

MELILITE: A PETROGENETIC INDICATOR IN REFRACTORY INCLUSIONS. D. S. Ebel and L. Grossman¹, Department of the Geophysical Sciences, 5734 South Ellis Ave., ¹also Enrico Fermi Institute, University of Chicago, Chicago, IL 60637 (debel@midway.uchicago.edu).

Introduction: Our collective knowledge of the thermodynamic properties of gas, solid, and liquid phases rests on over a century of experimental work. Over the last 35 years this work has been incorporated into increasingly more rigorous models to investigate nebular condensation [1-4], liquid-crystal equilibrium [5,6], and the evaporation of silicate liquids [7-11]. These tools can be combined to address the origin of Ca-, Al-rich refractory inclusions (CAIs) in the early solar nebula. The melilite solid solution ($\text{Ca}_2\text{Al}_2\text{SiO}_7$ - $\text{Ca}_2\text{MgSi}_2\text{O}_7$) is ubiquitous in CAIs, and its slow $\text{MgSi}=\text{Al}_2$ diffusion [12], makes melilite a potentially powerful petrogenetic indicator of the cosmochemical circumstances of CAI formation.

When a vapor containing solar proportions of the elements is cooled at low total pressure ($P^{\text{tot}} < 10^{-2}$ bar), the most refractory mineral assemblages to condense contain the oxides CaO , MgO , Al_2O_3 , SiO_2 (CMAS), and minor TiO_2 [3,4]. If a mass of this CMAS dust is heated to a melt, in pure H_2 gas, Mg and Si evaporate much more rapidly than Al and Ca [10]. Many CAIs exhibit bulk isotopic fractionation of Mg and Si, probably the result of such evaporative loss, and many CAIs show evidence of having been heated to a molten state prior to crystallizing. Melilites record the changing bulk chemical and isotopic composition of their host CAI, as melilite crystallized.

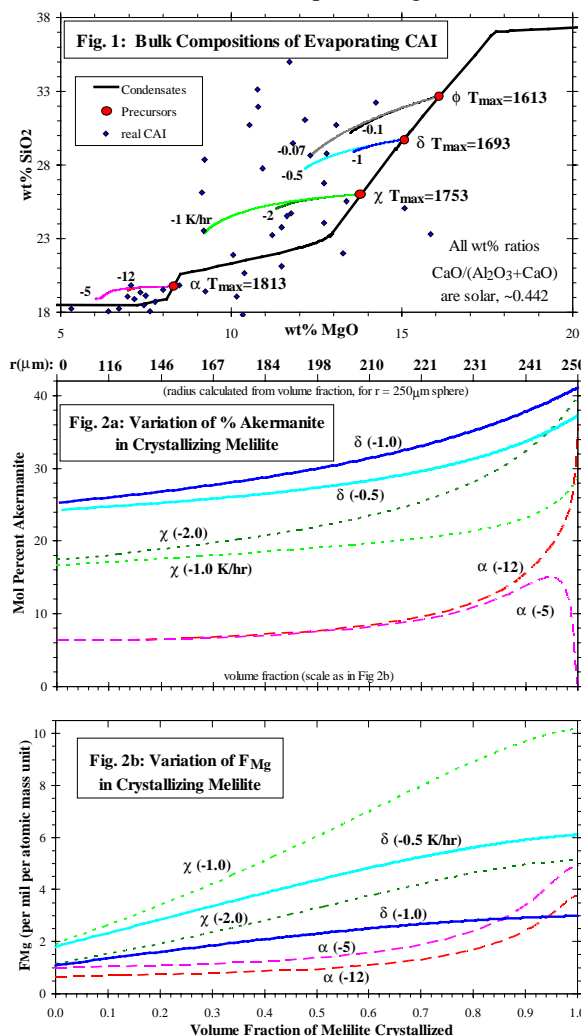
Methods: Earlier work describes our calculations of condensation [4], liquid-crystal equilibrium [6] using the CMAS liquid model of [5] substituted for that of [6], and evaporation of CMAS liquids [7-11].

Representative precursor condensates (α , χ , δ , ϕ) were chosen from the condensation trajectory (Fig. 1), instantaneously heated to T_{max} , then linearly cooled, all at $P(\text{H}_2)=10^{-6}$ b. As in [9], only liquid evaporates, solids don't occlude droplet surfaces, **diffusion in liquids is instantaneous**, only melilite is fractionated (100%), and spinel is trapped as melilite displaces liquid.

Results: Figure 1 shows trajectories of 0.25 cm radius precursors evaporated at different cooling rates (K/hr) in $P(\text{H}_2)=10^{-6}$ bar, crystallizing melilite and spinel, compared to bulk compositions of real CAIs, corrected to solar Al/Ca as per [8]. A family of similar evaporation trajectories accounts for the differences between aggregate condensed dust compositions and bulk compositions for a significant fraction of CAIs.

In figs. 2a and 2b, the predicted compositions of successive layers of melilite are shown for α , χ , and δ as functions of the crystallized volume fraction, relative

to the melilite volume at the solidus (1500K). Calculated radii are shown for each 10% of volume, for a hypothetical $r=250 \mu\text{m}$ spherical crystal. We are testing these predictions by investigating CAI melilites for correlated chemical and isotopic zoning.



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