**VENUS GRAVITY GRADIOMETRY: PLATEAUS, CHASMATA, CORONAE, AND THE NEED FOR A BETTER GLOBAL DATASET.**

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**Introduction:** While Venus and Earth have similar bulk geophysical properties, they have clearly followed divergent geodynamic paths – the former apparently characterized by a strong continuous lithosphere and stagnant lid convection, and the latter characterized by plate tectonic recycling of the lithosphere. Nevertheless, a number of features on Venus are tantalizingly similar to structures on Earth, including continent-like tesserae plateaus, chasmata interpreted as rift zones, and some coronae that are surrounded by troughs resembling subduction zones.

Gravity data provide a critical means by which to examine the subsurface structure and compensation state of such features, which are critical for understanding their formation mechanism and broader implications. Here we apply the technique of gravity gradiometry to Magellan gravity data in order to provide a new look at crustal plateaus, chasmata, and coronae. The results provide new evidence for the nature of the structures. However, these structures are at the limit of the highest resolution achievable with current data along the equator, whereas data over most of the planet are lower in resolution. In order to reveal the true nature of these structures as well as to enable similar analyses across the rest of the planet, a new gravity dataset that is globally of a consistent higher resolution is critical. Such a dataset will be provided by the proposed VERITAS mission to Venus [1].

**Methods:** The gravity gradients were calculated using the maximum eigenvalue of the horizontal second derivatives of the free air potential [2]. The gravity gradients highlight short-wavelength structures that are often undetectable in conventional free air gravity maps, and are particularly effective at identifying discrete structures such as faults and folds. Magellan gravity models have a maximum degree strength of ~105, corresponding to a half-wavelength resolution of >180 km [3]. However, more than half of the planet has a degree strength <80, and large areas of the planet have degree strengths less than 60 (resolution >315 km). Gravity gradients were calculated out to degrees 60, 80, 100, and 120 for comparison. We then examined the gravity gradients over Ovda Regio, the chasmata surrounding the Beta-Atla-Themis (BAT) region, and Artemis Chasma flanking Artemis corona.

**Results:** A map of the global gravity gradients expanded out to degree 100 (Fig. 1c) highlights a number of discrete structures. Strong gravity gradients are found associated with rift zones in the BAT region, in the interior of the tesserae plateau Ovda Regio, around Artemis chamsa, and surrounding Ishtar Terra. It is also noteworthy that the gravity gradients over the vast majority of the planet are much lower in magnitude

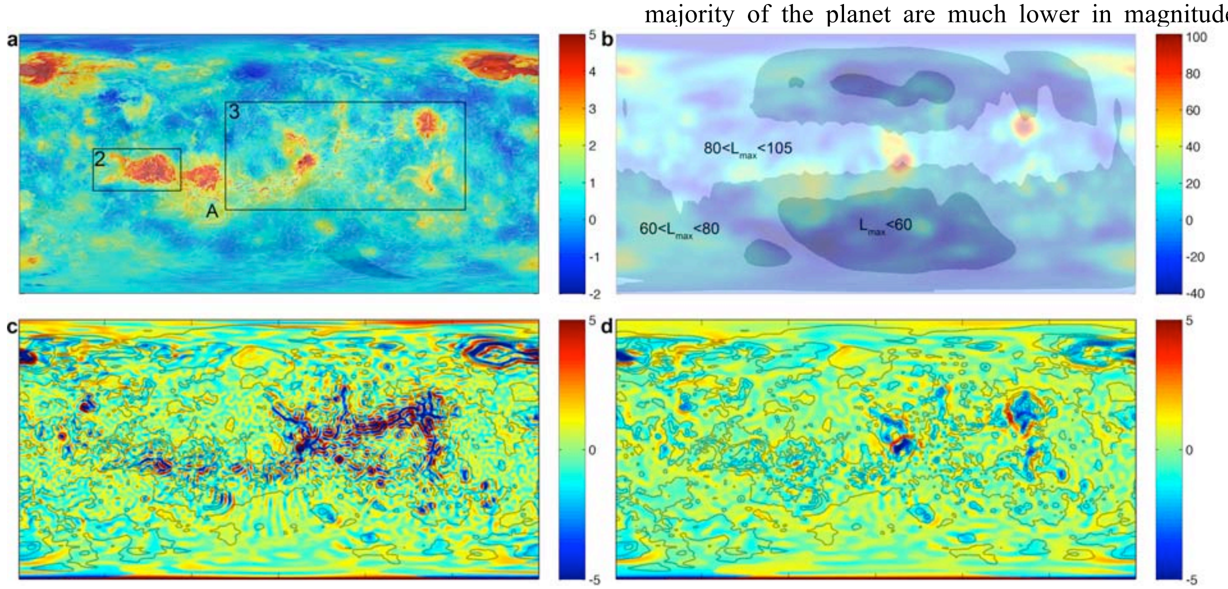


**Figure 1.** Topography (**a**; in km, overlain with SAR imagery), free air gravity (**b**; in mGal), and gravity gradients expanded out to degree 100 (**c**; in Eotvos) and degree 60 (**d**). A binned degree-strength map based on [3] is superimposed in b. Elevation contours are superimposed in **c-d** at a 1 km contour interval. Context boxes for Figs. 2 and 3 and Artemis Corona (A) labeled in **a**.

with little evidence for discrete structures either at the surface or buried beneath it.

