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Vesta Surface Dark Material Deposits from Dawn Observations: A Working Hypothesis for Origin and Processes

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Observations from the Dawn spacecraft [1] revealed surface dark mate-rial deposits (DMD). Their geological context (small, well-defined and often associated with impact features) and basic compositional nature (pyroxene evidence everywhere but more subdued in DMD) is reported [2]. We synthe-size these reports and present a working hypothesis for explaining the origin of and processes affecting these DMD [3]. DMD are strongly influenced by impact mixing and gardening. Many DMD appear as chunks or layers out-cropping in crater walls, uncovered, broken and tossed about by the impact process. Some impacts have excavated DM and spread it as ejecta. There are also large regions of low-albedo surface material, often with indistinct boundaries, that appear to include DM [3]. These may be older and better mixed (DM into background material) than the smaller deposits, perhaps from a larger or more extensive event. We modeled VIR spectra of DMD to show that they all may represent intimate and/or macroscopic mixtures of only two endmember materials. Most or all regions on Vesta can be modeled as a linear mixture of a bright, pyroxene-rich soil and a darker material with varying reddish color [3]. The main hypotheses for DM origin, identified so far are: 1) low velocity infall from objects containing DM, 2) basalt flows, dikes or sills on/in Vesta that are disrupted and redistributed by impacts, and 3) impact melt from major cratering events. From the imagery, there is no conclusive evidence of basalt flows, and evidence of basaltic intrusions is equivocal. In addition, it is difficult to understand how a Vesta-like object could retain sufficient heat to create secondary melting and near-surface extrusion of lava late enough in Vesta's evolution that the flows or major pieces of them would survive the impact history. On the other hand, there is morphological evidence of impact melt deposits that appear darker on Vesta. This would be expected, given the apparent active impact history of Vesta, which must have included some higher-velocity impactors. Infall origin for some material also seems probable. Surely, dark material from carbonaceous chondrite (CC) objects, especially from the outer parts of the asteroid belt and from comets, must strike Vesta's surface and at lower-velocities than for, say, the Moon, resulting in preservation of major fractions of the impac-tor material. Further, the spectrum for the DMD endmember, derived above, is similar to that for CC material and for organic-rich material in the outer solar system in general. The infall explanation is also supported by certain howardite meteorites, breccias thought representative of the regolith of Vesta that contain clasts of carbonaceous chondrite material within a matrix of pyroxene-rich basaltic material [e.g., 4].

References: [1] Russell and Raymond, 2011, Space Sci. Rev., 163, pp. 3-23, DOI 10.1007/s11214-011-9836-2; [2] Jaumann et al.; Reddy et al; Palomba et al., 2012, LPSC 43, and in this session. [3] McCord et al., 2012, LPSC 43. [4] McSween et al., 2012, LPSC 43.