TOPOGRAPHIC CONSTRAINTS AND RESOLUTION NECESSARY TO UNDERSTAND THE EMPLACEMENT OF THE OLYMPUS MONS AUREOLES.

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Introduction: Extensive examination of MOLA topography over the aureoles [1] has revealed that the shot-spacing between topographic measurements is sufficient in capturing large-scale form and surface roughness characteristics. The topographic profiles however provide little insight into apparently unique features of the aeurole units observed in MOC, HRSC, and THEMIS images. McGovern et al [2] showed the surface morphology and internal structure of aureole blocks exhibit remnants of volcanic flow units. These observations combined with geophysical modeling using MOLA and gravity data of edifice growth support a model of episodic failure of the flanks in large mass movement events, leaving behind headwalls that constitute the basal scarp. In available images and topography (Figure 1), aureoles are rough, contain blocks and are characterized by transverse ridges and troughs [1, 2] which all exist on terrestrial rock avalanches. The true number and size of avalanches may not be apparent due to the limitations of current data but the apparent volume of the smallest aureole [2,3,4] is comparable to the largest debris aprons found on Earth [5]. HRSC and MOC data have revealed numerous additional depositional aprons [6] and new geomorphic details. However, these data are aerially limited and details necessary to understand how materials involved in these failures behaved while in transit remain absent. This raises the question of what data resolutions are needed to understand emplacement.

As a way of addressing this question we are attempting to determine the topographic resolution required to capture essential information about the emplacement of selected terrestrial rock avalanches both on land [7,8] and on the seafloor [6] to positively identify avalanche emplacement for the aureoles.

Approach: In order to characterize the surface of terrestrial subareal rock avalanches we have used LiDAR DEMs collected over the Martinez Mountain and Chaos Jumbles rock avalanches in conjunction with spaceborne and airborne multispectral, visible and thermal sensors similar to those on current Mars missions. A similar approach is outlined by Byrnes et al [9]. Through an examination of the degree to which topography with varying resolutions (both vertical and horizontal) at Martinez represents the surfaces as observed in the field, and the processes responsible for creating and modifying the deposit we are able to constrain the scales at which they occur.

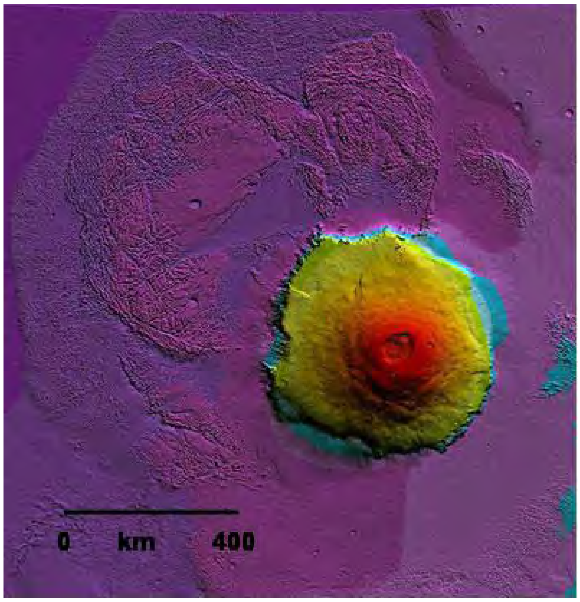
Martinez Mountain: The Martinez Mountain rock avalanche was chosen for study because it is rough at meter-scales and contains megaclasts [8]. The length of the deposit is 7.6 km and the width at the widest part is 0.137 km. The avalanche deposit is assessed by to be 3.8 x 10^8 m^3 of granitic gneiss that failed from the mountain slope (Figure 2). These dimensions are similar to landslide aprons in Eastern Gangis Chasma [10] and therefore smaller than published dimesions for aureole units [2,3,4]. It is likely that the Martinez avalanche was seismically triggered which would have provided the energy necessary to disaggregate the crystalline rock.

LiDAR Approach: NASA's ATM-IV waveform laser altimeter was used to obtain data over the Martinez avalanche deposits. It uses a 5 kHz 532 nm 1.2 ns laser, a wide dynamic range high speed optical receiver and a pair of multi channel 4-Giga Sample/second waveform digitizers. The footprint is 200 mm, and topographic details can be resolved at ~100 mm vertically and 400 mm horizontally. Point densities obtained were sufficient to produce high-resolution (1m/pixel) DEMs. In this process the value in any 1 m grid cell is an average of the values of the points contained within it. The original LiDAR points were then interpolated to create DEMs with bin-sizes larger than the original resolution and comparable to MOLA, HRSC, and MOC stereo topography.

