FORWARD MODELING OF VESTA'S INTERIOR STRUCTURE USING GRAVITY AND SHAPE MODELS FROM THE DAWN MISSION. Anton I. Ermakov[1], Maria T. Zuber[1], David E. Smith[1,2], [1]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA (eai@mit.edu), [2]NASA/Goddard Space Flight Center, Greenbelt, MD, 20771, USA.

Introduction: The Dawn spacecraft inserted into orbit around asteroid 4 Vesta in July of 2011. Radio tracking data from the survey and the High Altitude Mapping Orbit (HAMO) allowed an estimation of the gravity field of Vesta to spherical harmonic degree and order 6 [1]. Data from the Low Altitude Mapping Orbit (LAMO) are expected to allow the gravity field to be resolved up to degree and order 25 [2], allowing study of regional structure. Images obtained by Dawn's Framing Camera (FC) [3, 4] have been used to produce shape models of Vesta. However, the illumination conditions (i.e., polar night in the northern hemisphere higher than 50° N) prevent a complete map of the shape at this point in the Vesta mapping mission. Errors in the northern hemisphere shape represent the main source of uncertainty in computing the volume of Vesta. Gravity anomalies are being used to constrain models of Vesta's interior structure in the context of analyses of HED meteorites [5] as well as remote elemental and geochemical observations now being collected by Dawn's VIR and GRaND instruments.

Geoid calculations: Analysis of Dawn's gravity [1] and shape [3] data from the HAMO orbit show a strong positive correlation between the geoid and topography. With the current topography, geoid/topography relationship can be utilized to extrapolate for missing topography data in the northern gap. We can neglect the variations in this relationship and estimate the topographic surface that fits the observed gravitational acceleration in the northern gap. However, this assumption cannot be verified with the existing data and might be invalid because of the intrinsic dichotomy between the northern and southern hemisphere.

The best-fit ellipsoid for the shape model was calculated. The geoidal elevation was calculated with respect to the ellipsoid that has a semi-minor axis of 265 km and best approximates the equipotential surface. The ellipsoid size was chosen in order to avoid the divergence of the spherical harmonic expansion.

Center of Mass – Center of Figure offset: In order to perform a statistically reliable assessment of the center of mass – center of figure (COM-COF) offset, we need to process all the relevant geophysical data (orbit, gravity and control points of the shape models) in one global iteration. This is necessary in order to develop a self-consistent geodetic system.

We used both DLR [3] and Robert Gaskell's shape models in our analysis. Our preliminary result shows that the main difference in COM-COF offset between the two shape models is in the *Z*-component. This difference can be explained by the different methods of extrapolating the northern gap. That difference might cause an uncertainty up to 100 mGals in gravitational anomaly.

Numerical hydrodynamic simulations [6] show possible evidence of asymmetric interior structure caused by a large impact that produced the south pole structure which can affect COM-COF offset as well as low degree (odd zonal) spherical harmonic coefficients.

Interior structure modeling: The interior structure of Vesta (cf. Fig. 1) can be estimated using two types of constraints. One approach is to match the long-wavelength component of observed gravity field with the gravity field calculated from an interior structure model (cf. Fig. 2). A second approach is to take advantage of the evidence that Vesta is the parent body of the howardite, eucrite and diogenite (HED) meteorites [7, 8, 9]. Chemical composition of HED meteorites along with siderophile elements content in eucrites provides a constraint on the amount of metal in the asteroid, and therefore the size of the metal core.

Another factor that affects modeling of the interior structure is porosity. Porosity can also be estimated from meteoritic and geochemical evidence [10]. The porosity of the core is assumed to be negligible, whereas the mantle and crust porosity can significantly affect the interior structure.

Two end-member interior structure models are discussed in Ruzicka et al. [7]: olivine-rich and olivine-poor, depending on the assumed type of chondritic protolith. We are analyzing variants of these proposed models (e.g., Table 1) in light of new gravity and shape data obtained by the Dawn spacecraft (Fig. 2).

