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The Al/Si ratio: sub-solar in enstatite chondrites but supra-solar in the Earth - a plausible explanation

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The Al/Si ratio in enstatite chondrites (and in non-carbonaceous chondrites in general) is lower than the solar (i.e., CI-chondritic) value, in sharp contrast to the Earth, which is enriched in refractory elements. However, the Earth and enstatite chondrites have almost identical isotope ratios, suggesting that they formed mostly from the same source material. We show [1] that this can be the result of fractional condensation/sublimation at a temperature of 1,060-1,400K, depending on pressure and C/O ratio in the disk. This can occur in two ways. A first possibility is that, during the cooling of the disk, after the condensation of refractory elements, refractory grains grew large enough (or even formed planetesimals) to quit chemical equilibrium with the gas. The further cooling of the disk then condensed the residual gas forming “residual condensates”, with a strongly sub-solar Al/Si ratio. The mixing of residual condensates with different amounts of material with solar Al/Si element ratios explains the Al/Si values of non-carbonaceous chondrites. An alternative possibility, supported by recent planetesimal-formation models [2,3] is that dust with CI composition drifted across the sublimation line of silicates, so that Si evaporated while Al remained in solid state. The outward diffusion of the Si-rich vapor led to the re-condensation of Si beyond the silicate evaporation line, leading to the formation of Si-rich solids. Under some conditions, recondensation can enhance the dust/gas ratio enough to trigger the formation of Si-rich planetesimals, similar to the non-carbonaceous chondrites, by the streaming instability [3]. Instead, the refractory component of the sublimating grains continued its radial drift until it was captured into a pressure bump where it formed refractory-rich planetesimals [1]. In both scenarios, the accretion of a substantial fraction of the mass of the Earth from the refractory-rich planetesimals can explain the supra-solar Al/Si of our planet.

[1] Morbidelli, Libourel, Palme, Jacobson & Rubie (2020), *EPSL* 538, 116220

[2] Miyazaki and Korenaga (2021) *Icarus*, in press.

[3] Morbidelli, Baillie, Batygin, Charnoz, Guillot, Rubie and Kleine (2021) in preparation.