Burying the "Buried Channels" on Mars: An Alternative Explanation. A.J. Dombard, M.L. Searls, and R.J. Phillips. Dept. of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Washington University, Saint Louis, MO 63130 USA (adombard@levee.wustl.edu).

Introduction: A surprising feature found in martian gravity models is a suite of negative, linear, troughs in Chryse/Acidalia Planitiae that flank the northeastern edge of Tharsis (Tempe Terra) in the west and the Arabia highlands in the east. In particular, the largest, best-developed trough hugs the edge of Tempe Terra [1], running thousands of kilometers with maximum amplitudes exceeding 150 mGal. It has been proposed that these gravity troughs represent buried fluvial channels, transporting water and sediment from the outflow channels in the south to the northern lowlands [1,2]. Assuming densities appropriate to sediments, the size of this largest gravity trough suggests a canyon 1.5-4.5 km deep [1], putting it in the same league as Valles Marineris, yet these channels do not appear to show any topographic expression, indicating complete burial. Here, we consider the gravity trough flanking Tempe Terra; this analysis is chronicled more thoroughly in [3].

Data Tests: A first question is whether the gravity trough is real or a product of ringing in a truncated spherical harmonic expansion. Because of an additional power law constraint at short wavelengths, gravity models for Mars are only considered reliable out to spherical harmonic degree ~60 [1]. Additionally, degree 60 corresponds to a full-wavelength resolution of ~355 km on Mars, suggesting that a gravity anomaly from a canyon system the size of Valles Marineris may be poorly resolved. A simple, qualitative test for both of these possibilities is to compare several maps expanded to somewhat different spherical harmonic degrees. If a feature is actually due to ringing, then the peak/trough in the various expansions may exist at different spatial locations because there is no physical basis for establishing the position of the signal. Additionally, the robustness of a real feature can be assessed by comparing the mismatch between the features in expansions to somewhat different degrees. We have compared expansions of the MGS85F gravity model of Mars (available from NASA's Planetary Data System) from degree 2 through 50, 55, and 60. Profiles of the free-air gravity perturbation (a gravity measure referenced to the Martian geoid [see 4]) demonstrate that the Tempe Terra gravity trough exists at nearly the same longitude in all three expansions (an association not necessarily true for the side-lobes); however, the mismatch between the expansions indicates that it is relatively poorly resolved at this spatial scale. Thus, the gravity trough is likely a real signal, although its spatial scale is apt to be near several hundred kilometers.

A second question is whether there exists some evidence, albeit possibly quite subtle, in the high-resolution topography for a buried channel. To test this possibility, we perform a detailed examination of the MOLA topography flanking the edge of Tempe Terra. We employ several methods of data analysis to explore subtle changes in elevation corresponding to the proposed channel boundaries, using ENVI (an interactive IDL-based image-processing program). We apply directional or edge filters of various sizes in an attempt to highlight the edge of the channel. Shaded relief maps of the MOLA topography overlaid with a transparent free-air gravity map are also used to emphasize subtle changes in elevation. These images, however, do not show a broad depression centered over the negative gravity anomaly. If the linear gravity anomaly is due to a buried channel, then all traces of the channel have been removed by infilling, surface erosion, or both. The gravity anomaly, however, does directly straddle the boundary that separates the northern lowlands and the southern highlands, a correspondence that is found along the length of this gravity trough. This correspondence, however, seems counterintuitive to the buried channel hypothesis, because the channel should lie exterior to Tharsis in the Chryse/Acidalia basin and not directly straddle the boundary, partly underlying the highlands.

Alternative Explanation: It has already been concluded that the gravity trough does not arise from surface topography [1]. The full gravitational signal due to surface topography at longer wavelengths, however, was likely not detected, because of compensation. To first order, the near-surface interior structure of Mars can be described as a lower density crust overlying a denser mantle [e.g., 1], with shorter wavelength topography supported by the lithosphere and longer wavelength topography tending towards buoyant support via some level of compensation at the crust/mantle boundary. The consequences of this wavelength-dependent support are that shorter wavelength, lithosphere-supported topography is well represented in the free-air gravity, while longer wavelength, buoyantly supported topography is not [see Fig. 5-15 in 5].

This effect can be witnessed globally on Mars by observing the square root of the power spectra ratio [see 4] (Fig. 1) of the free-air gravity perturbation to the topography (both referenced to the geoid). Mars possesses significant extra power in the gravity at degrees 2-4 due to a global response to the Tharsis load [6], and this edge of Tempe Terra sits in a strong, regional, negative gravity anomaly that rings Tharsis and coincides with a broad topographic trough. We do not adjust for this extra power because at the horizontal scale of the features of interest, expansions at degrees 2-4 represent a fairly constant vertical offset. Neglecting the spike at l = 2-4, the reduction in the power in gravity at long wavelengths due to compensation is quite evident between degrees 5 and ~25.

