THE OLYMPUS MONS AUREOLE DEPOSITS: CONSTRAINTS ON EMPLACEMENT SCENARIOS BASED ON REMOTELY SENSED DATA. Donielle Chittenden[1] and Patrick J. McGovern[2], [1]Science and Technology International, 999 Bishop St. Suite 2700, Honolulu, HI 96813 (dchittenden@sti-hawaii.com). [2]Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston TX 77058, (mcgovern@lpi.usra.edu).

**Introduction:** Olympus Mons is one of the most extensively studied planetary volcanoes due to its vast overall size and unique physical characteristics. Located northwest of the Tharsis Plateau of Mars, the volcano is almost 23 km tall and 600 km in diameter. Surrounding the base of the volcano are four main aureole lobes, which are characterized by a hummocky terrain of several ridges, deep troughs and grabens [1]. The main aureole lobes extend radially from the edifice, up to a distance of 750 km, in the NE, N, NW, and W directions [1] (Figure 1). Another significant feature of this volcano is the scarp that encircles the base, acting as an abrupt margin between the edifice and aureole deposits. This basal escarpment truncates the edifice at approximately 300 km from the caldera, and ranges in height from 2 to 10 km.

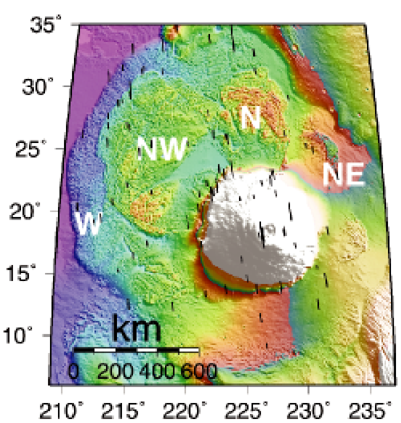


**Figure 1**- Olympus Mons and the aureole deposits. Black boxes indicate footprints of MOC images used in this study. The 4 most prominent aureole lobes are assigned labels based on their orientations with respect to the edifice.

High-resolution images from the Mars Orbital Camera (MOC) and topographic data from the Mars Orbiter Laser Altimeter (MOLA) enable detailed study of small- and medium-scale surface features (such as lava flows, channels, terraces, and faults) on and around the Olympus Mons edifice and aureole deposits. Here we describe the assemblage of a detailed database of 19 types of surface features, with the ultimate objective of illuminating the processes contributing to the emplacement of the aureole deposits and the evolution of the edifice and basal escarpment.

**Aureole Formation Mechanisms**: The formation mechanism of the Olympus Mons aureole lobes is one of the outstanding puzzles of Mars science. The most viable scenarios fall broadly into two categories: failure of the Olympus Mons flank (the "mass movement" category) or flow of locally derived volcanic products (termed "in-situ volcanism").

*Mass Movement*: Mechanisms in this category require that material from the flanks of the Olympus Mons edifice be transported to its current location beyond the scarp. Such movement may be either catastrophic (several hours timescale, [1, 2]), analogous to large rapidly emplaced landslides off the flanks of Hawaiian volcanoes [e.g., 3], or slow (several thousand years timescale, [4, 5]), comparable to a thrust-sheet mountain building event. Both subgroups of mass movement scenarios require a weakened layer at the volcano's base to facilitate flank movement and failure. Water likely plays an important weakening role, either as an over-pressurized pore fluid, which facilitates seismic slip [6], or in solid form as a creep-enhancing basal ice layer [5].

*In-situ Volcanism*: Under such scenarios, volcanic products erupted from vents located within the aureole lobes produce the material that makes up the aureole ridges and blocks. In order to explain the roughness of the aureoles, pyroclastic rather than effusive flows are usually invoked [7, 8] (but see also [9]).

**Methodology:** We collected 87 MOC images (Figure 1) from the group E01-E06 (February 2001- July 2001) in the Amazonis, Tharsis and Diacria quadrangles. The narrow-angle images had a spatial resolution range of 3-7 m/pixel, and almost all were accompanied by wide-angle context images of coarser spatial resolutions. We organized the images into three groups: edifice, scarp, and beyond scarp (aureoles and plains). We scanned the images for features that suggested previous volcanic, fluvial, or tectonic events.

With the USGS software ISIS (Integrated Software for Imagers and Spectrometers), we overlaid grid lines on the images at 1/16° intervals. We recorded the coordinates of the centers of the grid boxes and assembled a MATLAB database listing the specific surface features located inside each box. From a MOLA topography grid of the same resolution, we extracted the elevation and maximum slope of all the grid boxes. For each type of feature, we created maps of spatial distributions and histograms of elevations and max slopes.

**Results:** Of the 19 types of features considered, we will discuss only those most likely to help resolve the differences between the two classes of aureole formation mechanisms: leveed and lobate lava flows, terraces, channels, meandering channels, and teardrop-shaped islands. Such features imply previous volcanic or fluvial activity.

The data indicate that leveed flows are more common on the edifice and scarp than in the surrounding lowlands, whereas flows with lobate margins occur with comparable frequency in the lowlands and on the edifice. Furthermore, leveed flows tend to occur on more steeply-sloped terrain than lobate ones (Figure 2).

