GRAVITY OBSERVATIONS OF THE ARISTARCHUS PLATEAU ON THE MOON: IMPLICATIONS FOR THE VOLCANIC AND IMPACT HISTORIES OF THE PLATEAU

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Introduction The Aristarchus Plateau (Figure 1) is a distinctive, geologically complex volcanic highland in northern Oceanus Procellarum. It is roughly diamond shaped, 170 by 220 km across, and up to 2 km higher than the surrounding mare [1, 2]. The roughly linear edges of the plateau suggest that it is fault bounded. The plateau edges are essentially radial and concentric to the center of the Imbrium basin [1, 3] and the northeastern margin of the plateau lies on or very close to an Imbrium basin ring [3, 4]. These observations suggest that uplift of the plateau is related to the Imbrium impact.

Aristarchus contains a high density of diverse volcanic landforms. Much of the plateau is covered by a low albedo unit, interpreted as due to deposition of volcanic glass in a pyroclastic eruption [5-9]. These deposits cover 49,000 km^2, which is 5 times the area of the next largest lunar pyroclastic deposit [10]. 36 sinuous rilles occur in the region, demonstrating that effusive volcanism was also important [11]. Detection of the radioactive gas ^{222}Rn indicates that some type of on-going out-gassing from the interior is occurring in this region [12, 13].

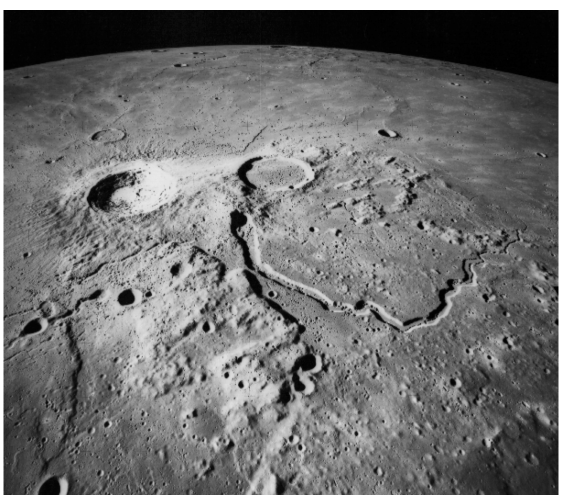

Figure 1: An oblique view of the Aristarchus Plateau, looking to the south. In the center of the image is Schröter's Valley, a 150 km long sinuous rille system. Apollo 15 Metric Photograph 2610.

Gravity Observations: The Plateau Interior

Figure 2 shows the free-air gravity anomaly for Lunar Prospector gravity model LP165P, complete to spherical harmonic degree 110 [14]. Degree 110 is the highest harmonic degree that is useful for geophysical interpretation in model LP165P, and corresponds to a half-wavelength resolution of 50 km. Figure 2 shows gravity highs both over the center of the Aristarchus Plateau as well as along the northeast and southeast boundaries of the plateau.

The gravity high over the central plateau is due to the high topography there. It is likely that the gravity anomaly in some portions of the study region is dominated by surface topography and that other parts of the study region are dominated by high density buried material. For this reason, I have not used standard admittance spectrum methods to determine the lithosphere's elastic thickness. Instead, I compare profiles of the observed gravity in portions of the central plateau that appear to be dominated by topographic loading with models of flexurally supported topography. The flexure models are calculated using Clementine topography model GLTM-2B up to spherical harmonic degree 70 [2], and the observed gravity is filtered to the same resolution. The results imply an elastic lithosphere thickness of 0-5 km, with a strong upper bound of 10 km. This result is consistent with previous work that showed that the Apennine Mountains, which form part of the eastern rim of the Imbrium basin, are also nearly isostatic [15]. The nearly isostatic state of the central Aristarchus Plateau implies that there are no deposits of dense material in the subsurface, which differs from the gravity observations of dense subsurface volcanic deposits in the Marius Hills region [16].

Gravity Observations: The Plateau Margins

The largest amplitude gravity anomalies in Figure 2 form a boomerang-shaped structure that wraps around the eastern margin of the plateau on the mare side of the plateau boundary. The geometry of the anomaly strongly suggests that it is associated with the faulting that produced the plateau. Faults can produce gravity anomalies by creating offsets of horizontal crustal layers that have different densities. On the Moon, possible density interfaces that could contribute to gravity anomalies include the upper crust (anorthite)-lower crust (norite) interface and the lower crust-mantle interface [17]. Thus, the magnitude of the expected gravity anomaly depends both on the magnitude of displacement along the fault and on the depth range over which the fault occurs. The thin elastic lithosphere may not permit offset of the lower crust-mantle interface. Preliminary modeling using the DISKGRAV program [18] indicates that thrust fault offsets of a few kilometers are consistent with the observations.