We can use this power spectra ratio root to estimate the expected free-air gravity signal due to the topography that is partially compensated at long wavelengths. We fit a scaled, inverted, and vertically shifted Gaussian to the power spectra ratio root between degrees 5 and 60 (Fig. 1), in order to generate a transfer function between the topography and gravity. We note that this transfer function has the dimensions of admittance, but it is not an admittance function; we seek only to find how much less power the gravity has relative to the topography. We then apply this fitted transfer function to the spherical harmonic coefficients of topography in order to generate a synthetic gravity map; essentially, this process employs the Bouguer formula to convert topography into gravity and then high-pass filters the Bouguer gravity to account for compensation at long wavelengths.

We compare profiles of observed free-air gravity and this synthetic gravity over the edge of Tempe Terra (Fig. 2), from expansions at degrees 2-60. The minimum in the observed gravity at ~310° E longitude corresponds to the gravity trough that has been interpreted as marking a buried channel [1,2]; however, a matching trough of similar shape and magnitude is found in the synthetic gravity field based on compensated topography (the vertical offset between the observed and synthetic gravity profiles is due to the existence of the regional negative gravity ring surrounding Tharsis [6]). Thus, instead of appealing to a subsurface density anomaly such as a buried channel, we conclude that the Tempe Terra gravity trough is a product of partially compensated surface topography.

The edge of Tempe Terra represents a sharp topographic boundary on a relatively long-wavelength feature (the highlands-lowlands boundary at the edge of Tharsis). That an orbiting spacecraft should gravitationally sense this boundary as a trough instead of a sharp boundary is, in retrospect, not surprising. Because short wavelengths are supported by the lithosphere, a spacecraft senses nearly the full signal. The spacecraft do not, however, fully sense the gravity from the long-wavelength topography because of compensation. At the scale of the sharp boundary, these long wavelengths represent a regional slope, and removal of this slope from the gravitational signal due to topography changes this boundary into a gravity trough. Indeed, this effect is to be expected whenever there exists a sharp boundary on a long-wavelength, partially compensated feature. Comparisons of global maps of the observed free-air gravity and this synthetic topography-based gravity show that observed gravity troughs flanking the edges of not only Tempe Terra, but also Arabia Terra, Hellas Planitia, Isidis Planitia, the Elysium Rise, Olympus Mons, and the Tharsis Montes also exist in the synthetic gravity.

References: [1] Zuber, M.T., *et al.* (2000) *Science, 287*, 1788-1793. [2] Phillips, R.J., *et al.* (2001) *LPSC XXXII*, #1176. [3] Dombard, A.J., et al. (2004) *GRL*, submitted. [4] Lambeck, K. (1988*) Geophysical Geodesy*, Oxford Press. [5] Turcotte, D.L., and G. Schubert (1982) *Geodynamics*, Wiley. [6] Phillips, R.J., *et al.* (2001), *Science, 291*, 2587-2591.

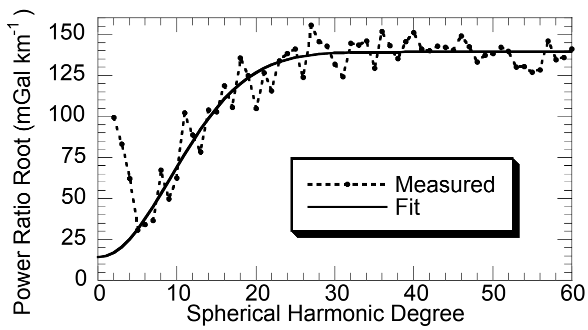

Figure 1. Square root of the power spectra ratio of the free-air gravity to topography of Mars. The solid line is a fit of the data from degrees 5-60. The spike at l = 2-4 is due to the global response to Tharsis [6].

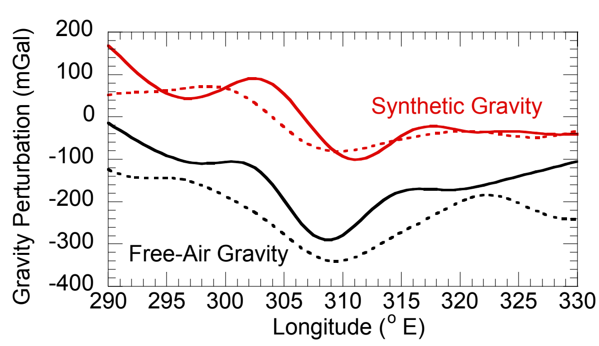

Figure 2. Profiles of observed gravity (black) and synthetic, topography-based gravity (red) at two latitudes (solid curve: 40° N; dashed curve: 47° N) over Tempe Terra's edge. The vertical offset between the observed and synthetic gravity for each case is due to the regional negative gravity ring surrounding Tharsis [6].