACE, Hanover, NH 03755, [3] Black Hills State University, Spearfish, SD 57799, [4]Planetary Science Institute, Tucson, AZ 85721**

**Introduction:**

Variable-resolution imaging and topographic datasets have revealed new detail regarding the Martian surface [1,2] raising questions about active geologic processes. Analysis of high-resolution topographic data from terrestrial geomorphic analog sites provides a basis for identifying the optimal collection parameters, analytical protocols, and additional data needed to positively identify similar surfaces on Mars. The value of obtaining global moderate-resolution topography data has been demonstrated with MOLA, from which improved dimensional characterization of surfaces at a mesoscale have been made. However, comparison of MOLA and HRSC topography with MOC and THEMIS images has shown that the intermediate and small scale topographic features, such as volcanic edifices, that may have been influential in the evolutionary history of Mars, have not been captured [3,4,5]. Topography from MOC stereo reveals small-scale data but is aerially limited. There is a need to identify techniques for obtaining the appropriate topographic resolution for surfaces on Mars to better interpret high-resolution image data.

We are attempting to define the topographic resolutions required to derive essential information for process-driven studies of geologic surfaces. We have examined eleven terrestrial surfaces that serve as analogs for those on Mars [6,7,8]. As many studies have shown, it can be extremely difficult to obtain topography or image data that represents the actual surface conditions. By conducting a systematic study of topography and imaging data at small, intermediate, and large-scale we have begun to identify the appropriate resolution, data type and geometry needed to truly characterize a series of selected surfaces on Earth that are analogous to Mars. We focus on rocky surfaces in this study because 1) it is a geomorphic parameter known to provide clues regarding active geomorphic processes [9,10,11,12,13,8,6], 2) block size distributions affect fine-scale topography [12], 3) of the dominance of blocks as a geomorphic feature in arid terrestrial and planetary settings, and 4) a number of quantitative techniques have been developed for studying rock sizes (10,8,6).

**Approach:**

We made detailed measurements of rock populations on terrestrial geologic surfaces to determine the range of material sizes that exist and their cumulative percentages. The size distribution of the matrix at each site was determined by two methods: field measurements of coarse sediments, and airborne laser scanning of the whole deposit.

**Field Approach:**

We have acquired rock size data at outwash channels, lava flows and rock avalanches (Table 1). Measurement protocols found in [8], were used to measure rock sizes along 20-30 m orthogonal transects. At each site, we stretched a line across the flow surface then measured the length of each rock cut by this line greater than 10 cm. Table 1 shows the results of rock measurements extending from all locations each from the source to the depositional apron are expressed using the modified Udden-Wentworth grain-size scale [14]. The number of transect sites and distances between them are shown in Table 2. For all the surfaces in Table 1, between 53-100% of the rocks are in size ranges < 1m. Even for the surfaces that displayed the coarsest rocks, only ~40% of the lava flows at Sabancaya and the rock avalanche at Martinez Mountain are > 1m in size. This indicates that topographic and image datasets > 1m in resolution are inadequate to resolve the full details of the surface.

The data for lava flows (Table 1) shows that larger rock sizes (up to fine blocks) are created on evolved flows than on basaltic surfaces. 60-70 % of the total rock population at the andesitic to trachyandesitic Sabanacaya lava flows are in the range of coarse to fine boulders [6]. For the rhyolite domes at Inyo [8,12] ~55 % are in the range of coarse to fine boulders. Basaltic to basaltic-andesite flows appear to be limited into creating rocks no larger than medium boulders. Lava flows are constructional events that create rocks that can then be modified during and post emplacement. The Chaos Jumbles rock avalanche occurred in a rock population-created from the emplacement of a dacite dome [6]. Based on data for the Inyo domes it might be expected that the Jumbles had similar rock size percentages. However, the Jumbles have a larger percentage of rocks smaller than fine cobbles compared to the domes. This can be explained by rocks being broken during avalanche emplacement causing the original population to be modified with more small rocks being created [6]. The rock avalanche at Martinez Mountain is composed of granitic gneiss that failed from the mountain slope. The percentages of coarse sizes (fine blocks to very coarse boulders) for Martinez are comparable to those at Sabancaya. However, 8 % of the rock at Sabancaya are smaller than coarse cobbles compared with around 16 % for Martinez. This larger percentage of smaller rocks can be explained by breakage of the original rock population during emplacement of this large avalanche creating more small rocks.

