

**PARTIAL MELTS OF THE EUCRITIC CRUST: ON THE ORIGIN OF DACITIC MELTS AND THE STANNERN TREND CONTAMINANT.** T.M. Hahn Jr.<sup>1</sup>, N.G. Lunning<sup>2</sup>, H.Y. McSween<sup>3</sup>, L.A. Taylor<sup>3</sup>, and B.L. Jolliff<sup>1</sup>, <sup>1</sup>Washington University, St. Louis (thahnjr@wustl.edu), <sup>2</sup>Smithsonian Institution, <sup>3</sup>University of Tennessee, Knoxville.

**Introduction:** Eucrites are meteoritic basalts and gabbros associated with the asteroid 4 Vesta [1,2], and are thought to have originated during the primordial differentiation of Vesta through either crystallization or partial melting processes [1,3,4,5,6]. Eucritic meteorites are divided into basaltic and cumulate types, with the latter typically showing more Mg-rich pyroxene compositions and cumulate textures. Basaltic eucrites are further divided into the Stannern-Residual and Main-Group Nuevo Laredo (MGNL) trends based on incompatible element correlations; Stannern-Residual trend eucrites show increasing or decreasing incompatible element concentrations, with a nearly constant Mg# [7,8]; incompatible element concentrations in the MGNL eucrites are negatively correlated with the bulk Mg# [3].

Differentiation models for Vesta predict the existence of evolved lithologies [e.g. 3]. Indeed, evolved clasts within howardite breccias provide evidence for such lithologies [e.g. 9]; however, their petrogenesis is debatable due to their small sizes. Fractional crystallization processes have been suggested as the source of major- and minor-element correlations in the MGNL eucrites [3]; therefore, extensive fractional crystallization is a plausible explanation for the origin of evolved lithologies on Vesta. Alternately, partial melting processes, which play a critical role in the generation of evolved lithologies on other planetary bodies such as the Moon and the Earth, may be responsible for the origin of evolved melts. Recently, the latter hypothesis

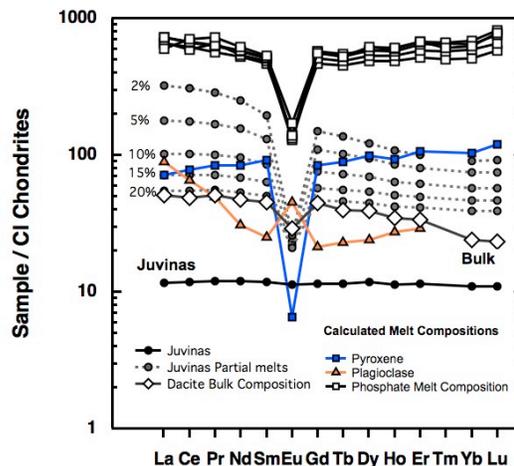


Figure 1. Calculated REE composition of the dacite clast. Melts in equilibrium with augite, plagioclase, and phosphate are shown. For comparison, compositions of partial melts derived from a Juvinas source are shown. The range in equilibrium melt composition is much larger for HREE; therefore, LREE are suitable for placing constraints on the parental melt composition. The REE budget of the melt parental to dacite is capable of being produced by ~10 to 20% partial melting of a Juvinas source.

has been proposed to explain the origin of Stannern trend eucrites, through the contamination of MGNL liquids with partial melts of the vestan crust [7]. This hypothesis is supported by the existence of partially melted residual eucrites [8]; however, no direct evidence of the contaminant melt has been identified.

We have identified a large clast (4 mm x 4 mm) with an evolved mineral assemblage [10], and of dacitic composition, within a Dominion Range 2010 howardite. For a detailed description of the mineralogy and textural characteristics, see [10]. Here we discuss the geochemistry of this clast within the context of eucrite petrogenesis. Implications for the production of evolved melts within the vestan crust, and the genesis of the Stannern trend eucrite contaminant are discussed.

**Methods:** Electron microprobe (EMP) and laser ablation inductively-coupled mass spectrometry (LA ICP-MS) analyses were conducted at the University of Tennessee and Virginia Tech to quantify the major-, minor-, and trace-element geochemistry of mineral phases. Mineral distribution mapping was used to quantify the modal percentages of phases [11]. Mineral abundance and compositional datasets were used in a modal recombination procedure, with an applied

Table 1. Reconstructed bulk composition of dacite clast.

| Wt.% oxide                     | Bulk composition  |                             |                       | Element (ppm) |      |
|--------------------------------|-------------------|-----------------------------|-----------------------|---------------|------|
|                                | Bulk <sup>a</sup> | Silicate-Oxide <sup>b</sup> | Bulk-FeS <sup>c</sup> | Element       | Bulk |
| SiO <sub>2</sub>               | 54.5              | 59.2                        | 58.4                  | Sc            | 62   |
| TiO <sub>2</sub>               | 1.5               | 1.6                         | 1.6                   | Sr            | 155  |
| Al <sub>2</sub> O <sub>3</sub> | 14.5              | 15.8                        | 15.6                  | Y             | 51   |
| Cr <sub>2</sub> O <sub>3</sub> | 0.1               | 0.1                         | 0.1                   | La            | 12   |
| MgO                            | 2.2               | 2.4                         | 2.4                   | Ce            | 29   |
| CaO                            | 11.2              | 12.2                        | 12.0                  | Pr            | 5    |
| MnO                            | 0.2               | 0.2                         | 0.2                   | Nd            | 21   |
| FeO <sup>T</sup>               | 13.2              | 6.9                         | 8.5                   | Sm            | 7    |
| Na <sub>2</sub> O              | 0.7               | 0.7                         | 0.7                   | Eu            | 2    |
| P <sub>2</sub> O <sub>5</sub>  | 0.2               | 0.2                         | 0.2                   | Gd            | 9    |
| K <sub>2</sub> O               | 0.1               | 0.2                         | 0.2                   | Tb            | 1    |
| S                              | 5.9               |                             |                       | Dy            | 9    |
|                                |                   |                             |                       | Ho            | 2    |
|                                |                   |                             |                       | Er            | 5    |
|                                |                   |                             |                       | Yb            | 4    |
|                                |                   |                             |                       | Lu            | 1    |
| Fe# (molar)                    | 77                | 61                          | 67                    |               |      |
| Total                          | 104.5             | 99.6                        | 100.0                 |               |      |

