

EVAPORATION OF CMAS-LIQUIDS UNDER REDUCING CONDITIONS: CONSTRAINTS ON THE FORMATION OF THE MELILITE MANTLE OF TYPE B1 CAIs.

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Introduction: We have argued that the melilite mantles of Type B1 CAIs could have formed by preferential crystallization in the outer parts of partially molten droplets due to rapid evaporative depletion of Mg and Si [1, 2]. If, however, the rate of evaporation is sufficiently slow for diffusion to maintain chemical homogeneity, there would be no distinction between the inner and outer parts of the molten droplet, and a much more uniform distribution of melilite, like that of the Type B2 CAIs, would result. Here we present the results of new evaporation experiments aimed at further refining the conditions determining the textures of the Type B CAIs.

Experimental: The evaporation experiments were conducted at 1425° and 1475°C using partially molten droplets of DT1 composition [2]. A Deltech 1 atm gas-mixing furnace operated with H₂-CO₂ gas mixtures with log *f*O₂ from IW-4 to ~IW-10 (nominally pure H₂) flowing at 0.8 to 5 cm s⁻¹ was used. The rate of evaporation is controlled by gas saturated in the evaporating species (which is a function of *f*O₂) being continuously removed at a prescribed flow rate. The samples were quenched in air after 0.5–50 h of exposure. Run products were examined by SEM and analyzed by EDX.

Results and discussion: Type B2-like textures were observed at log *f*O₂ > IW-4, independent of both cooling rate and gas flow rate. This suggests that the evaporation rates of Mg and Si were slow compared to their diffusion rates, thus maintaining a chemically homogeneous droplet. This was confirmed by SEM analyses of quenched samples run for up to 2 hours at temperatures above the crystallization temperature of melilite, which showed no chemical gradients. Type B1-like textures with relatively thick melilite rims were observed in experiments when samples were exposed to H₂ for more than ~ 2 h. Long exposure to H₂ also often results in formation of hibonite and nonstoichiometric spinel ($0.25 \leq (\text{Mg}/\text{Al})_{\text{atom}} \leq 0.50$) at the extreme edges of charges. These phases are only found in contact with melilite, not with glass. When similar samples were quenched after exposure to H₂ for 0.5–1 h, but before crystallization of melilite, the outer parts of the charges were found to be depleted in Mg and Si compared to the interior, with profiles similar to calculated ones [3]. This suggests that under more reducing conditions the evaporation rate is too fast for diffusion to maintain chemical homogeneity, and that the depletion of Mg and Si in the outer parts of the charges causes the formation of the melilite rim. Droplets exposed to gas with solar *f*O₂ (log *f*O₂ ~ IW-6) showed both B1- and B2-like textures depending on the evaporation rate (which is proportional to the flow rate of the gas). Under high (5 cm s⁻¹) flow rates, with high removal rates of the evaporating species, B1-like textures were observed, while under low flow rates (0.8 cm s⁻¹), B2-like textures were formed. The experimental results provide a generalizable estimate of the critical value of the evaporation rate relative to the chemical diffusion rate required to produce chemical gradients sufficient for the preferential crystallization of melilite in the vicinity of the evaporating surface. This critical evaporation rate is then used to characterize the conditions that led some Type B CAIs to have distinctive melilite mantles (B1) vs. others with more uniformly distributed melilite (B2).

References: [1] Richter et al. (2002) *LPS XXXIII*, #1901. [2] Mendybaev et al. (2003) *LPS XXXIV*, #2062. [3] Richter et al. (2003) *GCA*, 66, 521-540.