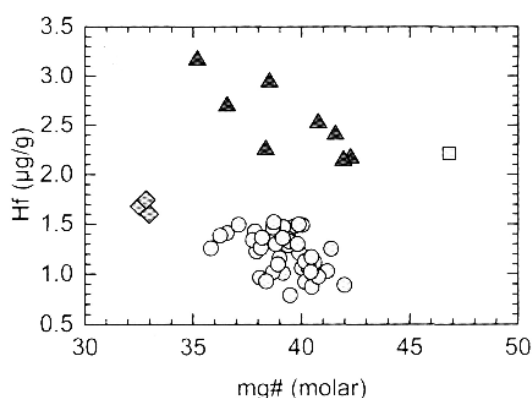


**EXPERIMENTAL INSIGHTS INTO THE ORIGIN OF THE STANNERN GROUP EUCRITES.** J.H. Jones<sup>1</sup> and C.K. Shearer, Jr.<sup>2</sup>. <sup>1</sup>XI-3, ARES, NASA/JSC, Houston, TX 77058 ([john.h.jones@nasa.gov](mailto:john.h.jones@nasa.gov)); <sup>2</sup>Institute of Meteoritics, Univ. of New Mexico, Albuquerque, NM 87131.

**Introduction:** In his experimental examination of the eucrite suite of basaltic achondrites, Stolper [1] postulated that Stannern, and eucrites of similar composition, were formed by low-degrees of partial melting. He further concluded that most other eucrites (Main Group eucrites) were formed by higher degrees of partial melting of the same mantle source that produced the Stannern group.

The rationale behind Stolper's model was that both the Stannern group and Main Group eucrites clustered tightly at an olivine-pyroxene-plagioclase invariant point in the OL-SI-AN ternary system. The first partial melts of a plagioclase peridotite source would be expected to have the composition of that invariant point. Additionally, on a TiO<sub>2</sub> v. Mg# diagram, the Main Group and Stannern trend eucrites appeared to have the same Mg#, but different TiO<sub>2</sub> contents [1]. Thus, the higher concentration of an incompatible element such as TiO<sub>2</sub> appeared to indicate that the Stannern trend formed by smaller degrees of partial melting than the Main Group eucrites, but that Mg# was buffered by olivine and pyroxene in the residuum.

Recently, Mittlefehldt and others [2,3] have argued that the Stannern trend does not exist. Modern eucrite data show a gap between the Stannern group and the Main Group, with no continuum between the two, as would be the result of different degrees of melting. On a Hf vs. Mg# diagram (Fig. 1), the Stannern group



**Figure 1.** Hf v. Mg# from [3]. Main Group eucrites (circles) clump about a Hf of ~1.0-1.5 ppm and Mg# of ~39; Nuevo Laredo eucrites (diamonds) clump at ~1.7 ppm Hf and Mg# of 32.5; and Stannern group eucrites (triangles) show a scattered trend of decreasing Hf with increasing Mg#. Pomozdino (square) appears to stand alone.

plots above the Main Group at roughly the same Mg#, but appears to have its own Hf v. Mg# trend that does not intersect the Main Group cluster [3].

Here we reexamine the origin of the Stannern group and its relationship to the Main Group eucrites and the potential for multiple eucritic parent bodies.

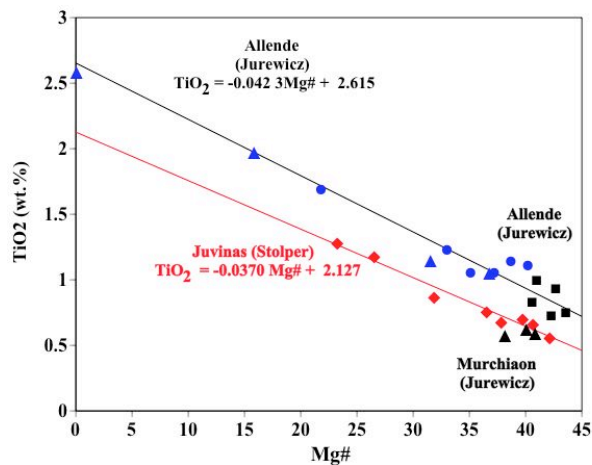
**Experimental Studies Relevant to the Stannern Eucrites:** In addition to the early work of Stolper [1], two other studies are of interest:

(i) Walker et al. [4] and Powell [5] performed both isothermal equilibration and cooling-rate experiments on Stannern. These experiments were performed at one-bar pressure, at various temperatures, and at fo<sub>2</sub>'s near IW-1. The combination of the isothermal experiments and the 1°C/hr cooling-rate experiments serve to delineate the Stannern liquid line of descent, as pyroxene and plagioclase crystallize (Fig. 2). These authors determined a liquidus temperature of 1167°C for Stannern, near the OL-SI-AN invariant point.

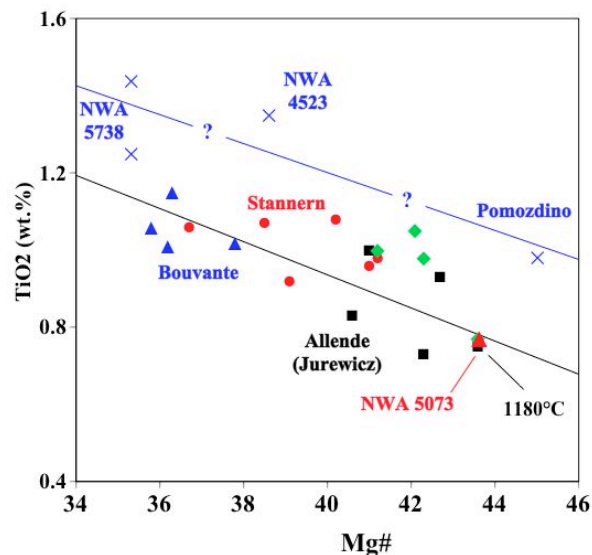
(ii) Jurewicz et al. [6] performed isothermal partial melting experiments on the Murchison (CM) and Allende (CV) chondrites. The experiments were performed at one-bar pressure, at temperatures of 1200-1160°C, and at an fo<sub>2</sub> of IW-1. Melts from the Allende experiments did not resemble Main Group eucrites because Allende is enriched in refractory lithophile elements such as Ca, Al, and Ti. However, the devolatilized, 1180-1200°C Murchison melts were extremely similar to Main Group eucrites such as Juvinas and Sioux Co. (Fig. 2).

**Discussion:** Glass compositions reported in [4,5] extend from 1037°C to 1200°C on a TiO<sub>2</sub> v. Mg# diagram (Fig. 2), and terminate at the Allende partial melts of [6]. This is a highly serendipitous result. Previously, no connection between the Stannern group and CV chondrites has been noted. In fact, Jurewicz et al. [6] explicitly stated that partial melts of Allende could not produce eucrites. However, this statement really only referred to Main Group eucrites.

Figure 3 shows the Allende experimental regression from Fig. 2, expanded and overprinted by bulk analyses of Stannern group eucrites. With the possible exceptions of NWA 4523, NWA 5738, and Pomozdino (which may form a separate trend?), the meteorite analyses cluster along the Allende melt regression. Taken at face value, this indicates that the Stannern group formed by partial melting of a CV-like source, accompanied by subsequent fractionation [e.g., Bouvante (Fig. 3)].



**Figure 2.** Experimental  $\text{TiO}_2$  vs.  $\text{Mg\#}$  for Stannern [4,5], Juvinas [1], Allende [6], and Murchison [6].



**Figure 3.** Expanded  $\text{TiO}_2$  vs.  $\text{Mg\#}$  for whole-rock Stannern group eucrites and Allende partial melts [6].