**Laser Scanning Approach:**

During the summer of 2005 airborne LiDAR surveys were acquired over geologic surfaces for which we have field measurements of rocks. These data provide point densities sufficient to produce both high-resolution (1 m/pixel) and reduced resolutions (300 m/pixel) making them comparable to data products currently available for Mars. We have created DEMs at 1 m postings. Rock data has been extracted using a combination of images, the DEM's and elevation values taken at 0.25 m intervals along transects that simulate our field data. However, capturing meter to sub-meter resolution data using a LiDAR is technically complex due to the footprint size of each laser measurement and scanning acquisition rates. We have begun using a ground-based laser scanner to capture resolutions (sub meter) over smaller areas than those obtained by LiDAR. We are currently analyzing these data, and determining methods to relate rock size to topographic roughness parameters.

**Conclusions:**

Table 1 demonstrates the need for < 1m resolution topography in process-driven studies, without which examinations of the relationship between surface characterization, emplacement, and subsequent modification processes are severely limited. We are obtaining these data through sub-meter resolution ground-based laser scans combined with meter resolution topographic data from the LiDAR and the field.

**References:**
[1]Malin *et al.*, 1998. [2]Smith *et al.*, 1998. [3]Glaze, 2003. [4]Byrnes *et al.*, 2006. [5]Finnegan *et al.*, 2004. [6]Bulmer *et al.*, 2002, 2004, 2005. [7]Bulmer and Zimmerman, 2005. [8]Anderson *et al.*, 1998. [9] Malin, 1988. [10] Golombek and Rapp, 1997; 2005. [11] Farr, 1992. [12]Plaut *et al.*, 2005. [13]Burke *et al.*, 2005 [14]Blair and McPherson, 1999 .

| **Material matrix** | **MC** | **MM** | **1A-L** | **2A-J** | **Flow1** | **Flow2a** | **Inyo** | **PP** | **Cima** |
|---|---|---|---|---|---|---|---|---|---|
| Silts to medium pebbles (0.8-1.6cm) | 81 | 10 | 11 | 4 | # | # | * | 21 | ^ |
| Coarse pebbles (1.6-3.2cm) | 0 | 0 | 3 | 3 | 0 | 0 | * | 4 | ^ |
| V. coarse pebbles (3.2-6.4cm) | 0 | 2 | 12 | 10 | 0 | 0 | 15 | 9 | 0 |
| Fine cobbles (6.4-12.8cm) | 1 | 5 | 21 | 22 | 1 | 1 | 2 | 13 | 5 |
| Coarse cobbles (12.8-25.6cm) | 3 | 9 | 22 | 24 | 7 | 7 | 19 | 15 | 58 |
| Fine boulders (25.6-51.2cm) | 5 | 15 | 16 | 20 | 15 | 18 | 26 | 16 | 29 |
| Medium boulders (51.2-102.4cm) | 7 | 18 | 6 | 11 | 31 | 27 | 20 | 8 | 8 |
| Coarse boulders (102.4-204.8cm) | 2 | 20 | 0 | 1 | 31 | 28 | 10 | 4 | 0 |
| V. coarse boulders (204.8-409.6cm) | 1 | 16 | 0 | 0 | 9 | 15 | 4 | 0 | 0 |
| Fine blocks (409.6-820cm) | 0 | 3 | 1 | 0 | 5 | 1 | 0 | 0 | 0 |
| Holes | 0 | 2 | 8 | 5 | 3 | 3 | 4 | 1 | 0 |
| Pumice | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 |
| **Total %** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 1.** The percentage of each class over the area measured. MC = Mission Creek outwash channel, MM = Martinez Mountain rock avalanche, 1A-L and 2A-J = Chaos Jumbles rock avalanche, Flow 1 and 2a = Lava flows at Sabancaya, Inyo = Domes at Glass Creek, Deadman, Obsidian, Wilson Butte, PP= Paint Pot lava flow, Cima = lava flow. Symbols #*^ refer to details in the measurements of rocks < 10 cm [6,12,13].

| Number of individual measurements | **MC** | **MM** | **1A-L** | **2A-J** | **Flow1** | **Flow2a** | **Inyo** | **PP** | **Cima** |
|---|---|---|---|---|---|---|---|---|---|
| Rocks | 243 | 361 | 3771 | 1708 | 335 | 869 | 9383 | 750 | 292 |
| Fines | 201 | 125 | 689 | 136 | 191 | 429 | 2798 | 214 | ^ |
| Holes | 0 | 38 | 801 | 366 | 28 | 64 | 1189 | 10 | ^ |
| Pumice | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 62 | ^ |
| Number of transects sites | 7 | 5 | 12 | 6 | 7 | 18 | 67 | 6 | 6 |
| Cumulative length of transects (m) | 420 | 200 | 720 | 360 | 420 | 1140 | 4020 | 360 | 360 |
| Distance between transect sites (m) | 150 | 150 | 150 | 150 | 250 | 250 | 150 | 150 | 150 |

**Table 2**. Details of the number of individual measurements at each site in Table 1 along with the numbers of transects.