Stannern-Trend Eucrite Petrogenesis: an Assessment of Partial Melt Contamination Models via Experimental Petrology. S. D. Crossley[1], R. G. Mayne[1], N. G. Lunning[2], T. J. McCoy[2], R. C. Greenwood[3], and I. A. Franchi[3]. [1]Texas Christian University Monnig Meteorite Collection, School of Geology, Energy, and the Environment, 2950 West Bowie SWR 207, Texas Christian University, Fort Worth, TX 76109 (s.crossley@tcu.edu), [2]Smithsonian Institution, NMNH, Washington DC, 20560, USA, [3]Open University, Planetary and Space Sciences, The Open University, Milton Keynes MK7 6AA, UK.

Introduction: HED meteorites have long been associated with the surface of the asteroid 4-Vesta [1]. NASA's Dawn mission has provided spectroscopic evidence to support this connection [2], but the petrogenesis and geochronology of eucrites, which represent Vesta's basaltic crust, have not been well-constrained. The Stannern-trend eucrites, in particular, are problematic in simple petrogenetic models, as they cannot be explained as either products of fractional crystallization in a magma ocean or through partial melting of a chondritic precursor [3]. Currently, the most widely accepted model of Stannern-trend eucrite petrogenesis asserts that Stannern-trend eucrites could have formed via the partial melting of a residual eucritic crust, wherein the partial melt product contaminated Main-Group-Nuevo-Laredo-trend eucritic magmas [3]. Melting experiments have been conducted with eucrites at near-solidus temperatures in order to determine carrier phases and transport mechanisms for incompatible elements [4]; mesostasis apatite was found to carry the majority of incompatible elements that contribute to the discrepancy between Stannern and MG-NL trends. These experiments were conducted at near-solidus temperatures and did not yield enough melt product in some samples for the partial melt to be analyzed [4]; however, we believe that expanding upon previous experimental conditions (i.e. increasing temperature) will yield a greater partial melt, which can be analyzed and used to test the currently accepted model of Stannern-trend eucrite petrogenesis. To most accurately replicate Vestan petrologic processes, the starting material would have to meet a set of petrologic and geochemical criteria in order to reflect the petrogenetic processes involved in the formation of Stannern-trend eucrites.

Starting Material: The starting material for experimentation must be an unbrecciated, unequilibrated eucrite that is preferably fine-grained and rich in mesostases. A fine-grained texture is preferred, because it would yield a larger crystal surface area-to-volume ratio, decreasing the amount of energy needed to melt areas rich in mesostases.

In June 2015, the Monnig Meteorite Collection at TCU acquired the main mass (510 g) of NWA 8562, an unbrecciated, unequilibrated eucrite [5] (Figure 1a).

Oxygen-isotope composition. Bulk oxygen isotope composition of a powdered sample of NWA 8562 was determined in duplicate by laser-assisted fluorination. The results obtained were as follows (1σ):
$\delta^{17}O = 1.768 \pm 0.042‰$, $\delta^{18}O = 3.842 \pm 0.072‰$,
$\Delta^{17}O = -0.246 \pm 0.004‰$ (linearized, slope: 0.5247)

The $\Delta^{17}O$ value of the sample plots close to and within error of the HED fractionation line of [6] and indicates that NWA 8562 is an isotopically normal member of the HED suite.

Petrographic characterization. Two thin sections of the meteorite were prepared in order to characterize the suitability of NWA 8562 for petrologic experimentation. NWA 8562 is composed of approximately 60% pyroxene and 35% plagioclase, with accessory silica, ilmenite, and troilite [5]. Both plagioclase and pyroxene show poikilitic texture (Figure 1b), and are predominantly anhedral. Most plagioclase range from <10μm to ~80 μm. Pyroxenes retain igneous zonation and range from pigeonite to ferro-augite [5]. The size of pyroxenes range from <10μm to ~100 μm. The presence of metastable ferro-augite and Fe-rich mineral endmembers places NWA 8562 within the Type 1 eucrite classification [7]. Some shock mosaicism is present in pyroxene.

Experimental Methods: Following experimental techniques established in [4], we prepared three samples (~0.3-0.4 g each) of NWA 8562, and placed each sample in an alumina tube inside a 1 atm gas mixing furnace. The three samples ran at 1050, 1100, 1150, and 1200°C for 24 hours at $\log f_{O_2}$ = IW-0.5. At the end of the run time, the samples were drop-quenched in water.

Preliminary Results: As of January 2016, quantitative data for the experiments have not yet been collected. However, a qualitative assessment of the experimental products (Figure 1c-d) shows preferential melting of mesostasis minerals at 1050°C with minor melting occurring along the rims of major minerals. At 1100°C, mesostasis is almost completely melted, along with the majority of metals. Pore spaces also begin to develop at this temperature as melt migrates toward the margins of the sample. At 1150°C, grain boundaries begin to become indistinct, and some of the pore spaces have been filled with melt. At 1200°C, very few relict crystals remain, and the remainder of the material has quenched to glass.

