



Timing of detachment and rates of exhumation constrained by in situ U-Th-Pb dating (monazite, allanite, xenotime): the Gran Paradiso case

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In the Gran Paradiso Massif (Western Alps), the Money Unit crops out as a tectonic window below the Gran Paradiso Unit. The Gran Paradiso and the Money Units reached peak pressure conditions at $\sim 18\text{-}20$ kbar, $480\text{-}520$ °C and $\sim 17\text{-}18$ kbar, $500\text{-}550$ °C, respectively. This testifies to continental crust subduction and yields a maximum difference of $\sim 9\text{-}10$ km in the subduction depth reached by these two units during the early Alpine history. Thrusting of the Gran Paradiso Unit over the Money Unit led to the conjointly development of the main foliation at the same metamorphic conditions (~ 12.5 kbar- 14.5 kbar and $530\text{-}560$ °C) in both units. The thrust contact was subsequently folded and then both units were exhumed together. The relative timing of growth and dissolution of accessory phases has been assessed by combining thermodynamic modelling with inclusion, textural and chemical (major and trace-element) data from both major and accessory phases. Age of monazite constrained the high pressure metamorphism in both the Gran Paradiso and Money Units at 41.5 ± 0.3 Ma and 42.0 ± 0.6 Ma, respectively. Allanite replacing monazite in the matrix has been dated at 32.7 ± 4.2 Ma. Late growth of xenotime associated with the crystallization of biotite pseudomorphs at the expense of garnet (at about 10 kbar) has been dated at 32.3 ± 1.0 Ma. Our petrochronological data indicate about 10 m.y. between the peak pressure conditions and the crystallization of xenotime leading to an exhumation rate of the order of 2.2 to 5 mm/yr.