Insights from Lu, Nd and W structural environment in melts on early Earth's differentiation

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Structural changes in silicate melts affect their physical properties such as density and viscosity. For instance, Si coordination change in magmas under high pressures affect their compressibility, and consequently their density at depth [1]. Structural changes in magmas also affect their chemical properties and the way elements partition between the melt and crystals upon partial melting of a source mantle rock.

To assess the effect of melt structure on partitioning at depth, we have investigated the structural environment around trace and minor elements such as Lu [3], Nd, and W, as a function of P-T conditions using in situ synchrotron X-rays based techniques (X-ray diffraction, X-ray absorption spectroscopy). Results show that each of these 3 elements experience a change of local environment in magmas at a given pressure, the latter depending on the element.

Nd/Sm and Lu/Hf systems are thus expected to be coupled in melts generated at low pressure but decoupled for melts produced at 4 GPa and above, melts also expected to have low W content. A scenario of melting processes in the Early Earth will be presented, built on these results. This scenario encompasses formation of a thick basaltic crust from very early melting at high pressures, eventually reprocessed by delamination processes, and followed by later melting of the residual mantle at lower P.

References:

[1] Sanloup et al. (2013), Nature 503, 104-108.
[2] de Grouchy et al. (2017), EPSL 464, 155-165.