GEOLOGY OF THARSIS THOLUS, MARS.

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Introduction: Tharsis Tholus is one of several volcanoes on the margin of the Tharsis volcanic province at 13.5°N, 91°W. The construct ~155 km x 126 km, reaches altitudes of +9 km and is characterized by large normal faults that cut the entire edifice (Figure 1). It is unique among the Tharsis volcanoes in the extent to which it has been deformed by tectonism.

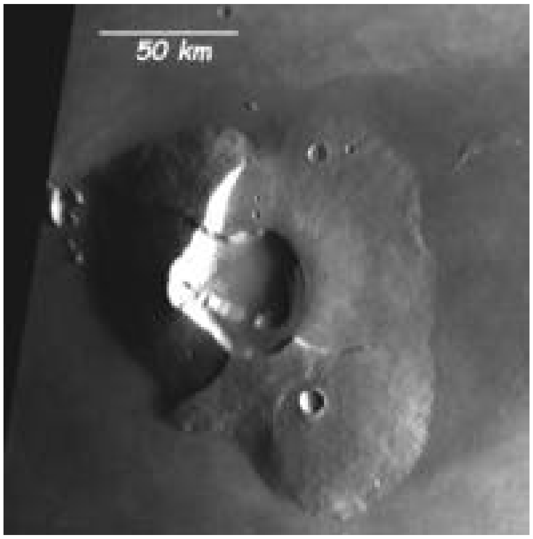

Figure 1. Tharsis Tholus. Note large scale normal faults cutting the edifice.

Geology: Most of the structure is mapped as flank material. There is relatively little variation in the surface morphology. Some areas do appear more hummocky than others, but the variations are not large. In some places the flank exhibits a radial texture suggestive of unresolved lava flows. The subdued appearance may be due to the limited resolution of Viking images and atmospheric obscuration; but MOC images indicate that some degree of surface mantling has occurred (Figure 2). MOC frames (23106) shows plains adjacent to the west flank on which the volcanic texture is preserved, suggesting the mantling may be restricted to the edifice. Apparent slopes are variable, ranging from ~4° to 16° with a convex profile. Depending upon the geometry of the MOLA profile and the actual slopes, these values may be minimum values.

The caldera is a complex structure with several down dropped blocks on the margin. In most places the interior scarp is a simple steep scarp, although the morphology of the scarp varies. The eastern edge is marked by several narrow fault slices with variable amounts of down dropping. The upper wall is fluted with exposed bedrock; talus occurs on the lower slope. MOLA data indicate the slope walls are 27°-30° which suggests talus rather than exposed bedrock. Four large amphitheater-shaped re-entrants occur in the caldera wall. At the bases of these re-entrants are landslide materials.

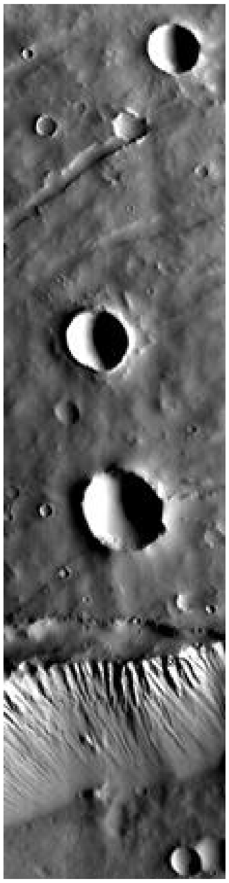

Figure 2. Northern caldera rim and adjacent flank. Note fluted upper caldera wall suggesting exposed bedrock, mantled nature of the flank; and northeast trending graben. Portion of MOC image 43405; scene is 0.8 km x 3.5 km.

Structure: Two fault types cut the flank: narrow northeast-trending graben and large normal faults which appear to dissect the entire edifice. These are in addition to the faults that form the caldera margins. Pit chains are also observed. Graben are simple structures, ~0.5 to 2.8 km wide, having single scarps on either side. These narrow graben occur across the entire edifice surface and strike about N58°E in a direction radial to Tharsis. Presumably they are related to one of the Pavonis faulting centers defined by [1]; however there is insufficient stratigraphic control to determine which center.

The large normal faults divide the edifice into 5 sectors. The western and eastern sector are dropped down with respect to the northern and southern sectors. The fault scarps are 400 m to 1 km high and have slopes of about 15°.

Chronology: Crater counts have been compiled from several Viking orbiter and MOC sequences. The Viking images used have resolutions of 23 to 252 m/pixel and show similar results. The 669A data (23 m/pixel) have crater numbers of N(2)=839±439 and N(5)=192±210 indicating an Early Hesperian age. Counts using MOC image 43405 are difficult to reconcile with the Viking counts. MOC images cover such a small area that there are large statistical uncertainties. In addition there is little or no overlap in the data sets. Frequencies based on the MOC image for N(2) are a factor of 4-16 higher. An Early Hesperian age for Tharsis Tholus would make it older than the Uranius Group to the north [2].

Discussion: Younger volcanic plains clearly embay the construct margins. Whitford-Stark [3] suggested ~850m of burial; Robinson [4] suggests 3.5 km, both based on ratio analogies to terrestrial volcanoes. The only data point that might indicate the plains thickness and hence provide an objective limit on burial is a partially buried crater east of the edifice. That crater has an apparent diameter, based on an exposed arcuate piece of cratered terrain, of ~47 km. However, the eastern flank of Tharsis Tholus has a concave boundary that might represent the actual crater rim, in which case the crater diameter is ~70 km. If so, it suggests the lavas are no more than 400-500 m thick. Assuming a 15° flank slope, then only about 1 - 5 km of the margin would be buried.

The narrow northeast-trending graben indicate the edifice experienced an episode of northwest-directed extension. Graben do not appear to cut the large normal faults, hence they predate them. Timing of both types of faulting are only poorly constrained as post Early Hesperian (the age of the edifice) and pre-middle Amazonian (the age of the surrounding unfaulted plains). The edifice cutting normal faults may indicate large-scale sector collapse of the flanks, as was also suggested by [4, 5]. Large scale deformation occurs in several terrestrial volcanoes and has been discussed by[6]. Of the various terrestrial examples, the Nicaraguan volcano Maderas [7] may be one of the better analogs. Maderas is built on Quaternary lake sediments and is cut by a number of large normal faults. The load of the volcanics causes sagging and brittle faulting of the edifice. If this is an analog for the deformation of Tharsis Tholus it suggests a weak layer at the base of the construct.

The large caldera indicates that a sizable magma chamber existed beneath or within the volcano. The relatively steep flank slopes suggest the style of volcanism may be more silicic (i.e., higher viscosity) than that which characterizes the other small volcanoes and the large shield of Tharsis.

References: [1] Plescia, J. and Saunders, R. (1982) *JGR*, *87*, 9775-9791. [2] Plescia, J. (2000) *Icarus*, 143, 376-296. [3] Whitford-Stark, J. (1982) *GRL,87*, 9829-9838. [4] Robinson, M. (1993) Dissertation, University of Hawaii., 257 pp. [5] Robinson M. and Rowland, S. (1994) *Geological Society of London*, *44*. [6] Borgia, A., Burr, J., Montergo, L., Morales, W., and Arvarado, G. (1990) *JGR*, *85*, 14358-14382. [7] Van Wyk de Vries, B., and Borgia, A. (1996) *in* Volcano instability on the Earth and Other Planets, Geological Society Special Publication 110, pp. 95-110.