

O, SI AND MG ISOTOPIC COMPOSITIONS OF FUN INCLUSION VIGARANO 1623-5.

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Introduction: Among the CAIs, some inclusions have extreme isotopic properties, with large mass-dependant isotopic fractionation of major elements (Mg, Si, O) accompanied by large nonradiogenic nuclear anomalies in various minor and trace elements [1]. The origin of these fractionations and the composition of the precursors of these so-called FUN inclusions are still unknown. Vigarano 1623-5 has strong isotopic affinities to the Allende FUN inclusion C1 and is the only “classical” FUN inclusion that still exists in thin section and so can be studied by in situ methods [2]. This object, which shows the first unequivocal correlated petrologic and isotopic evidence for volatilization [2,3], is composed of two chemically distinct parts, separated by a melilite-rich mantle and a hibonite-bearing vesicle. One part is pyroxene-rich and the other is a melilite-rich. A discontinuous 200 μm thick melilite mantle surrounds these cores [2]. Here, we investigate in situ isotopic compositions of O, Mg and Si of the different parts of this unique inclusion. Our goal is to better understand the relationship between the mantle and the cores of this inclusion to constrain its origin and environment of formation.

The analyses were done on a Cameca ims-1270 at UCLA at high mass resolution in multicollecion modes. Olivine, pyroxene, and melilite standards were used to correct for instrumental mass fractionation. The matrix effect due to variation of Åk content [4] was also investigated by analyzing synthetic zoned melilite.

Results: Individual minerals show a large range of mass fractionation in $\delta^{30}\text{Si}$ and $\delta^{26}\text{Mg}$. Olivine from both cores shows a range of $\delta^{18}\text{O}$ variations from -23.8 ‰ to -8.84 ‰, and has $\delta^{30}\text{Si}$ ranging from +6.9 ‰ to +23.2 ‰ and $\delta^{26}\text{Mg}$ ranging from +43.7 ‰ to +82.7 ‰. One pyroxene has been measured and shows a $\delta^{18}\text{O}$ value of -8.4 ‰, a $\delta^{26}\text{Mg}$ value of +60.0 ‰ and a $\delta^{30}\text{Si}$ value of + 21.8 ‰. Olivines show less mass-dependent fractionation for Mg than do pyroxene and melilite, but the same range of fractionation for Si is present in all of these minerals.

There are no large isotopic differences between the pyroxene-rich core and the melilite-rich core, although olivines from the melilite-rich are slightly less fractionated. The melilite-rich core shows a relationship between the Mg and Si isotopic compositions and the location of the olivines. The olivines close to the meli-

lite-rich part are more fractionated than the olivines from the inside of the core. The pyroxene-rich core does not show any spatial relationship.

Contrary to olivine and pyroxene, melilite from the mantle has ^{16}O deficient compositions and shows a small range of $\delta^{18}\text{O}$ variations from +4.6 ‰ to -8.9 ‰. Melilite from the mantle is also mass fractionated with $\delta^{30}\text{Si}$ ranging from +13.2‰ to +30.5‰ and $\delta^{26}\text{Mg}$ ranging from +54.9‰ to +66.3‰.

Discussion: The average $\delta^{30}\text{Si}$ and $\delta^{26}\text{Mg}$ values increase from olivine to melilite to pyroxene (Fig 1), which is consistent with the crystallization sequence already inferred by Davis et al. [2].

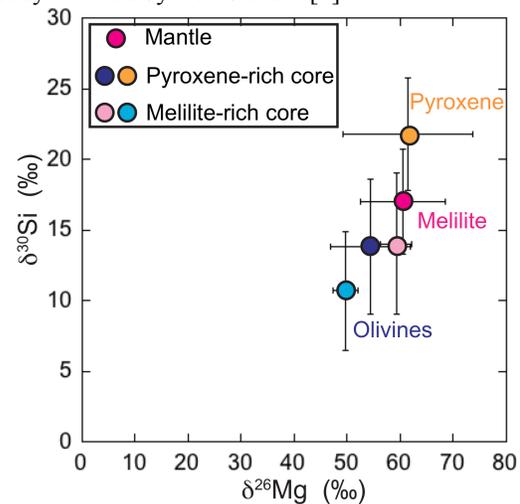


Figure 1 : Average $\delta^{30}\text{Si}$ versus $\delta^{26}\text{Mg}$ of different minerals of each parts of the FUN inclusion.

The olivines from the two cores show mass fractionated compositions both in Mg and Si, which follow Rayleigh fractionation curve on the 3 isotopes plot with a mass fractionation exponent close to the value measured for free evaporation of synthetic CAIs [5,6,7]. The olivines of the core have experienced an evaporation event, contemporously with their crystallization. However, the fraction of evaporation determined from the Rayleigh curve is not consistent between Mg and Si. This implies that the evaporation event can not be explained only by a single-stage Rayleigh distillation and must be due to more than one heating event.

