

DETERMINATION OF THE INTERDIFFUSION OF MG+SI VS. AL+AL IN THE ÅKermanite-GEHLENITE BINARY SYSTEM USING THE BOLTZMANN-MATANO METHOD

M. Ito^{1,2} and S. J. Clemett^{1,3}. ¹ARES, NASA Johnson Space Center, 2101 NASA parkway, Houston TX 77058, ²Lunar & Planetary Institute-USRA, ³ESCG/Jacobs

The melilite system in Ca, Al-rich inclusions (CAIs) is characterized by a solid solution of gehlenite (Ge: Ca₂Al₂SiO₇) and åkermanite (Åk: Ca₂MgSi₂O₇) end-members, and has played an important role in deciphering the origin and formation of the CAIs. Compositional zoning of melilites in CAIs reflects fractional crystallization from Ca, Al-rich liquid that subsequently experienced a diffusive disturbance followed by one, or more, thermal events [1].

A proper understanding of the diffusion kinetics of Mg in the CAI minerals is a prerequisite in calibrating the ²⁶Al-²⁶Mg chronometer; determining the extent of intercrystalline Mg isotope exchange; and, interpreting the thermal histories of the CAIs in terms of observed Mg isotopic heterogeneities [e.g., 2-3]. Nagasawa *et al.* [2] have previously reported interdiffusion coefficients ($D_{//a}$) for Mg+Si vs. Al+Al in the Åk-Ge system parallel to *a*-axis as being highly variable and correlating with the Åk-Ge composition. In this work, we have investigated interdiffusion coefficients for the Åk-Ge system parallel to the *c*-axis ($D_{//c}$). Diffusivities were calculated from element diffusion profiles using the Boltzman-Matano method [4]

Synthetic Åk & Ge crystals [2] were cut normal to the *c*-axis, polished to mirror finish [5], and bound together with Pt wire to form a diffusion couple. This was annealed for 7 days at 1350°C and subsequently re-polished prior to analysis. Element distribution profiles across the Åk-Ge interface were obtained using both SEM-EDX linescans and 2-D NanoSIMS mapping. The raw distribution profiles were then corrected for analytical artifacts and interpolated using monotonic smoothing splines, before fitting to a model function of the form $y = a + \sum_i b_i \cdot \operatorname{erfc}\left(\frac{x-c_i}{d_i}\right)$ using a constrained least squares algorithm. From these fits the interdiffusion coefficients were analytical determined by Boltzmann-Matano analysis.

$D_{//c}$ determined as function of Åk-Ge composition, using both SEM-EDX and NanoSIMS gave equivalent results, ranging from 1.8×10^{-14} - 3.5×10^{-12} cm²s⁻¹, which are ~ 5 - 10× lower than previously reported for $D_{//a}$ [2]. The highest diffusivities occurred at solid solution compositions of ~ Åk₇₀₋₈₀ corresponding to eutectic point [6]. The interdiffusion of Mg+Si vs. Al+Al in the Åk-Ge system demonstrates both spatial and compositional anisotropy, consistent with previous analogous studies [e.g., 1, 7].

Since Mg inter- and self-diffusivities in melilite are highly dependent on both Åk-Ge composition and crystallographic orientation [2, 3, 7], Al-Mg isochron generated from zoned melilites in CAIs may indicate the complex thermal histories of formation and effects of subsequent parent body processes.

References: [1] Grossman *et al.* 1977. *Geochim. Cosmochim. Acta* 41:1647. [2] Nagasawa *et al.* 2001. *Phys Chem Minerals*. 28:706. [3] Ito and Ganguly. 2009. *LPS* 40:1753. [4] Matano. 1933. *Jap. J. Phys.* 8:109. [5] Ganguly *et al.* (1998) *Contrib. Mineral Petrol.* 131:171. [6] Osborn & Schairer 1941. *Am. J. Sci.* 239:715. [7] Morioka *et al.* 1997. *Geochim. Cosmochim. Acta* 61:1009.