EVOLUTION OF THE OLYMPUS MONS CALDERA, MARS

Peter J. Mouginis-Mark[1]; Mark S. Robinson[1]; and Maria T. Zuber[2]. 1: Planetary Geosciences Division, SOEST, Univ. Hawaii, Honolulu, HI, 96822; 2: Code 621 Goddard Space Flight Center, Greenbelt, MD 20771.

Extensive high-resolution (15 - 20 m/pixel) coverage of Olympus Mons volcano permits the investigation of the sequence of events associated with the evolution of the nested summit caldera, thereby extending our previous study (1). The sequence of intra-caldera events is well illustrated by image data collected on orbits 473S and 474S of Viking Orbiter 1 (Fig. 1a). These data cover both the oldest and youngest portions of the caldera floor. Our observations permit the following chronology for the caldera floor to be inferred, which in turn can be interpreted in terms of the internal structure of the volcano (i.e., magma chamber depth, existence of dikes; ref. 2, 3):

Stage 1: The first preserved summit event was the catastrophic collapse and subsequent partial infilling of crater #1 (Fig. 1b). Our own shadow length measurements of the preserved wall (Viking frame 890A68, 156 m/pixel) indicate that at least 1,100 ± 60 m of collapse took place. Wall material from this collapse is now buried beneath younger materials. **Stage 2**: Subsidence across the entire caldera floor promoted the formation of the radial and concentric ridges similar to lunar mare ridges (Fig. 2). Continued subsidence (~1,300 ± 120 m of displacement) of the central portion of crater #1 created an extensional environment close to caldera wall and a compressional environment closer to caldera center. Concentric graben and ridges formed on the floor (Fig. 2). The transition from graben to ridges (local extension to compression) occurs at a radial distance of ~17 km from the center of the 65 km diameter caldera, and has been used to infer the magma chamber depth (2, 3). **Stage 3**: New collapse events occurred to the west, forming crater #3. A similar episode of circumferential graben formation took place within this portion of the caldera. **Stage 4**: Additional new collapse events just south of the caldera center post-date graben formation within craters #1 and 3. **Stage 5**: On the basis of morphologic evidence for resurfacing, during (or just after) its formation, the combined floor of craters 4 and 5 was probably occupied by a large lava lake. Linear ridges formed on surface that are interpreted to be compressional features produced by local convergence (rafting) on the lake surface. These ridges (Fig. 3) cross boundaries of craters 4 & 5, indicating that both craters were flooded (and, by inference, were convectively overturning) at the same time. **Stage 6**: Partial drainage of the lava lake surface produced a bench around perimeter of crater 4. **Stage 7**: Continued subsidence of entire summit area produced a compressional environment that promoted the formation of large (>3 km wide) wrinkle ridges in craters 1, 2 and 5 (Fig. 3). The numerous linear ridges formed in Stage 6 are now preserved on top of these larger wrinkle ridges. **Stage 8**: Final collapse event of ~350 m displacement produces crater #6. There is no evidence of surface features that could be associated with dynamic overturn of the lava lake on this crater floor. Nor is there any evidence of subsequent tectonic deformation.

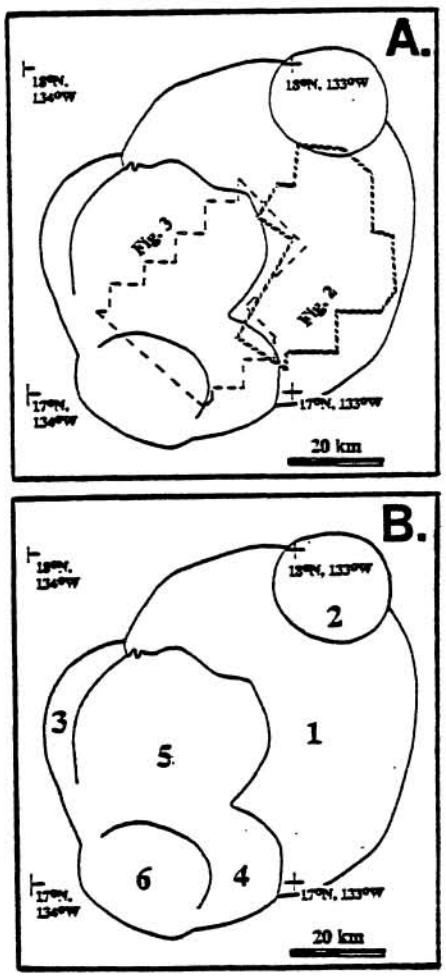

Fig. 1a (Top): Data coverage from Orbits 437S (Fig. 3) and 474S (Fig. 2). Fig. 1b (Bottom): Sequence of caldera collapse episodes. "1" oldest, "6" youngest (ref. 1).

OLYMPUS MONS CALDERA
Mouginis-Mark, P.J. et al.

This sequence of events demonstrates that Olympus Mons underwent a protracted period of summit activity. While all segments of the caldera floor possess craters that are interpreted to be impact in origin, no pronounced difference in crater size/frequency curves has been observed for different segments of the caldera floor, implying that all of the observed events probably occurred in a relatively short period of martian history.

