Evolution of the Oxidation State of the Earth’s Mantle

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The oxidation state of the Earth’s mantle during formation remains an unresolved question, whether it was constant throughout planetary accretion [1], transitioned from reduced to oxidized [2,3,4], or from oxidized to reduced [1,5]. We investigate the stability of Fe3+ at depth, in order to constrain processes (water, late accretion, dissociation of FeO) which may reduce or oxidize the Earth’s mantle.

In our previous experiments on shergottite compositions, variable fO2, T, and P <4 GPa, Fe3+/ΣFe decreased slightly with increasing P, similar to terrestrial basalt [6,7,8]. For oxidizing experiments < 7GPa, Fe3+/ΣFe decreased as well [9], but it’s unclear from previous modelling whether the deeper mantle could retain significant Fe3+ [1,10]. Our current experiments expand our pressure range deeper into the Earth’s mantle and focus on compositions and conditions relevant to the early Earth. Preliminary multi-anvil experiments with Knippa basalt as the starting composition were conducted at 5-7 GPa and 1800 °C, using a molybdenum capsule to set the fO2 near IW, by buffering with Mo-MoO3. TEM and EELS analyses revealed the run products quenched to polycrystalline phases, with the major phase pyroxene containing ≈ Fe3+/2+. Experiments are underway to produce glassy samples that can be measured by EELS and XANES, and are conducted at higher pressures.