**Implications:** These results have implications both for the origin of the Stannern group and for the nature of the Eucrite Parent Body(ies).

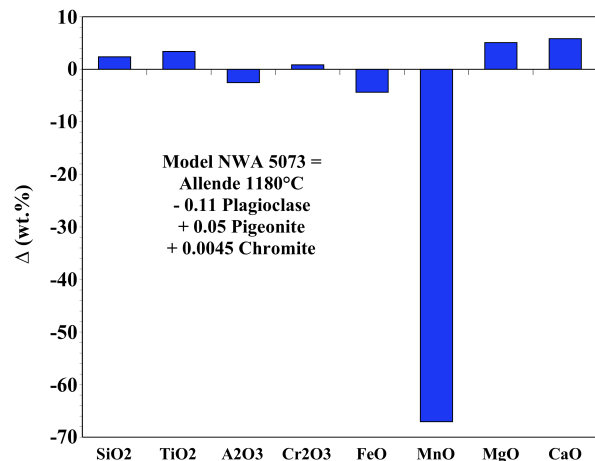
*Origin of the Stannern group.* Several models have been proposed to explain the origin of the Stannern group: (i) Small degree partial melts of a CO-like source region [1,6]; (ii) Contamination of a Main-Group-like melt by assimilation of a Main-Group-like crust [7]; and (iii) Partial melting of a CV-like source region and subsequent melt evolution (this study).

First, the lack of a continuum between the Main Group and the Stannern group makes possibility (i) now seem unlikely [3]. That said, new analyses that fill in the region between the two groups would temper this conclusion.

Second, the crustal contamination model [7] does not obviously predict that the composition of the crustal assimilate would lie on the extension of the Stannern group trend. It seems more likely that the assimilate's composition would lie on the extension of the Main Group trend (Fig. 2). But presently, it is not clear that this model can be ruled out. If the assimilate were to lie far out on the Main Group trend, it might not be distinguishable from an evolved Stannern group composition.

Currently, our favored model is that of (iii). The experiments and eucrite analyses form a defined trend; and, in terms of  $\text{TiO}_2$  v.  $\text{Mg\#}$ , some Stannern group eucrites are nearly indistinguishable from partial melts of Allende (Fig. 3). Comparison of the trends in Fig. 2 suggest that the Main Group and the Stannern group did not originate from the same source region.

*A model for NWA 5073.* In support of our Allende melting model for the Stannern group, we have modeled the composition of NWA 5073. In Fig. 3, NWA 5073 is indistinguishable from the 1180°C melt of [6]; however, this is an illusion, because Fig. 3 is based on only three elements: Ti, Mg, and Fe. A more complete assessment of NWA 5073 requires both differentiation and accumulation (Fig. 4). Our model ( $\pm 6\%$ ) reinforces the CV partial melting hypothesis, and seems consistent with the petrography of NWA 5073 [8].



**Figure 4.** Discrepancy ( $\Delta$ ) between NWA 5073 and a cumulate/differentiation model using the Allende data of [6]. Manganese is depleted in natural Allende.

**References:** [1] Stolper E. M. (1977) *G.C.A.* **41**, 587-611. [2] McSween H.Y., Jr. et al. (2011) *Space Sci. Rev.* **163**, 141-174. [3] Mittlefehldt D.W. (2015) *Chem. der Erde* **75**, 155-183. [4] Walker D. et al. (1978) *Proc. Lunar Planet Sci. Conf. 9<sup>th</sup>*, 1369-1391. [5] Powell M. A. (1981) Ph.D. Thesis, Harvard University. [6] Jurewicz A.J.G. et al. (1993) *G.C.A.* **57**, 2123-213. [7] Barrat J.-A. et al. (2007) *G.C.A.* **71**, 4108-4124. [8] Roszjar J. et al. (2011) *MAPS* **46**, 1754-1773.