Oxygen isotopic exchange between amorphous silicates and water vapor: Implications for lifetime of presolar silicates in the solar nebula

D. YAMAMOTO[1*] AND S. TACHIBANA[1]

[1] Department of Natural History Sciences, Hokkaido University, Sapporo, Hokkaido 060-0810, Japan (*correspondence: daiki@ep.sci.hokudai.ac.jp)

Presolar silicates with O-isotopic anomalies escaped from secondary processes in the solar nebula and planetesimals. The abundances of presolar silicates and oxides are not high even in least-altered carbonaceous chondrites, implying pre-accretional thermal destruction [1]. Here we experimentally explore a possibility of oxygen isotopic exchange between amorphous silicates and water vapor and estimate isotopic lifetime of presolar amorphous silicate in the solar nebula.

Reaction experiments between sub-μm-sized amorphous forsterite and $H_2{}^{18}O$ vapor were conducted at 803–1123 K and P_{H2O}~1 Pa in a gold-image vacuum furnace. Run products were analyzed with FT-IR, XRD and SIMS.

The 10-μm infrared absorption peak of amorphous forsterite shifted to longer wavelength with time at 803–883 K. Ion-microprobe measurements of run products showed a large ^{18}O enrichment. Both results indicate that O-isotopic exchange with amorphous forsterite occurred without crystallization. At 953 K, the overall spectral shape resembled to that of isotopically-normal crystalline forsterite, but the peaks shifted to higher wavelengths accompanied by peak broadening, suggesting simultaneous crystallization and oxygen isotopic exchange within amorphous forsterite. An infrared spectrum of a run product annealed at 1073 K showed several sharp peaks of isotopically-normal crystalline forsterite, suggesting that crystallization occurred effectively prior to effective isotopic exchange in amorphous forsterite.

O-isotopic exchange timescale of amorphous forsterite with water vapor can be estimated as a function of temperatures by fittings of time evolutions of relative peak shifts at 803–883 K with a modified Jander equation. Combining with timescales of crystallization [2] and oxygen self-diffusion in crystalline forsterite [3], O-isotopic signatures of presolar amorphous forsterite could be preserved only at temperatures lower than ~500 K in the early Solar System.

References: [1] Floss, C. & Stadermann, F. (2009) *Geochim. Cosmochim. Acta*, 73, 2415–2440. [2] Yamamoto, D. (2016) *Master thesis*. [3] Jaoul, O. et al. (1980) *Earth Planet. Sci. Lett.*, 47, 391–397.