SILICON-ISOTOPIC ABUNDANCES IN SILICATE MINERALS FROM THE KABA AND MOKOIA CV3 CARBONACEOUS CHONDRITES.

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Introduction: Silicon is one of the most important rock-forming elements. It has three stable isotopes (^{28}Si, ^{29}Si, and ^{30}Si). With the exception of Allende CAIs [1], variations of ^{29}Si/^{28}Si and ^{30}Si/^{28}Si ratios across the meteorite classes are small. Those variations in Allende CAIs have been attributed to evaporation while the host minerals were in the solar nebula. Our SIMS results measured in individual silicate minerals from Kaba and Mokoia show large Si-isotopic fractionations.

Analytical Methods and Results: The isotopic analyses were performed with a Cameca ims-6f ion microscope, using a 12.5 keV, ^{16}O– primary ion beam with 0.5–1.9 nA current focused into a spot ~15 µm in diameter. Low-energy (±50 eV) positive secondary ions were accelerated to 10 kV and analyzed at a mass resolving power of 3000 (m/µm) to separate potential interfering species from Si ions at masses 28, 29, and 30. We determined the instrumental mass fractionation and calibrated our SIMS measurements by comparing them to the mass spectrometry data measured by R. N. Clayton and T. K. Mayeda on our terrestrial standards.

Seven fayalite, 5 forsterite, and 2 enstatite grains from Mokoia and 14 fayalite, 3 forsterite, and 14 enstatite grains from Kaba were measured. The following results are noteworthy: (1) All measured Si data fall on or close to a mass-dependent fractionation line of slope 0.5; within the analytical uncertainty no unambiguous excesses of either ^{29}Si or ^{30}Si were detected. (2) Fayalite, forsterite, and enstatite in Kaba display large variations in their Si-isotopic concentrations. δ^{30}Si ranges from –7.7 to 3.7‰ in fayalite, from –2.2 to 6.0‰ in forsterite, and from –10.1 to 4.1‰ in enstatite. (3) Most measured fayalite in Mokoia contains heavier Si than the mean value of the solar system (δ^{30}Si ≈ –0.5‰) [2], and its δ^{30}Si ranges from –0.72 to 15.1‰. The enstatite contains the heaviest Si among all our measured grains, with δ^{30}Si ranging from 17.0 to 19.1‰, while forsterite has δ^{30}Si values from 0.36 to 4.1‰.

Discussion: Since our Si-isotopic compositions cover a significantly greater range than all other natural samples (except for some highly unusual CAIs from Allende), we treated these unusual results cautiously. (1) We did 90 analyses on our standards to estimate the analytical error. The scatter of these measurements, as determined by the standard deviations (1σ), is ~1% for δ^{29}Si and ~2% for δ^{30}Si. (2) We performed a control analyses of a corresponding standard before and after analyzing several grains of meteoritic fayalite, forsterite, and enstatite to make sure both samples and standards were measured under identical conditions. (3) We measured Mokoia and Kaba at different times (approximately one year apart), both meteorites show similar large isotopic fractionations among these three minerals. These results suggest the data are reliable.

The equilibrium vapor/solid or vapor/liquid isotope effect for Si has been estimated to be 2‰ at appropriate high temperature [3]. Silicon-isotopic fractionation greater than 2‰ can only be produced by either a kinetically controlled fractionation or a multistage (e.g., Rayleigh) process [1], as confirmed by evaporation experiments [4,5].

A large percentage of chondrules (>50% in CV3 chondrites, >25% in type 3 ordinary chondrites) experienced multiple heating events, during which melting occurred [6]. It is likely that such heating events were intensive enough to vaporize a substantial portion of the silicates. The evaporation from a silicate melt produces a kinetic isotope effect in which light isotopes evaporate at a greater rate than heavy ones. Thus Si vaporization and subsequent recondensation, especially if repeated several times, could produce a large isotopic fractionation with the residues enriched in heavy and the vapor enriched in light isotopes.

References: [1] Clayton R. N. (1986) *Reviews in Mineralogy, 16*, 129. [2] Molini-Velsko C. et al. (1986) *GCA, 50,* 2719. [3] Clayton R. N. et al. (1978) *Proc. LPSC 9th,* 1267. [4] Molini-Velsko C. et al. (1987) *Proc. LPSC 18th,* 657. [5] Davis A. M. et al. (1990) *Nature, 347,* 655. [6] Rubin A. E. and Krot A. N. (1996) in *Chondrules and the Protoplanetary Disk* (R. H. Hewins et al., eds.), pp. 173–180, Cambridge Univ., New York.