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CONSTRAINTS ON MARS' CRUSTAL STRUCTURE FROM CORRELATIONS OF GRAVITY AND AREOID WITH TOPOGRAPHY

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Spatial domain point correlations of gravity and areoid with topography on Mars are used to evaluate the extent of isostatic compensation (isostasy) for Martian surface features and constrain mean reference level crustal thickness for areas on the planet where Airy isostasy is a viable support mechanism. Regional correlations are carried out within long-wavelength spatial windows over the surface of Mars using point data values obtained from spherical harmonic solutions for Mars' global gravitational potential (Yuan et al., 2001) and topography (Smith et al., 1999) derived, respectively, from Mars Global Surveyor (MGS) Doppler tracking and altimetry data. We address the influence on Airy crustal thickness modeling results of departures from Mars' hydrostatic shape and areoid (essentially attributed to the Tharsis rise) by considering harmonic expansions for both gravity and topography defined by degrees 4 and 5 through 60. For a given data window location, a linear regression of Bouguer gravity anomalies versus gravity from uncompensated topography yields a regional degree of isostatic compensation C. We find that an appreciable portion of Martian surface topography is substantially isostatically compensated with $70\% \leq C \leq 100\%$ and a mean degree of compensation $\overline{C} \sim 82\%$. Assuming Airy isostasy, areoid anomaly (N) versus topography variation (h) data within a given window are then compared, in the least squares sense, to theoretical (h, N) correlations for the Airy compensation model yielding a regional crustal thickness at the reference zero elevation $H(h = 0)$. For those areas on Mars which meet selection criteria based on significantly compensated topography ($70\% \leq C \leq 100\%$), physically meaningful reference crustal thickness (50 km $\leq H \leq 130$ km), and small rms for Airy model fit, we find a mean reference level crustal thickness $\overline{H} \sim 80$ km. Regions which satisfy these selection

criteria are located essentially along the hemispheric dichotomy boundary zone and within the southern hemisphere highlands (Tharsis rise excluded) including most of the large Hellas impact basin and surroundings. For a $32° \times 32°$ region located in the north east rim of Hellas (NEH) we obtain $C_{\mathrm{NEH}} \sim 87\%$, and $H_{\mathrm{NEH}} \sim 83$ km, consistent with the obtained mean values. Without crustal recycling, magmatism could have created the thick present-day crust indicated by this study early in Mars' evolution, with a substantial fraction of radiogenic heat producing elements fractionated into the crust. Hypothesizing that the concentration of crustal radiogenic elements on Mars decreases exponentially with depth as for terrestrial continents results in a colder, high viscosity lower crust which could be maintained against relaxation for a significant part of Martian history.