FORMATION AND EVOLUTION OF SURFACE AND SUBSURFACE STRUCTURES WITHIN THE LARGE CALDERA OF OLYMPUS MONS, MARS.

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Introduction: A series of ridges and troughs, interpreted as contractional and extensional features [1], occur within Olympus Mons' largest caldera. These features trend sub-parallel to the rim and sub-circumferential to the caldera center. Ridges occur within a radial distance of ~16 km from the center and troughs (graben) occur at a radial distance of 16 km to 32 km [1-4]. Here we use these features in conjunction with physical caldera collapse models to suggest an associated subsurface structural configuration for Olympus Mons as well as a previous evolution of the caldera roof.

Data and Methods: Building on mapping from Viking data [1-4], we used images from the Context Camera (CTX, 6 m/px) in this work. CTX images were radiometrically corrected and projected using the Integrated Software for Imagers and Spectrometers (ISIS; [5-7]). The processed images were then imported into ArcGIS for mapping of the locations and measurement of the aerial extents of the ridges and graben.

Scaled physical experiments on caldera collapse [8] show a strong dependence of faulting style on roof aspect ratio (the ratio of the vertical to horizontal dimensions). Our data from Olympus Mons in conjunction with the results from [8] allows us to constrain the aspect ratio and corresponding depth to the magma chamber at the time of collapse.

Evolution of structures associated with the collapse of caldera roofs of various aspect ratios has also been modeled [8,9]. Thus, using MOLA data with both the newly mapped and previously observed [1-4] surface features in Olympus Mons' caldera, we can propose a scenario for the structural evolution of the caldera.

Results:

Current subsurface configuration: Using the method of [8], we found the measured 70% surface area of extension would be associated with a roof aspect ratio of ~0.5 and a corresponding depth to the magma chamber of ~32km.

According to the experiments of [8], the graben would likely be associated with a series of subsurface normal faults making up a ring of tilted material within the roof (shown in blue in figure 1e) with the master normal fault occurring at the caldera rim. Dips between 50° to 65° would be consistent with those observed in physical experiments [8].

Also following [8], we suggest that the ridges are surface manifestations of reverse faults (red in figure 1e) that dip away from the caldera center, with the master reverse fault being the most inward occurring fault. Modeling shows that the dips of these faults are likely between 45° to 85° at the surface, and may vary throughout the caldera [5].

Structural evolution: We used the observed evolution of modeled (experimental) collapse features [5] to suggest a possible series of events that led up to the current features observed in Olympus Mons' caldera. Figures 1a-d represent theoretical configurations beginning after initial subsidence took place above the magma chamber by flexure of the roof (step 0). Figure 1e representes the current configuration. This assumption is based on a consistent roof aspect ratio during collapse.

1. Two subvertical fractures initiate at the top of the magma chamber at opposite sides of the caldera (fig. 1a).

2. As these fractures propagate toward the surface, their dips vary from vertical resulting in one inward and one outward dipping fault. Downward displacement of the central block causes the inward dipping fault to become normal (N1) and the outward dipping fault to become reverse (R1). In map view both R1 and N1 extend outward on each side, continuing to trend circumferential to the caldera center. The normal fault keeps a relatively consistent dip at the surface of about 50° to 65°, while the reverse fault steepens away from the initiation point varying from 45° to 85°(fig. 1b).

3. As subsidence continues, a second reverse fault (R2) initiates on the opposite side of the caldera from R1, while a second normal fault (N2) initiates opposite that of N1 (fig. 1c).

4. Both R2 and N2 grow outwards until they interact with the end segments of R1 and N1 respectively. Here they cross at shallow angles as presently observed in map view. As a result of continuing downward shifting of the tilted block, a series of normal splay faults develop simultaneously with a series of reverse splay faults between R1 and N1 as well as R2 and N2. The oldest normal splays occur in the outer section of the block and younger faults progressively migrate inward toward R1. The oldest reverse faults occur closest to the caldera center and progress outward. As a result, small blocks bounded by these splays break away and slide further into the depression (fig. 1d).

5. The reverse and normal faults continue to propagate toward each other. This step represents the current structural configuration observed on the surface and a possible current subsurface configuration (fig. 1e).

Future work will include testing the proposed scenario. We also plan to apply this analysis technique to other martian calderae in order to assess temporal and spatial trends of caldera collapse on Mars.

References: [1] Mouginis-Mark P. J. and Robinson M. S. (1992) *BVOL*, *1992*, *54*, 347–360. [2] Zuber M. T. and Mouginis-Mark P. J. (1990) *LPS XXI*, *1387-1388*. [3] Watters T. T. and Chadwick D. J. (1990) *LPS*, *21*, 1310. [4] Zuber M. T. (1992) JGR, 97, 18,295-18,307. [5] Gaddis, L. et al. (1997) *LPS. XXVIII*, 387. [6] Torson J. M. and K. J. Becker (1997) *LPS XXVIII*,1443. [7] Anderson J. A. et al. (2004) *LPS XXXV*, 2039. [8] Roche O. et al. (2000) *JGR*, 105, 395-416. [9] Kennedy B. et al. (2004) *GSA Bulletin*, 116, 515-524.

Figure 1: Evolution of surface and subsurface structures shown in plan (top) and cross-sectional (bottom) views. Normal faults are shown in blue and reverse faults are displayed in red.