Figure 1a shows a DEM with a 300 m bin size, of the toe of the Martinez avalanche. This is comparable to a MOLA DEM and the avalanche deposits are indistinguishable from the mountain range. Figure 1b shows a DEM interpolated at a 10 m-bin size comparable to an HRSC DEM. The margins of the avalanche are visible as a lobate deposit but the origin could be the result of an avalanche or a glacier. Geomorphic research on Earth is increasingly recognizing that slow acting processes such as rock glaciers and mass rockcreep are capable of producing geomorphologies over time similar to those from short duration rock avalanches [see ref in 10]. Figure 1c shows a 1 m/pixel resolution DEM in which the toe can be seen to be composed of several lobes (Figure 3, transect A) and the scale is sufficient to examine origin. These lobes indicate temporal and spatial variability in velocity profiles during emplacement, and are more characteristics of avalanche origin rather than glacial. Taken as an avalanche deposit, these lobes also indicate that the whole toe was not emplaced in the same time instance. The temporal separation between lobes may have been sufficient that their flow dynamics were discrete. In such a case, using a single volume calculation for the toe to understand emplacement (Figure 1d) would be erroneous. This has tended to be the practice in studies of aureoles, resulting in models of catastrophic failures with high emplacement velocities [5]. Coarse clasts > 1m on the deposit (Figure 1e) are not obvious in the color-shade but are well defined in topographic profiles taken across the toe for the 1 m/pixel DEM (Figure 2, transect A).

Conclusion: Even at the apparent scale of the aureole units, our LiDAR experiment would suggest that many of the key indicators of emplacement of the aureoles are only going to be visible at image and topographic resolutions of 1 m/pixel. It could be that all scales are just greater on the aureoles, a fact which can be tested by a systematic analysis of the raw HRSC data.

References: [1] Smith et al. (2002). [2] McGovern et al. (2004) [3] Lopes et al., (1980, 1982). [4] Francis and Wadge (1983). [5] Moore et al., 1989. [6]Neukum (2006) [7] Bock (1977). [8]Bulmer et al. (2004,2007). [9]Byrnes et al. (2006). [10]Bulmer and Zimmerman (2004).



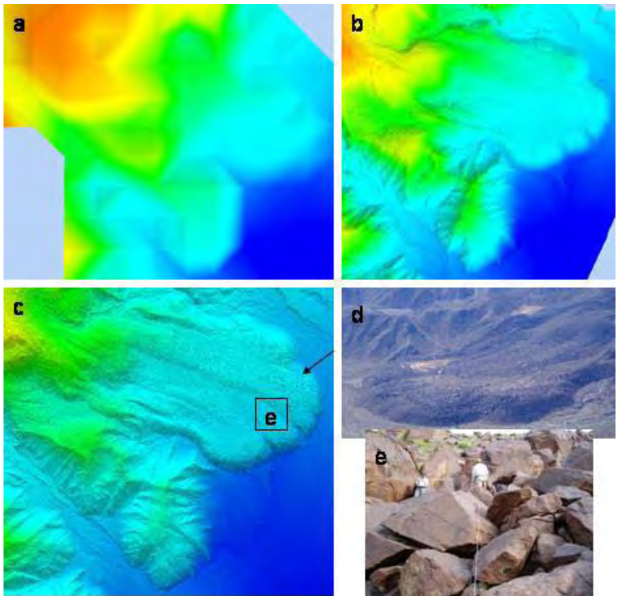


Figure 1 Left. View of MOLA topography over Olympus Mons showing the edifce and aureoles.

Figure 2 Right. Martinez Mountain color-shaded LiDAR DEM and images. **a, b, c** shows 300, 10 and 1m/pixel DEMs respectively of the fan-shaped rock avalanche. Use **c** to look for the deposit in **a** and **b**; **d** is an oblique view of the downslope left side of the toe, and **e** shows rock sizes at the toe with the author for scale .

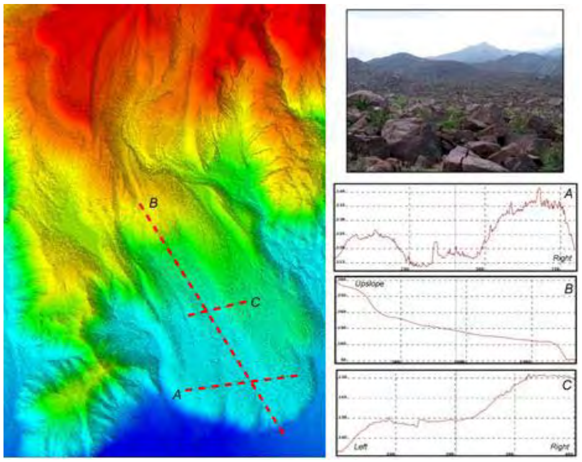


Figure 3. Martinez Mountain color-shaded NASA ATM LiDAR DEM, ground image and topographic profiles. Left shows 1m/pixel color-coded DEM with transect lines A, B and C. Top right shows a view up transect A. Bottom right shows the topographic profiles A, B, and C.