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Comparative study of equilibrated and unequilibrated eucrites: Subsolidus thermal histories of Haraiya and Pasamonte

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ABSTRACT

Thermal histories of non-cumulate eucrites, Pasamonte and Haraiya, were determined from Ca/(Ca + Fe + Mg) profiles of host/lamellae pyroxene pairs, from compositional profiles of pyroxene rims affected by metasomatism, and from lamellae thicknesses using a rate law for lamellar coarsening. Pasamonte, a Type 2 eucrite, experienced "partial" equilibration during a relatively short period of thermal annealing. This equilibration is expressed texturally by metasomatized rims in Mg-rich and Fe-rich pyroxene grains and by coarsening of nanometer-scale exsolution lamellae. A cooling rate of $\sim 10^{-2}$ °C/day corresponds to post-impact mixing and reburial of the polymict Pasamonte assemblage to a depth similar to that of the initial lava flow. Haraiya, a Type 7 eucrite, has experienced a complex thermal history involving multiple brecciation events and mixing of a single flow to produce a monomict assemblage containing clasts of variable grain size and texture. A period of thermal annealing, ~50 000 years in duration at temperatures between ~1000 and 700 ºC, corresponding to a cooling rate of $\sim 10^{-4}$ to 10^{-5} ºC /day, produced augite exsolution up to 3 μm thick in pigeonite. Rapid burial by successive flows during a period of high magma productivity and high heat flow due to ^{26}Al decay in the crust and mantle was a possible source of heat for metamorphism in the lower crust. However, cooling rates during relaxation of the lower crustal thermal gradient are much less than the mineralogically determined cooling rates. Heat derived from impact or from mid- to upper-crustal level intrusions is a plausible heat source for metamorphism and is consistent with observed cooling rates.