FLUID-ROCK INTERACTIONS RECORDED IN UNEQUILIBRATED EUCRITES. J. A. Barrat[1], A. Yamaguchi[2], T. E. Bunch[3], M. Bohn[1], C. Bollinger[1] and G. Ceuleneer[4], [1]Université Européenne de Bretagne and CNRS UMR 6538, U.B.O.-I.U.E.M., Place Nicolas Copernic, 29280 Plouzané Cedex, France. E-Mail: barrat@univ-brest.fr, [2]National Institute of Polar Research, Tachikawa, Tokyo 190-8518, and Department of Polar Science, School of Multidisciplinary Science, Graduate University for Advanced Sciences, Tokyo 190-8518, Japan, [3]Department of Geology, Northern Arizona University, Flagstaff, Arizona, [4]C.N.R.S., Université Paul Sabatier - Observatoire Midi-Pyrénées, 14, av. Édouard Belin, 31400 Toulouse, France.

Introduction: Eucrite meteorites are igneous rocks, basaltic or gabbroic in composition, that sample the oldest known basic crusts, formed about 4.5 Ga ago at the surface of small planetary bodies. Most of the eucrites originated from the same parent body, probably the asteroid 4-Vesta [1]. Eucrites have usually experienced extensive thermal annealing and many impact events. Rarely have "unmetamorphosed" (or unequilibrated) lithologies been preserved. Post-crystallization processes sustained by eucrites, are not limited to thermal annealing and brecciation. Veinlets made of secondary quartz have been described in Serra de Mage, and were ascribed to the circulation of water into the crust of its parent body [2]. Evidence of fluid-rock interactions in these lithologies is not restricted to this single meteorite. Some of the unequilibrated lithologies preserve a marked Fe-enrichment along the fractures that go through the pyroxenes ("Fe-metasomatism", [3]), and occasionally display Fe-rich olivine veins that clearly postdate the magmatic history of the rocks (e.g., [e.g., 4-6]. We have selected a series of eucritic rocks that display Fe-enrichment along cracks and fayalitic olivine veinlets, in order to discuss their origin, and their implications for the early history of their parent bodies.

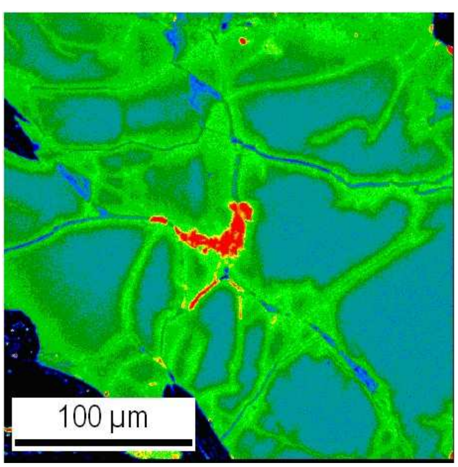

Fig. 1: Fe map of a pyroxene (blue) in Pasamonte, displaying Fe-enrichment (green) along the fractures. Secondary olivine (red) is rare in the studied PTS.

Results: SEM observations and numerous EMP analyses (more than 3500 analyses) have been performed on five unequilibrated eucrites (Pasamonte, Y-75011, Y-82202, NWA 049 and NWA 2061). Three successive stages of alteration have been characterized: 1/ Fe-enrichment along the cracks that cross cut the pyroxene crystals; secondary olivine is found occasionally in some fractures; Pasamonte is the best example of this stage (Fig. 1 and 2); 2/ deposits of Fe-rich olivine (Fa_{64-86}) and minor amounts of troilite inside the cracks; sporadic secondary Ca-rich plagioclase (An_{97-98}) is associated with the fayalitic olivine (Fig. 2 and 3);

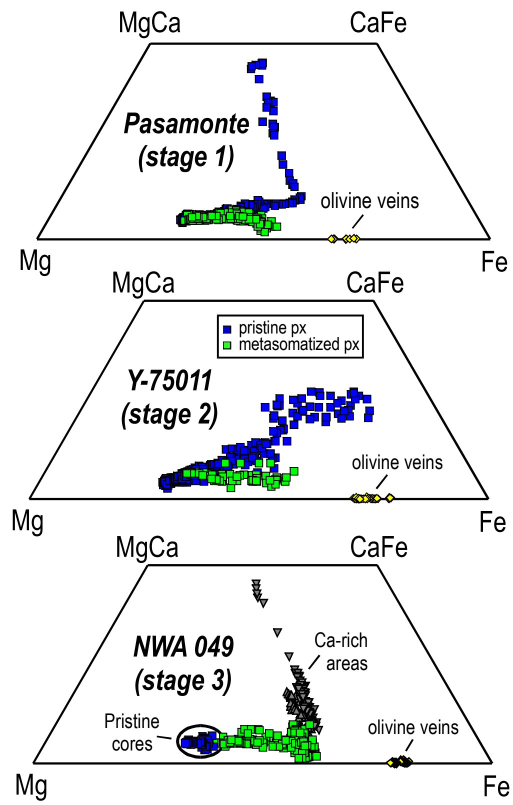

Fig. 2: Quadrilateral pyroxene and olivine compositions from Pasamonte, Y-75011 and NWA 049.

