MARS: GRAVITY, TOPOGRAPHY AND DYNAMIC COMPENSATION

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It is difficult to explain the relative amplitude of Martian gravity anomalies, as compared to the topography, in terms of purely static support (1,2,3). Figure 1 shows the observed gravity/topography spectral admittance inferred from harmonic analyses of gravity (4) and topography (5), both referred to hydrostatic values of J2 = 812.9 10-6 and J4 = 2.7 10-6 appropriate for a body with normalized moment of inertia I/MR2 = 0.365 (6,7,8). Also shown are admittance values for Airy compensation at depths from 100 km to 600 km (9). Pratt compensation curves for depth 2d are virtually identical to Airy curves for depth d (10,11). In the context of this figure, the argument against static support can be easily summarized in two parts: a) the implied depths of compensation of the low degree harmonics are great enough that, under any plausible thermal/rheological scenario, the material should have no significant long term strength, and b) different depths of compensation are required for each harmonic degree, contrary to a basic assumption of the model. On the basis of arguments similar to this, it has often been concluded that at least part of the gravity and topography of Mars must be dynamically supported. However, it appears that no models which explicitly include dynamic support have been applied to Mars.

We have recently applied a dynamic compensation model (12,13) to the topography and gravity of Venus (14,15,16), with excellent results (17,18). A major focus of the the present study is a similar application to Mars. We have used a five layer model for the internal structure of Mars (19). The bounding radii (km) and unperturbed densities (g cm-3) for the layers are: core (1690, 6.40), lower mantle (2250, 4.05), upper mantle (2940, 3.55), lower lithosphere (3340, 3.45), and crust (3390, 2.75). We have, in all cases, assumed free-slip boundary conditions at the core-mantle interface, and no-slip boundary conditions at the free surface. The major unknowns are the radial variations of viscosity and perturbing density outside the core. Figure 2 shows the model admittance for an extremely simple case: both viscosity and perturbing density are uniform throughout the mantle (1690 to 2940 km). We have considered more complex models, but none have fit the observed admittances appreciably better. The main point is that in order to match the observations, the density perturbation must be confined to the very deep interior. We conclude that the topography and gravity of Mars are, in fact, dynamically supported, but that more detailed inferences concerning the viscosity or perturbing density stratification will be difficult to obtain.

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