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Stochastic accretion of the Earth - *F.G. Houtermans Medal Lecture*

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Relative to the solar composition, the Earth is depleted in volatile elements, but these depletions are not accompanied by isotopic fractionation expected from partial evaporation or condensation during accretion [1, 2]. We identify that the variation of elemental abundances with volatility in the Earth follows a simple mathematical function, a logistic curve, indicative of a stochastic process in its formation.

Here we show that the Earth was formed by accretion of numerous, partially-vaporised precursor bodies whose elemental abundances were set by the temperature at the heliocentric distances at which they formed. Using N-body simulations to track the collisional history and composition of the growing Earth, we find that its pattern of volatile element depletion is reproduced when the disk temperature is set by an accretion rate of $(1.08\pm0.17)\times10^{-7}$ solar masses/yr.

By analogy with T-Tauri stars [3], these accretion rates imply planetesimal formation within ~1 Myr, in accord with terrestrial Mn-Cr and Rb-Sr depletion ages of the Earth [4, 5]. Impact events engender vaporisation, but atmospheric loss is only efficient during the early stages of accretion when an element can escape the proto-Earth's gravity field. Chemical- and isotopic signatures of evaporation are subsequently overprinted by late accretion of volatile-rich material, at which time the proto-Earth is large enough to limit atmospheric loss, resulting in near-chondritic elemental and isotopic ratios of volatile elements.

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