Origin of *r*-process nuclides in the Solar System: Astronomical and meteoritical perspectives

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The *r*-process is a chain reaction of rapid neutron captures and the cascade of β-decays that occurs in stellar environments with extremely high neutron density. Compared with the *s*-process, the origin of *r*-process nuclides in the Solar System has been poorly constrained. Although core-collapse supernovae (ccSNe) followed by the neutrino-driven winds from protoneutron stars has long been believed to be a promising site for the *r*-process, recent numerical simulations [1,2] demonstrated that the ccSNe cannot be the source of heavy, trans-iron elements with $A > \sim 130$ in the Solar System. Alternatively, some theoretical and astronomical studies proposed that the merger of two neutron stars in a binary system is the dominant site of *r*-process nucleosynthesis, especially for heavy, trans-iron elements [3].

Nucleosynthetic isotope anomalies for heavy elements recorded in bulk meteorites are key for elucidating this issue. Chondrites are known to be enriched in *r*-process nuclides relative to the Earth for elements including Sr, Zr, Mo, and Ru, indicating the heterogeneous distribution of presolar components in the nebula as a result of SN injection and/or nebular thermal processing [4]. Excluding Te, the extent of *r*-process enrichment for each element in chondrites decreases as A increases irrespective of $T_{50\%}$ (Fig. 1). This observation indicates that *r*-nuclides were homogeneously distributed in the nebula for elements with $A > \sim 150$, suggesting the absence of specific *r*-process carrier phases for the heavy elements that can cause isotope anomalies via SN injection and/or nebular thermal processing. This result favors neutron star mergers as for the dominant source of the *r*-nuclides heavier than Nd.

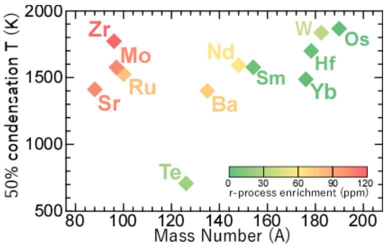

Fig. 1 Extent of r-process enrichment in chondrites relative to the Earth for trans-iron elements as a function of A and $T_{50\%}$

References: [1] Fischer et al. (2009) AA 517, A80. [2] Wanajo (2013) ApJ 770, L22. [3] Tsujimoto and Shigeyama (2014) AA 565, L5. [4] Dauphas and Schauble (2016) Ann. Rev. Earth Planet. Sci. 44, 709.