Correlated Pd-Ru-Mo nucleosynthetic anomalies in meteorites reflect nebular processing

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Ubiquitous correlated nucleosynthetic anomalies are known in bulk meteorites mostly recorded in refractory elements like, Ti, Mo, Ru. In Ru and Mo the anomalies are attributed to s-process deficits. Proposed causes include late injection of freshly nucleosynthesized matter from the ISM, the processing of refractory mineral carrier phases in the nebula, or other processes. To distinguish between these hypotheses, we have analyzed the less refractory Pd and its isotopic compositions in a variety of chondrites and iron meteorites. Palladium shows resolved nucleosynthetic anomalies that correlate with Ru and Mo anomalies. The maximum anomalies are in CV and CB chondrites, and in IVB iron meteorites. All meteorites form a single Pd-Mo (or Ru) correlation. However, unlike the uniform Ru-Mo correlation, the magnitude of the Pd anomalies is about half that predicted from Ru-Mo anomalies for the same meteorites assuming subtraction of a uniform s-process yield from solar abundances. This observation rules out that the Ru-Mo anomalies are due exclusively to late injection or to physical processing of presolar SiC/refractory metal in the nebula. It should be noted that elements of comparable volatility, like Fe, do not exhibit resolvable nucleosynthetic anomalies, so the preservation of isotope anomalies in Pd is even more remarkable. Moreover, the observed correlation of isotope anomalies in Mo, Ru with anomalies in Pd indicate separation and processing of presolar material within the solar nebula rather than initial disk heterogeneity. Metal from Gujba (CB chondrite) plots along the Pd-Mo correlation defined by iron meteorites, H and CV chondrites. This metal condensed from a dense, metal-enriched vapor plume, where Pd behaved more as a refractory element than in nebular settings, where the T_c of Pd is similar to that of Fe. Thus, thermal and physical processing of chemically diverse presolar carriers and the resulting anomalies must have occurred prior to the formation of the iron meteorite parent bodies and chondrites, i.e. <1 Ma after CAIs. Therefore, the observed Ru-Mo-Pd anomalies imply that nucleosynthetic anomalies observed in meteorites are likely to be isotopic relicts reflecting the different chemical behaviour of their presolar carriers rather than incomplete mixing of presolar material representing different stellar sources.