Velocities of Coriolis Deflected Mass-Wasting on Asteroid Vesta

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1 Introduction

The Dawn space craft orbited asteroid Vesta for one year arriving in August 2011 [1]. The on-board Framing Camera (FC) collected image data with a resolution up to 20 m/pixel [2]. The FC images revealed a large impact basin in the southern hemisphere, named Rheasilvia. Rheasilvia's central peak located at 75°S and 301°E nearly coincides with Vesta's south pole. Its diameter of about 500 km has the dimension of Vesta's diameter (525 km) [2, 3]. This and Vesta's relatively short rotation period of 5.3 hours indicate that the Coriolis force is likely to have an effect on mass motions within the Rheasilvia basin [4]. Indeed, a pervasive spiral deformation pattern has been observed [5].

2 The Coriolis Effect

The Coriolis force is a fictional force associated with rotating systems. The rotation deflects the motion perpendicular to the rotation axis to cause curved trajectories. The trajectory of a mass moving in the horizontal plane on a rotating sphere is described by a circle with inertial radius R. The inertial radius is dependent on the magnitude of the velocity v, the latitude ϕ and the magnitude of the angular velocity Ω. It is given by

$$R = \frac{v}{2\Omega \sin \phi} \tag{1}$$

Note that the radius is only dependent on the speed of the moving body but not on its mass. Solving Eq. 2 for the velocity v yields

$$v = 2R\Omega \sin \phi \tag{2}$$

3 Method

We mapped the most prominent curved features of the spiral deformation pattern in the Rheasilvia basin and used the data to calculate their three dimensional location. A reference spheroid of 282 km by 224 km was used to approximate Vesta's shape. At each point along a curved feature we determined the tangent plane and projected the neighbouring points on this plane. We approximated a circle through the point and two neighbouring points on the tangent plane and determined the radius R. By changing the set of neighbouring points we collected a number of radii for different point distances and determined R statistically for different length scales. Knowing the angular velocity Ω, the latitude ϕ and the inertial radius R, we calculated the velocity of the motion using Eq. 3.

4 Results

The velocities along each curved feature were determined for different length scales. They were plotted against the DTM profile and we analysed the correlation of elevation and velocity to find implications for the mass wasting type.

References: [1] Russell, C. T. et al. (2013) Dawn completes its mission at 4 Vesta, Meteorit. Planet. Sci., 1-14. [2] Jaumann, R. et al. (2012) Vesta's shape and morphology, Science, 336, 687-690. [3] Russell, C. T. et al. (2012) Dawn at Vesta: Testing the protoplanetary paradigm, Science, 336, 684-686. [4] Jutzi, M. et al. (2013) The structure of the asteroid 4 Vesta as revealed by models of planet-scale collisions, Nature, 494, 207-210. [5] Schenk, P. et al. (2012) The geologically recent giant impact basins at Vesta's south pole, Science, 336, 694-697.