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Re-melting of Vesta's crust with 26Al?

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Eucrites are pigeonite-plagioclase basalts and gabbros, most probably from the asteroid 4-Vesta. Along with diogenites and howardites, these rocks show evidence for a complex thermal history of the HED parent body, with relatively rapid emplacement of basaltic crust, extensive crustal metamorphism, possible re-melting, and maybe even serial magmatism involving Mg-rich cumulates. Understanding these complexities requires identification of appropriate heat sources, and modeling of associated thermal structures as a function of time and position within the parent body.

Geochemical analyses of various chondrite and achondrite meteorite groups are consistent with the idea that the principal energy source driving differentiation in the early solar system is the short-lived isotope 26Al. Within the framework of this scenario, basaltic eucrites are liquids produced directly or indirectly by the melting of chondritic precursors.

In detail, REE contents of primitive basaltic eucrites are consistent with two endmember scenarios: either such samples are the result of $\sim$20% direct partial melting, or they represent the liquid produced by 80% crystallization of a global magma ocean. Each of these scenarios puts a constraint on the latest possible time of accretion relative to condensation of calcium-aluminum inclusions (CAI) for which the 26Al /27Al is considered known. For example, to completely melt Vesta (magma ocean) accretion must have occurred less 1.4 Myr after CAI condensation, whereas, if only 20% melting occurred, accretion could have taken place as late as 1.9 Myr after CAI condensation.

While several studies have considered these global-scale considerations, it is less widely appreciated that once plagioclase has been eliminated from the mantle residue (at $\sim$20% partial melting) almost all available aluminum will be concentrated in the crust. Depending on exactly when the crust is emplaced, there is thus a possibility that sufficient 26Al will remain to reheat and possibly re-melt the crust, and maybe even reheat underlying magma-ocean cumulates that are Al-free.

This situation has been numerically modeled for a Vesta sized body of H-chondrite bulk composition, beginning with an endmember set of parameters that represent the pessimistic situation of emplacement of a 'cold' crust (290K) that is $\sim$15km thick. The results of these models show that if the crust is emplaced less than 5.5 Myr after CAI condensation, the lower crust may be completely re-melted and underlying cumulates partially molten by the available 26Al. On the other hand, for crust emplacement later than $\sim$6 Myr after CAI condensation, no partial melting of either the crust or the mantle is predicted for this scenario. More realistic scenarios for thermal profiles at the time of crust emplacement are being investigated to constrain the time and depth windows over which partial melting of HED lithologies may occur.