Isotopic heritage of the solar system

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Isotopic compositions of the elements are key indicators to processes that have operated in the solar system, as well as giving insight into the contributions of different nucleosynthetic sites.

Changes in isotope abundances through radioactive decay provide us with a timescale of Earth evolution. Mass dependent isotopic fractionation is a key indicator of temperature related kinetic processes such as oxygen isotope fractionation through evaporation at different latitudes. Materials from the early solar system indicate an age of 4567 Myr for the oldest materials, and a duration of planetary processes of order 10 Myr [1]. The earliest materials from the solar system, refractory inclusions composed of Ca, Al oxides and silicates, record extremely high temperatures, sufficient to volatilise normally refractory elements.

Refractory inclusions show distinct oxygen isotopic compositions related to apparent enrichments in ^{16}O. However, it is now apparent that the inclusi0ons have the solar oxygen isotopic composition and it is the terrestrial composition that is "anomalous" [e.g. 2]. Refractory inclusions also preserve isotopic anomalies that are inherited from precursor materials. These anomalies can be extremely large, up to 27% in the abundance of ^{50}Ti suggesting inheritance from a neutron rich source such as a Type 1 supernova. Despite the large anomalies, refractory inclusions have formed in the solar system and they simply have a chemical memory of nucleosynthesis [3].

Actual presolar grains are preserved in meteorites. These comprise carbon-rich grains (notably silicon carbide and graphite), as well as oxygen-rich grains (notably Ca-Al oxides, and silicates). These grains appear to have largely condensed around dust-producing asymptotic-giant-branch (red giant) stars. C, N, and Si isotopic compositions suggest that the stars are relatively small (1.5 to 3 solar masses) and near solar metallicity [4]. These grains also show enrichments in s-process (slow neutron addition). A small but significant (2%) fraction of the SiC grains appear to have formed in supernovae and preserve anomalies generally associated with short-lived radionuclides (e.g. ^{44}Ca from ^{44}Ti, ^{49}Ti from ^{49}V), as well as Si isotopic compositions enriched in ^{28}Si.

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