GRANULAR MATERIALS IN THE DISRUPTED TERRAIN OF OLYMPUS MONS AUREOLES. M. H. Bulmer[1] , D. Beller[2], J. Griswold[3], and P. J. McGovern[4], [1]Geophyiscal Flow Observatory, JCET/UMBC 1000 Hilltop Circle, Baltimore, MD 21250 (mbulmer@umbc.edu), [2]Brandeis University, 415 South St., Waltham, MA 02454, [3]Case Western Reserve, 10900 Euclid Avenue, Cleveland, OH 44106, [4]LPI, 3600 Bay Area Blvd, Houston TX 77058-1113.

Introduction: The rugged aureoles that surround Olympus Mons contain one of the two major global concentrations of slope streaks. To examine these units topography datasets from the last decade of Mars missions have been combined into a common projection and co-ordinate system. Aureole units show topographic variability suggestive of multiple deposits resulting from the same failure or multiple failures each of which can be considered to be a separate event. Slope streaks occur on all aureole units. Streaks appear to be granular derived from weathered basaltic lavas that form aureole units. To further understand their origin and emplacement the properties of slope streaks within aureoles have been quantified. An investigation has begun into the likely characteristics of granular materials and the importance of size, sphericity, and angularity to mobility.

Approach: Data from MOLA, MOC, THEMIS, HRSC and HiRISE have been used to 1) determine the geography of slope streaks in aureole units, 2) characterize streak dimensions, 3) determine topographic variability, and 4) describe the geomorphologic setting. This has enabled comparison with streaks reported at other geographic locations [1].

Streak Characteristics: The morphologies and morphometrics of over 300 streaks were examined in MOC (~1.4 m/pixel) and HiRISE (~30 cm/pixel) images plus MOLA topography. Slope streaks have dark to bright albedo features on Martian slopes (Figure 1).

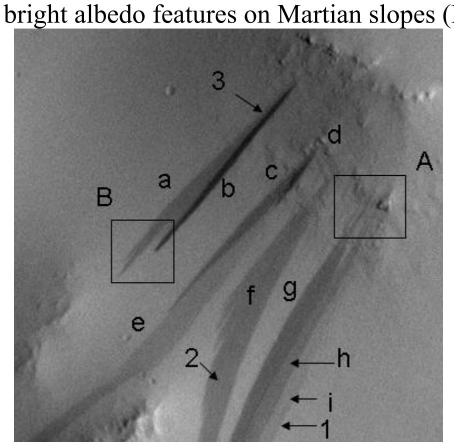

Figure 1. Examples of albedo variations 1-3, complex and simple streaks, source areas (box A) and digitate plus lobate distal margins (Box B). From MOC2-1621-b.

Each streak was assigned an albedo ranking of 1-3, with 3 being the darkest. If two streaks ranked 1 overlap they become briefly indistinguishable while in situations where streaks ranked either 2 or 3 overlap, 3 overlays 2. Morphologically, a streak was 'complex' if it has more than one flow source, or overlaps with another (e.g. a, b in Fig. 1). Streaks that are not complex are 'simple' (e.g. f in Fig. 1). In their distal regions (Box B in Fig. 1) streak were found to be: 1) wide, usually digitate (more often in larger streaks), and 2) narrow where beyond a point of maximum width the deposit narrows (more often in smaller streaks).

Analysis of HiRISE images reveals that the size class with the greatest percentage of streaks is <100 m in length and <10 m in width, compared with the 100-200 m in length and 10-20 m in width noted from MOC images [2]. Many small streaks visible in HiRISE images are not resolved in MOC images.

Emplacement: Processes responsible for streak formation operate today on Mars as evidenced by slope streak emplacement between repeat MOC and HiRISE images. Streaks are therefore some of the youngest geomorphic features on Mars and their signatures are thought to fade over time [3]. However, the emplacement of these streaks has never been observed, and their origin remains controversial. Proposed emplacement mechanisms include dry dust avalanches [4, 5, 6, 7], wet debris flow [8, 9], liquid water flow and liquid CO_2 flow [10]. Within aureole blocks there is evidence for "layering" but there are multiple orientations and angles. The layers within blocks likely had coherent orientations when they were part of the flanks of Olympus Mons that were disrupted during flank failure [11]. Streaks on aureole block slopes face all cardinal directions and do not correlate with any preferred aspect [6] or bedding angle none of which support emplacement models that invoke aquifers, a perched water table or seepage along bedding [e.g. 1, 3, 10]. Factors contributing to streak formation in the aureoles are likely not unique but rather ubiquitous such as dust, sand, wind, and gravity. The latter two can assist in material transport and have been well documented by others [e.g. 6], but particle characteristics remain only partially known due to lack of sufficient sampling and are critical to the effectiveness of wind and gravity.

A comparison of dimensional and morphologic characteristics of Martian streaks with naturally occurring gravity and wind-driven dry granular flows on terrestrial sand dunes shows them to be similar [2]. This prompted study into how these granular materials take-on flow-like behavior when in motion. Until sufficient Martian sampling occurs these studies can help to inform understanding of the behavior of granular material on Martian slopes. The term flow is used to describe a mass of clasts moving downslope in a coherent manner with individual clasts sliding, rolling and saltating.

