COMPOSITIONAL DIVERSITY OF ORTHOPYROXENITIC DIOGENITES & OLIVINE-BEARING DIOGENITES LINKED TO VARIABLE fO_2 & POST-EUCRITIC MAGMATISM

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Introduction: Diogenites are thought to represent either a) magma ocean cumulates [1,2] or b) late-stage crustal intrusions [3,4]. pMELTS [5] modelling of the melt and evolution of bulk silicate Vesta compositions [1,2,5,6,7] in a magma ocean scenario was carried out to determine whether or not diogenites can be formed in such a manner.

Results: Orthopyroxene compositions in diogenites range from En_{85-60}, with those in olivine-bearing diogenites being restricted to En_{71-76}. As such, olivine-bearing diogenites are not the most magnesian, contrary to what is expected from magma ocean mineral settling and accumulation. pMELTS modelling of orthopyroxene evolution found that equilibrium crystallization does not reproduce the observed range in orthopyroxene compositions, and that the intial degree of partial melting has no impact on compositions generated. The effects of varying oxygen fugacity were then investigated over the range ΔIW -2.5 to -1.0. As conditions become more oxidizing, orthopyroxene compositions become less magnesian, with fO_2 ΔIW -1.6 to -1.2 providing the best fit in terms of En-Fs for orthopyroxenitic and olivine-bearing diogenites. It was noted that the transition from dunitic to orthopyroxenitic diogenites occurs over approximately 20 °C of cooling. More advanced modelling used starting compositions with 5-20 % eucrite [8] removal at fO_2 ΔIW -1.6 and -1.2. Models with 10-15 % eucrite removal most accurately match the observed orthopyroxene compositions.

Discussion: Across all models, olivine-bearing diogenites are not commonly produced in comparison to orthopyroxenitic diogenites. This accurately reflects the global diogenite collection, in which less than 3% are classified as olivine-bearing diogenites. Small variations in oxygen fugacity were found to cause large changes in orthopyroxene composition. To account for this heterogeneous fO_2, we propose that the following sulfidation reaction: $S_2 + MgFeSiO_4 = FeS + MgFeSiO_3 + O_2$ variably affected the diogenite source region. It was observed that in all initial models pyroxene compositions were too Wo-rich, meaning that the modelled source was too rich in calcium to accurately reproduce the orthopyroxene compositions found in diogenites. Eucrites are high in Ca, and low in Mg, thus the removal of a eucrite component from the source composition would reduce the Ca available for diogenitic orthopyroxenes without greatly effecting the Mg content. Models with 10-15 % eucrite component removed satisfactorily reduced the Ca content of the generated orthopyroxenes to provide a more accurate match to the observed diogenite collection (Wo_{0-6}).

Our findings support the view that diogenites represent late-stage intrusions, and that a magma ocean scenario is an inappropriate model for their formation. Source heterogeneity in *f*O2 and an initial stage of eucrite removal are required to accurately reproduce diognenite orthopyroxene compositions. This is further supported by geochemical evidence that suggests diogenites interacted with a feldspar-rich lithology [9], and observations from the Dawn mission, which found no large mantle exposure in the southern impact basins, but instead detected olivine in the northern hemisphere [10,11].

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