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Fluid-melt evolution during prograde melting as recorded in the garnets of the Oberpfalz migmatites, Western Moldanubian Zone (Central Europe)

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Metapelitic migmatites from the Oberpfalz (Moldanubian Zone, Central Europe) consist of alternate layers of melanosome and leucosome. Garnet crystallizes as sub-mm porphyroblasts wrapped by a foliation materialized by oriented biotite and sillimanite, and is commonly partially overgrown by plagioclase. Garnet contains abundant included material (Figure 1a): ($CO_2 + N_2 \pm CH_4$)-rich fluid inclusions (FI) coexist with crystallized granitic melt (nanogranites) and crystallized calcite-rich inclusions (CRI, interpreted as former calcite-rich melt) in the inner portion of the garnet, with residual biotite, plagioclase and sillimanite as mineral inclusions. Three different inclusion assemblages (IA) are defined by different fluid and mineral inclusion associations (1) nanogranites + FI + Pl + Bt; (2) nanogranite + CRI + FI + Bt; and (3) Pl + FI, with Sil present in all three assemblages. Areas with different IAs have different composition, as visible in the calcium elemental map of inclusion-bearing garnet (Figures 1b,c). IA1 occurs in the mid-Ca (Grs ≈ 4) core, while IA2 is characteristic of the lower-Ca inner portion (Grs ≈ 2), which forms most of the garnet. IA3 occurs in the nearly symmetric outer portions of high Ca garnet (Grs ≈ 12–15). The surrounding lower-Ca mantle is completely free of inclusions. Polycrystalline inclusions of irregular shape and containing Bt, Qtz, Pl and And are present in the low-Ca area, and have been interpreted as former pockets of melt.

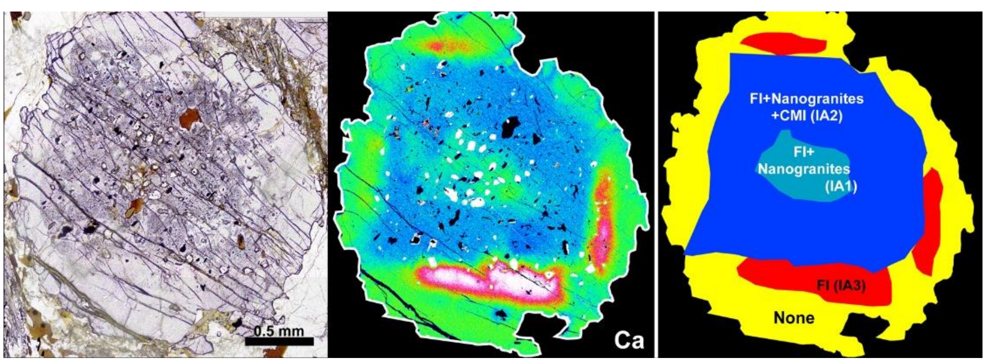

Figure 1: Representative garnet from the Oberpfalz migmatites. Subhedral porphyroblast (a) with Ca-zoning (b) and different inclusion assemblages

The presence of nanogranites and former melt pockets supports the interpretation that the garnet grew as a peritectic phase during biotite dehydration melting. Since Ca is one of the less mobile major elements in garnet, the visible zoning can be interpreted as a primary feature acquired during garnet growth. Mineral–mineral equilibria calculations, thermodynamic modelling and elemental maps suggest that garnet nucleated during partial melting and continued to grow as result of prograde metamorphism in the stability field of sillimanite, with P increasing from 0.5 GPa to 1.1 GPa, followed by a growth stage at lower P. Regarding the fluid regime during melting, IA1 in the garnet core testifies for inception of partial melting under COH fluid-present conditions, followed by a second stage of melting in presence of a further melt rich in calcite component (IA2). The highest Ca content is observed in garnet only containing FIs (IA3), thus suggesting that its formation is unrelated to partial melting processes, but still in presence of a COH fluid.

Summarizing, the detailed study of fluid/melt inclusion assemblages in peritectic garnet, combined with the petrological investigation of the host rocks allows us to describe in the detail the evolution of the fluid/melt regime during continent–continent collision in the Variscan orogen, and better characterize the processes responsible for crustal melting in the middle–lower crust.