Molybdenum isotope dichotomy of meteorites

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Nucleosynthetic isotope anomalies in meteorites and meteorite components are powerful tracers of genetic links among meteoritic and planetary materials. For instance, Cr and Ti isotope anomalies indicate a fundamental dichotomy between 'carbonaceous' and 'non-carbonaceous' meteorites [1]. However, this dichotomy has so far not been identified for other elements. Of the various elements showing nucleosynthetic isotope heterogeneities, Mo is particularly useful because *s*- and *r*-process variations result in distinct patterns, making it possible to distinguish, for example, an *s*-deficit from an *r*-excess [2]. Thus, if the aforementioned dichotomy of meteoritic and planetary materials exists, then it should have led to distinct Mo isotope systematics of carbonaceous and non-carbonaceous meteorites. However, Mo isotope anomalies in bulk meteorites seem to predominantly reflect variable *s*-deficits relative to the Earth [2] and no distinction between carbonaceous and non-carbonaceous meteorites could yet be made. Here we address this issue using high-precision Mo isotope measurements by MC-ICPMS. We obtained Mo isotope data for a large set of meteorites, including enstatite, ordinary, and carbonaceous chondrites, acid leachates and an insoluble residue from Allende (CV3), as well as several iron meteorite groups. All analyzed meteorites display well-resolved Mo isotope anomalies and show the characteristic *w*-shaped Mo isotope pattern indicative of an *s*-deficit. However, the Mo isotope compositions of the carbonaceous chondrites, the IID and IVB irons, and the Allende leachates cannot be explained by an *s*-deficit alone but require an additional *r*-process contribution. This is particularly clear in a plot of ε^{94}Mo *vs.* ε^{95}Mo, where carbonaceous chondrites and the Allende leachates together with the IID and IVB irons plot on a distinct *s*-mixing line than the other meteorites. The distinction between these two lines reflects the addition of *r*-process material to the carbonaceous meteorites, consistent with the dichotomy between carbonaceous and non-carbonaceous meteorites observed previously for Cr and Ti isotopes. Finally, the presence of well-resolved nucleosynthetic Mo isotope anomalies in enstatite chondrites excludes them as the major building blocks of the Earth.

[1] Warren (2011) *EPSL* **311**, 93-100. [2] Burkhardt et al. (2011) *EPSL* **312**, 390-400.