Wind driven sands in North America, North Africa, South America and the Middle East, have been observed to preferentially deposit in hollows on the slopes resulting in periodic failure of piles. Resulting flows (lobes or sheets) can form channels near the proximal zone, maintain relatively uniform widths, have a darker albedo than the surroundings that fades with time, can block each other and overlay older flows, can be triggered mid-slope, follow local topography and can anastomize or digitate in the distal region (Figure 2). Multiple flows can form a single larger apron. Rocks of pebble size and larger can trigger flows and can be ‘rafted’ on them.

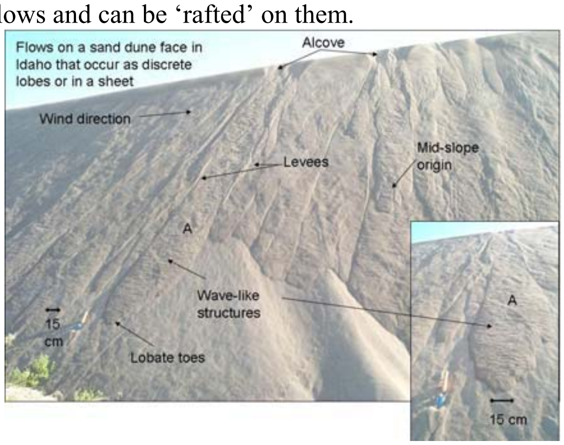

Figure 2. Examples of the characteristics resulting from dry granular flows on a terrestrial dune face.

Flow speeds (~ 10 cm/sec) are likely less than for gravity-driven dry granular flows on Mars (possibly 1-10 m/sec). Critical to mobility are the size, sphericity and angularity of individual clasts.

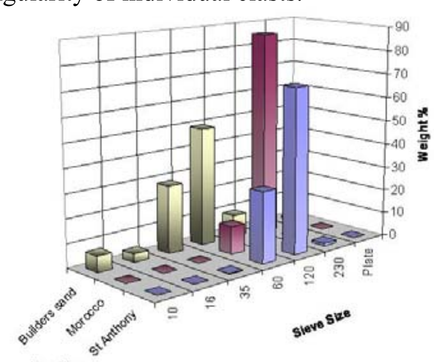

Figure 3. Particle size analyses for a sieve stack ranging from -1 Φ (sieve size 10) to 4 Φ (sieve size 230).

Analysis of the size distribution of Morocco and St Anthony sands observed to flow naturally with Builders sand that cannot, shows that the former have high weight percent in the 2 Φ (medium) and 3 Φ (fine) class (Figure 3). Sands that can flow possess a high proportion of clasts subrounded to well rounded and with high sphericity when examined under a microscope (Figure 4).

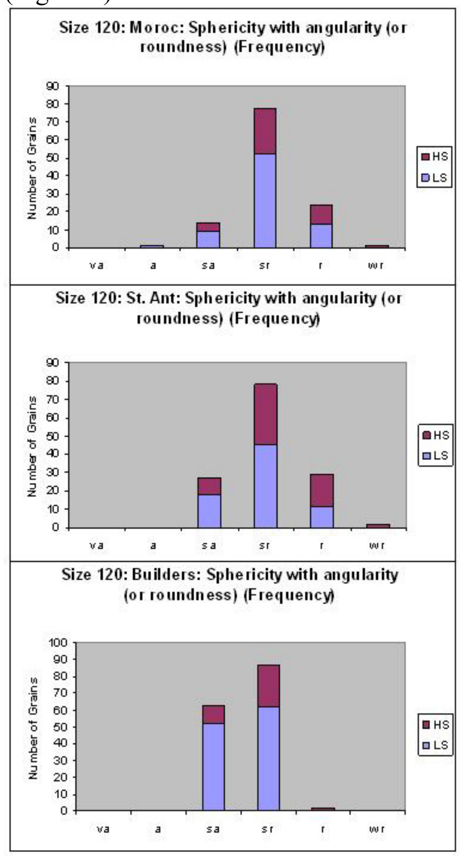

Figure 4. A comparison of sphericity and angularity of grains 3 Φ in size. Horizontal scale goes from very angular to well rounded.

This occurs as a result of physical and chemical weathering. This result indicates that if streaks on Mars are formed by gravity and wind-driven dry granular flows then individual clasts are likely to be rounded with high sphericity. The key factor for clasts on Mars may be the tens to hundreds of million years they are exposed to physical and chemical weathering. This can be tested in the future by in-situ sampling of Martian streaks to examine size, sphericity and angularity.

References: [1] Malin and Edgett, 2001. [2] Bulmer et al., 2007. [3] Schorghofer et al., 2007. [4] Sullivan et al., 2001. [5] Treiman and Louge, 2004. [6] Baratoux et al., 2006. [7] Chuang et al., 2007. [8] Ferguson and Lucchitta, 1984. [9] Williams, 1991. [10] Ferris et al., 2002. [11] McGovern et al., 2004.