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The Space Weathering Environment at Vesta

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Abstract

The space environment at Vesta contains elements that both create a surface regolith and alter its properties with time. Unlike the Moon and several S-type asteroids, however, the optical properties of the regolith of Vesta appear to be dominated by gardening and mixing processes (potentially including exotic/foreign materials) instead of processes that result in an accumulation of optically sensitive rims or coatings on regolith grains.

1. Introduction

Data from Dawn instruments reveal the cratered surface of Vesta to be covered with an extensive regolith [1] that varies in thickness [2]. Morphologically fresh craters often exhibit a surrounding ray system, most of which are brighter than surroundings, but some are also darker [3,4]. The attached figures illustrate some of these relations for a typical equatorial region on Vesta. Near-infrared spectra acquired with the Visible InfraRed mapping Spectrometer (VIR) [5] and 7-band multispectral data acquired with the Framing Camera (FC) [6] show that the form of space weathering that occurs on Vesta [7] is quite different from that of the Moon and some S-type asteroids [8]. Although a wide range of variations in albedo and band strength are observed at craters across Vesta, no systematic near-infrared continuum variations are observed. Development of nanophase-bearing rims or coatings on regolith grains (as seen on the Moon [9] and Itokawa [10]) is not consistent with Vesta spectroscopic data. The space weathering model for Vesta is instead one that depends on regolith formation and mixing processes [7]. We address several of the Vesta-specific effects that may account for the apparent lack of weathering rims on Vesta's regolith grains.

2. Environmental Effects

The development of nanophase metallic iron ($npFe^0$) on the rims of lunar grains is believed to result from Fe atoms being mobilized by solar wind processes or by vaporization during a micrometeoroid impact. At Vesta's location in the main asteroid belt, both processes are substantially reduced. Vesta is more than twice as far from the sun than the Earth/Moon system; its distance ranges from 2.15 to 2.57 AU. The solar wind impinging on Vesta is thus more than 5x thinner than at 1 AU. It has been suggested [11] that if Vesta has an intrinsic magnetic field, it could further shield the surface from solar wind particles. In addition, a low average impact velocity of micrometeoroids (~5 km/s) is projected for a main belt asteroid [12], making it more difficult to vaporize material during regolith evolution.

3. Physical Effects

The relatively weak gravity [13] and steep topography [1] across the surface of Vesta allows regolith to be mobile on a local scale. Furthermore, the giant Rheasilva impact [14] has clearly resurfaced a large fraction of the planetary body in the not too distant past.

4. Compositional Effects

Several of Vesta's mineralogical properties are also likely to hinder or slow the development of $npFe^0$. First, in contrast to ordinary chondrite parent bodies, the surface material of Vesta contains no macroscopic iron-nickel metal (based on HED meteorite analyses). Thus, the only source of iron for $npFe^0$ would have to come from FeO-bearing silicates. Although abundant pyroxene exists on the surface [5], very little olivine has been detected, but it has been demonstrated experimentally that pyroxene is far more resistant to development of

$npFe^0$ than is olivine. However, carbon-bearing opaque components may be incorporated into Vesta's regolith from asteroidal or cometary debris found in this part of the main asteroid belt [4].

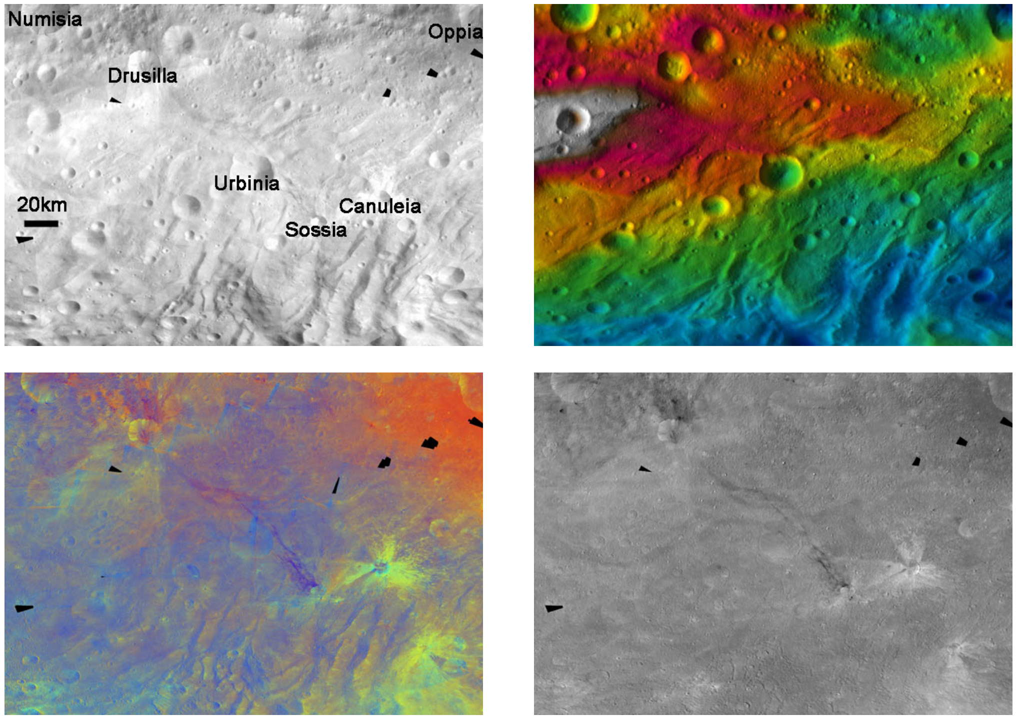

Figure 1. Dawn data for an area of Vesta centered near 30°S, 275°E (including parts of quadrangles Av9, 10, 13, 14). *Top Left:* FC brightness mosaic for 750 nm filter. *Top Right*: Color coded DTM derived from FC stereo images (white-high; blue-low). *Bottom Left:* Color composite mosaic. R=750/440, G=750/920, B=440/750. *Bottom Right*: Photometrically corrected FC brightness mosaic for 750 nm filter.

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