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Mass Wasting and the Coriolis Effect 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 19 km deep 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 and its diameter of about 500 km has the dimension of Vesta's diameter (525 km) [2, 3]. Additionally, Vesta has a relatively short rotation period of 5.3 hours which indicates that the Coriolis force is likely to have an effect on mass motions within the Rheasilvia basin [4]. A prominent spiral deformation pattern observed within the basin is postulated to be generated by the Coriolis Effect [4, 5].

2. Data

We used a Low Altitude Mapping Orbit (LAMO) mosaic with a resolution of 20 m/pixel [6] and a Digital Terrain Model (DTM) referenced to a bi-axial ellipsoid with axes of 285 km and 229 km [7] to identify mass wasting features and the spiral deformation pattern within Vesta's south polar region.

3. Wasting Features

We identified six different types of mass-wasting features within the south polar region of Vesta including intra-crater mass wasting features, flow-like features, creep-like features, slumping blocks and landslide bodies [8].

All features show the ongoing degradation of the Rheasilvia basin due to mass wasting which is often triggered by impact induced seismic shaking [9].

Additionally, curved radial and concentric ridges were observed. The concentric ridges show a step-like morphology and are related to slumping mechanisms. The curved radial ridges describe an undulating pattern which is likely representative of the structure produced during modification stage of the basin, when material wasted towards the basin floor and was deflected by the Coriolis Effect.

4. Coriolis Effect

The most prominent curved radial ridges in the Rheasilvia basin (Figure 1) were used to infer a mass wasting velocity. Therefore, we approximated a circle to each position along a curved ridge and determined the radius of curvature R. This radius is related to the mass motion velocity v: $R = vf$. Here, f is the Coriolis parameter which is dependent on the latitude of the point where the curvature is measured and the rotation rate of Vesta. Thus, velocity profiles along the curved ridges were determined.

The measurements reveal mass wasting velocities which are in good agreement with computer simulated velocities of Rheasilvia's modification stage of ~50 m/s [4]. Also, the material properties such as the viscosity inferred from the mass motion velocity agree with values postulated by the theory of acoustic fluidization of 10^5–10^7 Pa·s [10].

These findings support that the origin of the curved radial ridges is during the modification stage of Rheasilvia and that the Coriolis Effect is the cause of their curvature.

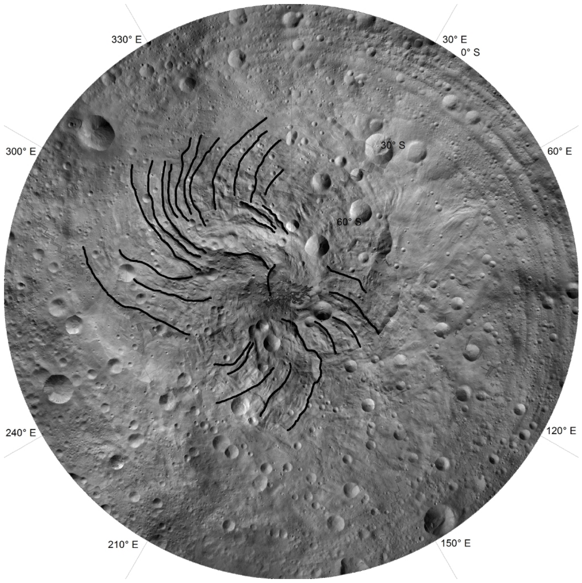

Figure 1: The distribution of curved radial ridges (black lines) on Vesta's southern hemisphere used for the velocity analysis based on the Coriolis Effect.

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