References: [1] Asmar S. W. et al. (2011) *EOS Trans. Am. Geophys. Un.,* U31A-006. [2] Konopliv A. S. et al. (2012) *Space Sci. Rev., 163,* doi: 10.1007/s11214-011-9794-8. [3] Preusker F. et al. (2011) *EOS Trans. Am. Geophys. Un.* [4] Raymond C. T. et al. (2012) *Space Sci. Rev*., 163, doi: 10.1007/s11214-011-9863-z. in press. [5] McSween H. Y. Jr. et al. (2012) *Space Sci. Rev.,* in press. [6] Ivanov B. A. et al. (2011) *LPS XLIII*. [7] Ruzicka A. et al. (1997) *Meteor. Planet. Sci. 32,* 825-840. [8] Binzel R. P. and Xu S. (1993) *Science 260,* 186-191. [9] Zuber M. T. et al. (2012) *Space Sci. Rev.,* doi: 10.1007/s11214-011-9806-8. [10] Consolmagno G. J. and Britt D. T. (1998) MPS 33, 1231-1241. [11] Balmino G. (1994) *Celestial Mechanics and Dynamical Astronomy*, 331-364.

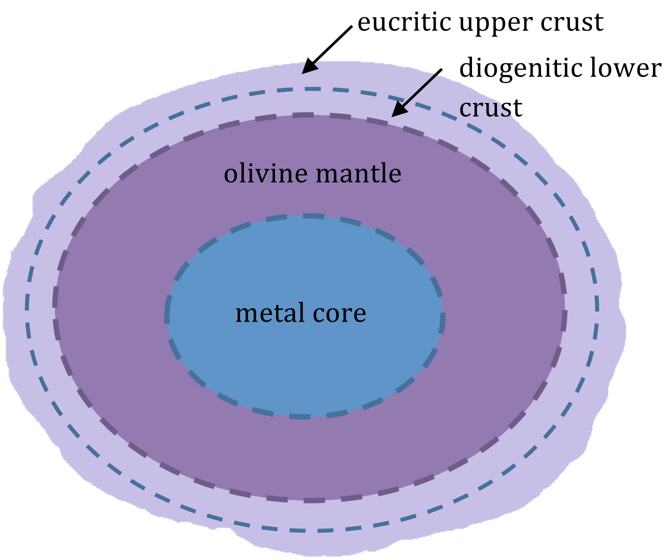

Figure 1: Vesta interior model. The interfaces can be modeled as triaxial ellipsoids or as low-degree spherical harmonics expansions of the radius-vector. The gravitational potential can be calculated as the potential of a multilayered body with homogeneous layers [11].

Table 1: Mean maximum and minimum thicknesses of the interior model layers from observed gravity and geochemical constraints, assuming an upper limit of 5% for mantle and crustal porosity

Unit	minimum thickness (km)	maximum thickness (km)
Core	80	115
Mantle	125	145
Crust	35	60

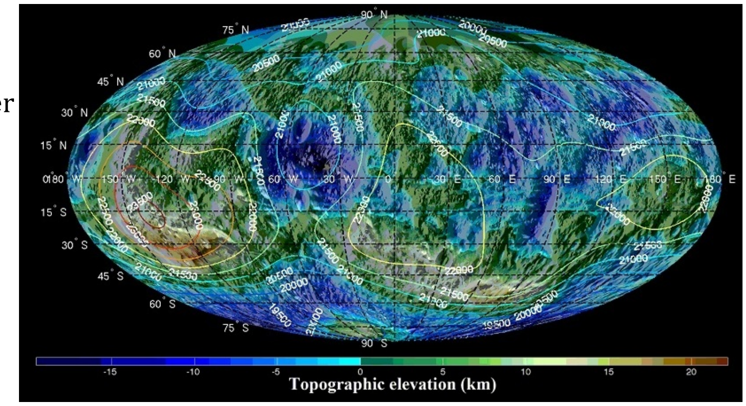

Figure 2: Topographic elevation and Vesta gravitational acceleration (mGals) at 265.0 km x 290.1 km ellipsoid. The algorithms from [11] were checked using Vesta's shape models assuming homogeneous density distribution.