GEOCHEMICAL CHARACTERIZATION OF THE DOMINION RANGE 2010 HOWARDITES: TOWARDS IDENTIFYING TRACE ELEMENT SIGNATURES OF VESTA'S UNIQUE LITHOLOGIES.

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Introduction: Howardites are complex meteorite breccias that contain an array of endogenic (eucrites and diogenites) and exogenic (carbonaceous chondrite) materials, and are characteristic of the vestan surface regolith and megaregolith [1-3]. Accordingly, howardites are well-suited for investigating the lithologic and geochemical heterogeneity on Vesta.

Within the last decade, numerous studies have systematically characterized the petrography and geochemistry of howardite pairing groups, which collectively represent the largest samples of the vestan surface [e.g., 4-8]. Recently, Hahn et al. [8] characterized the Dominion Range (DOM) 2010 howardite pairing group and identified 21 petrologically distinct lithologic types based on petrography, mineralogy, and pyroxene chemistry: 8 basaltic eucrites, 4 cumulate eucrites, 7 diogenites, a Mg-rich harzburgite-dunite [9], and an evolved dacite lithology [10]. Here we investigate the bulk geochemistry of these samples in an attempt to identify the trace-element signature of the two new, recently characterized, vestan lithologies [9,10]. Additionally, we estimate their percentage within the samples, and by inference the vestan regolith, using their geochemical signatures and mixing calculations.

Samples: The DOM 10 howardite pairing group comprises six stones (DOM 10100, 10105, 10120, 10837, 10838, and 10839), which are composed of polycrystalline and polymineralic (lithic) clasts, and secondary impact-derived breccia clasts (breccia-within-breccia), impact melts, and non-typical HED material, set in a fine-grained matrix of predominantly comminuted plagioclase and pyroxene [8]. Hahn et al. [8] reported inter- and intra-sample variation of lithic clast abundance, with some samples containing less than 3 visible clasts, while others included >15 [8]. Three types of breccias were distinguished petrographically: monomict diogenite, polymict eucrite, and a howardite breccia containing large and abundant Mg-rich olivines [8,9].

Methods: We analyzed select major and trace elements by INAA at Washington University in St. Louis. Five sub-samples were requested for DOM 10100; three sub-samples were requested for all other stones. Our goal was to capture the geochemical heterogeneity within the pairing group and attempt to identify the geochemical signature of atypical lithologies previously documented within the DOM 10 howardite pairing group [8]. All samples were photographed and separated into sub-splits weighing ~60 to 130 mg, with a total of twenty sub-splits analyzed.

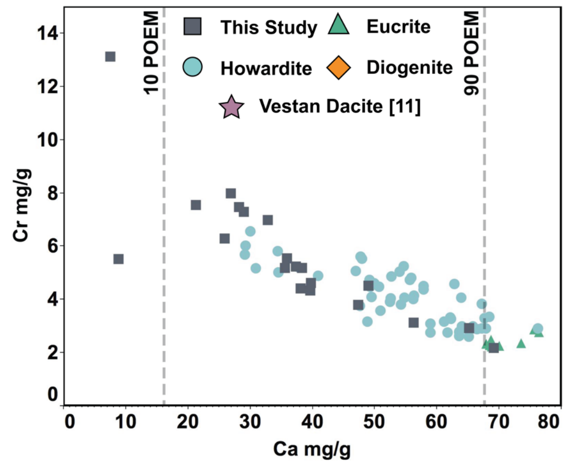

Figure 1. Element variation diagram for Cr and Ca. Values for 10 and 90 $POEM_{Ca}$ are shown for reference. The DOM 10 howardites display large variations in $POEM_{Ca}$. External data from [7]. Legend applies to all figures.

Results and Discussion: The DOM 10 howardites have again proven to be one of the most diverse and complex samples within the HED meteorite group. We estimated the percentage of eucritic material (POEM) in the howardites using the method of Jérome and Goles [11], which assumes the polymict breccias are two-component mixtures. Specifically, we compared Ca concentrations to mean basaltic eucrite and diogenite ($POEM_{Ca}$) [e.g, 12]. The $POEM_{Ca}$ in the breccias ranges from near end-member diogenite to 90 $POEM_{Ca}$ (Fig. 1), which supports the identification of multiple breccia domains in the DOM 10 howardites, and is consistent with the petrographic and lithologic diversity documented previously [8].

