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Triple oxygen isotope constraints on the nature of missing late veneer from Archean ultramafic rocks

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Ultramafic enclaves in the crust of the Eoarchean Itsaq Gneiss Complex and Mesoarchean Fiskefjord region of southwest Greenland carry a uniform excess in s-process Ru compared to the bulk silicate Earth [1]. The s-process Ru excess is explained by a deficit in late accreted materials that carried a deficit in s-process Ru. It was suggested that the missing late veneer component resembles carbonaceous chondrite-like materials with up to 0.3 % the mass of the Earth, and a missing CM chondrite-like component was favoured [1]. This suggestion provides impetus to study the triple oxygen isotope compositions of the ultramafic enclaves, because most carbonaceous chondrite groups have several thousands of ppm lower $\Delta'^{17}O$ values than the bulk silicate Earth [2]. We found that the $\Delta'^{17}O$ values of pristine olivine from the ultramafic enclaves are identical to olivine $\Delta'^{17}O$ values in post-Archean mantle peridotite, at the level of < 2 ppm. We show that not more than < 0.17 oxygen at.% CM-chondrite like materials can therefore be missing from the ultramafic enclaves. A missing late veneer component that would resemble most other carbonaceous chondrite groups is restricted at the level of ca. < 0.15 oxygen at.% as well, with the exception of CI chondrites, for which a larger missing component (< 1.9 oxygen at.%) is possible. If the missing late veneer component from the ultramafic enclaves resembles CM chondrites, it is therefore either small (< 0.17% the mass of the Earth; based on [3]) or, alternatively, its O/Ru ratio became fractionated such that the Ru isotope composition, but not the oxygen isotope composition of the pre-late veneer mantle was preserved in the Itsaq Gneiss Complex and Fiskefjord mantle. As a third possibility, we suggest that the missing late veneer component could resemble CI chondrites.

[1] Fisher-Gödde et al. 2020 *Nature* **579** 240-244. [2] Clayton, 1993 *Annu Rev Earth Planet Sci* **21.1** 115-149 [3] Palme and O'Neill 2003, *Treatise on Geochemistry* **2** 568