The Origin of Zr Isotope Variations in the Early Solar System

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Abstract

High precision isotope analyses on meteorites can be used to place constraints on early solar system evolution and stellar nucleosynthesis. Nucleosynthetic, isotope variations in Mo were reported for primitive and differentiated meteorites, relative to the Earth and Moon [1-3]. The observed isotopic pattern is consistent with different accretionary regions of the solar system that received variable amounts of s-process material, most likely from a low mass AGB star. The precise nature of s-process material, and the process(es) responsible for the heterogeneous distribution in our solar system requires further understanding.
Zirconium isotopes are ideal for addressing this issue as they are mainly neutron capture isotopes, on the first s-process peak. As such, they are synthesized in multiple s-process sources, including the main (low mass and intermediate mass AGB stars) and weak (massive stars) s-process. In this study, we compare Zr isotope data from [4] with updated stellar model predictions of the s-process [5] to further constrain the sources of the heterogeneously distributed s-process material. The bulk rock Zr data are consistent with an s-process component that encompasses contributions from multiple s-process production sites (stars). This excludes the possibility of the heterogeneous distribution of material from the injection of a single star into the solar system. As such, nebular processes - such as selective thermal processing of dust, or grain-size sorting - are considered a likely mechanism for the bulk heterogeneity.

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