CONSTRAINTS ON VESTA'S INTERIOR EVOLUTION FROM DAWN GEOPHYSICAL DATA. C. A. Raymond[1], R. S. Park[1], S. W. Asmar[1], A. S. Konopliv[1], M. C. De Sanctis[2], R. Jaumann[3], H. Y. McSween[4], C. T. Russell[5], D. E. Smith[6], M. Toplis[7], M. T. Zuber[6], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA (carol.a.raymond@jpl.nasa.gov), [2]INAF, Istituto di Astrofisica e Planetologia Spaziale, Area di Ricerca di Tor Vergata, Roma, Italy, [3]DLR, Inst. of Planetary Research, Berlin, Germany, [4]Dep. of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, USA; [5]UCLA, Los Angeles, CA, USA, [6]MIT, Cambridge, MA, USA, [7]Uni. de Toulouse, France.

Introduction: Dawn's year-long stay at Vesta allowed comprehensive mapping of the shape, topography, geology, mineralogy, elemental abundances, and gravity field using its three instruments and high-precision spacecraft navigation. A gravity field accurate to degree and order ~20 [1] was obtained from high-accuracy data in the Low Altitude Mapping Orbit (LAMO). Multi-angle imaging in the Survey and High Altitude Mapping Orbits (HAMO-1 and HAMO-2) has provided adequate stereo coverage to develop a shape model accurate to ~10 m at 100 m horizontal spatial resolution [2]. The shape and gravity of Vesta can be used to infer the interior density structure and investigate the nature of the crust, informing models for Vesta's formation and evolution. The low degree gravity constrains the radial density structure, while the higher degree terms reflect variations in the structure of the crust and mantle. Significant Bouguer anomalies are found within the vestan crust and mantle that can be interpreted as crustal thickness or density variations, and likely reflect both sources. The Bouguer anomalies are associated with structural features such has the Vestalia Terra highland and the deep Saturnalia Fossae, as well as lithological provinces, such as the extensive dark material deposits at the Veneneia impact basin rim, and the diogenitic central mound of the Rheasilvia impact basin.

Vesta's Core, Mantle and Crust: The gravity field of Vesta at degree and order 20, excluding degree 1 and J_2, ranges from -1000 to 2000 mgals, and is highly correlated to the topography [1]. The J_2 term is consistent with Vesta being a solid body out of hydrostatic equilibrium; it also indicates a central mass concentration. Applying constraints from meteoritic studies, Vesta's core size has been estimated using a mass balance approach that matches the observed J_2. We find a core of average size 110-km assuming an average density of 7400 kg/m3, consistent with iron meteorite densities [3]. Such an approach also yields the bulk silicate density, which averages around 3100 kg/m3, and indicates porosity in the crust and mantle of ~10%. Combinations of mantle and crust densities tand layer dimensions that satisfy the bulk silicate density and J_2, are used to derive the Bouguer gravity field by subtracting the predicted gravity from the observed. Applying a Bouguer correction results in an anomaly field ranging over hundreds of mgal, roughly 10% of the gravity field (Fig. 1). The three-layer model used to calculate the Bouguer field uses the core radius of 110 km and a crustal layer that averages, with the top surface following the shape model and bottom defined by the ellipsoidal mantle layer. The crustal layer is assumed to have zero thickness in the deepest point of the Rheasilvia basin, and averages ~19 km in thickness, consistent with a chondritic bulk composition [4].

The Bouguer anomalies reflect the modification of the vestan crust and mantle by impacts that have extensively fractured and pulverized it while also exposing deep-seated material and mixing it with the original crust; they also reflect the addition of low-density exogenic material to Vesta's surface. However, impacts alone can't account for the all of the density (and/or crustal thickness) variations implied by the Bouguer gravity field. The presence of significant density anomalies in concert with broad compositional and geologic variations is consistent with heterogeneity in the original crust and mantle of Vesta.

Considerable variation is seen in the crust/mantle density contrast that minimizes the major Bouguer anomalies in different regions of Vesta, indicating variations from the assumed layer thicknesses and/or variations in the density. Given the intense pummeling of Vesta by impacts, it is likely that the original crustal layering has been largely overprinted by impact gardening. Density variations include variations in porosity as well as compositional variations that may be related to the original crustal architecture. Several features are examined to probe the interior structure.

Vestalia Terra: A very strong positive Bouguer anomaly is seen over the southern postion of Vestalia Terra (Fig 1: -150 to -120 E; 15-30 S). Vestalia Terra (VT) is a large topographic rise that contains the highest topography on Vesta. It is recognized that VT is an ancient terrain, pre-dating the Rheasilvia and older Veneneia impacts as these basins carve the edges of VT [5]. The Bouguer anomaly of southern VT represents a significant mass concentration relative to the average bulk silicate density of Vesta; the estimated crustal density for southern Vestalia Terra is ~3200

kg/m^3 [6], which is an average of the crust and its ejecta blanket. The gravity data indicate that the Rheasilvia ejecta are resting on a dense topographic rise that likely is composed of ultramafic mantle material. The density of the underlying rise also appears higher than the mantle elsewhere in the southern hemisphere. Thus, the density structure of Vestalia Terra may be indicative of a more primordial state of the vestan interior. It is difficult to probe the nature of the bedrock beneath the mantling RS ejecta, but several small impact craters indicate at least localized presence of diogenitic material [5]. The origin of VT could be the result of magmatic processes during Vesta's early evolution, or may be explained by variable impact gardening of the vestan crust and mantle.

Rheasilvia Basin: The higher density implied for the RS central mound indicates thin crust and uplifted mantle at the central mound, in agreement with the presence of diogenitic material identified in VIR data [7]. The dense material extends beyond the central topographic mound, however, and may indicate crustal inhomogeneity that pre-dated the formation of RS.

Eastern Equatorial Troughs: The are to the north of the prominent RS basin eastern rim is an area of well-defined troughs (0-60E; 0-30S). There is a strong positive Bouguer anomaly associated with this area, which is part of a broad swath of positive anomalies that extends northward to the area where olivine was identified [8]. The positive Bouguer gravity generally follows the topography, but otherwise there is nothing that is unique about this region. The strong anomaly near the equator may indicate a buried dense body.

Features such as southern Vestalia Terra and similar high-density features suggest intracrustal plutons consistent with evidence from the trace element geochemistry of HED meteorites, and genetic models that include multiple magma chambers.

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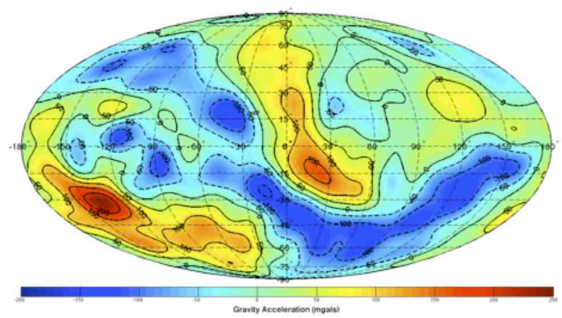

Figure 1. Color contour Bouguer anomaly map in mgals calculated using crustal density of 2800 kg/m^3 and mantle density of 3300 kg/m^3[1].