PETROLOGY AND MINERALOGY OF FINE-GRAINED EUCRITES AS A GUIDE TO UNDERSTANDING THE PETROGENESIS OF VESTA.

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Introduction: Vesta is the largest differentiated asteroid in the main belt between Mars and Jupiter. It is also the only asteroid for which we have identified an associated meteorite group, the Howardite-Eucrite-Diogenite suite, or HED's. Vesta offers us the ideal opportunity to understand the processes involved in planetary formation, particularly differentiation (separation into a core-mantle-crust structure), as it has remained largely unchanged since its initial formation [1]. Earth has remained geologically active and processes that occurred early in our Solar System's history have been erased.

Despite having ground-based telescope data, meteorite samples, and Hubble Space Telescope data of Vesta, its formation is still not well understood. The two main competing models are magma ocean [2], [3] and partial melting [4] which would produce global melting and localized melting respectively. One of the goals of the Dawn mission, due to arrive at Vesta in 2011, is to be able to understand the formation of Vesta [5]. For this to be achieved we must be able to predict how each model would effect the surface of Vesta.

Testing Models for the Petrogenesis of Vesta: Recent work on the ALH A81001 meteorite suggests that there may be a way to test the two competing petrogenetic models for Vesta with Dawn [6]. ALH A81001 is a quenched textured eucrite, which must have cooled quickly after its formation (Figure 1). Unlike most eucrites, ALH A81001 has not been re-equilibrated due to thermal metamorphism and as a result, it retains much of its original chemical zonation. Due to the large number of eucrites that have been re-equilibrated, it has been suggested that a global, metamorphic event occurred on Vesta [7]. Therefore, ALH A81001 must have either formed late after any metamorphic events or was somehow unaffected.

ALH A81001 pyroxene grains are Cr-rich compared to other eucrite pyroxenes. Chromium is a compatible element with pyroxene and so finding Cr-rich eucrites means that they have formed from a primitive melt. Eucrites depleted in chromium are therefore formed from later melts and are more Al-rich due to the reduction of chromium available [6].

In order to explain the formation of ALH A81001 on Vesta, in terms of both the partial melting and magma ocean models, very different scenarios must be

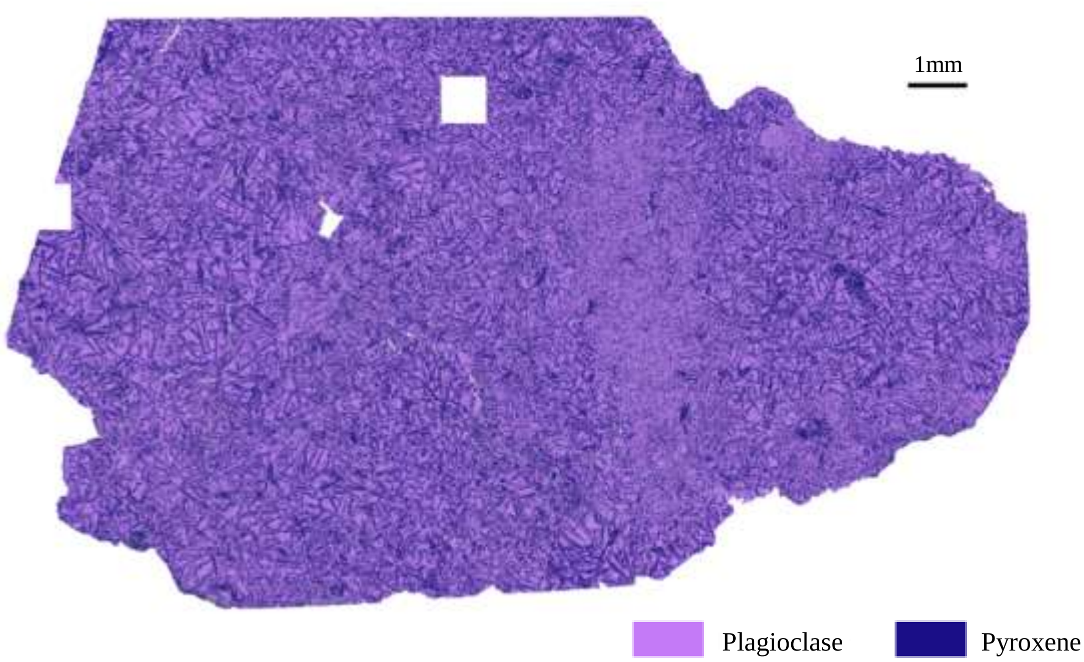

Figure 1: FEI Nova NanoSEM 600 mineral map of ALH A81001. Adapted from [8]

considered. In the partial melting model, ALH A81001 could have formed as a late-stage primitive melt on or close to the surface, or as a quench margin on an ascending melt [6]. Either way, any outcrops of ALH A81001 on the surface of Vesta would be small. The magma ocean model requires early crystallization of Cr-rich pyroxenes. However, early-crystallized material would sink to the bottom of the cumulate pile and be re-equilibrated. Mayne et al. [6] suggest that the only possible way to form ALH A81001-like material is for it to represent the quench-crust of the magma ocean. This implies large-scale, even global, outcrops of ALH A81001-like material on the surface of Vesta. By identifying units like ALH A81001 and their distribution, we may be able to determine which of these models best explains the formation of Vesta [6].

