

Homogeneous accretion of the Earth in the inner Solar System

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Nucleosynthetic isotope variations in meteorites show that they fall into either the non-carbonaceous- (NC) or the carbonaceous (CC) groups, thought to represent bodies that originally formed in the inner- or outer solar system, respectively. Whether the Earth could have been made from mixtures of these meteorites is uncertain; leading models posit it initially accreted chiefly NC material, before its feeding zone was inundated by between 5 % [1] or 40 % [2] CC material.

Here we examine the variations in 10 nucleosynthetic isotope anomalies among planetary materials in a self-consistent manner through Bayesian Latent Factor Analysis (B-LFA). This reduces the dimensionality of the data, and their representation in 2D space indicates that i) NC and CC groups are clearly separated, ii) CI chondrites are isotopically distinct from other CC, as previously suggested [3], and iii) the bulk silicate Earth (BSE) invariably lies at the extreme end of a linear array defined by ordinary-, enstatite- and Martian meteorites in all isotopic systems. We show that linear extensions of this array in any two isotopic anomalies *always* intersect the observed composition BSE to within 1σ , on average.

Because the elements in which such anomalies are expressed show a range of geochemical (i.e., lithophile or siderophile) and nucleosynthetic (e.g., iron-peak or heavier elements) affinities, their common provenance in the BSE indicates that the Earth accreted homogeneously from bodies of an exclusively NC nature. That is, either the mean isotopic provenance of the material was constant over time, and/or the mantle and core of the Earth were perfectly equilibrated. Given that the masses of the terrestrial planets are distributed in a Gaussian manner with heliocentric distance, extrapolations of this linear array permits the calculation of the isotopic compositions of Venus and Mercury.

[1] Nimmo et al. (2024), *EPSL* 648, 119112. [2] Onyett et al. (2023), *Nature* 619, 539-544. [3] Yap & Tissot (2024), *Icarus* 405, 115680.