IN-SITU INVESTIGATION OF SILICON ISOTOPE COMPOSITIONS IN A FUN INCLUSION. J. Marin-Carbonne[1], K.D. McKeegan[1], A.M Davis[2] and G.J. MacPherson[3]
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Introduction: Ca-Al-rich inclusions with fractionated and unknown nuclear isotope anomalies (FUN inclusions) are rare and their origin and relationships with normal CAIs are not completely understood. The inclusion 1623-5 from Vigarano is the only "classical" FUN inclusion studied by in situ methods to investigate correlations between isotopic and petrologic properties [1]. Previous ion microprobe measurements of oxygen and magnesium isotope compositions [2, 3] show a progressive enrichment in heavy isotopes suggesting that 1623-5 crystallized during an ongoing evaporation event. [4]. Like Mg, Si is one of the more volatile of the major elements in CAIs, but only few in-situ measurements of Si isotopes have been previously made in 1623-5 [1]. We report here the Si isotope compositions of individual minerals (olivine and melilite) in Vigarano 1623-5.

Sample and method: Vigarano 1623-5 is a forsterite-rich refractory inclusion which contains heavily mass fractionated O, Mg and Si [1,2,3]. The core of this inclusion is composed of olivine, fassaite and akermanitic melilite. Overlying the core is an discontinuous melilite-rich mantle. This Al-rich mantle is out of chemical equilibrium with the inclusion core.

Si isotope compositions were measured on the UCLA Cameca ims 1270 ion microprobe using a $^{16}O^-$ primary beam and positive secondary ions. The pressure in the sample chamber was maintained below 5 x10^{-9} torr. Sample and reference materials were sputtered with a primary beam of about 15 nA intensity and 10 kV acceleration voltage. The primary beam was focused through the primary aperture to produce an elliptical flat-bottomed crater of around 40 μm in longest dimension. The mass spectrometer resolution was set to ~2500, sufficient that the contribution of $^{28}SiH^+$ to $^{29}Si^+$ is considered as negligible. $^{28}Si^+$, $^{29}Si^+$ and $^{30}Si^+$ were simultaneously measured in multicollection mode using three Faraday cups (C, H1, L'2) with equivalent $^{28}Si^+$ count rates between 5x10^7 and 2x10^8 cps depending of the minerals analyzed. Internal precision was better than 0.1 ‰ per spot. Olivine and melilite were used to correct instrumental mass fractionation. The reproducibility on $\delta^{30}Si$ obtained on these reference materials were between 0.5 ‰ for the melilite to 0.71 ‰ for the olivine at one sigma.

Results : Measurements were performed on 15 olivine and melilite grains from 1623-5. In a first approximation, the mass fractionation increases from olivine to melilite (except one point), as previously found for oxygen and magnesium [3]. These minerals show a very large range of fractionation, with $\delta^{30}Si$ (relative to NBS 28) varying from +3.7 ‰ to +31.5 ‰ in the melilite and from +6.8 ‰ to 23.2 ‰ in the olivines. The variation in the olivine is mass dependant, and follows a Rayleigh fractionation curve with a slope of 0.5234 (Fig. 1), close to the value of 0.5175 measured in evaporation experiments [5].
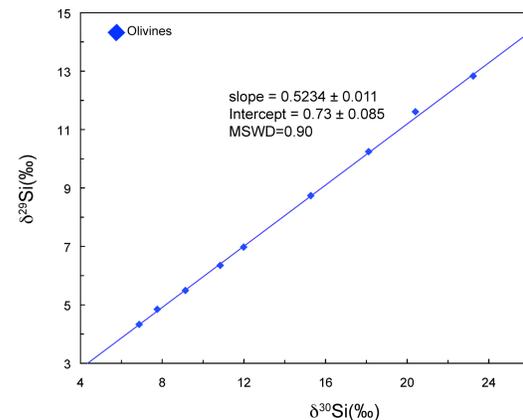

Figure 1: $\delta^{29}Si$ versus $\delta^{30}Si$ for matrix corrected silicon isotope compositions of forsterite. Uncertainties are similar to the size of the data points.

One profile was performed from the mantle edge to the inclusion interior. The profile shows a clear trend of an increasing degree of mass fractionation towards the core of the inclusion (Fig. 2).

Discussion: Si isotope compositions show a significant variation in the degree of mass fractionation in both olivine and melilite. These variations are correlated with the Mg isotope compositions in three forsterite grains measured so far [3]. This correlation, if it is confirmed by more analyses, is expected for evaporation residues of silicate liquids [4]. Hence, it confirms that the core of the 1623-5 crystallized during an evaporating event. However, the Si isotope composition in the melilite of the Al-rich mantle cannot be explained by this event suggesting that another heating event occured after the crystallization of the core of 1623-5.

Both the oxygen and silicon isotopes of melilite show evidence for exchange with a chondritic reservoir, probably the nebular gas. Although there is evidence [3] for ^{26}Al in Vigarano 1623-5, it is not possible to constrain the timing of this exchange event based on available data. Further high precision silicon isotope

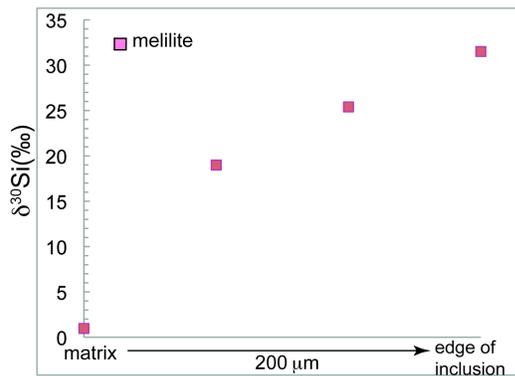data are necessary to confirm correlations with Mg and O isotope compositions.

Figure 2: Silicon isotope composition of the melilite from the matrix to the inclusion. Note that the isotopic fractionation increases into the inclusion interior with increasing distance from the matrix.

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