Discussion: A low percent melt that could produce Stannern-trend eucrites should be markedly enriched in incompatible elements (i.e. Ti and REEs) [3]. It is worth examining data from [4] in order to determine the plausibility of the aforementioned model of Stannern-trend eucrite petrogenesis prior to the analyses of our melt products. Partial melts of 1-2% in those experiments were markedly enriched in P_2O_5, TiO_2, K_2O, and REEs. A simple mixing calculation [8] for 80% MG-NL magma and 20% partial melt contaminant shows that La concentration in the partial melt fraction (10.6 µg/g) could produce a magma where La = 3.992 µg/g, which approaches the lower range of the Stannern trend (> 4 µg/g) [9]. By the time of this presentation, we plan to have analyzed a more complete dataset that will allow us to quantitatively assess the plausibility of the model.

Future Work: The melt products within these samples will be examined using a variety of analytic techniques (i.e. EMP, SIMS, SEM), which should account for the compositional variations between Stannern and MG-NL eucrite trends if the model of Stannern-eucrite petrogenesis is correct. It is our hope that EMP analyses will be prepared by the time of this presentation.

References: [1] McCord T.B. et al. (1970) *Science*, 168, 1445-1447. [2] De Sanctis M.C. et al. (2012) *Science*, 336, 697-700. [3] Barrat J.A. et al. (2007) *GCA*, 71, 4108-4124. [4] Yamaguchi A. et al. (2013) *Earth and Planet. Sci. Letters*, 368, 101-109. [5] Agee C. (2014) *Met. Bull., 103*. [6] Greenwood R. C. et al. (2006) *Science*, 313, 1763-1765. [7] Takeda H. and Graham A.L. (1991) *Meteoritics*, 26, 129-134. [8] DePaolo D.J. (1981) *Earth Planet. Sci. Lett.*, 53, 189-202. [9] Stolper E. (1977) *GCA*, 41, 587-611.

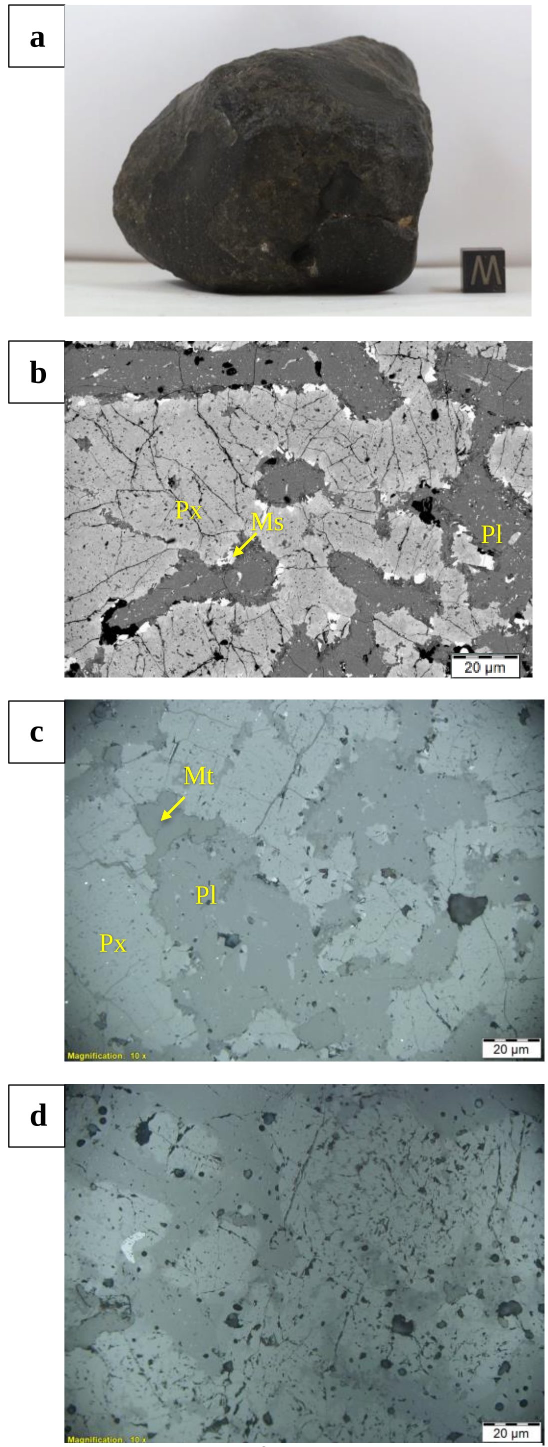

Figure 1: (a) Photograph of NWA 8562 main mass, (b) back-scatter electron SEM image of unheated material and reflected light photomicrographs of experimental products at (c) 1050°C and (d) 1100°C. Samples show a preferential melting of mesostases at lower temperatures. As temperature was increased, major phases also melted. Pl is plagioclase, Px is pyroxene, Ms is mesostasis, and Mt is melt product.