TITANIUM ISOTOPE SIGNATURES OF Ca-Al-RICH INCLUSIONS FROM VARIOUS TYPES OF CARBONACEOUS CHONDRITES

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Introduction: Ca-Al-rich inclusions (CAIs) are refractory mineral assemblages found in chondrites, interplanetary dust particles, and comets. Since they are the oldest dated solids that formed in the Solar System [*e.g.,* 1], understanding their origin and distribution is of paramount importance for models of accretion disk dynamics [e.g., 2]. However, the textural, mineralogical, and chemical appearance of CAIs is quite diverse and varies between different chondrite groups, such that the origin and genetic relationships among different types of CAIs remain enigmatic. For example, CAIs in CM chondrites typically are small, hibonite-rich objects (*e.g., PLACs* and *SHIBs*), whereas in CV chondrites, CAIs are more abundant, but variable in size and mineralogy.

Mass-independent isotopic anomalies of nucleosynthetic origin are a promising tool to untangle the genetics of CAIs from and within different groups of chondrites, since these anomalies are characteristic of the source reservoir and are not easily overprinted by secondary processes. However, with the exception of a few *in-situ* studies of highly anomalous hibonite-rich objects from CM, CO, and CR chondrites [*e.g.,* 3, 4], until recently all nucleosynthetic isotope data for CAIs were derived from carbonaceous chondrites of the CV class [*e.g.,* 5-7] and two CAIs from CK meteorites [8]. In a previous study, we reported Ti isotope data for two CAIs from CO chondrites [9] and showed that their anomalies are consistent with Ti isotope anomalies in CV CAIs. In contrast, hibonite-rich objects from CM chondrites have been shown to exhibit very different isotopic compositions [3, 4], suggesting a different origin. In order to better understand the relationship of the different CAI populations we here present nucleosynthetic Ti isotope data for CAIs from CM and CO chondrites.

Samples and methods: Twelve CAIs from five different CO3 chondrites with diameters of several hundred µm and ten CAIs (most <300 µm diameter) from the CM2 chondrite Jbilet Winselwan were selected for this study. Two inclusions from Jbilet Winselwan are of particular interest, as they consist largely of hibonite and spinel laths, and thus, could potentially represent a source of single PLAC and SHIB crystals. The inclusions were extracted from incompletely polished meteorite chips using a *New Wave Research Micro Mill* [10] and digested in concentrated acids. Titanium was separated from the sample matrix with a two-stage ion-exchange chemistry [11] and measurements were performed on the ThermoScientific Neptune *Plus* MC-ICP-MS at the University of Münster. Using 100 ppb Ti solutions and internally normalizing to $^{49}Ti/^{47}Ti$ to correct for mass bias, we achieve an external reproducibility of roughly 0.4, 0.3, and 0.3 for $\varepsilon^{46}Ti$, $\varepsilon^{48}Ti$, and $\varepsilon^{50}Ti$, respectively. This reflects a factor of >100 increase in precision compared to *in-situ* methods, with which such small samples previously had to be investigated.

Results and Discussion: All investigated regular CAIs from CO and CM chondrites show resolved excesses in ^{50}Ti, ranging in $\varepsilon^{50}Ti$ from 1.4 to 9.3 (Figure 1) and fall along (or very close to) the $\varepsilon^{50}Ti$-$\varepsilon^{46}Ti$ correlation defined by CV (and CK) CAIs [6-7]. These isotopic signatures suggest a strong genetic relationship, most likely reflecting that CAIs from these different chondrite classes formed contemporaneously and from similar matter.

In contrast, the two inclusions from Jbilet Winselwan consisting primarily of hibonite and spinel laths exhibit highly anomalous and seemingly unrelated Ti isotopic compositions (Figure 1). Intriguingly, these two samples also show large isotopic anomalies in $\varepsilon^{48}Ti$, where regular CAIs show no or very small nucleosynthetic isotope anomalies [7; this study]. As such, these inclusions must have formed from matter that was dissimilar from the aforementioned regular CAIs. Assuming that these two inclusions represent assemblages of PLACs and/or SHIBs—which have been found to lack the short-lived radionuclide ^{26}Al [4, 5]—they could represent an earlier generation of refractory material that formed prior to extensive homogenization and arrival of ^{26}Al.

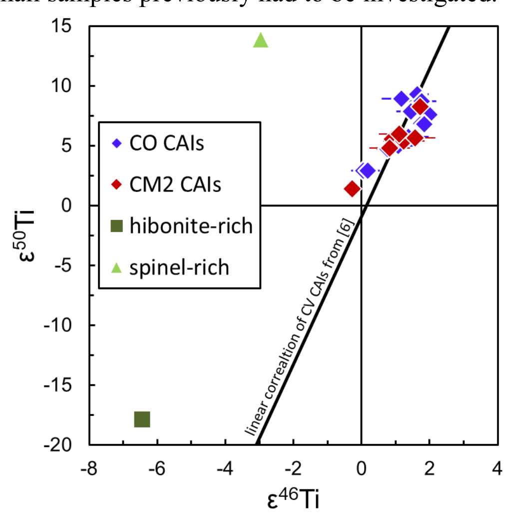

Fig. 1: Ti isotopic data for CO and CM CAIs, together with the two hibonite- and spinel-rich inclusions and the best-fit correlation defined by the array of CV CAIs from [6].

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