Earth's accretion history inferred from the molybdenum isotope dichotomy of meteorites

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Nucleosynthetic Mo isotope anomalies reveal a fundamental dichotomy in the genetic heritage of meteorites, where *carbonaceous* (CC) and *non-carbonaceous* (NC) materials define two distinct *s*-process mixing lines in Mo isotope space [1]. The CC and NC reservoirs were presumably separated by Jupiter [1,2], whose growth/ migration also provides a mechanism for the subsequent scattering of CC bodies into the inner solar system [3]. As CC bodies are the most likely source of Earth's water and volatiles [4], comparing the Mo isotope composition of the Earth's mantle with those of CC and NC bodies allows assessing when volatile-rich material was added to Earth and whether it is related to the CC reservoir.

To address this issue, we obtained Mo isotope data for terrestrial samples and a nearly complete set of meteorite groups. All newly analyzed meteorites clearly plot on either the CC-line or the NC-line, confirming an efficient separation of the NC (inside Jupiter's orbit) and CC (outside Jupiter's orbit) reservoirs during the formation of their asteroidal parent bodies. Based on the current data set, the NC-line has a resolved negative intercept, so that the Earth's mantle (as defined by terrestrial rock samples) plots in between the CC- and NC-lines. From this a contribution of ~30–40% CC-type Mo to the Earth's mantle can be inferred. As the Mo isotope composition of the mantle predominantly reflects the last ~10–20% of accretion [5], CC bodies were therefore a significant component in Earth's final accretionary assemblage. However, Ru isotope data strongly suggest that the *late veneer* was distinct from CC meteorites [6]. Moreover, inward scattering of CC bodies likely occurred at ~4–5 Ma after solar system formation [2], meaning that CC bodies should have been added to Earth throughout most of its accretion history. These seemingly contradictory observations can be reconciled if Mo and Ru in the Earth's mantle reflect the average composition of the inner solar system after admixture of CC bodies.

[1] Budde et al. (2016) *EPSL* **454**, 293-303. [2] Kruijer et al. (2017) *PNAS* **114**, 6712-6716. [3] Raymond & Izidoro (2017) *Icarus* **297**, 134-148. [4] Marty (2012) *EPSL* **313-314**, 56-66. [5] Dauphas (2017) *Nature* **541**, 521-524. [6] Fischer-Gödde & Kleine (2017) *Nature* **541**, 525-527.