References:
1) Mouginis-Mark, P. J. (1981), Proc. Lunar Planet. Sci., **12B**, p. 1431 - 1447. 2) Zuber, M. T. and Mouginis-Mark, P.J. (1989). *Proc. MEVTV Conf. on Tectonic Features on Mars*, LPI, Houston. 3) Zuber, M.T. and Mouginis-Mark P.J. (1990) This vol.

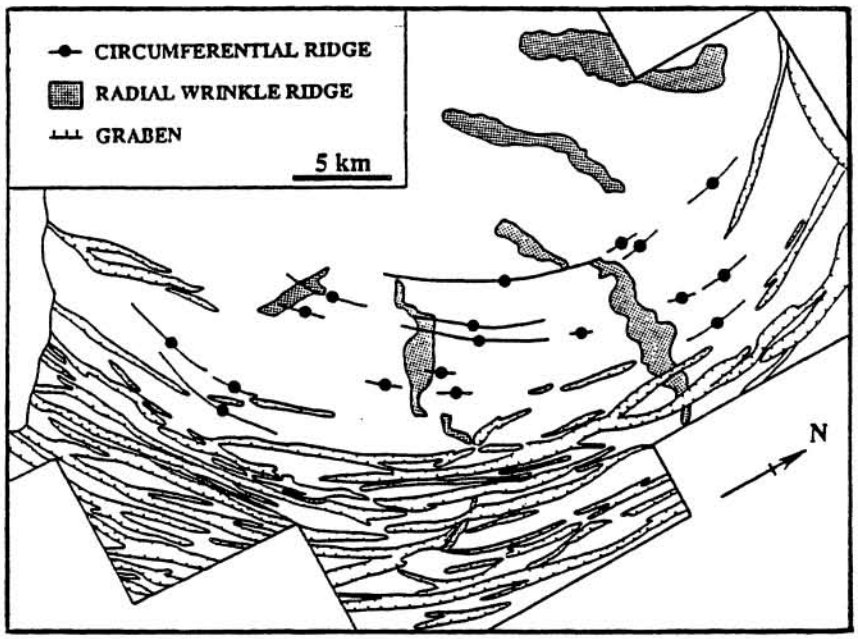

Fig. 2 (Top): Distribution of circumferential graben and ridges within the oldest portion (crater #1) of the Olympus Mons caldera. Note that these graben are truncated by the wall to crater #4. See Fig. 1a for location. Mapped from Viking Orbiter frames 473S27 - 29, 474S25 - 30.

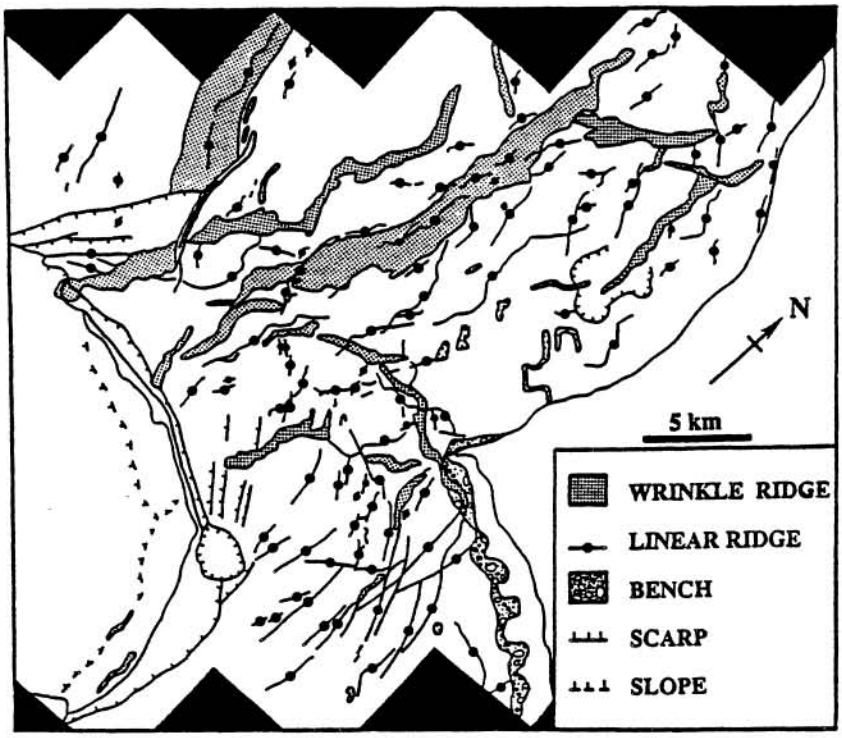

Fig. 3 (bottom): A complex series of linear ridges is seen on the floor of craters 4 and 5, indicating that a large over-turning lava lake may have existed soon after the initial collapse event. Note that these linear ridges are superposed upon the younger wrinkle ridges. See Fig. 1a for location. Mapped from Viking Orbiter frames 473S17 - 26.

Acknowledgement: The help of Eric Eliason at USGS Flagstaff in recovering the digital data used here for frame 860A68 is much appreciated.