

Timescales and mechanisms of continental crust differentiation in late- to post-orogenic settings viewed from lower crustal zircon petrochronology

OSCAR LAURENT¹, CALIMÉRIA PASSOS DO CARMO¹,
OLIVIER VANDERHAEGHE¹, ANDREA GALLI², SIMON
COUZINIÉ³ AND LUC DOUCET⁴

¹Géosciences Environnement Toulouse

²ETH Zürich

³Centre de Recherches Péetrographiques et Géochimiques

⁴Curtin University

Lower crustal magmatic-metamorphic processes control the compositional and structural evolution of the continental crust. Both anatexis during (ultra-)high temperature metamorphism and fractional crystallization of mantle-derived magmas contribute to silicic magma production, whose extraction and upwards migration result in crustal differentiation. However, the timescales of these phenomena, the relative crustal vs. mantle contributions and their interaction mechanisms, are still debated. We addressed these issues using zircon petrochronology (microtextural, U-Pb, trace element and Lu-Hf analyses) on lower crustal rocks from the French Massif Central (FMC) and Ivrea-Verbano Zone (IVZ). Both formed during the late- to post-orogenic stages of the late Paleozoic western European Variscan Belt in and allow to directly compare lower crustal data with complementary granites and volcanic rocks.

Meta-sedimentary and meta-igneous xenoliths hosted in Cenozoic volcanics of the FMC recorded late Variscan peak temperatures of ~950 °C at 8 ± 2 kbar. Zircons from these rocks testify for a continuous cooling over ~50 Myr (315-265 Ma) from the thermal peak, following melt loss along the prograde path. This coincides with granite crystallization in the upper crust that began at ~340 Ma and culminated at 320-310 Ma. In the IVZ, a suite of orthopyroxene-bearing rocks (gabbro-norite to charnockite) represents a solidified hybrid magmatic mush formed by the interactions of mantle-derived magmas with high-grade metapelites. Zircon textural and compositional evolution indicates crystallization occurred during cooling of chemically evolving and homogenizing melts, whose extraction formed the complementary IVZ granites/volcanics. The hybrid lower crustal mush evolved over longer periods (10-20 Myr) through reactive porous flow, whereas the upper crustal reservoirs evolved in a shorter period (ca. 2-4 Myr) in a closed-system.

The comparison of these two cases shows that (i) although crustal-scale migration and crystallization of granitic magmas may be relatively fast (1-5 Myr), lower crustal processes that produce them happen over a longer time span of 10-50 Myr; (ii) in systems dominated by intracrustal melting (FMC), melt production and extraction happen *before* lower crustal cooling, hence decoupling lower vs. upper crustal ages, whereas involvement of mantle magmas (IVZ) results in melt extraction