THE VESTAN REGOLITH: PETROLOGIC-CHEMICAL STUDY OF HED POLYMICT BRECCIAS.

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Introduction: The howardite, eucrite and diogenite (HED) clan of meteorites consists of igneous rocks and derived impact breccias of an asteroid, quite likely (4) Vesta, that differentiated within the first few million years of formation of the first solids in the Solar System [1]. The HED clan includes a suite of polymict breccias that are the products of impact fragmentation, mixing and gardening of crustal igneous rocks; lower crustal diogenites, and upper crustal eucrites. In order of increasing fraction of eucritic material, these breccias are polymict diogenites, howardites and polymict eucrites. There are two types of howardites: regolithic and fragmental [2]. The former are samples of the true regolith whilst the latter are intermediate members of the polymict diogenite/polymict eucrite series [1-5]. Lithophile-element compositions of HED polymict breccias are consistent with simple mixing of main-group basaltic eucrite with diogenite; other crustal components – e. g., cumulate gabbro and evolved basalt – are subordinate [3]. However, petrologic studies show that the mixtures are much more complex [3, 6-10]. We are continuing the study of HED polymict breccias using the methodologies of [3] to further understand regolith mixing processes on Vesta.

Petrology: Petrologic studies are defining textural components and determining mafic mineral compositions of polymict diogenites, polymict eucrites and howardites. We include here the meteorites discussed in [3], and two diogenites that are paired with the PCA 02 howardite group [6]. Considering possible pairings, the number of falls being investigated amongst the 60 named meteorites might be as low as 7 polymict eucrites and 24 howardites.

We have found pyroxenes with compositions like those of cumulate eucrites – with low-Ca and high-Ca pyroxenes between the fields for diogenites and basaltic eucrites (see [1]) – in 5 howardite and 2 polymict eucrite falls. We have yet to positively identify cumulate eucrite pyroxenes in members of the GRO 95534 pairing group. This is in contrast to [7], but in that study, compositions of low-Ca pyroxenes only were used to identify a cumulate eucrite component, a potential shortcoming noted by those authors. Our analyses of the GRO pairs include numerous low-Ca pyroxene analyses within the field of cumulate eucrites, fully consistent with [7]. Three polymict eucrite and 7 howardite falls contain pyroxenes that are more ferroan than those found in Nuevo-Laredo-group eucrites, and an additional polymict eucrite and 4 howardite falls contain pyroxenes compositionally similar to those of Nuevo-Laredo-group eucrites. Thus, evolved basaltic components are commonly present in the breccias.

Composition: Whole-rock analyses are underway. Multiple splits and paired samples are being studied to evaluate cm- to decimeter-scale heterogeneity (cf., [3]). Our previous study noted that the major and trace element contents of HED polymict breccias are consistent with mixtures of average diogenite and main-group basaltic eucrite [3], but we did not attempt quantitative mixing-model calculations. Exceptions noted were: (i) polymict eucrite LEW 86001 that is dominated by Stannern-group eucrite material; (ii) howardite LAP 04838 that contains a significant component of evolved basaltic material; and (iii) howardite PRA 04401 that contains ~55 wt% CM chondrite material. These compositional exceptions are consistent with petrologic observations [3, 10, 11].

Discussion: One conclusion of [3] is that because many howardites contain >30% of a lower-crustal diogenite component, the lack of a cumulate-eucrite compositional signature in the breccias is unlikely to have been caused by under sampling deep-seated intrusions. Whilst [3] did conclude that main-group eucrites are the dominant upper-crustal component in the breccias, they also noted that the result could be explained by thorough blending of all mafic components in the breccias. This latter possibility was not explored. Petrogenetic models for vestan differentiation indicate that the upper crust ought to be basically main-group eucrite in bulk composition (e.g., [12]). Thus, regolithic howardites, posited to represent ancient, well-mixed regolith [2], ought to contain a mafic component that averages to main-group eucrite in composition regardless of what other components are petrologically identifiable: cumulate gabbro + evolved basalt ≈ main-group eucrite. Fragmental polymict breccias with higher percentages of mafic component, would be more likely to deviate from simple diogenite-main-group-eucrite mixing lines. This is the case for LEW 86001 and LAP 04838, but not for three other howardites/polymict eucrite falls with >80% mafic component [3]. Continuing work will focus on comparing mixing signatures in different types of vestan polymict breccias.

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