Nucleosynthetic anomalies of Ni and other transition metals in chondrites and possible carrier phases

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Introduction

The numerous nucleosynthetic anomalies found in refractory inclusions, presolar grains and particular phases carried by chondrites suggest that the matter constituting the solar system results from a mixing between different sources. Over the last few years, Ni isotope heterogeneities – among other elements – have been reported in various meteorites. Many samples including ureilite silicates, CAIs, CB metal nodules fall on a mixing line between an s-process and a e-process components [e.g. 1-2] ; altogether it is clear that meteorites come from at least 3 isotopically distinct Ni reservoirs [2-3]. However, the carrier phases of these nucleosynthetic anomalies have not been fully identified yet.

Leachates of carbonaceous chondrites

Focused studies of specific components or stepwise dissolution of carbonaceous chondrites are powerful tools to characterize the fine-scale isotope heterogeneities of the solar system, even if leaching procedures may induce some mixing between the various nucleosynthetic components. Acid leachates of carbonaceous chondrites already display anomalies for a variety of elements [e.g. 4-5]. A stepwise dissolution procedure similar to those previously used in other studies has been applied to facilitate the comparison of the isotopic results. Nickel is a suitable element to resolve the different nucleosynthetic components as ^{61}Ni is overproduced by s-process (AGB stars) when excesses of ^{62}Ni and ^{64}Ni witness nucleosynthesis in a neutron-rich environment (e.g. supernova explosion). Powdered whole rock samples of Allende, Murchison, and Orgueil were sequentially digested with reagents of increasing acid strength. Nickel is not isotopically uniform among the various host phases. Murchison and Orgueil show similar patterns, with widespread deficits in neutron-rich Ni isotopes. Allende is quite different: most leachates are slightly enriched in those isotopes. In Orgueil, the ^{62}Ni-deficit increases with increasing acid strength, which is consistent with the s-process component being carried by acid-resistant SiC presolar grains. Besides, most of the Ni is dissolved by concentrated acetic acid and nitric acid confirming that metal is a major carrier phase. As ^{58}Fe is the most neutron-rich Fe isotope, a correlation is expected with the neutron-rich Ni isotopes: hint towards negative $\varepsilon(^{58}\text{Fe}/^{54}\text{Fe})$ values indeed exists in Orgueil fractions [6]. Isotope measurements of Cu and Zn in the same leachates are in progress with the aim of combining data for several elements from the “iron peak group”. Correlations, if any, will potentially bring stronger and more precise constraints on the astrophysical setting where the nuclides have been produced, and help better identify the carrier phases of the isotope anomalies.

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