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Dynamics of mineral crystallization at inclusion-garnet interface from precipitated slab-derived fluid phase: first in-situ synchrotron x-ray measurements

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Remnants of the fluid phase at ultrahigh pressure (UHP) in subduction environments may be preserved as primary multiphase inclusions in UHP minerals. These inclusions are frequently hosted by minerals stable at mantle depths, such as garnet, and show the same textural features as fluid inclusions. The mineral infillings of the solid multiphase inclusions are generally assumed to have crystallized by precipitation from the solute load of dense supercritical fluids equilibrating with the host rock. Notwithstanding the validity of this assumption, the mode of crystallization of daughter minerals during precipitation within the inclusion and/or the mechanism of interaction between the fluid at supercritical conditions and the host mineral are still poorly understood from a crystallographic point of view. A case study is represented by garnet orthopyroxenites from the Maowu Ultramafic Complex (China) deriving from harzburgite precursors metasomatised at $\sim$ 4 GPa, 750 °C by a silica- and incompatible trace element-rich fluid phase. This metasomatism produced poikilitic orthopyroxene and inclusion-rich garnet porphyroblasts. Solid multiphase primary inclusions in garnet display a size within a few tens of micrometers and negative crystal shapes. Infilling minerals (spinel: 10–20 vol.%; amphibole, chlorite, talc, mica: 80– 90 vol.%) occur with constant volume ratios and derive from trapped solute-rich aqueous fluids. To constrain the possible mode of precipitation of daughter minerals, we performed for the first time a single-crystal X-ray diffraction experiment by means of Synchrotron Radiation at DLS-Diamond Light Source. In combination with electron probe microanalyses, this measurement allowed the unique identification of each mineral phase and their reciprocal orientations. We demonstrated the epitaxial relationship between spinel and garnet and between some hydrous minerals. Epitaxy drives a first-stage nucleation of spinel under near-to-equilibrium conditions, likely promoted by a dissolution and precipitation mechanism between the UHP fluid and the host garnet. A second-stage nucleation involved hydrous phases (amphiboles, chlorite and phlogopite), which nucleate in a non-registered manner and under far-from-equilibrium conditions. From the mineral chemistry of the mineral infillings and the crystallization sequence, nucleation and subsequent precipitation of the mineral phases occurred as a consequence of a fluid/garnet interaction. Such information is discussed in relation to physico-chemical aspects of nucleation and growth shedding light on the mode of mineral crystallization from a fluid phase at supercritical conditions.