ANALYSIS OF TITANIUM ISOTOPE RATIOS IN REFRACTORY INCLUSIONS BY LA-MC-ICPMS

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Introduction: Calcium-aluminum-rich inclusions (CAIs) with Fractionation and Unknown Nuclear (FUN) effects preserve a record of large isotopic heterogeneities at small spatial scales in the early Solar System (ESS). Constraining the origin of these isotopic heterogeneities and their temporal and spatial distribution is critical for understanding stellar inputs into the solar nebula and the conditions that prevailed during the earliest epoch of Solar System formation. Thus far, no absolute dates have been determined for any FUN CAIs and there is little to no material remaining from previously studied ones for chronological investigations. As such, it is important to locate new FUN CAIs so that their distinctive isotopic signatures can be placed in temporal context in the ESS.

The FUN CAIs preserve large anomalies in several neutron-rich isotopes including ^{50}Ti (e.g., [1-2]). Therefore, the titanium isotope system is well suited for the identification of these objects. Furthermore, laser ablation multicollector inductively coupled plasma mass spectrometry (LA-MC-ICPMS) allows precise, yet rapid analysis of Ti isotopic compositions, making this technique suitable for analyzing a large number of CAIs to search for ones with FUN effects. Here we report preliminary results of titanium isotope ratio measurements of two coarse-grained Allende CAIs by LA-MC-ICPMS.

Analytical Technique: Titanium isotope ratios were measured with the Thermo Finnigan Neptune MC-ICPMS at ASU. The isotope ratios were measured in two peak jumping steps: ^{44}Ca, ^{46}Ti, ^{47}Ti, ^{48}Ti, ^{49}Ti, ^{50}Ti (step 1) and ^{49}Ti, ^{51}V, ^{53}Cr (step 2). All analyses were made in medium-resolution with count times of 8.4 s in step 1 and 4.2 s in step 2. Each run consisted of 20 integrations, resulting in a ~5 minute analysis time. Gas blanks were measured at least four times per analytical session. In situ analyses of minerals in polished sections were made using a Photon Machines Analyte 193 excimer laser ablation system connected to the MC-ICPMS using He as the carrier gas. Typical laser operating conditions included a 150 µm spot size and 4 Hz repeat rate at full power (7mJ/pulse). Instrumental mass bias was corrected using the sample-standard bracketing technique (with a San Carlos augite megacryst as the bracketing standard) and internal normalization to a ^{49}Ti/^{47}Ti ratio of 0.749766 [3]. Typical ^{48}Ti intensity measured on the San Carlos augite (~1.5 wt. % TiO_2) was 1.6×10^{-11} A.

Results: Several runs (10-15) were made on titanium-rich phases (predominantly fassaite) in each of two coarse-grained Allende CAIs (19B65 and CPM2-1). The average values for the Ti isotopic ratios and 2SD uncertainties for each CAI were as follows: For 19B65, ε^{46}Ti/^{47}Ti =4.38±6.68, ε^{48}Ti/^{47}Ti=0.98±1.96 and ε^{50}Ti/^{47}Ti=10.50±4.35; For CPM2-1, ε^{46}Ti/^{47}Ti=6.22±4.52, ε^{48}Ti/^{47}Ti=2.87±2.58 and ε^{50}Ti/^{47}Ti=0.67±7.74. These values are within the reported range for normal, non-FUN CAIs (e.g., [1-3]). Analyses of additional CAIs are currently in progress.

References: [1] Niederer F. R. et al. 1980. *The Astrophysical Journal* 240:L73-L77. [2] Niemeyer S. and Lugmair G. W. 1981. *Earth and Planetary Science Letters* 53: 211-225. [3] Niederer F. R. et al. 1985. *Geochimica et Cosmochimica Acta* 49: 835-851.