Current Research: Before Dawn reaches Vesta and maps its surface we can use eucrites in meteorite collections to ascertain the abundance of ALH A81001-type eucrite material. Abundant fine-grained, Cr-rich material would suggest that ALH A81001-type eucrites are abundant on Vesta. From previous studies, such as [4], [8], [9] we know that individual fine-grained eucrites are not common; however, the textural variety of eucrite clast types within howardites is far greater. Howardites are the most abundant of the HED family and can contain unique eucrite clasts not found in eucrite-only samples.

In this study, we have examined the entire US Antarctic Meteorite Collection of howardites at the Smithsonian for the presence of fine-grained eucrite clasts. We are also in the progress of expanding this to include the non-Antarctics. Clasts that have a quenched texture will be mapped using the scanning electron microscope in the Mineral Sciences Department at the Smithsonian. The resulting x-ray maps and BSE images will be used to analyze minerals present, modal abundances, and textures. The mineral chemistries of pyroxne and plagioclase within each clast will be analyzed using an electron microprobe. There will be a focus on the Cr-content of the eucrite pyroxenes as it is the combination of the fine-grained nature of ALH A81001 ***with*** its Cr-rich pyroxenes that makes it such an important sample. So far five fine-grained clasts have been identified in four howardites (Figure 2). Four have been mapped using the SEM and our initial findings for each of these clasts will be presented at LPSC.

By conducting this research and with eventual data from Dawn, we can further understand unique ALH A81001-like samples and their distribution on Vesta to determine the model that best fits its petrogenesis.

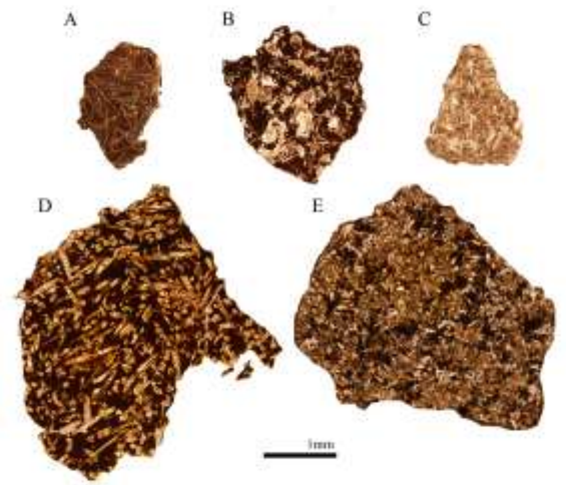

Figure 2: Photomicrographs in plain-polarized light of 5 fine-grained clasts in various howardites samples. (A) and (B) MIL 07664,4 (C) EE96002 (D) QUE 97001 (E) QUE 99033,2.

References: [1] Russell, C.T, Capaccioni, F, Coradini, A, Christensen, U, De Sanctis, M.C, Feldman, W.C, Jaumann, R, Keller, H.U, Konopliv, A, McCord, T.B, McFadden, L.A, McSween, H.Y, Mottola, S, Neukum, G, Pieters, C.M, Prettyman, T.H, Raymond, C.A, Smith, D.E, Sykes, M.V, Williams, C.M, Zuber, M.T. (2006) *Advances in Space Research*, 38, 2043-2048. [2] Righter K. and Drake M. J. (1997) *Meteoritics & Planetary Science.*, 32, 929-944. [3] Ruzicka, A, Snyder, G.A, & Taylor, L.A. (1997) *Meteoritics & Planetary Science*, 32, 825-840. [4] Stolper E. (1977) *Geochim. Cosmochim. Acta*, 41, 587-611.
[5] Russell, C.T, Coradini, A, Feldman, W.C, Jaumann, R, Konopliv, A.S, McCord, T.B, McFadden, L.A, McSween, H.Y, Mottola, S, Neukum, G, Pieters, C.M, Raymond, C.A, Smith, D.E, Sykes, M.V, Williams, B.G, & Zuber, M.T. (2002) *Proceedings of Asteroids, Comets, Meteors*, 63-66.
[6] Mayne, R.G, Sunshine, J.M, McSween, H.Y, McCoy, T.J, Corrigan, C.M, & Gale, A. (2010). *Meteoritics & Planetary Science*, In press. [7] Yamaguchi A., Taylor G. J., and Keil K. (1997) *Journal of Geophysical Research,* 102, 13381–13386. [8] Mayne, R.G., McSween, H.Y., McCoy, T.J., & Gale, A. (2008). *Geochimica et Cosmochimica Acta*, 73, 794-819. [9] Russell, C.T, Coradini, A, Christensen, U, De Sanctis, M.C, Feldman, W.C, Jaumann, R, Keller, H.U, Konopliv, A.S, McCord, T.B, McFadden, L.A, McSween, H.Y, Mttola, S, Neukum, G, Pieters, C.M, Prettyman, T.H, Raymond, C.A, Smith, D.E, Sykes, M.V, Williams, B.G, Wise, J, Zuber, M.T. (2004) *Planetary and Space Science*, 52, 465-489.