Deformation of the upper crustal levels of the Western Alps during Tertiary time: constraints for the terrigenous supply in the foredeeps

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The cooling ages of metamorphic rocks from collisional thrust-belts are generally used to constrain P-T-t paths. However, to determine the final evolution of the metamorphic units located at the uppermost crustal levels we need zircon and apatite fission track age data. In the Western Alps, radiometric ages (i.e. cooling ages) obtained from the metamorphic minerals crystallized along ductile thrust planes did not give ages younger than 32 Ma (Late Oligocene). These ages, still related to ductile deformation, correspond to the time when the foredeep basins surrounding the present-day alpine belt just began to open.

In the Aosta Valley the thrust-belt is formed by continental and ophiolitic units which suffered a polyphased metamorphic history reaching blueschist, eclogitic or greenschist metamorphic peaks during a time spanning between Late Cretaceous and Eocene. The units are juxtaposed each other along both low-angle ductile and high-angle brittle faults, i.e. structures which intervened at different structural levels and at different times, exhuming the metamorphic Alpine unit stack. Chronologic constraints are necessary to demonstrate that a correspondence exists between the exhumation of the thrust-belt in the Western Alps and the clastic supply to the contiguous sedimentary basins from Late Oliocene up to present. The distribution of the apatite ages in the Aosta valley approximately suggests at what time each metamorphic unit cooled below 100–60 °C and then was eroded. From this distribution three main domains appear: i) a southern sector that includes the Sesia-Lanzo and Gran Paradiso units characterized by apatite fission track ages ranging between 20–30 Ma including the large Ranzola fault area up to the Dent Blanche southern boundary, ii) a second domain around 11 Ma, and (iii) a third domain corresponding to the Penninic Front characterized by ages lower than 10 Ma. Each cooling domain seems to be independent from the major lithologic and tectonic boundaries, it rather reflects the location of thickened crust in the Western Alps during Oligocene–Pliocene times. On the base of the apatite fission tracks the internal Sesia Lanzo and Gran Paradiso units could have been the sources of clastic material filling Oligocene foredeeps.

We have concentrated our attention on two geological profiles. The former is a N–S profile across the Aosta-Ranzola fault from the Gran Paradiso to the Dent Blanche units, the latter is a E–W profile across the Gran Paradiso, the Piedmont ophiolites and the Gran San Bernardo units. The former does not display any evidence of differential uplift inside the large area deformed by the Ranzola fault, which includes the Mont Mary unit, part of the Zermatt Saas ophiolites in Valtournanche and the southern Mont Emilius and Gran Paradiso areas. These units show a common exhumation path after the metamorphic peak, completely independent from the tectonic setting. The latter profile shows an abrupt change of exhumation rate and cooling time along a lineament which cuts across the western side of the Gran Paradiso (11–17 Ma) indicating a young exhumation for different portions of the Gran Paradiso massif along steep faults. Regional exhumation seems to have been influenced by both processes thickening and thinning at depth and displacements along slightly dipping or steep fault planes in the shallow crust.