Paper Number: 1589

Carbonatitic melt and silicate melt produced during partial melting of metasediments at lower crustal depth

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Investigation of melt and fluid inclusions in migmatites grant access to the unadulterated products of crustal melting, shedding light on the processes driving crustal differentiation. Stromatic migmatites from the Oberpfalz (Moldanubian Zone, Bohemain Massif) present a unique occurrence of calcite-rich inclusions (CRI), crystallized inclusions of anatectic melt (nanogranites) and CO_2-rich inclusions, all hosted in peritectic garnet. The distribution of inclusions as clusters in the host suggests a primary nature, i.e. that they formed during garnet growth.

CRI are generally small (≤10 µm in diameter) and, from a microstructural point of view, strikingly resemble the coexisting nanogranites, i.e. they show a well-developed negative crystal shape and have a cryptocrystalline nature. Their phase assemblage, identified via Raman spectroscopy and EDS mapping, consists of calcite, white mica and chlorite, with quartz as an accessory mineral. Moreover, calcite crystals locally show euhedral faces, further supporting the hypothesis that this phase crystallized from originally homogeneous calcite-rich melt.

Piston-cylinder re-homogenization experiments achieved re-melting of nanogranites at pressure–temperature conditions consistent with geothermobarometric estimates for the garnet-bearing assemblage of 800–850°C and 0.7–0.9 GPa. After having been re-heated at these conditions, the calcite-rich inclusions appear modified, with formation of internal porosity and recrystallization of calcite in microcrystalline aggregates, suggesting that during the experimental run calcite melting was achieved. CRIs are generally highly enriched in LILE (particularly Sr, Ba) and LREE (up to LaN ≈ 500, with moderate to low fractionation among LREE, La/Sm = 1-9) with respect both to the host garnet and the coexistent nanogranites. The higher abundance of LREE in CRIs is consistent with the commonly observed preferential partitioning of REE into carbonatitic melts with respect to silicic melts.

Petrological investigation, calcite-rich character and enrichment in LILE and in LREE of the CRI suggest that they originally trapped a carbonatitic melt. Carbonatites are generally interpreted as products of partial melting of carbonates at mantle depths, or as resulting from differentiation of deep, Ca-rich silicate melt during migration toward the surface. The coexistence of this melt along with nanogranites and COH inclusions during partial melting suggests primary melt-melt-fluid immiscibility conditions at lower crustal conditions. Such an occurrence most likely requires synchronous melting of a heterogeneous protolith where metapelites and carbonate-rich sedimentary rocks are closely spatially associated. In the present case study, the original metasedimentary pelitic sequence likely hosted scattered, meter-thick lenses of impure marbles, a situation similar to what can be observed in the Moldanubian Zone farther east with respect to the study area.