TITANIUM ISOTOPE ANOMALIES IN CARBONACEOUS CHONDRITES: IMPLICATIONS FOR ISOTOPIC HETEROGENEITY IN THE EARLY SOLAR SYSTEM.

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Introduction: The isotopic compositions of meteorites provide valuable insights into the earliest history of our Solar System and, in some cases, provide constraints on presolar components that contributed to the solar nebula. For titanium, mass-independent anomalies in the most neutron-rich isotope (^{50}Ti) have been used to distinguish between carbonaceous chondritic (CC) and non-carbonaceous chondritic (NC) materials (e.g., [1, 2]). While the titanium isotope compositions of CC and NC materials are clearly distinct, the full range of compositional variability within each group is less clear. This study is a continuation of work that we recently published [4, 5] as an effort to better characterize the variability of Ti isotope compositions within and among the carbonaceous chondrites.

Methods: Sample preparation, elemental purification and isotopic analysis of Ti were performed in the Isotope Cosmochemistry and Geochronology Laboratory (ICGL) at Arizona State University (ASU). Clean interior fragments (~200 mg) were obtained for each meteorite from the Buseck Center for Meteorite Studies (BCMS) at ASU. These fragments were powdered and homogenized after which, an aliquot of approximately 20-30 mg for each meteorite was digested using HF:HNO_3 in a Parr bomb. The samples were then brought into solution in HNO_3, from which an aliquot containing approximately 5 ug of Ti was chemically processed using methods outlined in [4] to purify Ti. Once the column separation procedure was completed, each sample was measured on the iCAP-Q quadrupole ICPMS to ensure that the Ti yield was >95% and that abundances of elements that could result in isobaric interference (i.e., Ca, V and Cr) were negligible [3-5]. The remaining purified Ti samples and standards were diluted to a concentration of ~600-700 ppb and analyzed using a Thermo Neptune XT MC-ICPMS in high-resolution mode (MRP > 8000). The overall long-term reproducibility (2SD), based on repeat analyses of synthetic and rock standards measured during the course of this work, of mass-independent variations in Ti isotope ratios (ε^{46}Ti, ε^{48}Ti, and ε^{50}Ti) are similar to those reported previously [4,5]. Errors reported for a given sample are the larger of either 2SE based on repeat analyses of the sample or 2SD of multiple synthetic and rock standards analyzed over the course of this study.

Results & Discussion: The ε^{50}Ti values for the Allende (CV3) chondrite fall within the expected range based on data reported previously [4, 5]. The ε^{50}Ti value for the Murchison (CM2) chondrite from this study (2.77 ± 0.16) also agrees with some of the previously reported data but is at the lower end of these values [1, 5]. Given the high abundance of presolar silicon-carbide (SiC) grains in Murchison [6], it is possible that the variations observed in previous data could result from inhomogeneous distributions of such grains on the small sampling scales of those studies. Jbilet Winselwan is classified as a CM2 chondrite [7] and its ε^{50}Ti value (2.79 ± 0.16) agrees well with that for Murchison analyzed here. Sutter's Mill is currently classified as a C meteorite, although it shares similarities to the CM chondrite group [10]. Its ε^{50}Ti value of 2.53 ± 0.16 agrees within the errors to values reported here for the Murchison and Jbilet Winselwan CM2 chondrites; as such, it likely originated from the same or similar isotopic reservoir. Maralinga, a CK4-anomalous meteorite, has a ε^{50}Ti value of 3.46 ± 0.16 which agrees well with that reported for the Karoonda CK4 chondrite by [8] (but is resolvably lower than the value for Karoonda reported earlier by [1]). The ε^{50}Ti value reported in our work for Maralinga additionally agrees with values reported for the Allende CV3 chondrite. This is not surprising given that the CV/CK chondrites show similarities in their mineralogic-geochemical characteristics suggesting that their parent bodies originated in proximity to each other in the solar nebula [9].

Conclusions: The Ti isotope data reported here show similar ε^{50}Ti values for the Allende CV3 and the Maralinga CK4-anomalous meteorites. The two CM2 chondrites, Murchison and Jbilet Winselwan, and the C chondrite Sutter's Mill have ε^{50}Ti values that are comparatively lower, but similar to each other. These likely reflect the distinct isotopic compositions of the reservoirs from which these two groups of carbonaceous chondrites originated. This work emphasizes the potential importance of representative sampling for Ti isotopic analyses for inferring the degree of isotopic heterogeneity in the solar nebula. Further investigations of such representative samples from other chondrites will be needed to better constrain such heterogeneity.

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