

COULD STANNERN-TREND EUCRITES BE CRUSTAL-CONTAMINATED MELTS ? J. A. Barrat¹, A. Yamaguchi², R.C. Greenwood³, M. Bohn¹, J. Cotten¹, M. Benoit¹ and I. A. Franchi³, ¹UBO-IUEM, CNRS-UMR 6538, Place Nicolas Copernic, F-29280 Plouzané Cedex (barrat@univ-brest.fr), ²Antarctic Meteorite Research Center, National Institute of Polar Research, 1-9-10 Kaga, Itabashi, Tokyo 173-8515, Japan. ³PSSRI, Open University, Walton Hall, Milton Keynes MK7 6AA, UK.

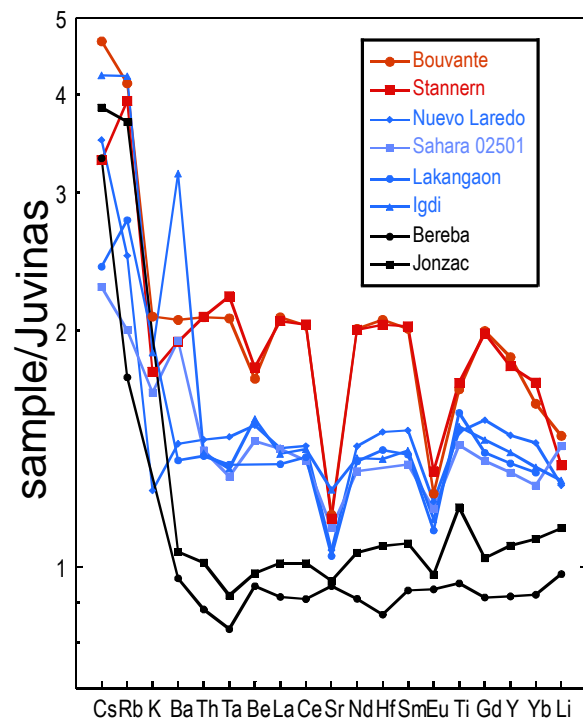
Introduction: Eucrites are a ~4.6 Ga old suite of basaltic or gabbroic rocks, often brecciated, that probably originate from a single body, thought to be the asteroid 4-Vesta [e.g., 1 and 2]. Based on their petrographic and chemical features, monomict and unbrecciated eucrites are subdivided into cumulate and noncumulate groups [e.g., 3]. The non cumulate eucrites have been subdivided into two compositional series on the basis of their Mg-number (or FeO/MgO ratio), Ti and incompatible trace element abundances: the main group-Nuevo Laredo (MG-NL) trend eucrites and the Stannern trend eucrites. The MG-NL trend eucrites comprise the majority of eucrites characterized by FeO/MgO ratios close to 2.5 and about 2-3 µg/g La, and more evolved types. Stannern trend eucrites are very similar to MG eucrites for major elements but are significantly richer in incompatible trace elements.

The MG-NL trend eucrites can be explained by fractional crystallization [e.g., 4-5]. However, the origin of the Stannern trend eucrites is more problematic. Stannern trend eucrites could be generated from the same mantle source as MG eucrites but at smaller degrees of melting, and possibly at slightly differing oxygen fugacities. Hence, the diversity of the eucritic melts could simply reflect part of the diversity of the primary melts from the parent body mantle [e.g., 1, 4, 6]. Alternatively, to explain the decoupling of major elements from incompatible trace elements requires a complex scenario involving interaction between eucritic and highly residual melts [7-8].

Here, we report on new chemical analyses of a large set of eucrites obtained by ICP-AES and ICP-MS in Brest, and discuss the origin of the incompatible trace element enrichment displayed by the Stannern trend eucrites. We propose that this feature can be explained satisfactorily by contamination of normal eucrites by liquids formed through partial melting of preexisting asteroidal crust.

Results: A selection of our new analyses are shown normalized to Juvinas, a reference MG eucrite (Fig.1). The patterns of typical MG eucrites such as Bereba and Jonzac, are rather flat with a significant Cs and Rb enrichment. The patterns of NL eucrites (Nuevo Laredo, Lakangaon, Igdi, Sahara 02501) exhibit higher incompatible element concentrations, and Sr and Eu negative anomalies, in agreement with their more evolved compositions. (Note that high Ba and Sr

abundances in Saharan finds are produced by alteration [9]). The Stannern trend eucrites (Stannern and Bouvante) are not only richer in incompatible trace element than the other eucrites, but their trace element patterns are clearly distinctive, with pronounced negative Be, Sr and Eu anomalies. As is the case for the MG-NL trend eucrites the behavior of alkali elements seems somewhat erratic, and has not yet been properly explained (fingerprints of impact processes? Mobility of alkalis during metamorphism?).

