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Elemental composition of Vesta and Ceres

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Abstract

Dawn's decade-long journey has provided a close look at the largest objects in the main asteroid belt, Vesta and Ceres. Dawn confirmed many of our hypotheses about Vesta, the putative source of the basaltic, howardite, eucrite and diogenite (HED) meteorites. The unexpected presence of exogenic hydrogen on Vesta and the absence of an olivine signature within the largest impact basin provided further constraints on impact processes and Vesta's geochemical evolution. In contrast to Vesta, Ceres is "wet" and formed beyond the snow line in the solar nebula. Dawn confirmed that Ceres is water rich and showed that Ceres underwent aqueous alteration on a global scale. Here we present measurements of the sub-surface elemental composition of Vesta and Ceres by Dawn's Gamma Ray and Neutron Detector (GRaND) [1]. We describe how elemental measurements constrain the origins and evolution of these largely intact protoplanets.

1. Elemental data

Gamma rays and neutrons are produced by the steady bombardment of the regolith of Vesta and Ceres by galactic cosmic rays. Gamma rays are also made by the decay of long-lived radioelements, K, Th, and U. A portion of the gammas and neutrons escape the surface and are detected by GRaND in orbit. These provide a fingerprint of the elemental composition of the bulk regolith to depths of about a meter.

2. Vesta

The globally-averaged Fe/O, Fe/Si, and K/Th ratios were found to be consistent with the HED meteorites [e.g. 2], providing further indication that Vesta is the HED parent body. The elemental data are consistent with a differentiated planetesimal that accreted inside the snow line from a volatile poor source. Vesta's basaltic regolith contains exogenic hydrogen in the form of hydrated minerals delivered by carbonaceous chondrite impactors [e.g. 2, 3] (Figs. 1A, 1B).

3. Ceres

Hydrated minerals, including OH and ammoniated phyllosilicates, are widespread on Ceres [e.g. 4] (Fig. 1C). Beneath the optical surface, the regolith is H-rich, with equatorial concentrations similar to that of the the aqueously-altered CI chondrites. Excess hydrogen near the poles is probably in the form of water ice, which is stable near the surface at high latitudes [5] (Fig. 1D). Analyses of Fe indicate that Ceres' underwent modest ice-rock fractionation, resulting in a partially differentiated interior [5]. The latest elemental analyses and implications for Ceres' origin and hydrothermal evolution are presented.

References

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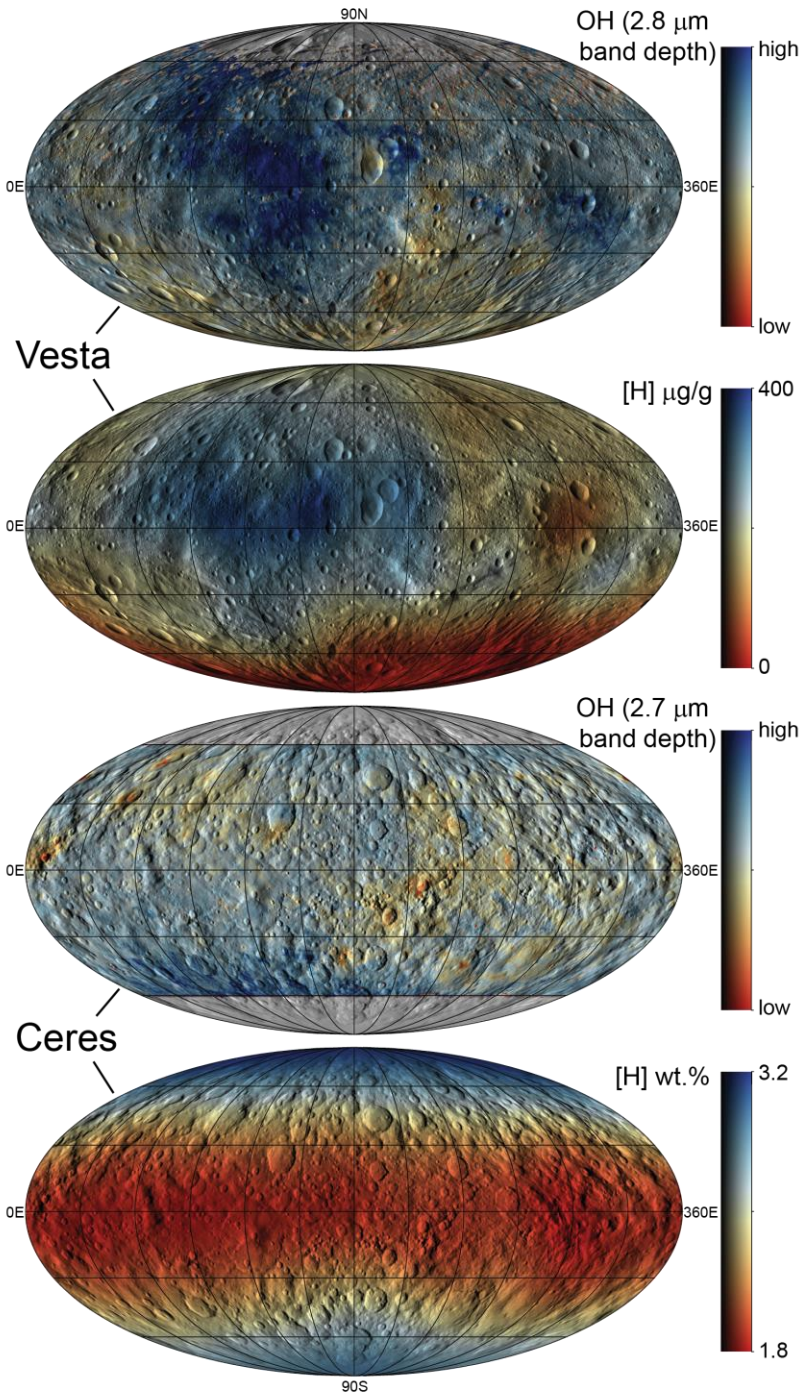

Figure 1.

(Data superimposed on shaded relief)

A. Map of 2.8 μm absorption band by Dawn's Visible and Infrared Mapping Spectrometer (VIR) gives the distribution of hydroxyl (OH) on Vesta's surface [3].

B. Distribution of hydrogen determined within the top meter of Vesta's surface, determined by neutron spectroscopy (GRaND) [2].

C. Distribution of hydrated minerals on Ceres' surface (VIR) [4].

D. Distribution of hydrogen within the top meter of Ceres' surface, deterined by neutron spectroscopy (GRaND) [5].