EXCESS ^{40}Ar IN THE ZAGAMI SHERGOTTITE: DOES IT REVEAL CRYSTALLIZATION HISTORY?

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The Zagami basaltic shergottite has fine- and coarse-grained (FG & CG) areas, which may reflect partial crystallization in a deep, slowly cooled magma chamber to form Mg-rich pyroxene cores, followed by entrainment of these crystals into a magma that rose and crystallized near the surface (1,2,3). Late-stage melt pockets formed mesostasis and feldspar (maskelynite) having a range of compositions, but low water abundance (2). Higher I_{Sr} in the FG portion may result from the second stage having incorporated old crustal rocks that failed to reach isotopic equilibrium (4,5). Zagami, like other shergottites, contains excess $^{40}Ar_{xs}$ beyond that expected from internal decay of ^{40}K during its Sm-Nd age of 177 Myr. We suggest that at least a portion of this $^{40}Ar_{xs}$ in Zagami and some other shergottites was inherited from the magma, much as is the case of MORBs on Earth. We made ^{39}Ar-^{40}Ar age determinations on feldspar and pyroxene separates from both the FG and CG portions of Zagami. If Zagami experienced an evolving fractional crystallization history, including possible crustal contamination of the magma, that might be indicated in differing amounts of $^{40}Ar_{xs}$ between mineral phases and between FG and CG portions.

Surprisingly the concentration of $^{40}Ar_{xs}$ is similar for all Zagami FG and CG separates at ~10^{-6} cm^3/g (~2 ppb), in spite of differences between feld. and pyx. crystallization temperature and Ar diffusivity. $^{40}Ar_{xs}$ is not proportional to the K concentration, which agues against the $^{40}Ar_{xs}$ being residual from diffusion loss of ^{40}Ar formed by *in situ* K decay. These data indicate that neither the FG nor CG portions of Zagami are the major carrier of $^{40}Ar_{xs}$, but rather that $^{40}Ar_{xs}$ is present in similar amounts in all phases. If different Zagami textures originated from progressive fractionation at different time and depths in the magma (1,2), the magmas must have contained similar ^{40}Ar concentrations. The concentration of $^{40}Ar_{xs}$ in Zagami falls within the broad range of ~10^{-8}-10^{-5} cm^3/g seen in terrestrial MORBs and deep oceanic samples. Because the mineral-melt distribution coefficient for Ar in basaltic material is ~10^{-3} (6), if Zagami formed by fractional crystallization from a melt, the melt would have contained ~10^{-3} cm^3/g of ^{40}Ar. As the solubility of Ar in magma is ~5x10^{-5} cm^3/g-bar, this would imply rather high partial Ar pressures (~20 bar). The initial estimated lithostatic pressure on Zagami and Shergotty magma is ~5-7 kbar (2, 7). If such a melt fully crystallized to form Zagami, we might expect the last feldspathic phases to crystallize would contain much larger $^{40}Ar_{xs}$. Alternatively, if assimilation of crustal rocks contributed $^{40}Ar_{xs}$, this must have occurred prior to significant crystallization. Possibly Zagami fractional crystallization occurred as the magma ascended, releasing pressure so as to maintain nearly constant ^{40}Ar concentration in the magma before allowing most of the ^{40}Ar to ultimately escape. This was suggested by (7) for water loss from Shergotty. Whether rich in water or not, the source of $^{40}Ar_{xs}$ must have been relatively rich in K. If the magma, like bulk Zagami, had K=0.1%, ~10^{-3} cm^3/g of ^{40}Ar would require >5 Gyr to accumulate, whereas 4 Gyr-old crustal rock with K=2% would accumulate ~10^{-3} cm^3/g of ^{40}Ar in <4 Gyr. Clearly the full implications of excess ^{40}Ar in Zagami for its petrogenesis deserve additional study.

References. (1) McCoy et al. GCA 56, 3571, 1992; (2) McCoy et al. GCA 63, 1249, 1999; (3) Lentz & McSween, MaPS 35, 919, 2000; (4) Nyquist, Planet. Chron. Workshop, LPI, May, 2006; (5) Jones, Proc. 19th LPSC, 465, 1989; (6) Heber et al. GCA 71, 1041, 2007; (7) McSween et al. Nature 409, 487, 2001.