Profiles have been performed in the mantle for O, Si and Mg isotopes measurements (Fig 2). The

mantle is characterized by a chemical variation of the åkermanite content, the matrix edge being depleted by ~ 20 % compared to the olivine edge of the pyroxene-rich core.

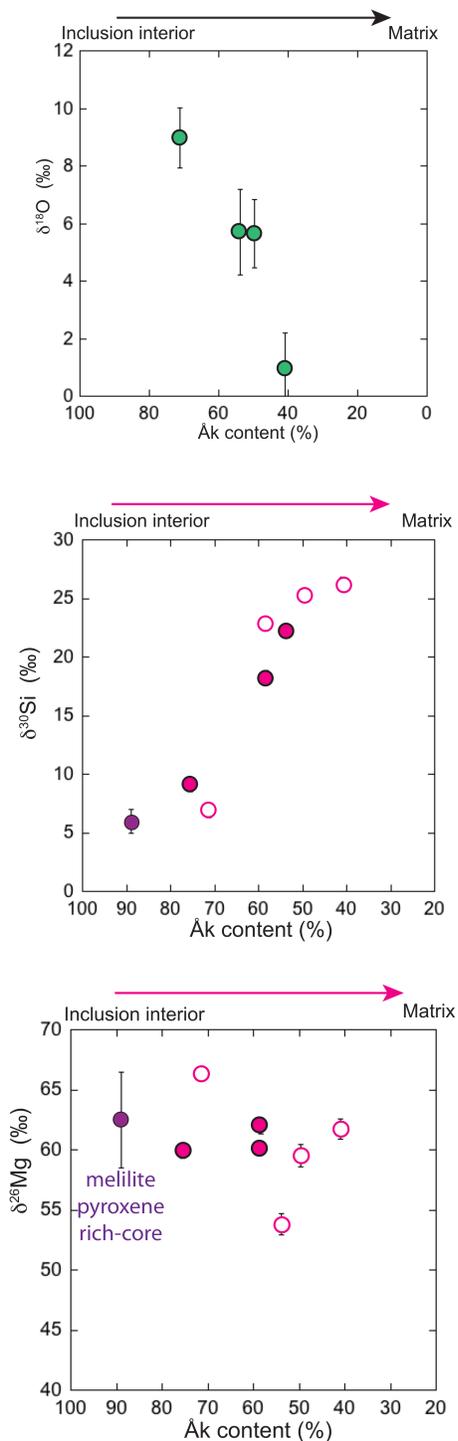


Figure 2: Profiles performed in the melilite mantle for $\delta^{18}\text{O}$, $\delta^{30}\text{Si}$ and $\delta^{26}\text{Mg}$ respectively. The $\delta^{18}\text{O}$ of melilite from the inside of the Pyroxene-rich core has not been measured yet.

The $\delta^{18}\text{O}$ value of the melilite decreases with the distance from the edge of the pyroxene-rich core and increases with the åkermanite content. This trend is not due to a matrix effect, because the matrix effect of Al content on oxygen isotopes analyses is considered as negligible. In contrast, the $\delta^{30}\text{Si}$ of the melilite increases by ~15-20 ‰ with the distance from the olivine edge and also with decreasing åkermanite content. The $\delta^{26}\text{Mg}$ of the melilite is relatively homogeneous across the profile and does not show any correlation with the chemical composition. These profiles reveal a complex story of the heating event, which produced the inclusion mantle. Indeed, during an evaporation event, Mg and Si isotope fractionation should be correlated, but that is not the case. We are still investigating why the Mg behaves differently from the Si in the melilite mantle. However, during this last evaporation event process, the oxygen isotopic composition of the melilite was exchanged.

Conclusions : FUN 1623-5 is a complex object reflecting a complex history. The two cores are chemically different but show very similar isotopic compositions. We found that these cores have experienced more than one evaporation event and these composition can not be explained by a simple Rayleigh distillation process. The mantle surrounding the cores has undergone the highest degree of evaporation (~ 80 %). This evaporation event was followed by an isotopic exchange of O. Several heating events are required to understand the fractionation recorded in this CAI. With a more complete set of experimental data starting with similar composition than FUN 1623-5, we will be able to better understand the story of this inclusion and may be able to determine the conditions of its formation.

References: [1] Loss, R.D. et al., (1994) *Astrophysical Journal*, 436 193-196. [2] Davis A.M. et al., (1991) *Geochimica et Cosmochimica Acta*, 55, 621-637. [3] McKeegan K.D. et al., (2005) *Lunar & Planetary Science* 36, #2077. [4] Knight K.B. et al. (2009) *Geochimica et Cosmochimica Acta*, 73, 6390-6401. [5] Davis A.M. et al. (2005) *Lunar and Planetary Science XXXVI*. [6] Mendybaev et al. (2009) *Lunar & Planetary Science* 40, #2461. [7] Richter et al. (2007) *Geochimica et Cosmochimica Acta*, 71(22): 5544-5564. [8] Kita et al. (2007) *Lunar and Planetary Sciences XXXVIII*.