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Silicate-rich aqueous fluids sources for diamond crystallisation in deep mantle wedge

Nadia Malaspina (1), Marco Scambelluri (2), Stefano Poli (1), Herman L.M. van Roermund (3), and Falko Langenhorst (4)

(1) Università degli Studi di Milano, Dipartimento di Scienze della Terra, Milano, Italy (Nadia.Malaspina@unimi.it), (2) Università degli Studi di Genova, Dipartimento per lo Studio del Territorio e delle sue Risorse, Italy, (3) Utrecht University, 3Institute of Earth Sciences, Netherlands, (4) Universität Bayreuth, Bayerisches Geoinstitut, Germany

The majoritic garnet-bearing websterites from Bardane (Western Gneiss Region, Norway) are unique examples of metasomatised mantle wedge slices that interacted with C-saturated COH subduction fluid phases at 200 km depth. These peridotites represent slices of former Archean transition zone mantle that upwelled, melted and accreted to a thick cratonic lithosphere, where it cooled until the Middle Proterozoic (stages M1-M2). During the subsequent Caledonian to Scandian subduction cycle (stage M3) these depleted mantle rocks were dragged into deep portions of the supra-subduction mantle wedge, where the infiltration of crustal fluids initiated diamond crystallisation. During this stage majoritic garnet crystallised at grain boundaries and in veins. Evidence of COH fluid influx is provided by the precipitation of dolomite/magnesite, pyroxene, phlogopite, spinel and diamond/graphite in solid multiphase inclusions within orthopyroxene and garnet, as weel as by centimetric veins of majoritic garnet.

We studied the peak M3 mineral assemblage garnet + orthopyroxene + olivine $\pm$ clinopyroxene $\pm$ phlogopite, where garnet turns to majoritic with pressure increase from 3 to 6.5 GPa and 800-1000 °C temperature. Majoritic garnet contains polyphase inclusions with daughter Cr-spinel + phlogopite/K-amphibole + dolomite/magnesite + graphite/diamond, witnessing fluid/mineral interaction closely related to the oxidation state of the rock and responsible for diamond formation. We determined the fO2 in the M3 assemblage starting from Fe3+ analyses in majoritic garnet and we estimated the speciation of the graphite/diamond-COH slab fluids. The Fe3+/Fe of M3-majoritic garnet was measured with the "Flank Method" on wavelength dispersive spectra, acquired on garnets with electron microprobe at the University of Milano. Natural and synthetic standards were used for calibration, together with an additional pyrope-rich standard, measured with electron energy loss spectroscopy. The results indicate a progressive enrichment in Fe3+/Fe up to 0.15 in M3-majoritic garnet. Majoritic garnet shows a core-to-rim zonation with decreasing Fe3+/Fe from 0.15-0.10 in the core to $\leq$0.05-0.00 in the rim. The fO2 calculations have been performed with an improved thermodynamic solution model for the Fe3+-bearing garnet skiagite. The resulting fO2 is variably lower than the fayalite-quartz-magnetite (FMQ) buffer ($\leq$ 1 log unit). However, these values are higher than fO2 of garnet peridotite xenoliths from sub-cratonic mantle equilibrated at similar pressure conditions ($\leq$ FMQ-3), but lower than mantle wedge garnet peridotites from the ultrahigh pressure Sulu belt (FMQ÷FMQ+2) equilibrated at 4-5 GPa.

The determination of oxygen fugacity of these hydrate–carbonate-bearing garnet peridotites enables us to estimate the speciation of COH metasomatic fluids derived from the subducting slab, responsible for polyphase inclusions precipitation. Our results indicate that the metasomatic COH fluid was a H2O+CO2 mixture, with increasing H2O/CO2 with pressure. The peculiar composition of majorite-hosted diamond-bearing polyphase inclusions from Bardane and the speciation of its COH component point to an “oxidised” silicate-rich aqueous fluid contaminant, carrier of Fe3+ from the subducted slab to the mantle wedge.