VALLES MARINERIS--GRAVITY AND TECTONICS; K. L. Tanaka, N. E. Witbeck, and D. H. Scott, U.S. Geological Survey, Flagstaff, Arizona 86001

As part of a detailed mapping project of the Valles Marineris-Noctis Labyrinthus region of Mars (1:2,000,000 scale), Viking gravity profiles over the chasmata are being studied. This work involves (1) selection of favorable profiles, (2) simulation of topographic effects (Bouguer correction), and (3) modeling of the isostatic correction. These procedures and our preliminary results are reported here.

Five gravity profiles were obtained by Viking Orbiter 2 [1] over the deepest Valles Marineris canyons, between longitudes 50° and 90°. Of these profiles, those of revs 487, 489, 528, and 641 are dominated by regional, high-amplitude anomalies or complicated by local anomalies north and south of the canyons. Because of these complexities, those profiles were not studied. However, the profile of rev 488, which passes over the center of Valles Marineris (Melas, Candor, and Ophir Chasmata), is dominated by a gravity low centered over the canyons (Fig. 1). This profile, therefore, is suitable for a simplistic gravity analysis of the canyons.

The gravity effect of topography is accounted for on a new topographic map of Mars [2]. This map, showing 1-km contours superposed on the 4th-order spherical harmonic geoid of Mars [3], was converted into a terrain model for the area between lat 40° S. and 20° N. and long 40° and 90°. In the canyon region, where relief is high and slopes are steep, 1° by 1° latitude-longitude bins were used; in the surrounding plateau regions, 2° by 2° bins suffice. Theoretical line-of-sight gravity profiles were then determined by using the orbital simulation program of the Geophysical Data Facility at the Lunar and Planetary Institute in Houston.

The range in profile relief resulting from this simulation was too great to match that of the observed gravity profile. Thus, a subsurface correction was introduced that represents a compensation mass at depth. This mass was opposite in sign to the anomalous mass produced by the topography. Of the various simulations of depths of compensation, 50- to 75-km depths produced optimal simulation of the regional effects, particularly of the southern limb of the profile (Fig. 1). These depths, although somewhat lower than estimates for the old cratered terrain [4, 5], are in the range of values estimated for the large shield volcanoes of Tharsis Montes and Elysium Mons [6].

The theoretical anomaly over the canyons, however, remained too high. Again, it can be attributed to a subsurface anomaly. If the canyons are relatively young features to which the subsurface mass distribution has not responded, then a different subsurface geophysical model is required. Valles Marineris dissects the high-elevation area of the Lunae-Sinai Plana. If the subsurface has been compensated according to the pre-Valles Marineris topography, then a large compensating mass for the presently missing material in Valles Marineris should be introduced into the model. When we respond by placing negative masses at compensation depth below the central canyons and below Hebes Chasma, we approach a reasonable fit for the observed gravity profiles within geologic constraints (Fig. 1). The north limb of the profile, however, is not closely simulated. This offset may be caused by unknown subsurface mass deficiencies or overestimation of surface elevations.

A possible tectonic history for Valles Marineris, in accord with this preliminary gravity study and our detailed mapping and stratigraphic work, is as follows:

(1) An elongate thermal anomaly developed under the Valles Marineris region, where the lithosphere was originally about 100 km thick.

(2) The thermal anomaly eroded the lithosphere, converting it to asthenosphere and thinning it to 50 to 75 km. Concomitantly, the region was uplifted and rifting was initiated because of the volume increase produced by melting at the base of the lithosphere.

(3) Effusion of magma and removal of ground ice and canyon material by erosion resulted in continued rifting and expansion of canyons. These processes caused a mass imbalance that for the most part is not isostatically adjusted, but is impeded by the flexural strength of the lithosphere.

[1] Sjogren, W. L. (1979) Science, v. 203, p. 1006.
[2] Wu, S. S. C. and others, NASA TM, in press.
[3] Jordan, J. F. and Lorell, J. (1975) Icarus, v. 25, p. 146.
[4] Sjogren, W. L. and Wimberley, R. N. (1981) Icarus, v. 45, p.331.
[5] Sjogren, W. L. and Ritke, S. J. (1982) GRL, v. 9, p. 739.
[6] Comer, R. P. and others (1985) Rev. Geophys., v. 23, p. 61.

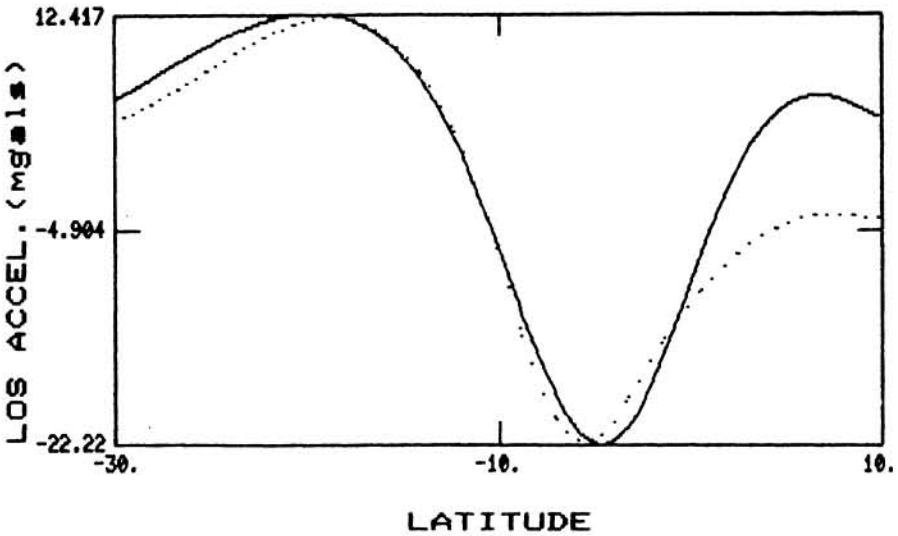

Figure 1. Rev 488 gravity data over central Valles Marineris. Line-of-sight accelerations (dots) and simulated accelerations (solid line) produced by topographic-geophysical model (see text).