CUMULUS ORIGIN OF OLIVINE MEGACRYSTS IN YAMATO 980459?

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Primitive melts provide critical information on their mantle source regions, but most Martian meteorites have been fractionated. An olivine-phyric shergottite, Yamato 980459 (Y98), is interpreted to represent a primary melt, because its olivine megacrysts have magnesian cores (Fo84) that appear to be in equilibrium with the Y98 whole-rock composition based on Fe-Mg partitioning [e.g.1]. However, CSD plots for Y98 olivines show a size gap [1, 2], suggesting a cumulus origin. Since melting experiments were recently performed using the Y98 whole-rock composition to infer the thermal structure and volatile contents of the Martian mantle, this interpretation should be scrutinized.

Y98 is characterized by magnesian olivine megacrysts, and pyroxenes with orthopyroxene cores mantled by pigeonite and augite. Here we report major, minor and trace element compositions of Y98 olivines and compare them with results from melting experiments [3, 4] and thermodynamic calculations [5, 6]. Cores of the olivine megacrysts have major and minor element contents identical to those of the most magnesian olivines from the experiments, but they differ slightly from those of thermodynamic calculations. This is probably because the Y98 whole-rock composition lies outside the range of liquids used to calibrate these models. The megacryst cores (Fo80-85) exhibit minor and trace element (Mn-Ni-Co-Cr-V) characteristics distinct from other olivines (megacryst rims and groundmass olivines, Fo<80), implying that the megacryst cores crystallized under more reduced and higher temperature conditions. We also found some reversely zoned pyroxenes that have augite cores (low-Mg#) mantled by orthopyroxene (high-Mg#), although they are uncommon. The augite cores have distinctly LREE-enriched patterns relative to the other pyroxenes. The calculated REE pattern of a melt in equilibrium with the augite cores is not consistent with Y98 or other depleted shergottites, but is consistent with the enriched shergottites.

Considering the CSD patterns of Y98 olivines, we propose that the olivine megacrysts are cumulus grains which probably formed in a feeder conduit by continuous melt replenishment, and the melt compositions are indistinguishable from the Y98 whole-rock. The magma replenishments may have produced a fractionated mush that assimilated crust, resulting in the formation of the LREE-enriched augite cores. The final magma pulse entrained these cumulus olivines and pyroxenes and then crystallized groundmass olivines and pyroxenes. Although Y98 contains small amounts of cumulus materials (<~6 vol%), we conclude that the Y98 whole-rock composition can be used to represent a Martian primary melt composition.

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