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Nucleosynthetic fingerprints in meteorites and planets

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During the past decade, it has been well established that virtually each planetary body in our solar system carries its own distinct nucleosynthetic isotope compositions. The variable compositions represent the heterogeneous distribution of presolar nm-to-µm size dust grains in our Solar System. While they were destroyed in most planetary bodies, primitive meteorites preserved these dust grains, which formed around evolved stars or in ejecta of stellar explosions. These grains still carry the extreme isotope compositions of their production sites. Primitive meteorites also contain mm-to-cm sized refractory inclusions. They show smaller isotopic variations in neutron-rich isotopes (e.g., 48Ca, 50Ti and 96Zr). Their subdued compositions compared to presolar dust results from mixing of material within the solar system. The smallest variations are observed on the largest scale: bulk meteorites and samples from terrestrial planets preserved unique nucleosynthetic fingerprints in the 0.01 to 0.1 permil range, which require challenging high precision measurements to be resolved. Hence, mixing processes in the protoplanetary disk led to homogenisation of extreme compositions, but did not fully erase them. Well established are enrichments in neutron-rich isotopes (e.g., 48Ca, 50Ti and 52Cr) compared to the Earth in samples from the outer region of our solar system (i.e. carbonaceous chondrites). These isotopes point towards supernova material that is enriched in the outer solar system. Correlated variations in Zr, Mo, Ru and Pd isotopes are well explained by the heterogeneous distribution of s-process material [1,2]. Such s-process variations are now also identified for heavier nuclides of Nd and W [3,4] and these variations are even smaller (few parts per million) than those of lighter isotopes e.g., of Zr and Mo. Overall, nucleosynthetic variations at bulk rock scale in heavier elements (Hf, W, Os, Pt, Hg) are very small or not resolvable. This also applies for p-process isotopes. For example, new high precision data of the rare 190Pt isotope demonstrate homogeneity in the solar system [5]. The same is true for the short-lived p-process radionuclide 92Nb (half-life = 37 million years). New data indicate an initial 92Nb/93Nb ratio of 1.68 (±0.10) × 10-5 for our solar system [6]. However, very specific refractory inclusions in meteorites (Group II CAIs) display 92Nb heterogeneities, apparently correlated with variations in the p-process isotope 84Sr. This correlation hints at the presence of a p-process dust carrier in the early solar system.

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