GENETIC RELATIONSHIPS OF SOLAR SYSTEM BODIES BASED ON THEIR NUCLEOSYNTHETIC TITANIUM ISOTOPE COMPOSITIONS

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Introduction: Nucleosynthetic isotope variations are a new tool to investigate genetic relationships among different solar system bodies. These isotopic variations reflect the isotopic heterogeneity carried by presolar dust that was present during the planetary formation period in the solar nebula. Bodies inherited the local isotopic signatures of the dust in the region where they accreted. This led to distinct and unique isotopic compositions for each body enabling the investigation of genetic relationships among them. Nucleosynthetic isotope variations in bulk meteorite samples from different inner solar system bodies are now well documented for many elements including Ti [e.g., 1]. Titanium is a powerful element for isotopic studies because it is a refractory lithophile element and therefore, relatively abundant in silicates. Recent studies reported well resolved nucleosynthetic variations in ^{46}Ti and ^{50}Ti for different solar system materials [1-3]. However, the dataset is not yet completed for some crucial meteorite groups. Hence, we present here new high-precision nucleosynthetic Ti isotope compositions for terrestrial basalts, Martian meteorites, mesosiderites, an acapulcoite, an IAB silicate inclusion, and a winonaite. The analyses of these additional meteorite groups allow us to better understand further genetic relationships. For instance, it may strengthen the common origin of IABs and winonaites that was already proposed based on previous isotopic and petrologic studies [e.g., 4, 5]. Moreover, previous studies suggested a genetic link between mesosiderites and eucrites [e.g., 5], although the mesosiderite formation process is still enigmatic and the question whether the mesosiderites and HEDs have a common parent body (i.e., 4 Vesta) is still open.

Methods: Meteorite samples were dissolved by a Parr® bomb acid digestion procedure modified after [6]. Titanium was purified in a three-stage ion exchange procedure after [2, 6]. The isotope analyses were performed on a Neptune Plus multi-collector ICP-MS at ETH Zurich. Nucleosynthetic Ti isotope data were corrected for instrumental mass-bias by internal normalization to a ^{49}Ti/^{47}Ti ratio of 0.749766 [7]. Terrestrial basalts (BHVO-2 and BCR-2) were analyzed to assess data accuracy and precision yielding an external reproducibility (2 SD) of ~20 ppm, ~10 ppm and ~20 ppm for ^{46}Ti/^{47}Ti, ^{48}Ti/^{47}Ti, and ^{50}Ti/^{47}Ti, respectively.

Results: Different meteorite groups show distinct nucleosynthetic Ti compositions with variations in ^{46}Ti and more prominent in ^{50}Ti, which is consistent with previous studies. The analyzed samples are well resolved from terrestrial materials showing negative Ti isotope anomalies. Based on the ^{50}Ti isotope compositions, different groups can be distinguished: (1) eucrites, mesosiderites and the acapulcoite have identical isotopic compositions, (2) Martian meteorites and ordinary chondrites have identical isotopic compositions within errors with a potentially slightly bigger offset for ordinary chondrites from the terrestrial composition and (3) the IAB silicate inclusion and the winonaite are expected to have identical isotopic compositions based on other isotopic and petrologic studies [e.g., 4, 5]. The winonaite data is currently being acquired.

Discussion: Identical nucleosynthetic isotope compositions suggest a common origin, i.e., meteorites either derive from the same parent body or the parent bodies formed in isotopically similar regions of the solar nebula. Interestingly, the acapulcoite shares the same nucleosynthetic composition with eucrites and mesosiderites, but is clearly distinct from ordinary chondrites, the group with which it shares strong petrologic similarities [8]. Mesosiderites and eucrites yield identical nucleosynthetic compositions not only for ^{50}Ti [this work] but also for ^{54}Cr and ^{17}O [5, 9]. Additionally, petrologic similarities strongly suggest a common origin for these two meteorite types [e.g., 10]. Two different hypotheses were proposed to explain the formation of the mesosiderites: (i) they derive from 4 Vesta as the HEDs [e.g., 10], or (ii) they come from a different, once disrupted and reassembled parent body [e.g., 11]. In the case mesosiderites derived from a different body than the HEDs, the nucleosynthetic data suggest that this body formed in the same nebular region as Vesta. Near-infrared spectral data from members of the Maria asteroid family indicate mineralogical assemblages analogous to mesosiderites and thus, this may be a potential source for these meteorites [12].

References: [1] Trinquier A. et al. (2009) *Science* 324: 374-376. [2] Williams N.H. et al. (2014) *LPSC XLV*, Abstract #2183. [3] Zhang et al. (2012) *Nature Geoscience* 6: 251-255. [4] Hunt A.C. et al. (2017) *Geochimica et Cosmochimica Acta* 199: 13-30. [5] Clayton R.N. and Mayeda T.K. (1996) *Geochimica et Cosmochimica Acta* 60: 1999-2017. [6] Schönbächler M. et al. (2004) *Analyst* 129: 32-37. [7] Niederer F.R. et al. (1985) *Geochimica et Cosmochimica Acta* 49: 835-851. [8] McCoy T.J. et al. (2000) *Icarus* 148: 29-36. [9] Trinquier A. et al. (2007) *Astrophysical Journal* 655: 1179-1185. [10] Scott E.R.D. et al. (2014) *LPSC XLV*, Abstract #2260. [11] Rubin A.E. (1997) *American Scientist* 85: 26-35. [12] Fieber-Beyer S.K. et al. (2011) *Icarus* 213: 524-537.