Dawn at Vesta: Characterizing a minor planet

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The Dawn spacecraft arrived at Vesta in July 2011, spent more than a year exploring the surface with orbital instruments, and is now on its way to Ceres to do the same [1]. Beginning the investigations at Vesta, we were in the unique position of having what we believed to be samples from the surface (the HED family of meteorites) to guide our planning of scientific exploration. We also had telescopic spectra of Vesta that linked it to the meteorites [2] and had spatially resolved images of Vesta from HST [3] that indicated variations exist across the surface, and that an enormous depression occurs at the south pole. Since the HED meteorites show evidence of early melting and differentiation, we expected an ancient evolved anhydrous surface, perhaps similar to that of the Moon complete with early magma ocean.

Although the Moon has often been considered a small body 'end member' that can be used to study early terrestrial planet evolution, with the year-long exploration of Vesta by Dawn, we now have extensive information for an even smaller differentiated planetary body with which to compare and test models and paradigms. We now know that both bodies are heavily cratered and exhibit at least one enormous basin that models predict should have excavated (and possibly exposed) the mantle [4]. Nevertheless, although compositional diversity is found on both, evidence for mantle material has been illusive. These two airless differentiated silicate bodies are ancient and essentially (but not completely) anhydrous. Regionally coherent areas containing H as well as OH are identified across the surface of Vesta [5] but exhibit no apparent relation to OH recently detected on the Moon [6]. Instead, Vesta's hydrated areas are spatially correlated with low-albedo regions, suggesting an exogeneous source (such as delivery by and mixing with carbonaceous chondritic material) [5,7]. Vesta exhibits its own style of space weathering that transforms fresh craters into background soils, one that involves regolith mixing instead of accumulation of nano-phase opaque components on surface grains [8]. The apparent dearth of nano-phase opaque coatings on regolith grains is due to a combination of factors involving Vesta's location and specific surface composition. The result is a mineralogically rich surface exposed to Dawn's sensors [9], although substantially rearranged by impact processes. Major scientific insights will continue to emerge as calibration improves for the Dawn instruments that measure spectral properties of the surface.

References: [1] Russell et al. 2013, MAPS. [2] McCord et al., 1970, Science; Binzel and Xu, 1993, Science. [3] Binzel et al. 1994, Icarus; Thomas et al. 1997, Icarus. [4] Jaumann et al., 2012, Science; Russell et al., 2012, Science. [5] Prettyman et al. 2012, Science; De Sanctis et al., 2012, ApJ Lett. [6] Feldman et al., 2001, J. Geophys. Res; Pieters et al., 2009, Science; Clark et al., 2009, Science; Sunshine et al., 2009, Science. [7] McCord et al., 2012, Nature. [8] Pieters et al. 2012, Nature. [9] De Sanctis et al., 2013, MAPS; Ammannito et al., 2013, MAPS; Ammannito et al., Nature, 2013.