EVIDENCE FOR SUBSOLIDUS METASOMATISM IN THE EUCRITE PARENT BODY. I. Stewart McCallum, Jeffrey M. Schwartz, and Emily K. Mullen. Department of Earth and Space Sciences, Box 351310, University of Washington, Seattle, WA 98195.

The eucrite parent body (4Vesta) was continuously and rapidy resurfaced by basaltic lavas that formed the non-cumulate eucrites. Ophitic and variolitic textures have been preserved even though eucrites exhibit varying degrees of equilibration based on the extent of thermal metamorphism. Types range from least metamorphosed (type 1) to most metamorphosed (type 7) [1, 2] based in part on the interpretation of textures and compositional zoning profiles within pigeonitic pyroxenes. To provide constraints on the source and duration of the heating event responsible for metamorphism we have investigated primary and secondary textural and compositional relations in non-cumulate eucrites with emphasis on subsolidus textures developed in pyroxenes. We have studied examples of most metamorphic types including Pasamonte (type 2) Stannern (4), Nuevo Laredo (4), Juvinas (5), Lakangaon (5), Millbillillie (6), Palo Blanco Creek (7), Jonzac (7), Haraiya (7), along with the cumulate eucrites Moama and Moore County.

Analytical Methods: Polished sections of each sample were analyzed by EMP-WDS/EDS and pyroxene separates were studied by single crystal XRD and TEM methods. Information on cooling rates and durations was extracted from measured M1, M2 site occupancies in pyroxenes [3], from simulation of exsolution in pyroxenes [4], from lamellar coarsening features [5], and from modeling of zoning profiles [6].

Evidence for metasomatism: The pyroxene in Fig. 1 provides persuasive evidence for metasomatism. This fractured pyroxene clast from Pasamonte shows not only a well-developed Fe-enriched rim of variable width but also Fe-enriched zones adjacent to internal fractures that clearly cannot represent primary (magmatic) zoning patterns. In addition, several pyroxenes in Pasamonte show well-defined reverse zoning that must be a secondary feature (Figs. 2, 3).

This texture is most plausibly explained as the result of a post-magmatic metasomatic reaction between pyroxene grain rims and a Fe-rich fluid/vapor that migrated through fractures between affected grains. In most cases products of the metasomatic process in the form of precipitated phases are either non-existent or not resolvable using standard EMP methods. Rare fayalitic olivine and/or augite, blebby chromites, and Fe-Ni metal can be found along fractures adjacent to zoning. The paucity of phases adjacent to Fe-enriched pigeonite rims is suggestive of cryptic metasomatism. Dohmen et al. [7] have demonstrated the efficacy of a dry, internally generated, vapor as a transport agent for Fe, Mg, Si and O.

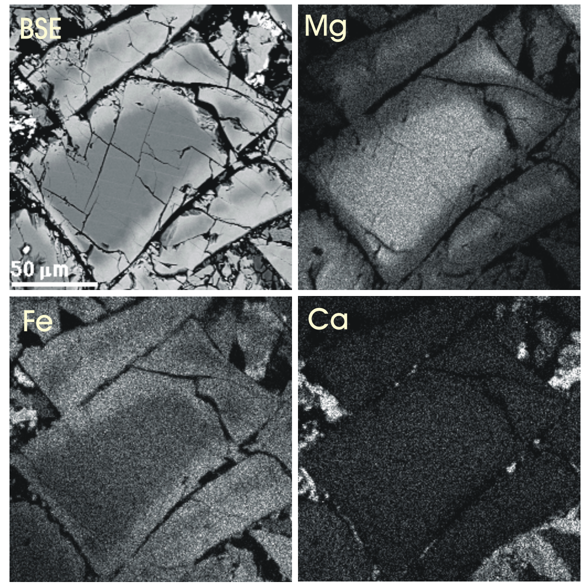

Fig. 1. BSE and WDS images (Mg, Fe, Ca) of fractured clast showing Fe enrichment adjacent to fractures.

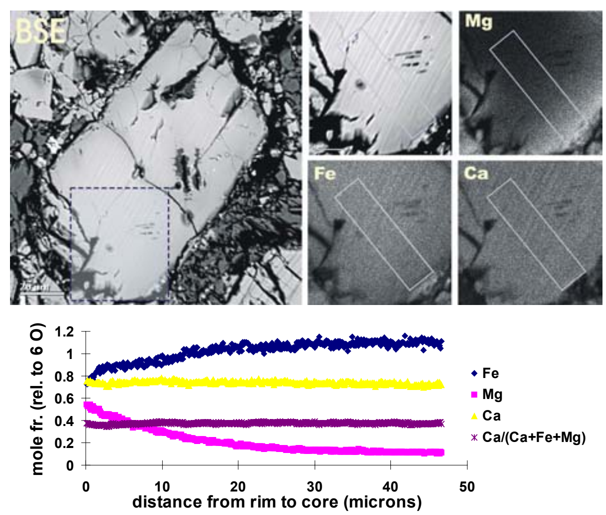

Fig. 2: BSE image and WDS X-ray maps and compositional profile of a reverse-zoned ferroaugite clast from Pasamonte.

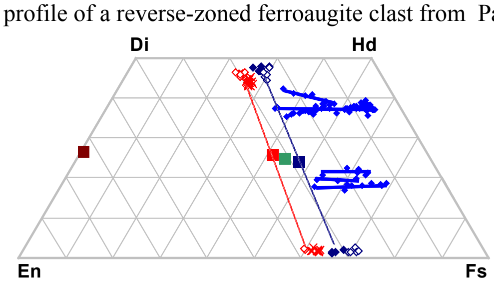

Fig. 3. Blue: Pasamonte reverse-zoned ferroaugite/pigeonite.