We found terraces at numerous locations along the northern edges of the NW and N aureoles, as well as in the central parts of the W aureole. Such features are commonly seen encircling aureole ridges (Figure 3c).

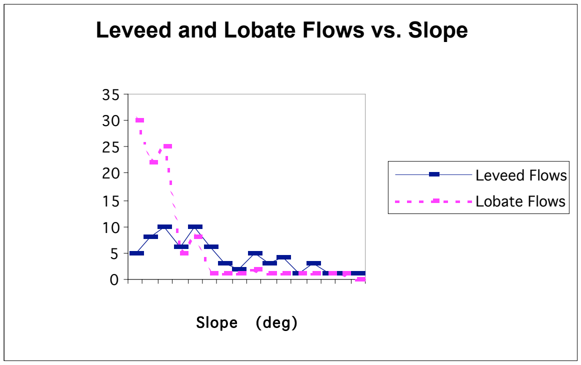


**Figure 2**- A comparison between the slopes of leveed flows and the slopes of lobate flows

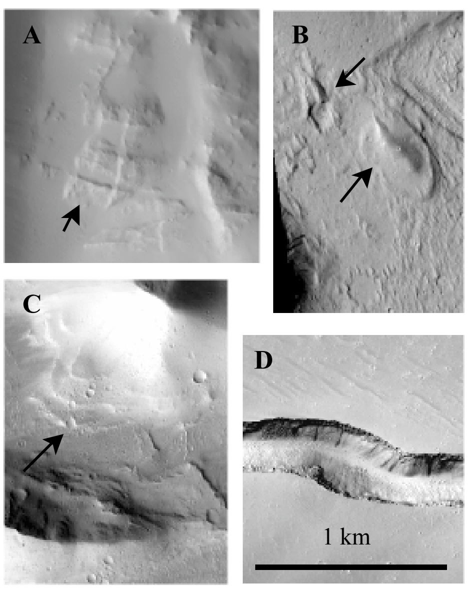


**Figure 3**- A: Grabens oriented WNW-ESE; B: Teardrop-shaped islands; C: Terraces; D: Channel with layering; illumination is from lower left corners of all images and scale bar applies to all images.

Channels found within the data set are steep-sided, linear or sinuous, and sometimes exhibit layering along the internal walls (Figure 3d). We found them located along the northern edge of the NW and W aureoles, near the north and northwest sections of the scarp, and on the north flank. A few are also in the central parts of the W and NW aureoles. In general, channels occur near terraced features around Olympus Mons, although the converse is not always true.

Teardrop-shaped islands (Figure 3b) are closely associated with terrestrial fluvial activity. Near Olympus Mons, teardrop-shaped islands are most common in the W aureole, and also coincide with the location of terraces in that area. They do not, however, accompany terraces found in the other aureole lobes.

**Discussion**: The distribution of leveed flows has important implications for aureole formation scenarios. Several MOC images (not included in this study) show aureole blocks with what appear to be remnants of leveed flows on their surfaces [6]. The flows terminate at block edges, indicating that they predate the block-producing process. Our data indicate that leveed flows preferentially occur on moderately-sloped surfaces (2-6 degrees), such as those of the Olympus Mons edifice (see Figure 2). Thus, the leveed flow remnants link aureole blocks directly to the flanks of Olympus Mons, providing strong support for the mass-movement mechanism of aureole formation [6].

In contrast to the remnant leveed flows, features consistent with ongoing effusive volcanic activity (e.g., intact flow features such as levees, skylights, or lobate flows) are generally scarce in the region surrounding the Olympus Mons edifice. Those that exist are generally close to the edifice and scarp rather than the aureole deposits, suggesting that effusive volcanism [9] is unlikely to have contributed to aureole formation.

Features that indicate fluvial activity (e.g., channels, terraces, and teardrop-shaped islands) generally occur in the lowlands surrounding Olympus Mons. Furthermore, they tend to occur near the margins of aureole lobes rather than their interiors. The latter observation is consistent with the hypothesis that overpressurized pore fluid existed at the base of aureole lobes, enabling part of the Olympus Mons flank to fail [6]; some such fluid would tend to be expelled from the margin of the resulting deposit. While localized volcanism within the aureole lobes could produce liquid water by melting ground water or ice, such fluid should be present throughout the lobe. Alternatively, the water may originate elsewhere, possibly from hydro-magmatic interactions either high on the Tharsis rise or southwest of the Olympus Mons edifice [10].

**References:** [1] R. Lopes et al. (1982) *JGR, 87,* 9917. [2] P.J. McGovern, and S.C. Solomon (1993) *JGR, 98*, 23553. [3] Moore et al. (1989) *JGR, 94*, 17465. [4] P.W. Francis and G. Wadge, *JGR, 88*, 9333, 1983, [5] K.L. Tanaka, *Icarus, 62*, 191, 1985. [6] P.J. McGovern et al., *LPS XXXV* (this volume) 2004. [7] E.C. Morris, *JGR, 87,* 1164, 1982. [8] E.C. Morris and K. L. Tanaka, *USGS map I-2327*, 1994. [9] E.C. Morris and S.E. Dwornik, *USGS Map I-1049*, 1978. [10] P. Mouginis-Mark*, Icarus, 84*, 362, 1990.