A potential problem for this model is that it implies crustal uplift on the east side of the boundary faults, whereas the topographic high is west of the faults. One possible explanation for the high topography within the plateau is viscous flow of lower crustal material radially away from Imbrium during basin formation (the thin elastic lithosphere inferred in this work is consistent with a ductile lower crust). Alternately, a significant component of the plateau may be built by crustal thickening during later volcanism.

References [1] Zisk et al., Moon 17, 59-99, 1977. [2] Smith et al., JGR 102, 1591-1611, 1997 [3] Spudis, *The Geology of Multi-ring Impact Basins*, Cambridge University Press, 1993. [4] Wilhelms, *The Geologic History of the Moon*, USGS Prof. Paper 1348, 1987. [5] Head, Proc. Lunar Sci. Conf. 5, 207-222, 1974. [6] Gaddis et al., Icarus 61, 461-489, 1985. [7] Lucey et al., Proc. LPSC 16, D344-D354, 1986. [8] McEwen et al., Science 266, 1858-1862, 1994. [9] Weitz et al., JGR 103, 22,725-22,759, 1998. [10] Gaddis et al., Icarus 161, 262-280, 2003. [11] Whitford-Stark and Head, Proc. Lun. Sci. Conf. 8, 2705-2724, 1977. [12] Gorenstein and Bjorkholm, Science 179, 792-794, 1973. [13] Lawson et al., JGR 110, doi:10.1029/2005JE002433, 2005. [14] Konopliv et al., Icarus 150, 1-18, 2001. [15] Ferrari et al., JGR 83, 2863-2871, 1978. [16] Kiefer, GSA Annual Meeting, abstract 133-03, 2008, and manuscript in preparation. [17] Wieczorek and Phillips, JGR 102, 10,933-10,943, 1997. [18] Kiefer, Earth Planet. Sci. Lett. 222, 349-361, 2004.

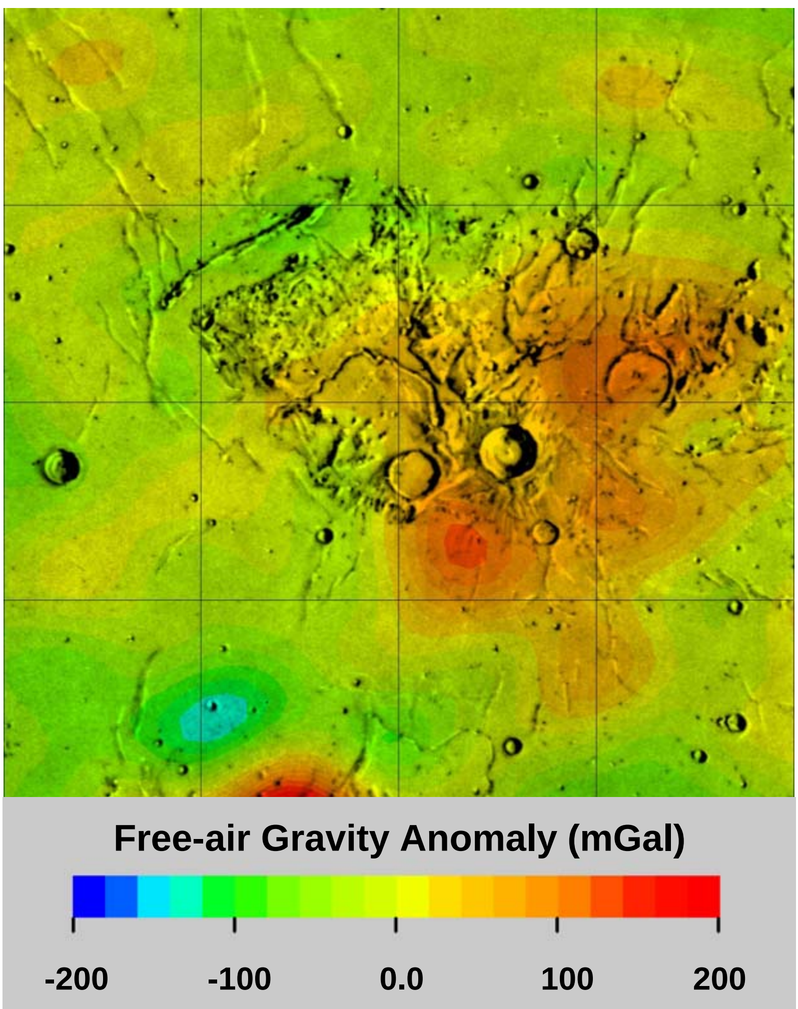

Figure 2. Free-air gravity anomalies in Aristarchus, 15^o – 35^o North, 300^o – 320^o East, overlaid on a shaded-relief map of the region. Simple cylindrical projection. The region shown is 550 km across at map center (25° North).