Evidence for Extensive Fluvial Erosion around Olympus Mons: A Multi-Resolution Survey. S.C. Cull[1] and Patrick J. McGovern[2], [1]Hampshire College (cull@jyi.org), [2]Lunar and Planetary Institute (mcgovern@lpi.usra.edu)

Introduction: Olympus Mons on Mars has been well studied in terms of tectonic and volcanic evolution; however, few studies have focused on fluvial features around Olympus Mons and their relationship to the tectonic evolution of the volcano. Previous studies have examined the small-scale relationship between tectonic and fluvial features around Olympus Mons [1], small-scale fluvial features in and around the aureoles [2, 3], the relationship between volcanics and the cryosphere [4], and the proposed rock glacier deposits on the western flank of the volcano [5, 6]. This study surveys the aureole lobes and regions surrounding Olympus Mons for signs of large- and small-scale fluvial activity.

Data & Methods: We used several types of data at different resolutions. First, daytime infrared images from the Thermal Emission Imaging System (THEMIS) aboard *Mars Odyssey* were mosaicked over the region 7° – 34° N and 209° - 236° E using the USGS Integrated Software for Imagers and Spectrometers (ISIS). These images are moderately high-resolution, at 100 meters-per-pixel, and provide nearly complete coverage of the Olympus Mons area. Second, visual THEMIS (THEMIS-VIS) images in the 7° – 34° N and 209° – 236° E range were examined. Though they provide very limited coverage, the THEMIS-VIS images are higher resolution, at about 18 meters-per-pixel. Third, topography data from the Mars Orbiting Laser Altimeter (MOLA) aboard *Mars Global Surveyor* were used (resolution of 1/128th degree per pixel) [7]. Fourth, pulse width data from MOLA (resolution of 1/8th degree per pixel) were used to estimate and compare surface roughnesses. [8]

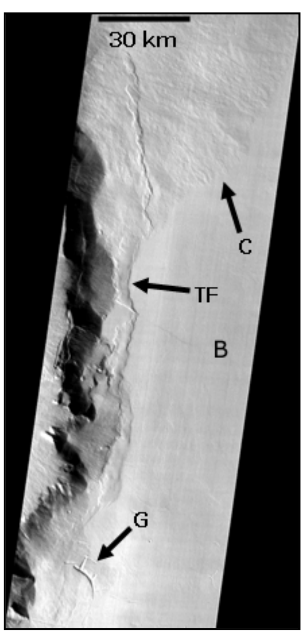

Figure 1 (left): Portion of Mosaic of THEMIS Day IR images I01028005 and I01390005. The western half of the basin (B) is shown. The contact (C) between the lava flows and the overlying sediments is labeled, and is clearly visible in THEMIS Vis image V01028006. The thrust fault (TF) is labeled, and is clearly visible in THEMIS Vis image V06583017. An arcuate graben (G) previously identified by [2] is also labeled. The center of this mosaic is at approximately 17.6° N, 231.5° E.

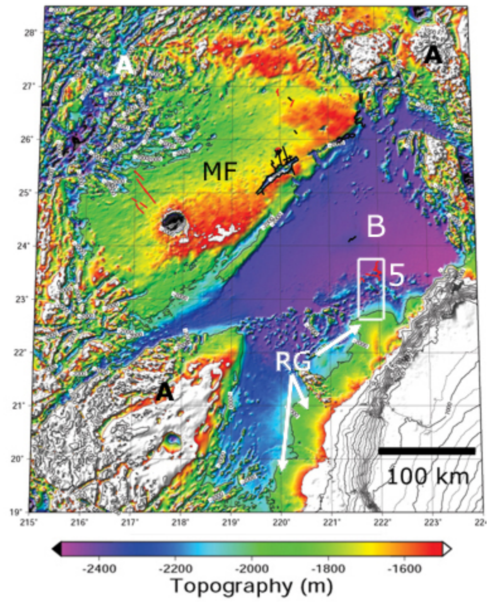

Figure 2 (above): MOLA topographic map of the northwestern basin (B). MF represents a portion of the Medusa Fossae unit mapped by [9], RG shows the location of rock glacier deposits identified by [5, 6], and A represents aureole deposits. The area covered by Figure 5 is boxed and labeled.

Results: *Evidence for Ponded Water:* Two areas around Olympus Mons show evidence of past ponded water (enclosed basin, topographic low, extremely smooth, sediments overlying other features): a small basin near the eastern basal scarp, and a larger area to the northwest of the volcano.

The eastern basin (centered at ~17.6° N, ~231.3° E) is about 60 km wide, 160 km long, and 500 m deep. It is topographically enclosed, and has an RMS roughness that ranges from 0.7 to 1.0 m in MOLA pulse width data, significantly smoother than its surroundings, which average between 4 and 10 m. The basin is located just east of the basal scarp, and appears to be filled with sediments, which cover lava flows from the edifice (Figure 1 C). A wrinkle ridge cuts these lava flows and traces the western side of the basin (Figure 1 TF).

The northwestern basin (centered at ~24.5° N, ~221.5° E) is much larger: nearly 300 km across, 200 km long, and 500 m deep. It too is topographically low and enclosed (Figure 2), and has a roughness that ranges from 0.7 to 1.0 based on MOLA pulse width data, compared to a roughness between 5 and 15 m for its surroundings. No lava flows were observed within the basin. The unusual smoothness, flatness, low elevation, and lack of lava flows in the middle of a region made of rough, high elevation aureole blocks and lava flows all suggest that this basin also once held ponded water [10].

