TITANIUM AND CHROMIUM NUCLEOSYNTHETIC ISOTOPE VARIATIONS IN SAMPLES FROM THE ALMAHATA SITTA STREWNFIELD

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Introduction: Nucleosynthetic isotope variations, which reflect the heterogeneous distribution of presolar dust in the protoplanetary disk, can be used to constrain the genetic relationships between planetary materials in the solar system. Previous studies identified distinct nucleosynthetic ^{50}Ti and ^{54}Cr compositions in different solar system materials [1-3]. Early solar system processes and asteroid belt dynamics can be investigated using these isotope variations. The disruption of asteroid 2008 TC_3 in the atmosphere delivered fragments of chondritic origin, enstatite achondrites and ureilites of varying lithologies collectively described as the Almahata Sitta samples [4,5]. Sample fragments also include four ureilite-related trachyandesites [5], which are thought to originate from the ureilite parent body (UPB) [6]. The nucleosynthetic Ti and Cr isotope composition of these fragments can provide powerful insights into their origin and genetic relationship to other planetary bodies. The diversity of meteorite fragments indicates that the parent body of the Almahata Sitta samples, asteroid 2008 TC_3, may be the product of second-generation asteroid accretion [4,5]. This study presents high-precision Ti and Cr isotope compositions for nine Almahata Sitta meteorite fragments, which are representative of non-carbonaceous chondrites (NC) and carbonaceous chondrites (CC). They are linked through the formation of asteroid 2008 TC_3. The Ti and Cr isotope data of these samples contributes to the Almahata Sitta meteorite research, evaluating the various meteorite types existing within the parent body (asteroid 2008 TC_3), as well as further constraining the composition of the ureilite-related trachyandesites.

Methods: The samples were dissolved following the Ti-Cr procedure of [7]. A three-stage ion-exchange chromatographic procedure described in [8] was performed for Ti separation and purification. Chromium was collected in the matrix elution step of the first ion exchange column for Ti separation and then further purified using the Cr separation protocol modified after [7]. Isotopic analyses were performed on a Neptune Plus multi-collector ICP-MS at ETH Zürich. The Ti isotope data was corrected for instrumental mass bias using internal normalisation to a ^{49}Ti/^{47}Ti ratio of 0.749766 [9]. The terrestrial basalt BHVO-2 was analysed to evaluate data precision and accuracy and yielded an external reproducibility (2SD) of ~20 ppm for ^{46}Ti/^{47}Ti, ~10 ppm for ^{48}Ti/^{47}Ti, and ~20 ppm for ^{50}Ti/^{47}Ti. The Cr isotope data were internally normalised to a ^{50}Cr/^{52}Cr ratio of 0.051859 [10]. Repeat analyses of the terrestrial rock standards DTS2-b and JP-1 yielded an external reproducibility (2SD) of ~10 ppm for ^{54}Cr/^{52}Cr and ^{53}Cr/^{52}Cr.

Results and Discussion: We analysed Almahata Sitta samples previously classified by [5,11]. They included four ureilites, two enstatite chondrites, one CB and one R-like chondrite. Our nucleosynthetic Ti and Cr isotope data of the analysed samples overlap with those of the respective meteorite groups. Thus, the combined Ti and Cr isotope analysis confirms the petrological determination of the Almahata Sitta sample fragments. For example, the sample fragments proposed to be CB-, R- and enstatite chondrite-like through petrological classification have a Ti and Cr isotope composition identical to the CB-, R- and enstatite chondrites, respectively. Our data also indicates that our ureilitic samples do not contain significant CC clasts because the data is consistent with the average ureilitic composition of [12,13]. The ureilite-related trachyandesite sample MS-MU-011, also called ALM-A, yields ^{54}Cr isotope data that are identical within analytical uncertainties with ALM-A from [13]. Both the Cr and Ti isotope data of ALM-A fall within the ureilite composition field. This confirms that the trachyandesites likely originated from the UPB. Furthermore, our ^{50}Ti and ^{54}Cr isotope data shows that the Almahata Sitta parent body also contains CB-, R- and enstatite chondrites like fragments, which originated from the CC and NC reservoir. This supports the previous conclusion that planetary materials with two distinct isotope compositions (NC and CC) exist within asteroid 2008 TC3 [4,11].

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