SOME PETROLOGICAL CONSTRAINS ON THE VESTA MANTLE FROM THE STUDY OF GRAVITATIONAL POTENTIAL BY THE DAWN MISSION. S. A. Voropaev, GEOKHI RAS, Moscow, Kosygina str. 19, 119991 voropaev@geokhi.ru

Introduction: Space mission Dawn targeted 4 Vesta provides a number of remarkable results concerning as surface coverage as physical parameters of the surviving protoplanet. It was confirmed that Vesta differentiated and Rheasilvia, a giant impact basin at the the south polar region, is the most likely source of howardite-eucrite-diogenite (HED) meteorites [1]. But, degree of Vesta's primary hondritic body melting is not clear till now and depends on the time of its formation at the beginning of the life of the Solar System [2]. So, the core/mantle size and the composition of theirs rocks remains questionable.

Analytical procedure: The Vesta precession rate (due to the gravitational torque from the Sun) and the gravitational potential (modeled by a spherical harmonic expansion) will be determined by unnormalized oblateness J_2 [3]

$C – (A + B) / 2 = J_2MR^2$,

where $A < B < C$ are principal moments of inertia, M is mass, R is the mean radius (adopt value 265 km) and $J_2 = 0.071060892$.

Most recent and relevant data from Dawn are [4]

major axes, a/b/c - 286.3/278.6/223.2 (km);

mass, M - 2.59076 x 10^{20} (kg);

bulk density, ρ_b – 3456 (kg/m3);

rotation rate, ω - 1617.333119 (deg/day).

For our purose, the shape of Vesta is reasonably well approximated by a twoaxial oblate ellipsoid, $a_1 = b_1 =$ 282.4 (km), c_1 = 223.2 (km) with hydrostatic structure at first harmonic degree. An exact analytical treatment provides for homogeneous twoaxial oblate ellipsoid (with an arbitrary bulk density)

$J_2^{(0)} = 1/5\ \varepsilon_1^2$, where eccentricity $\varepsilon_1^2 = 1 – c_1^2/a_1^2$.

So, for homogenous Vesta, $J_2^{(0)} = 0.075$ ($\varepsilon_1 = 0.613$) and $J_2 < J_2^{(0)}$ - indication on the more dense core relative mantle.

In order to explore the implications of the gravity and shape for the interior structure of Vesta, simple two-layer mass-balance model was explored with an assumed core as twoaxial oblate ellipsoid with major axes $a_2 = b_2 > c_2$ and eccentricity $\varepsilon_2^2 = 1 – c_2^2/a_2^2$. In this case,

$M = M_1 + M_2,$

where $M_1 = 4\pi/3\ \rho_1 a_1^2 c_1$, ρ_1 is the mantle's density, $M_2 = 4\pi/3\ (\rho_2 - \rho_1) a_2^2 c_2$, ρ_2 is the core's density. So, mass-balance provides

$1 = \rho_1/\ \rho_b + (\rho_2 - \rho_1)/\rho_b\ (a_2/a_1)^2\ c_2/c_1$

or

$(a_2/a_1)^2 = (\rho_b - \rho_1)/\ (\rho_2 - \rho_1)\ \sqrt{1- \varepsilon_1^2}\ /\ \sqrt{1- \varepsilon_2^2}$ (1)

For two-layer model an exact analytical treatment provides

$J_2^{(1)} = 1/5\ (M_1/M\ \varepsilon_1^2 + M_2/M\ \varepsilon_2^2\ (a_2/a_1)^2)$ (2)

After comparison with (1) we have

$\varepsilon_2^2/\sqrt{1- \varepsilon_2^2} = (5\ J_2^{(1)} - \rho_1/\rho_b\ \varepsilon_1^2\ )/\ \sqrt{1- \varepsilon_1^2}\ (1 - \rho_1/\rho_b)\ (\rho_b - \rho_1)/(\rho_2 - \rho_1) = D1(x,y) > 0,$ (3)

$x = \rho_1,\ y = (\rho_2 - \rho_1)$

We assume that the core's eccentricity $\varepsilon_2 < \varepsilon_1$ as for more dense rocks relative mantle. In this case left part of (3) should be less then 0.476. For $J_2^{(1)} = J_2 =$ 0.071060892 the right part of the later expression D1(x,y) set limits for the unknown mantle's density x as shown on Fig.1

$3.24 < x = \rho_1 < 3.26$ (g/cm^3)

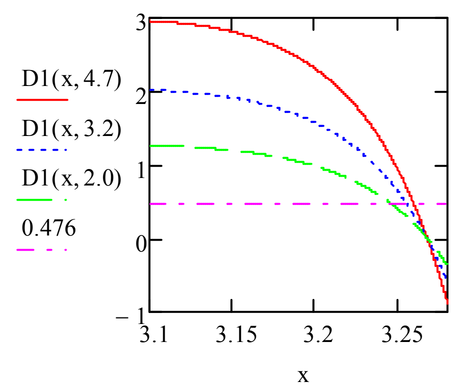

Fig.1

Results and discussion: The above discussed simple core/mantle model provides reasonable value for mean mantle's density. Diogenites are currently believed to originate from deep within the crust of the Vesta and relatively unbrecciated olivine-rich diogenites consist of an equilibrium assemblage of olivine (3.27-3.37 g/cm^3) and magnesian orthopyroxene – harzburgite (2.99-3.2 g/cm^3) [5]. So, we can use this model at analytical treatment for more detailed analyses of the gravitaty of Vesta and implications for internal stresses [6] and hydrostatic equilibrium.

References:

[1] S. Marchi et al. (2012) *Science, 336*, 690-694. [2] A. Coradini et al. (2011) *Space Sci. Rev.*, *163*, 25-40. [3] A.S. Konopliv et al. (2013) *Icarus*, http://dx.doi.org/10.1016/j.icarus.2013.09.005. [4] C. T. Russell et al. (2012) *Science, 336*, 684-686. [5] A.W. Beck, H.Y. McSween (2010) *Meteoritics & Planetary Science, 45*, 850–872. [6] S.A. Voropaev (2013), 44th *LPSC,* Abstract #1135.