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Combining in situ LA-ICP-MS U-Pb monazite dating and thermobarometric modeling confirms an Alpine UHT event in the Gruf Complex of the Central Alps

Jeffrey Oalmann (1), Andreas Möller (1), and Romain Bousquet (2)

(1) Department of Geology, The University of Kansas, Lawrence, USA (joalmann@ku.edu; amoller@ku.edu), (2) Institute of Geosciences, Christian-Albrechts-Universität zu Kiel, Kiel, Germany (bousquet@min.uni-kiel.de)

Ultra-high temperature (UHT) metamorphism requires geodynamic processes that bring excess heat to the lower crust. Therefore, understanding the exact timing of a UHT event has important implications for the thermal, tectonic, and rheological evolution of mountain belts. The sapphirine-bearing granulites and charnockites of the Gruf Complex are enigmatic in that they are the only known UHT rocks in the Central Alps. Different researchers have attributed UHT metamorphism to either Permian rifting (Galli et al., 2012, Contrib. Mineral. Petrol.) or Paleogene Alpine orogenic processes (e.g., Oalmann et al., in prep.). U-Pb zircon geochronology alone does not constrain the timing of UHT metamorphism because the zircons in the granulites are dominated by inherited Permian (and Jurassic) age populations, which were partly resorbed during UHT metamorphism. The Alpine zircon rims likely crystallized from partial melts during cooling from UHT conditions (Oalmann et al., in prep.). Texturally-controlled U-Pb monazite dating combined with P-T estimates for the monazite-bearing textures constrains an important near-peak part of the P-T-t evolution of the UHT sapphirine granulites.

Sapphirine + high-Al orthopyroxene + cordierite +monazite textures equilibrated at ca. 900–1000°C and 7.5–9.5 kbar. UHT garnet breakdown possibly provided the chemical components necessary for phosphate mineral growth. All analyzed monazite domains record concordant U-Pb ages between ca. 33 and 31 Ma, and no inherited components were observed (consistent with chemical dates presented by Schmitz et al. (2009, Eur. J. Mineral.). This age overlaps with the age of the oldest population of Alpine zircon rims (32.5 $\pm$ 0.5 Ma), which are interpreted to have crystallized shortly after UHT metamorphism (Oalmann et al., in prep.).

Intergrowths of monazite with UHT indicator minerals indicate that the monazite grew during UHT metamorphism. The lack of Permian (or any older) monazite domains precludes a Permian UHT event. A singular Alpine UHT event, with nearly complete recrystallization of metamorphic minerals is a viable explanation for the observed ages. We postulate that UHT metamorphism was the result of mantle upwelling or increased heat flow after slab breakoff or an episode of lithospheric thinning during the Alpine orogeny. The lower crustal UHT granulites and charnockites were subsequently juxtaposed against upper amphibolite facies migmatitic gneisses in the middle crust shortly after UHT metamorphism.