

NEW MARS FREE-AIR AND BOUGUER GRAVITY: CORRELATION WITH TOPOGRAPHY, GEOLOGY AND LARGE IMPACT BASINS Herbert Frey¹, Bruce G. Bills¹, Walter S. Kiefer^{1,2}, R. Steven Nerem¹, James H. Roark^{1,3} and Maria T. Zuber^{1,4}, ¹Laboratory for Terrestrial Physics, Goddard Space Flight Center, Greenbelt MD 20771, 301-286-5450, ²Lunar and Planetary Institute, Houston, TX 77058, ³Astronomy Program, University of Maryland, College Park, MD 20742, ⁴Dept. Earth and Planetary Sciences, Johns Hopkins University, Baltimore MD 21218.

Introduction

This paper compares free-air and Bouguer gravity anomalies from a 50x50 field (MGM-635), derived at the Goddard Space Flight Center [1], with global topography, geology and the distribution of large impact basins. The **free-air** gravity anomalies were derived from re-analysis of Viking Orbiter and Mariner 9 tracking data and have a spatial resolution of 250-300 km. **Bouguer anomalies** were calculated using a 50x50 expansion of the current Mars topography [2] and the GSFC degree 50 geoid as the equipotential reference surface. Rotational flattening was removed using a moment of inertia of 0.365 and the corrections from Table B2 of Sleep and Phillips [3]. Crustal density and mean density were assumed to be 2.9 and 3.93 gm/cm³.

The spherical harmonic topography used in this study has zero mean elevation, and differs from the USGS maps [2] by about 2 km. Comparisons with global geology use a simplified map with about 1/3 the number of units on the current maps [4,5]. For correlation with impact basins, the recent compilation by Schultz and Frey [6] was used.

General Relations

The long wavelength **free-air anomaly** pattern [1] has a crude longitudinal dichotomy: longitudes 210 to 360°W (Elysium westward into Arabia) and 70 to 140°W (Tharsis, Alba) are dominated by positive anomalies and the remainder of Mars by negative anomalies. There is also a crude topographic relation: the highest volcanic and tectonic regions have positive and the deeper impact basins mostly negative anomalies. The relationship is imperfect, however, with strong positives in Isidis and Utopia and broad regions of highstanding ancient cratered terrain having both strong positive and moderate negative anomalies associated with them. **Bouguer anomalies** have more consistency, showing strong negative with flanking positive anomalies over major volcanoes, lower amplitude negatives over most cratered terrain, and general positives over major topographic basins. Below we examine these relations in more detail.

Bouguer Gravity Anomalies and the Crustal Dichotomy Boundary

Bouguer anomalies over heavily cratered terrain are mostly *negative* (150-250 mgals) regardless of elevation [7]. That is, Tempe and portions of SE Acidalia have negative Bouguer anomalies even though they lie 2-4 km lower than most cratered terrain. Two exceptions are low elevation cratered terrain with 50-100 mgal positive anomalies east of Hellas and in Arabia. Most lowlying plains units have *positive* Bouguer anomalies, ranging from 250-300 mgals in Utopia, Chryse and Arcadia to 100-150 mgal in northern Utopia, Acidalia and Amazonis.

Profiles across the dichotomy boundary zone vary in a complicated way. Generally the amplitude of the **Bouguer anomaly** is intermediate over the boundary zone by comparison with the low amplitude negatives over the cratered terrain and the positives that occur in lowlying plains to the north. Exceptions do occur; these are discussed in a companion abstract [7].

Bouguer Gravity Anomalies and Volcanic Constructs

All the major volcanic constructs have *negative Bouguer anomalies* with positive flanking anomalies. Amplitudes systematically decrease with *age* (not size or height) from youngest (Olympus Mons, -1000 mgal) through oldest (Elysium and Alba, -200 mgal). USGS topography and our spherical harmonic expansion both show a moat-like depression around Olympus Mons, which gives rise to a positive Bouguer flanking anomaly of +300 to +600 mgals. This is discussed in a companion paper by Zuber et al. [8]. Ascraeus Mons has a similar but lower amplitude positive flanking anomaly but this feature is missing from the older volcanoes.

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Bouguer Gravity Anomalies and the Valles Marineris

In free-air gravity, the Valles Marineris is dominated by a -250 mgal negative over the central canyons, flanked by 50-75 mgal positives over the narrower eastern and western troughs. **Bouguer anomalies** are positive for the deeper southern canyons, flanked by linear negative anomalies to the north and south. Profiles show the strong, localized positive Bouguer anomaly superimposed on a broader low; this centralized positive is most pronounced over Melas and Coprates Chasmata but also occurs over the narrow Tithonia and Ius Chasmata to the west. The shallower northern canyons (Ophir, Candor, Juventae) do not have this central positive anomaly.

Bouguer Gravity Anomalies and Large Impact Basins

In free-air gravity the Utopia (+200 mgals) and Isidis (+150 mgals) Basins show strong positive anomalies; weaker (< 50 mgal) positive free-air anomalies occur in Hellas, Chryse and Argyre. The **Bouguer anomalies** are different: all these basins show relatively strong positive anomalies (>250 mgals for Chryse to >650 mgals for Hellas). Smaller or less well-defined [6] basins (Ladon, Acidalia) have weaker positive (~ 150 mgal) Bouguer anomalies. For Argyre, Isidis and Hellas the positive anomaly lies within the most prominent ring (see Figure 1); the relative amplitude increases systematically from +350 to +550 mgals with basin diameter: the anomaly width at half maximum power divided by basin diameter scales linearly with the basin diameter normalized by the radius of Mars. The smaller and more poorly defined basins also show a general increase in Bouguer anomaly amplitude with increasing size.

References: [1] Smith, D. E. et al., *LPSC XXIV*, this issue, 1993. [2] USGS *Misc. Inv. Ser.*, Map I-2030, 1:15M, 1989. [3] Sleep, N. H. and R.J. Phillips, *J. Geophys. Res.* 90, 4469-4489, 1985. [4] Scott, D. L. and K. L. Tanaka, USGS *Misc. Inv. Ser.* Map I-1082-A, 1:15, 1986. [5] Greeley, R. and J.E. Guest, USGS *Misc. Inv. Ser.* Map I-1082-B, 1:15M, 1987. [6] Schultz, R. A. and H. V. Frey, *J. Geophys. Res.* 95, 14,175-14,189, 1990. [7] Frey, H. et al., *LPSC XXIV*, this issue, 1993. [8] Zuber, M. T. et al., *LPSC XXIV*, this issue, 1993.

Figure 1: N-S and W-E profiles across Argyre, Isidis and Hellas. Ring locations shown by short vertical lines; diamond shows most prominent ring. Note strong Bouguer positive anomalies.

