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Petrochronological investigations to unravel the tectono-metamorphic history of Alpine subduction (Briançonnais, Queyras, Western Alps)

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The study of the tectonic and metamorphic history of the Alpine metamorphic belt involving oceanic and continental subduction processes requires knowledge of detailed Pressure-Temperature-time-deformation (P-T-t-ε) paths recorded by different tectono-metamorphic units across the belt. This task is particularly challenging in low-grade rocks, e.g. metapelites, (a) for thermobarometry, and (b) for geochronology. Metapelites at greenschist facies metamorphic conditions show a narrow spectrum of metamorphic minerals, notably quartz, chlorite and K-white mica, in addition to commonly detrital relics inherited from previous metamorphic rocks. To obtain reliable P-T estimates, a multi-method approach is required, which usefully combines Raman study of Carbonaceous Material (RSCM), chemical analysis in standardized X-ray maps, and multi-equilibrium inverse thermodynamic modelling of chlorite and white mica. In order to be able to link each assemblage to a specific metamorphic stage and determine the time scales and rates of metamorphism, it is critical to use in situ dating techniques. In this study, high-resolution geochronology was conducted including single-grain 40Ar/39Ar dating (step heating), where possible in combination with U-Th-Pb age-dating of allanite by LA-ICP-MS analysis.

In the French western Alps, the Briançonnais zone is a remnant of the continental subduction wedge, while the Liguro-Piedmontais zone is a fossil oceanic subduction wedge. Metapelites from these two complexes were investigated to constrain the individual P-T-t paths recorded in each tectonic slice. This study focussed on deciphering four tectono-metamorphic units in the Briançonnais zone: (B1) The Internal basement; (B2) the Lower and (B3) Upper Zone Houillère; (B4) the Mesozoic Nappe Stack. These continental units recorded green-schist Alpine metamorphic conditions. In the Liguro-Piedmontais zone, five tectono-metamorphic units are identified: (LP1) the Péouvou; (LP2) Saint-Véran; (LP3) Longet; (LP4) and Agnel slices within the Schistes lustrés complex (blueschist facies), and the (LP5) Monviso unit (eclogite facies). Detailed P-T-t paths were reconstructed for units B1, LP3 and LP4, while only P-T estimates were obtained for B2 and B3 due to the absence of datable mineral. The external part of the Briançonais zone (units B2 and B3) records Alpine peak conditions at 275°C and 6 kbar. These conditions, intermediate between a subduction and collision geothermal gradient, suggest incorporation late in the Alpine subduction, in line with the paleogeographic position. In basements slices (belonging to B1) that were pinched out at the Briançonnais Front, phengite crystallized at 270°C and 8.1 kbar at 46 Ma. In oceanic-derived units, phengite from the first foliation reflects an early metamorphic imprint at P-T conditions of 300°C and 10 kbar at 68 Ma. Exhumation started at ca. 46 Ma in internal units (LP4, metamorphic conditions: 450°C and 15 kbar), whereas more external, shallow units (LP3, metamorphic conditions: 330°C and 11 kbar) started at 40 Ma.

These new constraints nourish a new geodynamic model for the burial and the exhumation of these units, based on metamorphic rates calculated from the P-T-t data. An interesting implication of the new model is that the exhumation history of the continental and oceanic-derived units are clearly linked, both starting in the most internal parts at ca. 46 Ma.