POSSIBLE FLEXURAL SIGNATURES AROUND OLYMPUS AND ASCRAEUS MONTES, MARS;
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The effective elastic thickness (h) of the lithosphere provides a measure of the thermal and mechanical state of a planet's shallow interior. An estimate of h in the vicinity of a feature that constitutes a load on a planetary surface can be determined from the flexural response of the lithosphere to the load. This approach has been applied to Mars by calculating radial stresses associated with lithospheric flexure associated with surface loads, and comparing the results to the positions of circumferential graben surrounding the major Martian shield volcanoes and mascon basins [1,2]. However, many prominent surface loads on Mars, most notably the Olympus Mons volcano, do not exhibit flexural graben. In these instances application of the above method can provide only a lower limit of effective elastic thickness [*cf.* 3]. An alternative method of determining h is to calculate the vertical displacements associated with the flexural loading and to compare the amplitude and shape of the flexural profile to observed topography. This method has not been applied to flexural problems on Mars because of the poor resolution of Martian topographic data. However, previous analyses have shown that the lithosphere around major volcanic shields should exhibit vertical deflections of order 1 km over horizontal baselines of order 100 km [1,2]. We were thus motivated to search for the presence of flexural troughs in the existing Mars topography data.

The primary data set that we utilized was a 50^{th} degree and order spherical harmonic expansion that we performed on the Mars Digital Topographic Model (DTM)[4]. Figure 1 shows topographic profiles across three prominent volcanic shields: Pavonis, Ascraeus and Olympus Montes. We also investigated Arsia and Elysium Montes and Alba Patera. Of these features, we have identified possible flexural troughs around Olympus and Ascraeus Montes, denoted by the arrows in the figure. These are the two youngest, and highest, of the major Tharsis shields. These signatures are also present in the Mars DTM. A previous analysis of an earlier verison of the DTM [5] failed to identify the candidate flexural trough around Olympus Mons.

If these features are a consequence of lithospheric flexure in response to the volcanic loads, then h can be constrained from the deflection profiles. We have performed a preliminary calculation of effective elastic thickness for Olympus Mons by treating the volcanic load (q) as a series of superposed cylinders with density 2900 kg m^{-3}. We solved the flexural equation for a thin spherical shell [6]

$$\nabla^2 w + w/l^4 = q/D \tag{1}$$

where w is the vertical displacement, $l\{=D/[(Eh^3/R^2)+\rho g]\}$ is the flexural length, $D[=Eh^3/12(1-\nu^2)]$ is the flexural rigidity of the lithosphere, E is Young's modulus, ν is Poisson's ratio, R is the radius of Mars, $\rho=\rho_m-\rho_p$, and g is the acceleration due to gravity. The solution of (1) for a uniform cylindrical load in which $r_p<<R$ is [7]

$$w = [q/(Eh/R^2+\rho g)]\ [d\ ker'(d)\ ber(x) - d\ kei'(d)\ bei(x) + 1] \tag{2}$$

for $x \le d = r_p/l$ and

$$w = [qd/(Eh/R^2+\rho g)]\ [ber'(d)\ ker(x) - bei'(d)\ kei(x)] \tag{3}$$

for $x \ge d$. The zero–order Bessel–Kelvin functions *ber*, *bei*, *ker*, and *kei* and their derivatives were evaluated following [1]. We found a best–fit elastic thickness of 50 km. This is in contrast to the lower limit of 150 km found using the absence of flexural graben as a constraint. The value we determine is in the range though somewhat greater than values (20–30 km) for the other Tharsis montes that exhibit circumferential graben [1].

The Mars Observer Laser Altimeter (MOLA), with its 330–m along–track spatial resolution, 1.5–m vertical resolution, and 30–m global vertical accuracy [8], is expected to provide a high quality, geodetically referenced topographic model of Mars which should permit the detection of flexural displacements associated with many major topographic loads. If the features we identified are real, they will be detectable with MOLA. Flexural troughs should also be observed in association with most of the other features we examined. MOLA topography should permit independent estimates of effective elastic thickness in the vicinity of these features and new estimates in areas with loads that lack associated concentric graben, such as the polar layered terrains [9].

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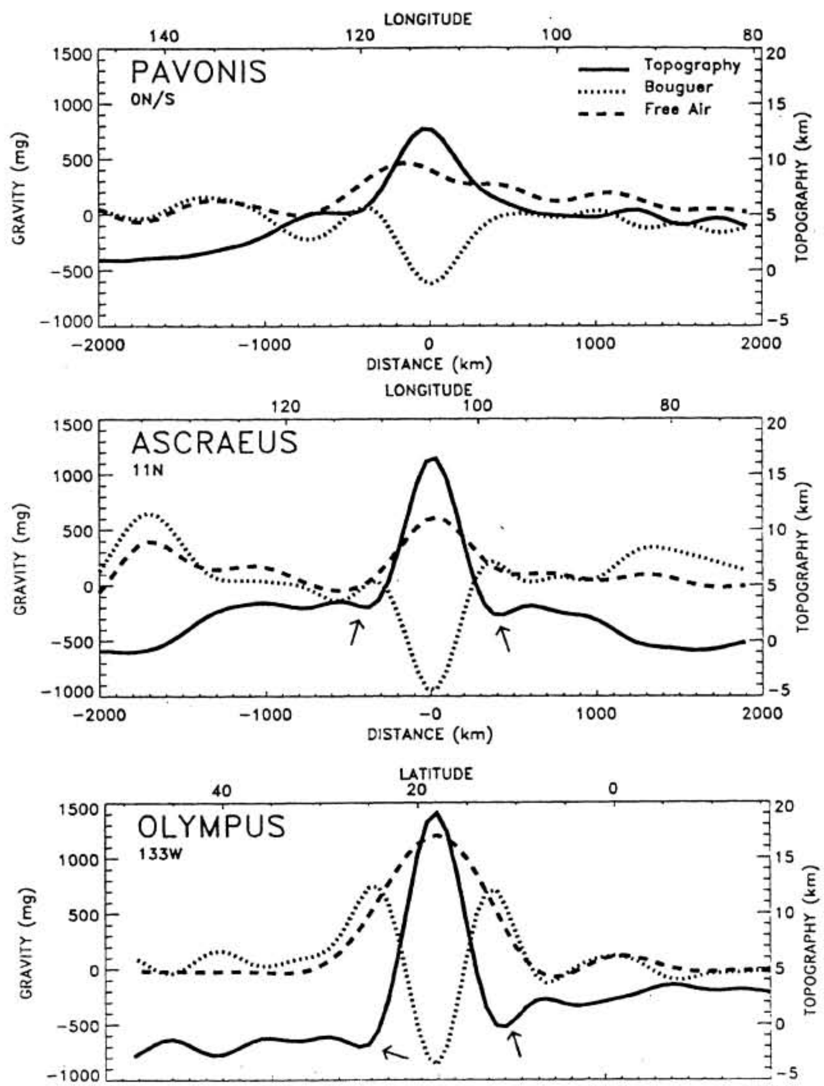

Figure 1. Profiles of topography, and Bouguer and free air gravity anomalies across three Martian volcanoes. Olympus and Ascraeus Montes display possible flexural troughs (arrows). Pavonis Mons does not. Topography is from a 50[th] degree and order spherical harmonic expansion of the MarsDTM [4]. Gravity is taken from Goddard Mars Model–1 (GMM–1) [10].