Evidence for a Relationship Between Channels and Tectonic Features: Previous authors have suggested a relationship between tectonic features and fluvial activity near Olympus Mons [1]. The THEMIS IR and VIS data examined in this survey provide further evidence for such a relationship. Of the 110 tectonic features (faults, wrinkle ridges, graben, etc.) examined in this survey, 79 were associated with or modified by fluvial activity.

Evidence for a "Spillway": Between the northeast aureole lobe and the Tharsis rise is a narrow, flat plain filled with lava flows. This plain runs continuously for several hundred km, up to the northern edge of the North aureole lobe.

Several THEMIS-VIS images (v05834011, v02139009, v05909003, v08518015, v01490006, v02988003, v02314010) show that this plain is covered with scoured surfaces (Figure 3 B), wide and shallow channels (Figure 3 A, C, D), and stream-lined islands (Figure 3 C, D).

Discussion: This survey found evidence for extensive fluvial activity around Olympus Mons and its aureole deposits. Here we discuss where the water may have come from, where it went, and how it may relate to the tectonics around Olympus Mons.

For the northwestern basin, fluids may have come from a variety of sources. Water has been expelled from the aureole lobes along their margins [3], so water from the northern lobe may have ponded in the northwestern basin. Water may also have come from melting of the nearby glaciers [5,6]. Although these workers proposed that these glaciers were cold-based, this survey found THEMIS Day IR images showing several channels near these deposits that may be related to basal melting.

For the eastern basin, we interpret the wrinkle ridge running along the basin's edge as a thrust fault indicative of volcanic spreading (e.g., [11]). Further, we propose that water squeezed out along a pressurized detachment from a water-rich layer below Olympus Mons [3] then ponded in the eastern basin, depositing the smooth sediments that now cover the lava flows off the edifice. Since it is a topographic low in the area, the basin may also have been filled by run-off from the surroundings; however, no channels running into the basin were observed. We hypothesize that a similar process of water moving along a pressurized detachment fault from below Olympus Mons may have supplied the water needed to form the glaciers on the western side of the volcano. The fault, though not observed, may be hidden beneath the glacier deposits. The channels observed near the deposits may therefore have come from basal melting or from water moving along the fault.

Further evidence for a water-rich layer beneath Olympus Mons comes from the relationship of tectonic and fluvial features seen around the volcano. Faults are well-known as zones that can facilitate the transport of fluids, and we propose that faults and grabens around Olympus Mons serve as conduits for liquid water to reach the surface [1]. This survey has provided further evidence for a groundwater system beneath Olympus Mons, and suggests that it is extensive, extending at least below the southeastern, eastern, and northeastern aureole lobes.

Water issuing from the groundwater system through tectonic features may have joined water running down off the Tharsis rise (e.g., [1]) to produce the features seen in the spillway. The scouring and wide, flat channels observed in the spillway suggest that the flows were rapid, and the absence of deep narrow channels and incomplete stream-lining of islands suggest that the flows were short-lived.

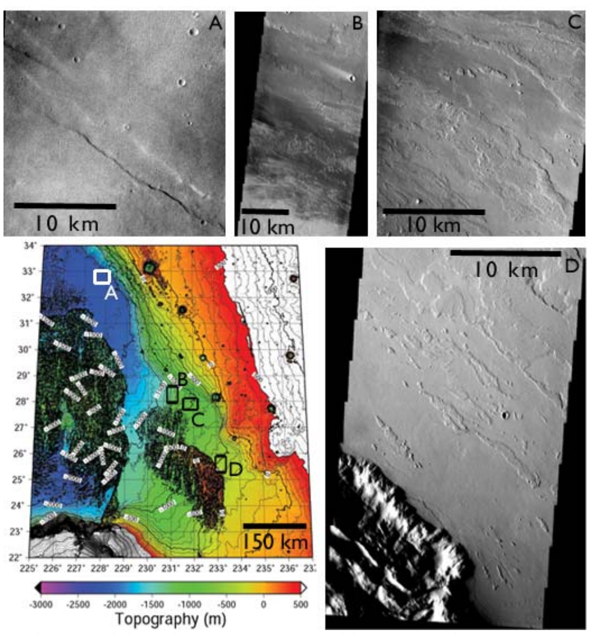

Figure 3 (above): MOLA topographic map of the northeastern aureole lobe (bottom left). The spillway runs from the lower right to upper left, above the northeastern and northern lobes. Some interesting features from THEMIS Vis images: (A) a graben modified by water (uneven banks, flat bottom, branching to the north) from V02988003. (B) Scoured surface from V02164008. (C) Flat, broad channel carved in lava flows with stream-lined islands from V02139009. (D) Flat, broad channel carved in lava flows with stream-lined islands from V05833011.

References: [1] Mouginis-Mark PJ (1990) Icarus 84: 362-272. [2] Chittenden D and McGovern PJ (2004) Proc. of Lunar and Planetary Science Conference XXXV, Abstract #2074. [3] McGovern PJ et al. [2004] JGR *in press*. [4] Wilson L and Mouginis-Mark PJ (2003) Icarus 165: 242-252. *[5] Milkovich SM and Head JW (2003) Sixth International Conference on Mars, Abstract #3149.* [6] Head JW et al. (2003) Third Mars Polar Science Conference, Abstract #8105. [7] Smith et al. (2001) JGR 106: 23689-23722. [8] Neumann et al. (2003) GRL 30: 15-1. [9] Morris EM and Tanaka KL (1994) USGS Map I-2327. [10] Morgan J, personal communication, June 2004 [11] Borgia A et al. (1990) JGR 95: 14357-14382.