However, as noted above, the majority of the planet has degree strengths <80 in the Magellan gravity model, and much of the planet has degree strengths <60. Upon reducing the maximum spherical harmonic degree of the gravity gradients to 60 (Fig. 1d), the vast majority of structures seen at higher resolution disappear. Thus, we cannot say with confidence whether the gravitational signatures of these structures are truly unique, or whether they appear prominent only because they happen to be in areas of higher resolution in the Magellan data. Nevertheless, there is real signal associated with these structures at the limit of the Magellan resolution, which we here consider further.

*Ovda Regio.* Ovda Regio is a tesserae plateau, with steep margins surrounding an isostatically compensated and heavily tectonized plateau. The weak free-air gravity gradient signature along the margins of the plateau is consistent with its isostatic compensation. However, the strong gradient anomalies in the interior of the plateau reveal uncompensated shorter-wavelength structures, consistent with folding of the lithosphere during the formation of Ovda [4]. The lack of similar structures in other plateaus may be evidence of their viscous relaxation [5], or may simply be a result of the lower gravity resolution in these areas.

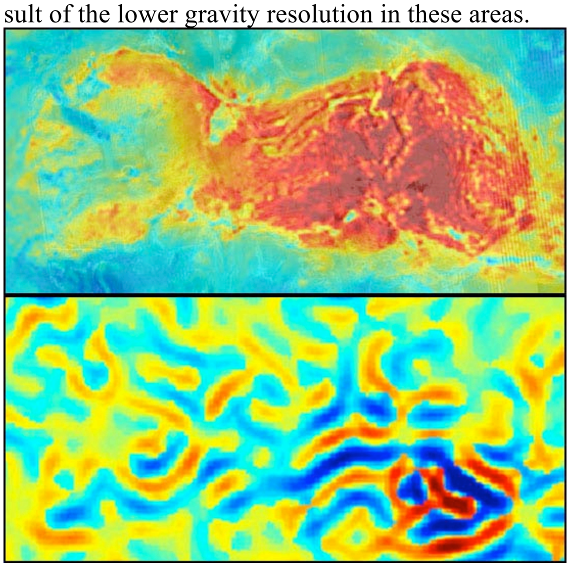

**Figure 2.** Topography (top) and gravity gradients (bottom; expanded to degree 100) over Ovda Regio.

*BAT Chasmata.* The strong gravitational signatures associated with the rift zones surrounding the BAT region (in particular, Hecate and Devana chasmata) are consistent with thermal uplift of the lithosphere during rifting. In contrast, the Diana, Dali, and Parga chasmata show weaker anomalies. This difference in gravity gradient signature supports the interpretation that Hecate is actively rifting while Parga is not [6], but this interpretation is hampered by the variable degree strength of the current data.

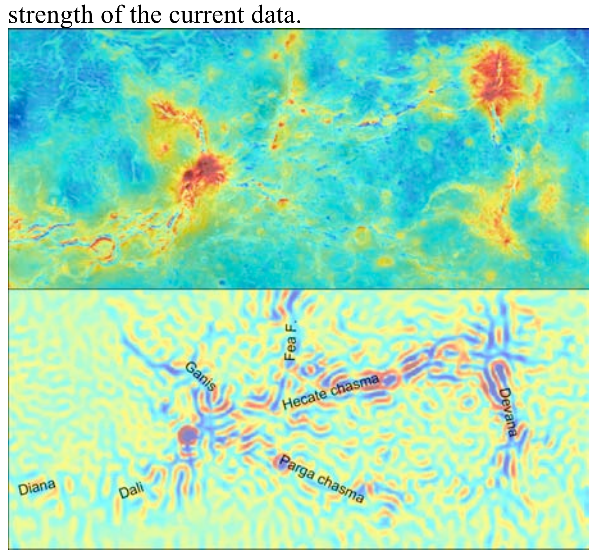


**Figure 3.** Topography (top) and gravity gradients (bottom; expanded to degree 120) over chasmata in the BAT region.

*Artemis:* The partial trench at Artemis Corona has a topographic signature consistent with a subduction zone [7]. Active subduction zones on Earth have very strong gravity signals. Strong gravity gradients are observed over Artemis Chasma in the high resolution gravity gradients (Fig. 1c), but the N-S alignment of these anomalies suggests that they are at least in part due to orbit-parallel striping in the data. The anomalies disappear in the lower resolution gradient map.

**Conclusions:** The Magellan gravity gradients reveal new aspects of the structure of plateaus, chasmata, and corona on Venus. These results are suggestive of crustal folding in the interior of Ovda, active rifting in the BAT region, and subduction at Artemis Corona. However, the existing Magellan-derived gravity is just sufficient to begin revealing these structures at its highest resolution, and is a factor of 2 coarser in resolution over much of the planet. To adequately resolve these and other structures, a gravity model of globally uniform degree strength >95 is needed. Additionaly this resolution would permit admittance and coherence methods for estimating elastic thickness, which is currently limited to regions with the highest resolution. Such a gravity model will be generated by the proposed VERITAS mission [1].

**References:** [1] Smrekar, S. E. et al., (2016), *LPSC abs*. [2] Andrews-Hanna, J. C. et al., (2013), *Science*. **339**, 675–8 (2013). [3] Konopliv, A. S. et al., (1999), *Icarus*. **139**, 3–18. [4] Ghent, R., Hansen, V., (1999), *Icarus*. **139**, 116–136.. [5] Nunes, D. C., (2004), *JGR* **109**, doi:10.1029/ 2003JE002119. [6] Smrekar, S. E. et al., (2010), *JGR* **115**, 1–19. [7] Schubert, G., Sandwell, D. T., (1995), *Icarus*. **117**, 173–196.