DAWN AND THE VESTA – HED CONNECTION. H. Y. McSween[1], D. W. Mittlefehldt[2], A. W. Beck[3], T. McCoy[3], S. Marchi[4], M. C. DeSanctis[5], E. Ammannito[5], C. A. Raymond[6], C. T. Russell[7], and the Dawn Science Team. [1]University of Tennessee, mcsween@utk.edu, [2]NASA/Johnson Space Center, [3]Smithsonian Museum of Natural History, [4]NASA Lunar Science Institute, [5]INAF/ISAF, [6]Jet Propulsion Laboratory, Caltech, [7]University of California, Los Angeles.

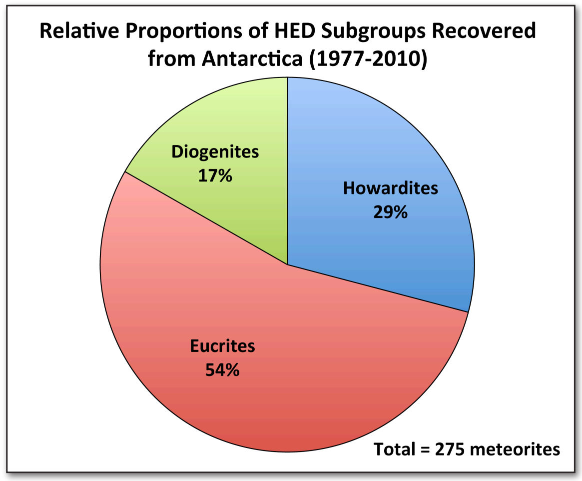
Introduction: Although it is difficult to explain exactly how eucrites and diogenites are related through simple magmatic processes, their shared oxygen isotopic compositions and the common occurrence of clasts of both lithologies in howardite breccias support derivation from a common parent body. For decades, HED meteorites have been linked to asteroid 4 Vesta, based on spectral similarities [1] and the discovery of a dynamical family (Vestoids) that provides a bridge between Vesta and nearby resonance escape hatches [2]. Although recently derived constraints on the rapidity of HED parent body differentiation, based on measurements of ^{26}Al in diogenites, have been used to argue against the Vesta-HED connection [3], new thermal evolution models [e.g., 4] appear to be heated and melted fast enough to account for this constraint.

Data from the Dawn orbiter strengthen the Vesta – HED linkage and provide new insights into petrogenetic interpretations of these meteorites.

Geologic context and rock proportions: Dawn VIR spectral maps of Vesta [5] show a relationship between compositions and depth of excavation. Although almost all of the surface materials exhibit howardite-like spectra, the units interpreted to have been excavated from deeper crustal levels by formation of the Rheasilvia basin and several other large craters are enriched in diogenite (based on pyroxene band depths and band centers); eucrite-enriched howardite dominates units of shallow derivation. This pattern is consistent with igneous textures and other indications of cooling rates of diogenites within subsurface plutons and of basaltic eucrites within surficial flows. Cumulate eucrites also crystallized within the subsurface crust and should be concentrated in deeply excavated materials, but VIR and GRaND data may not be able to distinguish cumulate and basaltic eucrites.

The recognition of harzburgitic diogenites [6] and a related dunite [7] reveal the occurrence of olivine-bearing ultramafic rocks, in addition to the more common orthopyroxenitic diogenites. The spectral signature of a significant concentration of olivine has not yet been found in Dawn data [5]. The proportion of olivine in harzburgitic diogenites (<30%) may be too low to be detected using the 2 μm/1 μm band area ratio [8]. However, GRaND may be able to distinguish olivine abundances in this range [9].

The relative proportions of HED lithologies among Antarctic finds, whether considered by number or mass, are clearly dominated by eucrites (Fig. 1). The Vestan surface is virtually covered by howardites [5], and eucrites and howardites dominate Vestoid spectra. The lower abundance of diogenite relative to eucrite is broadly consistent with their mapped areal exposures on Vesta and relative proportions of Vestoid spectra. The lower proportion of howardites among falls may reflect lack of lithification in the regolith, to be assessed from thermal inertia data.



