Constraining the rates of subduction metamorphism and metasomatism using chronology and chronometry: insights from the Eocene

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High-pressure metamorphic rocks exhumed from subduction zones offer the only direct samples of the subduction interface, providing important information for understanding active subduction zones. While the timing of subduction zone metamorphism in exhumed terranes has been achievable using geochronology, the timescales and rates of subduction zone processes has been more elusive. However, approaches utilizing multiple mineral-isotope systems, in-situ techniques and/or microsampling of crystal growth domains have provided important constraints on these processes.

By coupling high-precision direct chronology with thermobarometric constraints (*i.e.*, petrochronology), greater detail about the metamorphic evolution of a particular lithology can be obtained. Importantly, assessing pressure-temperature-time (*P-T-t*) constraints for various localities across a fossil subduction terrane can establish a 'snapshot' of the geothermal gradient, which can offer insights into the paleo-thermal structure and the rates and durations of tectonism, with implications for our understanding of seismicity, geochemical fluxing, and the stress distribution of deeper parts of the subduction interface.

The timescales of other critical processes occurring along the subduction interface, notably fluid flow/metasomatism and deformation, are too short to ascertain via bulk and in-situ chronometers. A technique with continued promise involves the relaxation of bulk rock stable isotope diffusion profiles (*i.e.*, chronometry) to constrain the timescales of fluid-rock interaction on the order of months to years (Taetz *et al.*, 2018). These profiles still only offer time-integrated assessments of fluid flow durations and many features within exhumed subducted lithologies suggest that fluid flow is cyclic and may revisit pathways (Locatelli *et al.*, 2019). Recent, intra-mineral stable isotope measurements in garnet offer the potential for resolving the duration and cyclicity of fluid flow events (Hoover *et al.*, 2022). Coupling such measurements with petrochronology allows for constraints on the absolute timing and *P-T* conditions of these events.

This contribution highlights the use of direct chronology and chronometry from the subduction zone rock record, with particular attention to examples from the Western Alps and the Cyclades.

Taetz, S., John, T., Bröcker, M., Spandler, C., Stracke, A., 2018. Fast intra-slab fluid-flow events linked to pulses of high pore fluid pressure at the subducted plate interface. *Earth and Planetary Science Letters*, 482, 33-43.

Locatelli, M., Verlaguet, A., Agard, P., Pettke, T., Federico, L., 2019. Fluid pulses during the stepwise brecciation at intermediate subduction depths (Monvosi Eclogites, W. Alps): First internally then externally sourced. *Geochemistry, Geophysics, Geosystems*, 20, 5285-5318.

Hoover, W.F., Penniston-Dorland, S., Baumgartner, L., Bouvier, A.-S., Dragovic, B., Locatelli, M., Angiboust, S., Agard, P., 2022. *Geology*, https://doi.org/10.1130/G49737.1.