EPSC Abstracts
Vol. 11, EPSC2017-176, 2017
European Planetary Science Congress 2017

DAWN FC Results at Vesta and Ceres

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1. Introduction

Dawn, the first spacecraft orbiting successively two planetary bodies beyond the Earth environment, has returned a wealth of information about the first two massive asteroids (4) Vesta and (1) Ceres. Both differ by a factor of two in size [1], and in their location in the asteroid belt, being separated by the snow-line [2]. While previous ground-based observations identified several key properties [3, 4], the detailed exploration of these objects, spatially and spectrally well resolved information on mineralogy and geology, had been left for Dawn. The spacecraft has orbited Vesta 2011-2012, and Ceres from 2015 onwards.

2. Results

Collisional history has led to a bare escape of destruction for Vesta but only to some major basins on Ceres. Their difference in material density reflects different compositions. While Vesta is a fully differentiated [5], igneous body, Ceres' primitive crust is consistent with an incomplete differentiation [6], a fact also confirmed by Dawn. These constitutional differences imply different histories of accretion. Vesta's violent collisional history has led to a widespread deep regolith [7], unprecedented elsewhere in the solar system. That Ceres is very different in this respect is consistent with its different composition and thermal history. Vesta's surface is characterized by basaltic and gabbroic rocks, i.e., by HED lithology [8]. However, the expected content of olivine turned out to be restricted to almost negligible parts of the surface and to an exogenic origin of the olivine [9]. On the other hand, the presence of dark carbonaceous impactor material, which even delivered hydrated minerals to Vesta's surface, was another major surprise [10]. On the contrary, several expectations about the surface composition of Ceres could be confirmed, but the way these are represented, had not been expected. The most obvious new findings are the substantial proportion of carbonates in its surface materials [11], and their concentration associated with very young impact craters, where they are exposed in high albedo areas termed "faculae" [12, 13]. The data indicate still ongoing sublimation of hydrous components including water-ice [13, 14]. Despite the remarkable findings and already performed analysis, there are still many issues that need to be resolved. For example, the enigmatic orange materials seen in global colour mosaic of Vesta (Fig. 1) and the unique red materials on Ceres are of the prioritized issues. On Ceres, it indicates the presence of aliphatic organic material [15] whose distribution hints at an exogenous origin [18]. The orange material on Vesta comes in at least two varieties whose origin is not understood yet uniquely [16]. Dawn FC imagery led to the discovery of many unusual surface features on Ceres and Vesta. Both asteroids have been globally mapped in seven colours and one clear filter [17, 18].

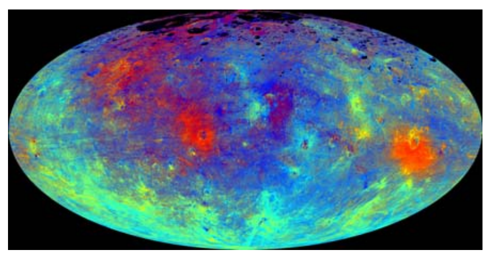

Figure 1: *Global color mosaic of Vesta (R = 0.75/0.44 µm, G = 0.75/0.92 µm, B = 0.44/0.75 µm).*

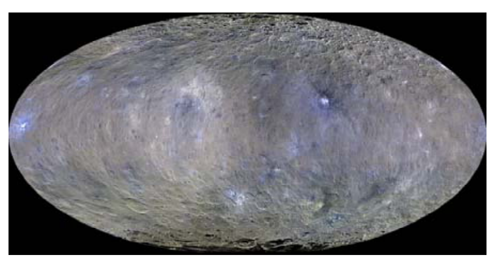

Figure 2: *Global color mosaic of Ceres (R = 0.96 µm, G = 0.75 µm, and B = 0.44 µm).*

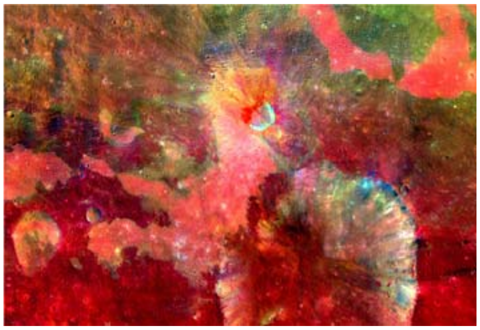

Figure 3: *Vesta's Oppia crater with potential impact melt-related materials (orange patches).*

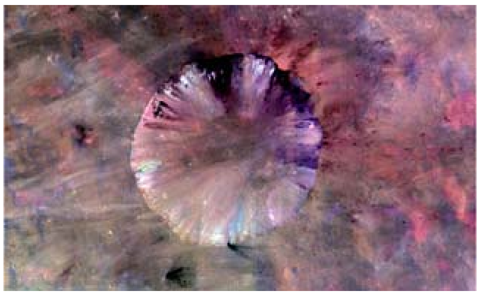

Figure 4: *Remarkable green-red transitions in a narrow putative impact generated melt flow on the western inner wall of crater Numisia on Vesta.*

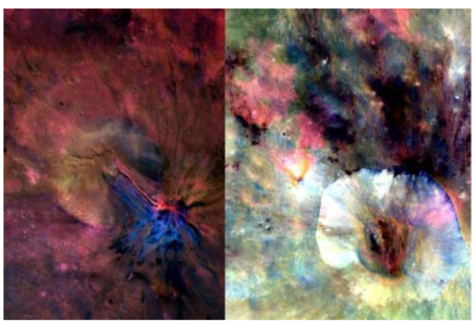

Figure 5: *Craters with complex distribution of potential melt-related and other unique features on Vesta. Aelia (left) and Drusilia (right).*

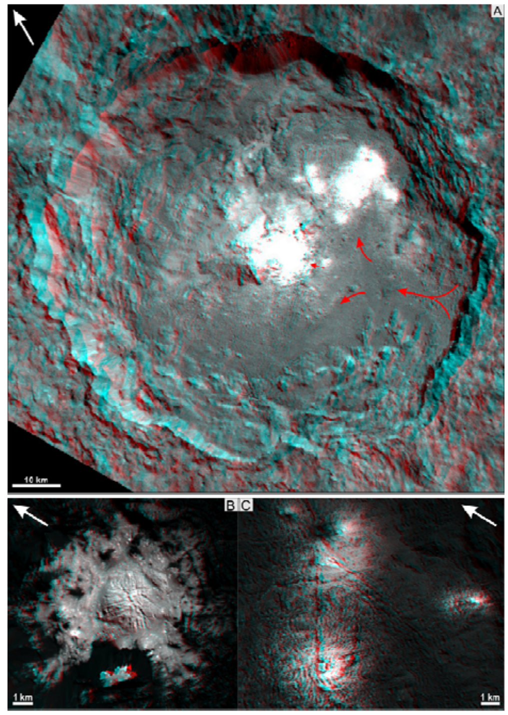

Figure 6: Occator crater on Ceres in 3D. (A) Entire crater, (B) Central pit and dome (Cerealia Facula), (C) *Vinalia Facula.*

References

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