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# Melt migration in Vesta and petrogenesis of eucrites and diogenites

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Eucrites are pigeonite-plagioclase basalts and gabbros. Along with diogenites and howardites, they belong to the HED meteorite group, for which asteroid 4-Vesta is the likely parent. Basaltic eucrites form the upper crust of Vesta. They were produced either by direct equilibrium partial melting of an initial chondritic precursor, or complete melting followed by equilibrium crystallization. Diogenites are orthopyroxene and olivine cumulates that crystallized at depth, either as plutons or as a continuous layer below the eucrite crust. In addition, these rocks show evidence for a complex thermal history, with relatively rapid emplacement of basaltic crust, extensive crustal metamorphism, possible re-melting, and maybe even serial magmatism (McSween2010).

Understanding the complexities of eucrite and diogenite petrogenesis requires identification of appropriate heat sources and modeling of the associated physical and chemical processes taking place during Vesta's differentiation. Concerning heat sources, geochemical analyses of various chondrite and achondrite meteorite groups indicate that the principal energy source driving differentiation in the early solar system was the short-lived radioisotope 26Al. This source of energy has important consequences for differentiation on asteroidal bodies, because Al is concentrated in the melt phase during early melting of plagioclase, and thus will be redistributed in the body due to melt migration.

The separation velocity between a liquid and its residue is thus a critical parameter, this migration rate depending upon whether or not porosity is organized into a hierarchical network of veins (Wilson&Keil2012). Even if vein networks exist, their formation time is also of importance, but currently uncertain.

In the case of rapid melt migration and extraction, eucrites can potentially form by direct equilibrium partial melting of the mantle. Depending on when the crust is emplaced, there is a possibility that sufficient 26Al will remain in the basalt fraction to reheat and possibly re-melt the lower crust and the upper mantle offering the possibility of a second magmatic episode that may be associated with the production of diogenites. Secondary magmatic episodes may also allow assimilation of earlier crust to account for the composition of some eucrites.

On the other hand, if melt migration is slow, it is possible to melt the initial silicate to a larger extent, even to total melting. Previous work has shown that the equilibrium crystallization of a global magma ocean can result in the production of eucritic liquids. However, the equilibrium solids produced in this way contain far more olivine than observed in most diogenites or suggested in the lower crust/upper mantle of Vesta by the Dawn mission.

In an intermediate scenario, significant but incomplete melting and/or melt migration would leave a certain amount of olivine at the bottom of the magma ocean. In this case, thermodynamic simulations using the MELTS calculator indicate that eucritic liquids can still be the result of equilibrium crystallization, and orthopyroxenes-rich cumulates (diogenites) can be produced in abundance at the end of the crystallization sequence.

References:

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- Wilson, L. and Keil, K., Chemie der Erde-Geochemistry, vol. 72(4), p289-321, 2012