HETEROGENEITY IN PRESOLAR TITANIUM BETWEEN CHONDRITES

K. M. M. Shaw[1], C. D. Coath[1], T. Elliott[1],
[1]Bristol Isotope Group, School of Earth Sciences, University of Bristol, Queens Road, Bristol, BS8 1RJ, UK
(Correspondence: kathryn.shaw@bristol.ac.uk)

Introduction: Solar System materials display a range of nucleosynthetic isotopic variations in titanium compared to terrestrial values. The most striking feature of this is the correlation between Δ'^{46}Ti and Δ'^{50}Ti that helps define a dichotomy between the non-carbonaceous (NC) and carbonaceous (CC) undifferentiated chondrites [1]. The origin of this dichotomy and other nucleosynthetic variations in the Solar System materials is tied to the leftover heterogeneity in the distribution of original presolar carriers or grains. Presolar grains in primitive chondrite matrices are surviving examples of the original stellar material from which the Solar System formed and exhibit remarkably large nucleosynthetic anomalies that can be linked to specific stellar sources/environments [2-3].

Previous measurements of Ti in presolar grains using techniques involving strong dissolutions of bulk meteorite matter have permitted the classification of presolar Ti signatures in SiC and some rare oxides [4-5]. However, these signatures cannot fully explain the Δ'^{46}Ti and Δ'^{50}Ti in the bulk. Given *in situ* oxygen and silicon isotope studies have concluded that presolar silicates are up to two orders of magnitude more abundant than SiC grains in some chondrites [6], these could have had a large yet undetermined effect on the Ti isotope composition of the Solar System.

Earlier studies have concluded that the isotopic variation in Ti cannot be explained by just the variable incorporation of a singular presolar carrier [7]. Instead, multiple carriers are needed, but how these presolar grains were distributed across the Solar System is unclear. Some models suggest a change in the infall material in the protoplanetary disk can explain the difference in Ti isotopic compositions between NC and CC chondrites, with later infall being more representative of the inner Solar System bulk compared to more anomalous, early presolar-rich material [8], although this is at odds with a relatively homogeneous disc for some volatile elements and ^{27}Al. Alternatively it has been argued that nucleosynthetic variations could be explained if different processes within the disk itself unmix presolar carriers i.e. thermal/compositional or size discrimination process [1,9]. This is perhaps supported by nucleosynthetic model data which show that a common nucleosynthetic environment is hard to assign to the production of both ^{46}Ti and ^{50}Ti in the quantities observed in Solar System material [10], suggesting that it was a distinct process that resulted in the Solar System correlation for these isotopes rather than a singular carrier bearing ^{46}Ti and ^{50}Ti enrichments.

Analysing the distribution of surviving presolar grains that bear distinctive anomalous Ti signatures, including presolar silicates, in different chondrites can give an insight to how the presolar carriers of Ti varied through the formation of the Solar System.

Methods: 'Proteus', a prototype collision cell MC-ICPMS with mass pre-filter, allows *in situ* measurements of Ti isotopes by reacting Ti with O_2 gas to form TiO^+, and measuring in a region of the mass spectrum cleared by the mass pre-filter. By virtue of the differential reactivity of ion species with O_2, isobaric interferences on Ti (Ca, V and Cr) are greatly reduced.

Results: Novel *in situ* Ti isotope measurements have provided presolar measurements of Ti in O-rich grains from four samples of chondrite; two carbonaceous NWA 8267 (CM2) and Acfer 094 (C2-ungrouped), one enstatite SAH 97146 (EH3), and one ordinary NWA 8276 (L3.00). Four distinct isotopic patterns have been identified. The distribution of these presolar grains and patterns varies between the NC and CC chondrites. For example, grains from both Acfer-094 (C2-ungrouped) and NWA 8267 (CM2) mainly show large (200-1300‰) $\Delta\ ^{50}$Ti enrichments, while only a single grain from NWA 8276 (L3.00) showed a similar enrichment. Instead both SAH 97146 (EH3) and NWA 8276 (L3.00) produced presolar grains (albeit only 1 and 3 grains each respectively) with enrichments and depletions that would result in generally negative Δ'^{46}Ti and Δ'^{50}Ti signatures when internally normalised to ^{49}Ti/^{47}Ti to match with bulk solution Ti measurements.

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