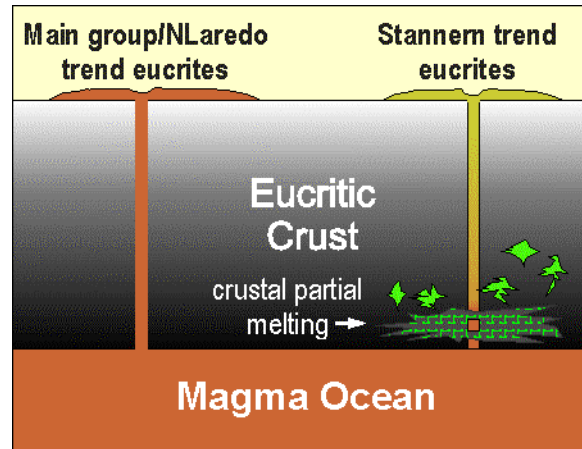


1. Juvinas normalized element patterns of non cumulate eucrites (black: main group, blue: Nuevo Laredo eucrites, red: Stannern trend eucrites).

Discussion: As an alternative to previous hypotheses for the origin of Stannern trend eucrites, we propose a model of contamination of normal MG eucrites by melts produced by melting of the asteroidal crust (Fig. 2). The composition of melts generated by the partial melting of eucritic crust can be calculated theoretically. The first partial melts would certainly not be acidic, but rather intermediate to basic in composition,

depending on the amount of silica and proportion of mesostasis contained in the rocks before melting.

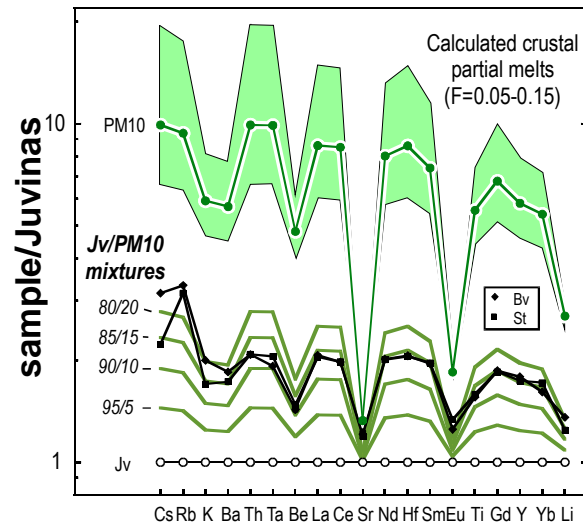
We have calculated the trace element abundances of melts produced by partial melting of an equilibrated eucrite (60 % pyroxene, 40 % plagioclase) using literature partition coefficients, and the composition of our reference eucrite Juvinas. In reality, the melting of a eucrite would be more complex than is considered by our model, in particular because of the involvement of accessory phases, which would be important at very low degrees of melting. However, these calculations should give a relatively realistic picture of the trace element abundances in the melts produced when the accessory phases such phosphates are no longer present in the residue. The calculated magmas produced by partial melting of a MG eucrite are rich in incompatible trace elements and display pronounced negative anomalies in K, Ba, Be, Sr, Eu and Ti relative to MG eucrites (Fig. 3).



2. Model for the origin of the Stannern trend eucrites. The eucritic crust is made by the stacking up of eucrite flows and magma intrusions derived from a magma ocean. Locally, the warmest areas of the 4-Vesta's crust suffered partial melting. MG-NL eucrites have directly crossed the Vestan crust, but the Stannern trend eucrites have assimilated a small amount of crustal partial melts.

Contamination of a MG magma by a crustal partial melt should have little effect on its major element concentration, but a huge impact on the incompatible trace element abundance, which is exactly the variation displayed by Stannern trend eucrites. For the purposes of discussion we have calculated the melts obtained by simple mixing between a MG eucrite and a crustal partial melt produced by 10 % melting. The trace element abundances are strikingly well reproduced by this model. The trace element concentrations of Stannern, and Bouvante are explained by a combination of about

85 % Juvinas and 15 % crustal partial melt. The calculated proportions are obviously dependent to the compositions of the end members. For example, very different proportions are obtained using the partial melts calculated for 5 % or 15 % of melting of the eucritic crust.



3. Juvinas normalized element patterns of calculated magmas derived by modal partial melting of a typical eucrite, and for Juvinas/partial melt (PM10) mixtures. The patterns of Stannern and Bouvante are drawn for comparison.

References: [1] Consolmagno G.J. and Drake M.J. (1977) *Geochim. Cosmochim. Acta* 41, 1271-1282. [2] Misawa K. et al. (2006) *Geochim. Cosmochim. Acta* 69, 5847-5861. [3] BVSP (1981) Pergamon press, New York, 1286 pp. [4] Stolper E. (1977) *Geochim. Cosmochim. Acta* 41, 587-611. [5] Warren P.H, Jerde E. (1987) *Geochim. Cosmochim. Acta* 51, 713-725. [6] Mittlefehldt D.W. and Lindstrom M.M. (2003) *Geochim. Cosmochim. Acta* 67, 1911-1935. [7] Barrat J.A. et al. (2000) *Meteoritics Planet. Sci.* 35, 1087-1100. [8] Warren P.H. and Kallemeyn G.W. (2001) *Lunar Planet. Sci.* 32, 2114. [9] Barrat J.A. et al. (2003) *Geochim. Cosmochim. Acta* 67, 3959-3970.