Trace-element characteristics of the DOM 10 howardites share similarities to historical HED analyses (Fig. 2) [e.g., 7,12]; however, several sub-samples are anomalous, indicating the breccias are not simply two component mixtures. For instance, sub-samples of 10837 and 10838 display a factor of 2 to 3 enrichment in K relative to average eucrite (Figs. 2 and 3). For reference, we plot the calculated major- and trace-element chemistry for the dacite lithology identified in [10]. A preliminary investigation of the INAA data suggests a dacite component in the analyses could account for the increase in K; however, a relative and corresponding increase in REEs is absent, or at least, masked by the inclusion of REE-depleted components (i.e., diogenites). Our preliminary examination of the INAA data suggests that although the dacite, and possibly Mg-rich

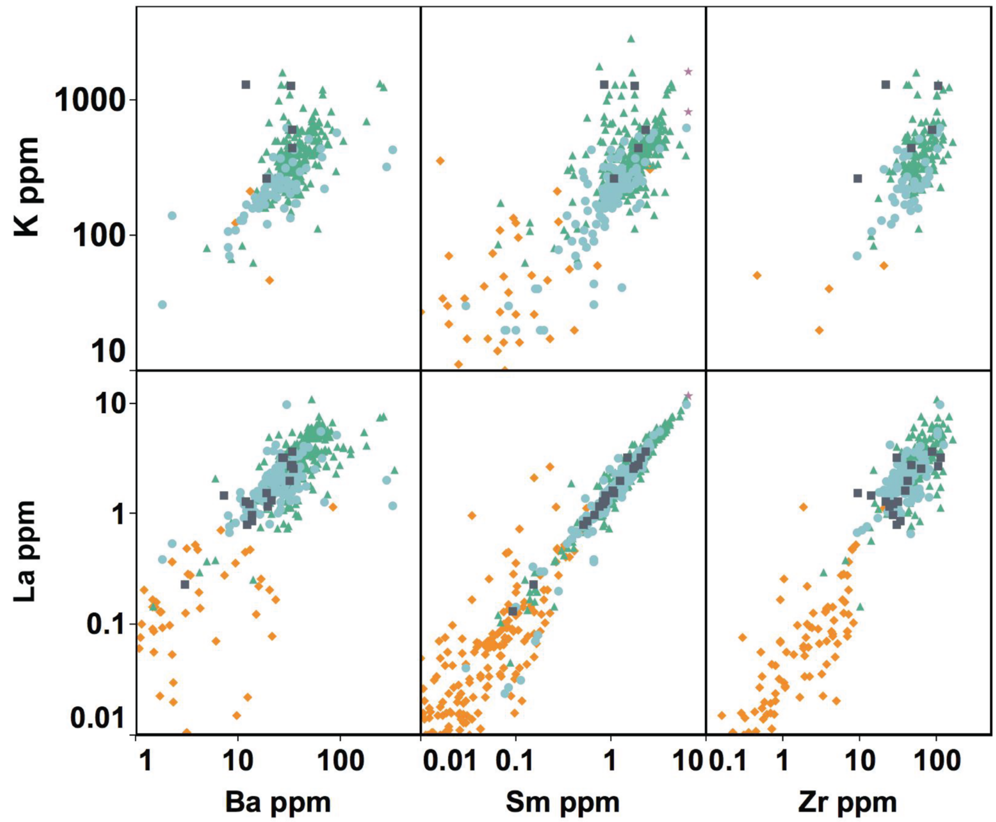

Figure 2. Element variation diagrams for select major- and trace-elements in the DOM 10 howardites. External data for HEDs from [7]. Calculated dacite composition from [10].

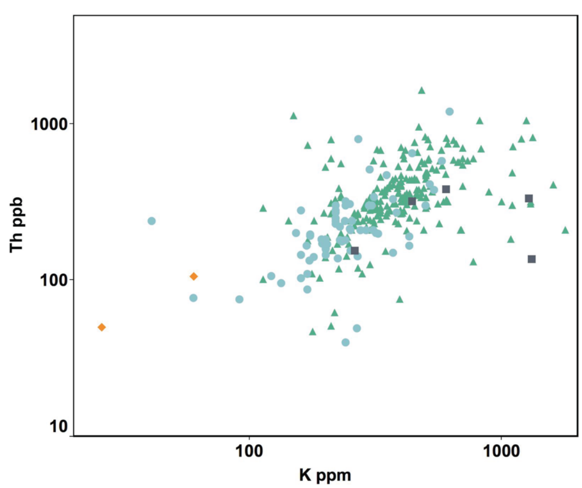

Figure 3. Element variation diagram for K and La. The DOM 10 howardite sub-samples contain both K-enriched and K-depleted samples. From our preliminary analysis, we interpret this as contributions from the dacite and Mg-rich harzburgite components, respectively [10 and 9, respectively]. External data from [7]. Calculated dacite composition from [10].

harzburgite, are rare and minor components in the HED meteorite suite, their geochemical signatures may be distinct enough for identification in bulk geochemical data; we will continue interrogation of the INAA dataset to further support our hypotheses. If successful, we will use the geochemical signatures identified as end-members in mixing calculations to estimate the percentage of components within each sample, and compare our results to values determined independently using qualitative and quantitative compositional mapping by [8].

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