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Melt-melt immiscibility as result of synchronous melting of metapelites and impure marbles at crustal depth in the Moldanubian Zone, Bohemian Massif.

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Investigation of melt and fluid inclusions in migmatites grants 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. Their distribution as clusters in the host suggests a primary nature, i.e. that they formed during garnet growth, thus testifying for the coexistence of different melts and fluid during partial melting in the middle-lower crust.
CRI are generally small ($\leq$10 μm in diameter) and, from a microstructural point of view, strikingly resemble the coexistent 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 accessory mineral. Moreover, calcite crystals locally develop euhedral faces, further supporting the hypothesis that this phase crystallized from an originally homogeneous calcite-rich melt.
Piston-cylinder re-homogenization experiments achieved nanogranites re-melting at pressure-temperature conditions consistent with geothermobarometric estimates, 800-850°C and 0.7-0.9 GPa. After having been re-heated at these conditions, the coexistent calcite-rich inclusions appear modified, with formation of internal porosity and re-crystallization of calcite in microcrystalline aggregates, suggesting that during the experimental run calcite melting was achieved. LA-ICPMS analyses show that CRIs are generally highly enriched in LILE (particularly Sr, Ba) and LREE (up to LaN $\approx$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 preferentially partitioning of REE in carbonatic melts with respect to silicatic melts.
The formation of this carbonatic melt under conditions of primary melt-melt immiscibility at relatively shallow crustal levels is a novel finding. Primary carbonatic melts, i.e. carbonatites, are characteristically the product of partial melting of carbonates at mantle depths, or result from differentiation of deep, Ca-rich silicate melt during migration toward the surface. In the present case study, the protolith of these migmatites was likely a heterogeneous (meta)sedimentary sequence, mainly composed of pelitic sediments and including scattered lenses of impure limestones, which underwent synchronous partial melting during the Variscan orogeny.