ON THE REORIENTATION OF MARS BY THE THARSIS RISE.
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Apart from rotational flattening, the major departure of Mars from spherical symmetry is the Tharsis rise. The geoid high associated with the Tharsis rise is centered near the equator. It has been common to assume that Tharsis could have been constructed at an arbitrary location relative to the Martian equator and that the Martian surface would have re-oriented with respect to the rotation axis so that Tharsis would be at the equator. However, this assumption neglects the fact that an elastic lithosphere will resist motion with respect to the rotation axis due to the rotational flattening [1]. The correlation of a geoid anomaly with the Tharsis rise is evidence that, at least since the time of Tharsis construction, Mars has been capable of supporting non-hydrostatic stresses near its surface. That is, Mars has had an effectively elastic lithosphere at least since the time of Tharsis construction [2].

The reorientation due to a surface load of a planet with an elastic lithosphere has been computed using thin shell theory [3]. It is assumed that the response to the applied load has the same mechanical basis as the response to the rotational flattening load. The amount of reorientation, γ, depends on the colatitude of the applied load, ϕ_o, and on the ratio of the amplitude of the applied load compared to the flattening. this ratio is expressed as

$$f = \frac{1}{C - A} \int_o^{\psi_o} \frac{q(\psi)}{\bar{\rho}\, g\, R} \frac{2}{5} P_2 (\cos\psi)\, d(\cos\psi)$$

where C - A is the difference between the polar and equatorial moments of inertia of the planet, $q(\psi)$ is the applied load as a function of distance from the center of the load, $\bar{\rho}$ is the mean density of the planet, g is gravitational acceleration at the surface, R is mean radius of the planet, and P_2 is the second degree Legendre polynomial. The reorientation is independent of the strength of the lithosphere. The dependence of the reorientation on the amplitude and colatitude of the applied load is shown in Figure 1. The difference between the curve for any finite f and the curve for f >> 1 shows the final latitude, ϕ_f, of the load. For Tharsis $f \approx 0.3$ and $\phi_f \lesssim 10°$ [2]. Thus, $\gamma \lesssim 5°$.

In addition to computing re-orientation it is also possible to compute stresses from thin shell theory. The equator about the rotation axis after reorientation will be a region of tensional stresses in part because the equatorial circumference is larger than other great circle circumferences. Although most of the tectonic faulting around Tharsis can be explained by an axisymmetrical load model [2,4], Valles Marineris is enigima to axisymmetrical models because it is the largest zone of tectonic faulting in the region and is clearly not axisymmetrical. However, if the stresses due to reorientation are included, especially tension near the new equator, then an axisymmetrical load may be taken at least to contribute to the stresses which give rise to Valles Marineris.

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