YOUNG VESTA (REGOLITH)? Carlé M. Pieters[1] and Richard P. Binzel[2]. [1]Dept. Geological Sci., Brown University, Providence, RI 02912, [2]EAPS, Mass. Inst. of Technology, Cambridge, Mass. 02139

For more than two decades asteroid 4 Vesta has presented dilemmas to the asteroid and meteorite communities. Vesta, 500 km in diameter, is one of the largest asteroids in the main belt. On the one hand, Vesta's reflectance spectrum (1, 2, 3) provides clear identification of the mineral composition of the surface: low-Ca pyroxene plus plagioclase. This mineral composition is directly comparable to the HED basaltic achondrites, and the eucrites in particular. In fact, visible to near-infrared spectra of Vesta and this class of meteorites are almost indistinguishable. Yet, while ample HED meteorite falls have been recorded, Vesta remained the only large main belt asteroid observed with HED properties. Vesta's 360 m/s surface escape velocity and location relatively far from any resonances makes it dynamically difficult to deliver fragments from Vesta to the inner solar system. Thus, while the composition of Vesta appeared to provide a direct link between asteroids and meteorites, the actual origin of the HEDs that fall to Earth was unresolved. Furthermore, since the spectrum of Vesta was so similar to spectra of eucrites measured in Earth-based laboratories, it was felt that, unlike the Moon, very little space weathering (alteration) occurred on Vesta, and consequently on small airless bodies in general (4). We consider the opposite argument here. Namely that if space weathering *does* occur on asteroidal surfaces, then the regolith of Vesta would have to be quite young, probably created by a relatively recent (impact) event. This scenario meshes nicely with the discovery of several small Vesta-like asteroids stretching from Vesta to the 3:1 Jovian resonance (5), which reveals a dynamically plausible link between the HED meteorites and Vesta, their preferred parent body.

Hypothesis considered: A major impact event recently occurred on Vesta. This event was energetic enough to eject 4 - 10 km fragments to the vicinity of the 3:1 resonance and also led to a freshly exposed regolith (globally) on the surface of Vesta. More numerous smaller (meteoroid-sized) ejecta sent toward the resonance, or subsequent collisional events on larger Vesta fragments near the resonance, has led to samples from Vesta being delivered to the inner solar system resulting in the occurrence of HED meteorites in Earth-based collections.

Evidence in favor of this scenario: If space weathering does occur in any significant amount on asteroids, a recent event that freshly exposes surface material on Vesta would be an unavoidable consequence since Vesta's spectrum shows no evidence of alteration. The occurrence of space weathering on asteroids is suggested by Galileo spectral observations of the asteroid Gaspra (6) which showed small fresh craters to have optical properties different than surrounding regolith (an effect similar to, but less pronounced than lunar space weathering (7)). The Vesta impact event must be large to redistribute regolith across the 500 km body; the existence of 20 small (<10 km) fragments probably derived from Vesta and trailing to the 3:1

resonance (5) speaks of a large impact event on Vesta. The possible basin suggested by Gaffey's rotational data (8) would be the principal remaining evidence of the impact. The orbits of two (possibly three) small near-Earth asteroids that exhibit Vesta-like composition are very similar, probably poorly evolved (young), and are candidates for part of an asteroid stream (9, 10). These NEA's, which themselves are short lived, were presumably fragments placed in the 3:1 resonance as a result of the impact and quickly joined the near-Earth population.

Evidence against this scenario: The character, magnitude, and rate of space weathering on asteroids is unknown. If the stony-iron meteorites are directly related to the HEDs (e.g. 11), the impact would have to have penetrated to the core mantle boundary while allowing the impactee (Vesta) to remain largely intact.

Discussion: While the discovery of the large "chips" off of Vesta imply one or more major impact events, the timing of any such event is not well constrained. Cosmic ray exposure ages of HED's suggest 10^7 - 10^8 yrs exposure time. Dynamical evolution of near-Earth asteroids suggests a shorter time scale. If the rate of space weathering were known, an upper limit could be set. The properties of the impactor and direction of impact await analysis. Furthermore, if a recent major impact and the young Vesta scenario is correct, then it is more plausible that Vesta is the sole parent body of HED meteorites and may be a unique asteroid--the only large asteroid known to have differentiated that still retains its crust. The young Vesta scenario also contributes to the ordinary chondrite parent body problem: if space weathering produces OC surfaces that mask the OC spectral characteristics, a young Vesta regolith is required to be consistent with Vesta observations.

Conclusions: If space weathering is an active process on asteroid surfaces, then the similarity of spectral characteristics between Vesta and the eucrite meteorites (absorption strength, absorption character, continuum, etc.) would require a recent (relative to the age of the solar system) impact to give Vesta a fresh unweathered regolith. An impact occurring relatively recently is a plausible scenario for forming the observed Vesta family of fragments and for yielding the current flux of HED meteorites.

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