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The role of Tuite, γ-$Ca_3(PO_4)_2$ in the Earth phosphate and volatile cycle

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Ca-phosphates play a unique role in the mineral inventory of the silicate Earth. Apatite is the most abundant Ca-phosphate phase in both terrestrial and extraterrestrial rocks. It is a major accessory mineral in almost all igneous and metamorphic rocks and also an important carrier of incompatible trace elements and halogens. During subduction, apatite breaks down at upper mantle conditions to form the nominally anhydrous calcium phosphate tuite (γ-$Ca_3(PO_4)_2$) [1], which may then take over as the major phosphorus carrier. Previous studies suggest that tuite can accommodate significant amounts of incompatible trace elements [2]. However, its role as a volatile carrier, its upper P-T stability and the accompanying phase relations in the major lithologies of subducting lithosphere at the upper-to-lower mantle transition zone remain to be determined.

In the present study, a series of experiments were performed using a spinel lherzolite starting material doped with 3% synthetic β-$Ca_3(PO_4)_2$ and a trace element mix at pressures ranging from 15 to 25 GPa and temperatures between 1600 and 2000 °C, to determine tuite stability and investigate its role as potential volatile carrier in the Earth's mantle. Preliminary results show that tuite reaches its upper stability limit between temperatures of 1600 °C and 1800 °C at pressures ranging from 20 GPa to 25 GPa. This implies that tuite is a key transport and storage mineral for phosphorus down to the mantle transition zone. However, EPMA analyses reveal that tuite contains significantly smaller amounts of volatiles compared to apatite, thus questioning the role of tuite as major volatile carrier in greater depths. The stable phase assemblage of tuite + Mg-silicates + Ca-silicates + majoritic garnet + ringwoodite + ferropericlase + melt at 20 GPa and 1600 °C involves several other candidates that may take up this role after the breakdown of apatite, which are currently being investigated.

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