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3D characterization of garnet from metamorphic sole amphibolite of ophiolite from the central Dinarides

Dražen Balen[1], Marko Kudrna Prašek[2], Pia Pleše[3], and Hans-Joachim Massonne[4]
[1]Department of Geology, Faculty of Science, University of Zagreb, Horvatovac 95, 10000 Zagreb, Croatia (drbalen@geol.pmf.unizg.hr)
[2]Department of Earth and Planetary Sciences, McGill University, 3450 University Street, H3A 0E8, Montreal, Quebec, Canada (marko.kudrnaprasek@mail.mcgill.ca)
[3]Department of Earth and Environmental Sciences, University of Ottawa, STEM Complex 150, Louis-Pasteur Private, K1N 6N5, Ottawa, ON, Canada (pplese@uottawa.ca)
[4]State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences, China University of Geosciences, Wuhan, 430074, China (h-j.massonne@imi.uni-stuttgart.de)

The textural and chemical characteristics of garnet blasts have been routinely used to provide useful indicators on the rock evolution. However, a more precise 3D characterization of mineral volumes and relations leads to a better understanding of particular metamorphic processes.

The Dinarides, a mountain chain in south-eastern Europe, comprises ultramafic massifs and metamorphic rocks that are relics of ophiolite complexes, which originated along the contact of the European plate and the Adria microplate during the Alpine orogeny. The associated regional geodynamic processes brought in contact hot upper mantle and cold subducted material leading to the formation of high-grade garnet-bearing amphibolites ("metamorphic sole"). A clockwise pressure-temperature path with maximum pressure conditions of 2.1 GPa (ca. 70 km depth) at temperatures around 800 °C was determined for such an amphibolite (Krivaja-Konjuh ultramafic massif (KKUM), Bosnia and Herzegovina) that originated from a N-MORB protolith (Balen & Massonne, 2021). These conditions were followed by a nearly isothermal pressure decrease to 0.4 GPa. Pyrope-almandine garnet, rich in mineral inclusions (plagioclase, amphibole, clinopyroxene, ilmenite, rutile, titanite), is a major mineral in metamorphic sole amphibolites from KKUM. Around garnet, fine-grained symplectites usually form a corona (kelyphite), which consists of Ca-amphibole, plagioclase and opaque phases. A plausible explanation of the observed kelyphite is its formation during rapid decompression caused by the uplift of deep-seated rocks for more than 50 km.

We conducted a micro-scale 3D tomography of mineral blasts in metamorphic sole amphibolites from KKUM using phase-contrast synchrotron radiation computed microtomography (SR μCT) at the SYRMEP beamline (Elettra-Sincrotrone Trieste facility). This X-ray micro-tomography allowed us to retrieve micro-scale morphologic features of minerals, mineral inclusions and symplectites in order to quantify their 3D shapes, dimensions, spatial distribution and orientation. We obtained a full high-precision 3D characterization of the mineral volume and textural description including the

3D morphological features of the smallest components. Statistically relevant data were gathered to study the garnet crystallization and decomposition history and thus the metamorphic evolution of the garnet-bearing amphibolites.

Preliminary SR μCT results indicate garnet grains which vary in size from 150 to 1500 μm in diameter. Their associated reaction rims show a thickness from 5 to 60 μm. Initial measurements indicate the tendency of thicker reaction rims around smaller grains. Further 3D measurements and data treatment to statistically describe the entire garnet and reaction rim populations will follow.

The tomography combined with electron microprobe analyses of minerals, whole-rock chemistry and thermodynamic modelling gave us already insights into the growth stages and resorption of garnet as well as the growth of corona minerals. We will use this information to decipher the amount, nature and morphology of mineral grains formed at different stages of the metamorphic evolution. The 3D approach provides many additional details that can be easily overlooked when only a classical petrological approach to the study of the aforementioned amphibolites is applied.

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