



Anisotropy of Mg isotopic fractionation and Mg lattice diffusion during evaporation of forsterite in vacuum

M. Yamada, S. Tachibana, H. Nagahara and K. Ozawa

Department of Earth and Planetary Science, University of Tokyo, 7-3-1 Hongo, Tokyo 113-0033, Japan (maho@eps.s.u-tokyo.ac.jp)

Isotopic fractionation of a solid material due to kinetic evaporation is controlled by the evaporation rate (v), diffusion rate (D), size of the solid (X), and kinetic isotopic fractionation factor (α) [1]. Understanding of such fundamental parameters for kinetic evaporation allows us to elucidate high temperature events in the early solar system, of which signatures may have been recorded in primitive meteorites and interplanetary dusts. In this study, we measured Mg isotopic compositions of forsterite, one of the most comprehensive solids in the solar system, evaporated in vacuum at a rate of v [2], by depth profiling with ion microprobe to determine α for Mg and D_{Mg} based on a diffusion-controlled evaporation model.

Depth-profile measurements of Mg isotopes along each crystallographic axis showed diffusion profiles of Mg isotopes induced by evaporation, where isotopically fractionated regions were limited within several tens of μm from the surface. The diffusion profiles along different crystallographic axes of a sample heated at 1692°C were not identical and α and D_{Mg} , both of which were obtained by fitting the profiles with the diffusion-controlled evaporation model, showed anisotropy. Alpha is furthest from and closest to unity along the c-axis and b-axis, respectively. Although further investigations are needed, D_{Mg} seems to be larger along the c-axis than those along the a- and b-axes, which is consistent with previous work by [3]. We also found temperature dependences of α and D_{Mg} along the a-axis for samples heated at 1692 - 1504°C . It was clearly seen that α is further from unity at higher temperatures. Diffusion coefficient of Mg along the a-axis at 1692 - 1504°C agrees well with that in [1]. Moreover, we have found that the values of α in this study were always closer to unity in this study than the square root of mass ratio expected from the kinetic theory of gases. These lines of evidence suggest that isotopic fractionation of Mg due to evaporation

of forsterite cannot be attributed only to difference of detaching velocities of isotopes from the surface and that some surface kinetic processes should play a role in isotopic fractionation.

[1] Wang J. et al. (1999) GCA 63, 953. [2] Ozawa K. et al. (1996) LPS XXVII, 989, [3] Misener D. J. (1974) in Geochemical transport and kinetics, ed. by A. W. Hofmann et al., Carnegie Inst. Washington Publ. 634.