Neutron-rich iron group isotopic anomalies among meteorites. H. W. Chen[1, 2] and T. Lee[2], [1]School of Earth Sciences, University of Bristol, [2]Institute of Earth Sciences, Academia Sinica.

The solar system is made of the remnants with vast different isotopic compositions ejected from many different stars [1], yet theoretical model suggested that these materials were effectively homogenized in some stage of formation epoch [2]. Extensive experimental works on various meteoritic samples suggest all isotopic variations in the solar system can be explained by later modification processes such as isotopic fractionation or radionuclides decay from a uniform composition [3]. Some observed isotopic anomalies, especially for neutron-rich nuclear statistical equilibrium (nNSE) isotopes, e.g. ^{48}Ca, ^{50}Ti, and ^{54}Cr, are endemic existed in the earliest solids [4], e.g., Ca-Al rich inclusions (CAIs) and hibonites, from primitive chondrites that had experienced very little thermal alteration. This heterogeneities are suggested to be preserved by either solids condensed before the solar system materials were completed homogeneous or rare nNSE nuclides carrier grains were random captured by various sizes of refractory inclusions to cause the variation of NSE isotopic anomalous effects (ex. ^{50}Ti variation: -6.8%~+27.3% in hibonites and 0~1.5‰ in normal CAIs). However, the solar system was still believed as isotopic homogeneity in planetary scale [5].

Recently, high precision Ca, Ti and Cr isotope works had distinguished correlated ^{48}Ca, ^{50}Ti and ^{54}Cr anomalies in numerous bulk differentiated meteorites [6-8] and defined an apparent linear correlation of ^{48}Ca: ^{50}Ti: ^{54}Cr~ 2.1:2.0:1 (Neutron-rich iron-group Isotopes Correlated Heterogeneities; NICH). The most likely stellar sources responsible for ^{48}Ca, ^{50}Ti and ^{54}Cr are from a rare kind of neutron-rich Type Ia supernovae (nSNe Ia) with igniting density about $5.8\sim7.4\times10^{9}$g cm^{-3} [9]. However, the ^{48}Ca and ^{50}Ti anoamlies in CAIs are plotted on the ^{50}Ti rich (or ^{48}Ca deplete) side of the NICH line. Further compared with other reported isotopic anomalies in CAIs, we found that assuming ^{48}Ca came from single type of source, and the trend represents the intake of component from n-rich SNe-Ia, the excess ^{50}Ti by subtracting the part that correlates with ^{48}Ca could surprisingly show a linear correlation trend with ^{138}La anomaly [10], a rare isotope most likely synthesized by neutrino process [11]. Thus according to present stellar nucleosynthetic model, there were two types of source for ^{50}Ti, the first one came from n-rich SNe-Ia, which produced all ^{48}Ca and part of other neutron-rich iron group isotopes, ^{50}Ti, while the other came perhaps from O/Ne layer of SNe-II where the neutrino process is thought to be producing ^{138}La, and also contribute rest of ^{50}Ti anomaly by s process.

References:

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