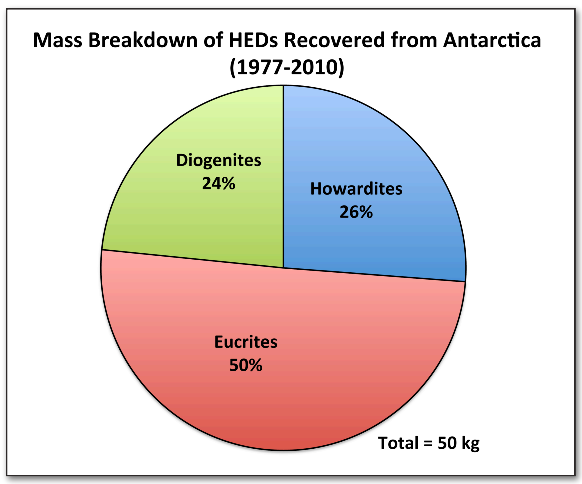


Fig. 1. *Relative proportions of eucrites, diogenites, and howardites by number (top), adjusted for pairings, and mass (bottom) among Antarctic meteorites. If only non-Antarctic falls are considered, the results are almost identical.*

Preponderance of breccias and thermally metamorphosed rocks: Most eucrites and diogenites, and all howardites, are breccias. Dawn images reveal a pervasive regolith-covered surface. Regolith thickness estimates vary up to a kilometer [10], allowing the likelihood of slow cooling of insulated ejecta. Coupled with the apparent absence of flows or volcanic constructs, we can predict the preponderance of HED breccias and shock-recrystallized rocks. The rarity of occurrences of pure eucrite or diogenite on Vesta, as judged from spectral maps, suggests that many unbrecciated eucrite and diogenite samples were probably blocks in the megaregolith. Pairing of some diogenites and howardites [11] supports this view.

Unusual or distinctive materials: Clasts of carbonaceous chondrite commonly comprise a few vol.% of howardites, although one howardite contains up to 70% [12]. Low impact velocities could allow significant concentrations of impactor to have been preserved. This exogenous, organic-rich material might account for localized dark materials on Vesta [13], although shock-blackened materials are another possibility. Impact melts in some howardites comprise up to 30 vol.% [11]. Other howardite components offer the possibility of Vestan materials not represented as whole meteorites. For example, K-rich glasses in howardites have been interpreted as impact melts of an unknown, highly fractionated lithology [14]; GRaND offers the potential to identify K- and Th-rich materials, though none have been seen to date. Light toned materials on Vesta do not yet have a recognized HED counterpart.

Impact chronology: Our understanding of HED impact histories is based of necessity on $^{40}Ar/^{39}Ar$ ages of brecciated eucrites [15, Fig. 2], since diogenites have such low K contents. Crater counts on the floor of Rheasilvia basin suggest a younger age than for other impact craters on Vesta [16], consistent with a young age for the Vestoids possibly ejected in that impact. Rheasilvia overlaps other, older craters, consistent with the complex shock history recorded in brecciated eucrites. A complex impact/thermal history is also indicated by recognition of metamorphosed, recrystallized breccias among the diogenites [17]. The Vestoids may be the immediate parent bodies of many or most HEDs. The absence of a young $^{40}Ar/^{39}Ar$ age peak that would define the Vestoid-producing event in HEDs is explainable because age resetting requires protracted heating within crater floor deposits or ejecta blankets [15].

Differentiation: The estimated mean density and J_2 for a two-layer model of Vesta, based on Dawn observations and orbital tracking, are consistent with a ~110 km diameter metallic core [18]. Siderophile element depletions in HEDs [19] also indicate core metal fractionation, and models for the HED parent body [19, 20, 21] predict a core of comparable size, although with fairly large uncertainties. Models based on HEDs also make predictions about the mantle composition, but no clear examples of excavated mantle on Vesta have yet been discovered. The thickness of the crust, as constrained by an HED model [20], is consistent with the apparent excavation depth of Rheasilvia.

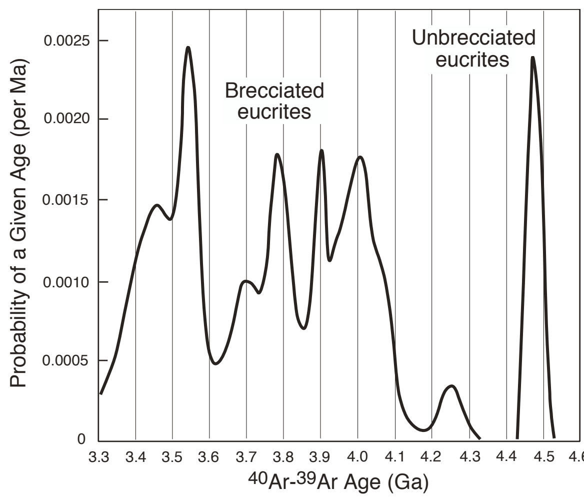


Fig. 2. *Probability plot of $^{40}Ar/^{39}Ar$ ages [after 15], with peaks representing major impact events.*

Conclusion: The hypothesis that Vesta is the HED parent body is consistent with, and strengthened by, the geologic context for HEDs provided by Dawn. Additional Dawn data should allow more informed interpretations of HED petrogenesis and geochronology.

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