The metasomatic event was relatively short-lived as shown in Fig 4. in which the measured Mg/(Mg+Fe) profile is modeled using known Fe-Mg interdiffusion coefficients in orthopyroxene [8]

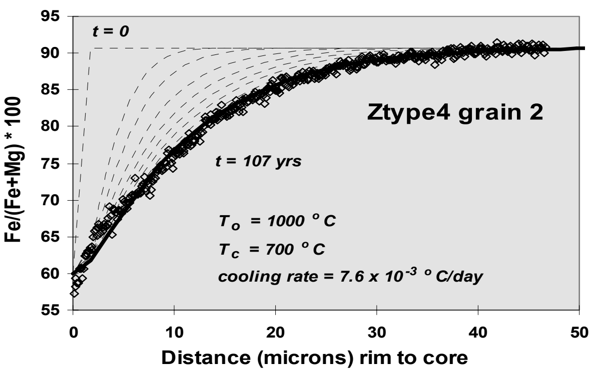

Fig. 4. 1D diffusion models fit to compositional profiles for ferroaugite grain in the matrix of Pasamonte.

Additional evidence for metasomatism can be found in the textures of virtually all equilibrated eucrites. Evidence for recrystallization is pervasive and many grains contain linear trails of inclusions consistent with precipitation from a vapor phase along fractures. Examples are shown in Figs. 5 and 6.

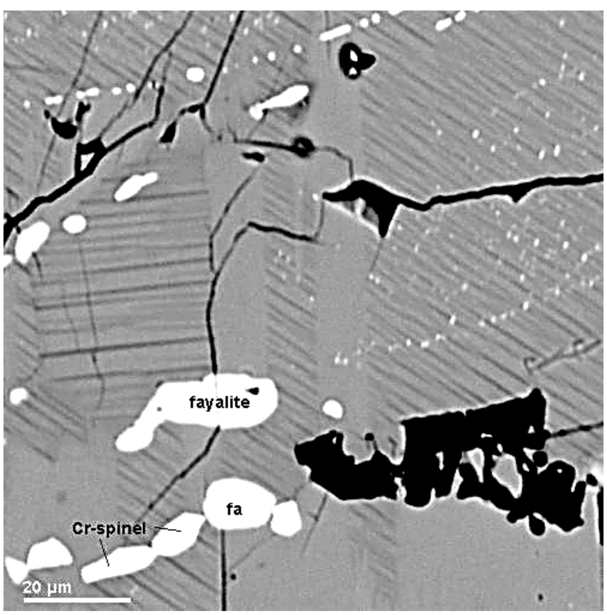

Fig. 5. Juvinas. Fayalite and Cr-spinel veins in coarsely exsolved pyroxene.

Nature and source of metasomatizing agent: Terrestrial metamorphic/metasomatic processes involve transport of material via diffusion and/or a fluid phase.

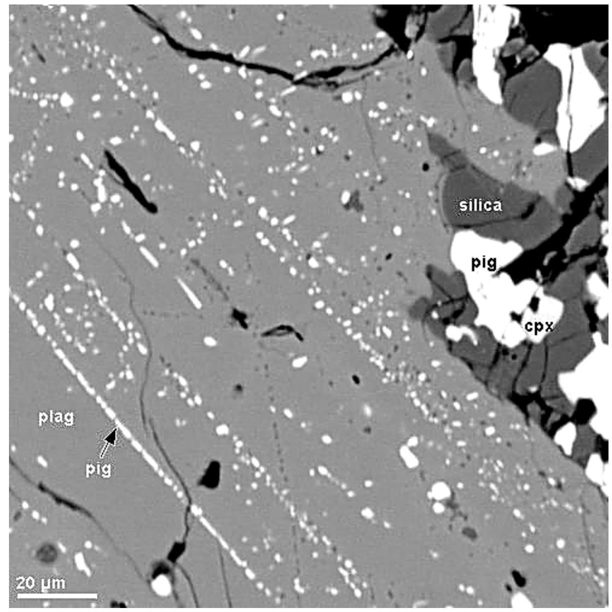

Fig. 6. Lakangaon. Trains of pigeonite within plagioclase.

In the case of the eucrites evidence for a conventional (COHS) fluid phase is absent—in many cases there are no precipitated phases on fracture surfaces. Dohmen et al. [4] showed that a dry vapor phase can coexist with solids at high temperatures and is a viable transport agent for Fe, Mg, and Si under certain petrologic conditions. It seems likely that any internally-generated vapor was derived at high, subsolidus temperatures from the bulk eucrite composition. As such the vapor would tend to drive the compositions of primary zoned minerals towards a uniform (equilibrium) composition. It is significant that the rim compositions of all pyroxenes in Pasamonte plot very close to an equilibrium tie line as shown by the dark blue line in Fig. 3. The normalized bulk composition of Pasamonte (Foshag [8])[green square, Fig. 3] also plots close to the equilibrium tie line. The metasomatic fluid is effective at least to the scale of the meteorite. However, since all equilibrated eucrites plot near this tie line, vapor with a near-uniform composition may be a ubiquitous metasomatizing agent in the upper crust of Vesta.

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References: [1] Yamaguchi et al. (1996) Icarus 124, 97. [2] Takeda and Graham (1991) Meteoritics 26, 129. [3] Ganguly and Stimpfl (2000) GCA 64, 1291. [4] McCallum and O'Brien (1996) Am Min 81, 1166. [5] Brady (1987) Am Min 72, 697. [6] Schwartz and McCallum (2003) LPSC XXXIV. [7] Dohmen et al. (1998) Am Min 83, 970. [8] Ganguly and Tazzoli (1994) Am Min 79, 930 [9] Foshag (1938) AJS 35, 374.