<sup>T</sup> FeO<sup>T</sup> assuming all Fe as FeO.

<sup>a</sup>Bulk composition includes all phases within the dacite clast.

<sup>b</sup>Bulk composition excludes FeNi metal and FeS.

<sup>c</sup>Bulk composition excludes FeS component.

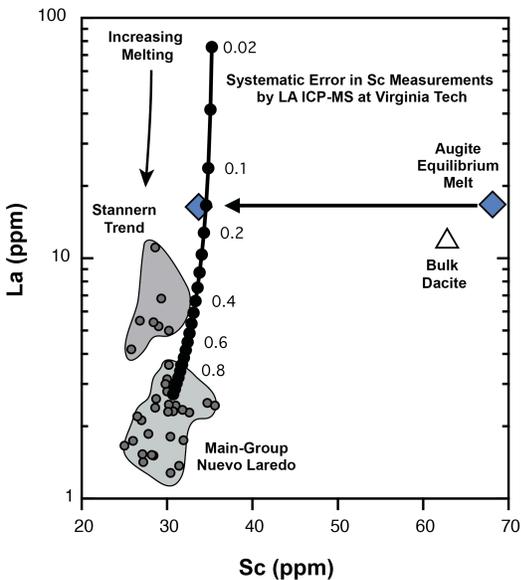


Figure 2. Trace-element evolution during the partial melting of a Juvinas source. Stannern trend eucrites have been proposed as mixtures of MGNL parental liquids, and crustal partial melts. The bulk dacite composition and melts in equilibrium with augite suggest ~15 % partial melting could yield the trace-element characteristics of the dacite clast. Although our Sc values appear to be a factor of two greater than eucritic compositions, this is attributed to systematic error in measured Sc values. We note, that for comparison, our measured values of Sc are commonly twice that of the true values; this is also a consequence of large errors (>20 %) in measured Sc values.

density correction, to reconstruct the bulk composition for major- and minor-elements, and selected trace elements. The calculated bulk composition was used in partial melting and crystallization models using the MELTS software [12], to evaluate hypotheses for the origin of the dacitic clast. Quantitative models for trace-element partitioning were used to assess trace-element evolution [13]. For the purpose of this abstract, we focus on the trace-element constraints for the petrogenesis of the dacite clast.

**Results:** The calculated bulk composition of the dacite clast is shown in Table 1. The compositions listed correspond to normalized mineral assemblages, which include all phases (bulk), an assemblage with only silicates and oxides (silicate-oxide), and an assemblage lacking FeS (bulk-FeS). We calculated these compositions to evaluate error associated with calculating Fe in FeNi metal as FeO, and textural features that suggest the FeS may be a secondary phase.

Our MELTS modeling, using Juvinas as an initial composition, leads to the conclusion that fractional crystallization processes cannot explain the major- and minor-element composition of the dacite. To evaluate partial melting using MELTS, an equilibrium crystallization model was used, as crystallization and partial melting under equilibrium conditions are equivalent

processes. Interestingly, 80 to 90 % equilibrium crystallization (10 to 20 % partial melting) can account for the major- and minor-element composition of the dacite lithology.

Quantitative models for the trace-element evolution of melts during fractional crystallization and partial melting provide consistent conclusions that are in accordance with our MELTS models. Specifically, the trace-element composition can be produced by ~10 to 20 % partial melting of a eucritic source (Figure 1 and 2). The range in REE melt compositions calculated for melts in equilibrium with minerals in the dacite clast may be explained by subsequent fractional crystallization of the derivative partial melts; this hypothesis is consistent with textural considerations that suggest the order of crystallization was plagioclase, augite, and phosphates (Figure 1).

**Discussion and Conclusion:** Our investigation of the dacite clast indicates that tertiary samples exist on Vesta – a product of partial melting and subsequent crystallization processes; this suggests that crustal processes on Vesta were complex, and is in agreement with current models of the vestan crust. We propose that the liquid parental to the dacite clast is a plausible candidate for the contaminant melt responsible for the genesis of the Stannern trend eucrites. Barrat et al. [7] hypothesized that mixing between crustal partial melts from a Juvinas source (5 to 15 %) and MGNL liquids are responsible for the genesis of the Stannern trend eucrites. Indeed, our trace-element modeling implies that melts parental to the dacite lithology can be produced by 10 to 20 % partial melting of a Juvinas source. Additionally, the rarity of dacite in HEDs (1 clast in >100 HEDs) is also consistent with the lower abundance of Stannern trend eucrites. The dacite clast offers further evidence of partial melting in the vestan crust, and direct evidence of plausible contaminant melts responsible for the origin of the Stannern trend eucrites.

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