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# Porphyritic olivine chondrules with enstatite chondrite isotopic composition as a main building block of Earth

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The nature and origin of the Earth's building blocks remain intensely debated. While enstatite chondrites (ECs) have similar isotopic composition to terrestrial rocks and thus may be representative of the material that formed Earth [1], they nevertheless exhibit significant chemical differences. Specifically, the Earth is enriched in refractory elements and depleted in moderately volatile elements compared to ECs. Alternative planetary growth models proposed that Earth formed *via* accretion of chondrule-sized pebbles [2]. However, the claim that these pebbles correspond to chondrules similar to those observed in carbonaceous chondrites [3] is difficult to reconcile with the constraints imposed by multi-isotopic systems and astrophysical modeling [4]. Furthermore, these models treat chondrules as black boxes, without accounting for their different petrographic types within each chondrite class.

We propose a scenario that explains the chemical divergence between the Earth and ECs by considering the complex magmatic process at the origin of chondrules of various petrological types. We first reevaluate the budget of rare earth elements in enstatite chondrites and show that EC chondrule precursors condensed in the inner protoplanetary disk. Taking condensation models into account, we propose that these condensates are mostly composed of olivine. Olivine originally present in EC chondrule precursors subsequently transformed into enstatite due to gas-melt interactions during chondrule formation [5]. We show that the accretion of the Earth from olivine-rich EC chondrules, which underwent shorter gas-melt interactions compared to those present in ECs, satisfactorily reproduces its chemical ratios (i.e., Mg/Si, Al/Si, Na/Si, Ti/Si, Ca/Si) and oxygen isotopic composition. This difference in the duration of gas-melt interactions in the protoplanetary disk had thus major consequences on the chemical composition of the planetesimals accreted by planetary embryos. Our approach thus addresses the chemical divergence between Earth and ECs without altering their isotopic compositions, while also supporting planet formation models involving large embryos formed in the inner protoplanetary disk.

[1] Dauphas (2017) *Nature* 541, 521-524 [2] Johansen et al. (2015) *Science Advances* 3, e1500109 [3] Garai et al. (2025) *GCA* 390, 86-104 [4] Morbidelli et al. (2025) *EPSL* 650, 119120 [5] Marrocchi et al. 2024 *Space Science Reviews* 220:69.