# THE ISOSTATIC STATE OF MARTIAN TOPOGRAPHY - REVISITED

H. V. Frey, B. G. Bills, R. S. Nerem, Goddard Space Flight Center, Greenbelt MD 20771, 301-286-5450, and J. H.. Roark, Science Systems & Applications, Inc., Lanham, MD 20706.

Phillips and Saunders [1] first discussed the isostatic state of martian topography through a plot of free-air gravity versus gravity from topography. Their analysis was limited by the relatively low resolution gravity then available [2] and by the relatively sparse and low quality of the available topography [3]. We repeat that analysis here using the new higher resolution (degree and order 50) GMM-1 gravity field of Smith et al. [4] and the current USGS topography [5] now available as a digital elevation model. The new gravity field fully resolves anomalies associated with individual structures such as volcanic constructs and the Valles Marineris [4, 6], making possible study of the isostatic nature of localized areas, some of which show significant departures from simple isostatic compensation at shallow depth.

Figure 1 shows GMM-1 free-air gravity versus gravity calculated from topography, assuming a crustal density of 2.9 gm/cm3. The topography used is a spherical harmonic expansion of the current USGS DEM, referenced to the degree and order 50 geoid of Smith et al. [4]. This topography has zero mean elevation and differs from earlier representations (referenced to the degree, order 4 geoid of Jordan and Lorell [7]) by about 2 kilometers. A $\pm 1$ kilometer uncertainty in the topography (USGS, 1989) produces an uncertainty of about 100 milligals in the gravity from topography, comparable to the uncertainty in free-air gravity at higher latitudes. The data sets used here are 1-degree averages.

Figure 1a shows the scatter plot for all 360x180 points. It is obvious that different conditions for isostacy exist. Many points lie along the x-axis (indicating isostatic compensation at shallow depth); others lie along trends with significant slopes (suggesting a lack of isostacy or partial compensation at various depths). Because the resolution of the data allows it, we replot the diagram for specific regions and structures, using current geologic maps for identifying and isolating the regions of interest.

Old units mostly plot along the horizontal axis. The central and eastern highlands (1b), terrain along the crustal dichotomy boundary (1c), knobby terrain away from the dichotomy boundary (1f), and the Hellas, Argyre and Isidis Basin rims (1d) all have this character. The central portions of Hellas and Argyre (1e) plot along the x-axis as well, but the central portion of Isidis, a known mascon [2, 4], is significantly different, with a negative slope. The cratered terrain of Tempe Terra also departs from the isostatic tend. Points from eastern Tempe plot low (1g) compared to other highlands (1b), and points from western Tempe near Alba show a definite slope (1h) suggesting only patial compensation. The central Valles Marineris has a trend departing from isostacy (1i) but outflow channels (1j) appear more nearly compensated.

Among plains units, Lunae Planum appears fully compensated (1k), but other ridged plains of different ages (*Nplr, Hr, Hs, Hsu, Hsl, Htu, Htm, Htl*) show considerably more scatter perhaps suggesting a positive slope (1l). Hesperian age plains in the northern lowland (*Hvm, Hvg, Hvr*, Figure 1m) and Amazonian plains (1n) plot in a similar region of the diagram, which, together with the plains from Daedalia and southern Tharsis (1r) form a trend with a significant positive slope. These may be only partially compensated, perhaps consistent with their younger age. The Utopia mascon has a negative slope (1o) somewhat like that of central Isidis (1e).

Obvious departures from isostacy occur for Olympus Mons (1p), the Tharsis Montes (1q), southern Tharsis plains (1r), and for Elysium (1s). Alba shows the most extreme case with a slope approaching 1 (1t), indicating no real depth of compensation is deriveable.

MARS ISOSTATIC TOPOGRAPHY, Frey, H. V. et al.

The trends described above are generally consistent with full compensation for the oldest features (basin rims, most cratered highlands, the dichotomy boundary), and a lack of such compensation for the youngest features (large volcanic constructs, young lava plains). Lack of total shallow compensation appears to exist for Tempe Terra, the central Isidis and Utopia regions where mascons are present, and for the older volcanic regions of Elysium and Alba.

REFERENCES: [1] Phillips, R.J. and R.S. Saunders, JGR 80, 2893-2898, 1975. [2] Sjogren, W.L., et al., JGR 80,.2899-2908, 1975. [3] Christensen, E.J., JGR 80, 2909-2913, 1975. [4] Smith, D.E. et al., JGR 98, 20,871-20,890, 1993. [5] USGS, Topographic Map of Mars, Misc. Inv. Series, I-2160, 1991. [6] Frey, H. et al., LPSC XXIV, 513-514,1993. [7] Jordan, G.T. and J. Lorell, Icarus 25, 146-165, 1975.