"stage 2" eucrites include NWA 2061, Y-75011, Y-82202, probably NWA 1000 [5] and NWA 5073 [6]; 3/ secondary Ca-rich plagioclase is more frequent and partly fills some cracks or rims of the primary plagioclase crystals (Fig. 4); moreover, the Fe-enrichment of the pyroxene is accompanied by a marked Al-depletion (Fig. 5); NWA 049 is the only "stage 3" eucrite we have examined at present; we suspect NWA 4470 to be a second example of this type.

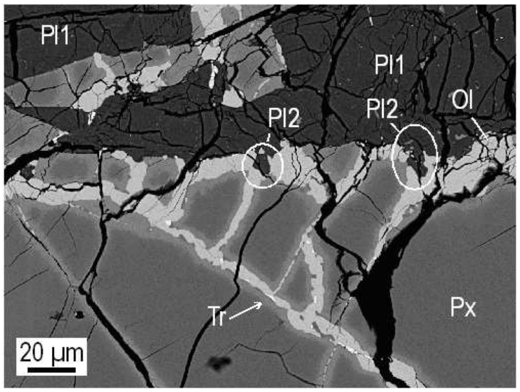

Fig. 3: BSE image of the "stage 2" Y-75011 eucrite (Ol: olivine, Pl1: primary plagioclase, PL2: secondary plagioclase, Px: pyroxene, Tr: troilite).

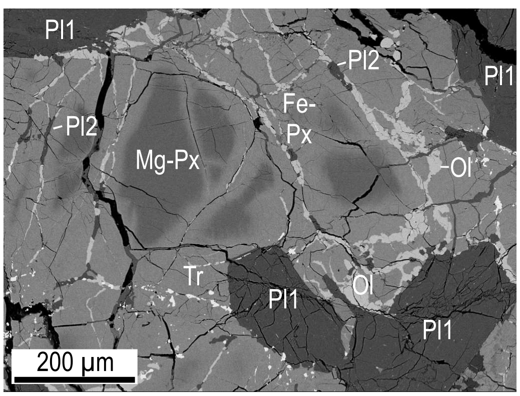

Fig. 4: BSE image of the "stage 3" NWA 049 eucrite (Ol: olivine, Pl1: primary plagioclase, PL2: secondary plagioclase, Mg-Px: pristine pyroxene area, Fe-Px: Fe-rich secondary pyroxene (chiefly Al-poor type), Tr: troilite).

Discussion and conclusions: The compositions displayed by the pyroxenes in unequilibrated eucrites, cannot be interpreted solely as the result of primary fractionation of a melt. It has been proposed that during a short-duration reheating event (presumably shock), the late-stage phases contained by the mesostasis of the eucrites were partly remelted, and the resulting Fe-rich melts were directly injected into the fractures [e.g., 4-5]. This explanation is unlikely because in all the samples we have examined, the mesostasis shows neither evidence of remelting, nor evidence of connection with the olivine veins. More likely, the Fe-enrichments displayed by the interiors of the fractured pyroxenes require the involvement of a metasomatic agent, probably a fluid or a vapor [3, 7]. Because fayalitic olivine and troilite that fill the cracks were precipitated phases from this fluid, the latter should have mobilized not only Fe, but Si, Mg, Mn, S, and in at least the three cases containing anorthitic plagioclase (Y-75011, NWA 2061 and NWA 049), Ca and Al. Our results rule out an infiltrated silicate melt, but point to the involvement of a vapor phase in agreement with some previous studies [3, 7]. Although no hydrous phase has been identified in the studied samples, aqueous fluids are plausible candidates for explaining the deposits of ferroan olivine and anorthitic plagioclase inside the fractures. The involvement of aqueous fluids has been previously invoked by [2] for explaining some quartz veinlets displayed by the Serra de Magé cumulate eucrite. In agreement with these authors, episodic aqueous fluids could have been brought to the surface of dry asteroidal bodies by cometary impacts.

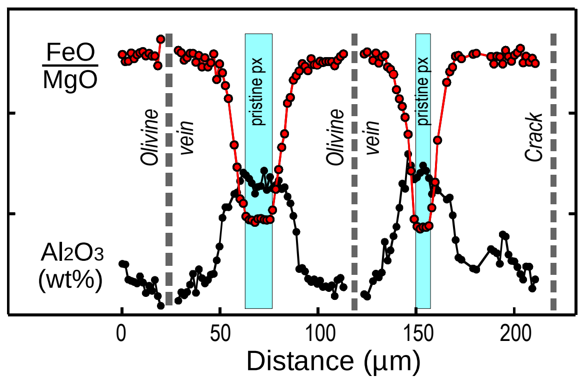

Fig. 5: Chemical zoning of a pyroxene from NWA 049, displaying Fe-enrichments and Al-depletions along cracks and olivine veinlets.

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