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Structural, metamorphic, magmatic and sedimentological signature of episodic lithospheric thinning along a convergent plate margin: the Lower Oligocene Alps

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Large scale tectonic mode switches from lithospheric shortening to lithospheric extension may play a fundamental role in the tectonometamorphic evolution of orogens located along convergent plate margins. Short lived episodes of lithospheric extension can be inferred from the concomitant occurrence of bimodal magmatism, rapid exhumation of rock units, activity of extensional shear zones, steep geothermal gradients and topographic collapse of the orogenic belt.

Here we provide a synthesis of existing data from the European Alps, supporting this hypothesis on tectonic mode switches. Data are interpreted to suggest that at ca. 37-35 Ma a period of N-S (orogen perpendicular) shortening led to the formation of medium to ultra-high-pressure mineral assemblages by lithosphere-scale thrust imbrication. A tectonic mode switch took place at ca. 35 Ma, marked by the onset of E-W extension. During the extensional event, internal units of the Western and Central Alps were rapidly exhumed to mid-crustal level in the footwall of regional-scale extensional shear zones. Tectonic thinning was also accomplished through pervasive E-W stretching of the nappe pile. Lithospheric stretching resulted in the onset of an anomalous thermal regime, which was responsible for the overprint of the older medium- to ultra-high pressure mineral assemblages by Barrovian-type mineral assemblages and by migmatization. At the same time, attenuation of the isotherms led to partial melting of mantle lithosphere and to bimodal magmatism. Lithospheric stretching resulted in destruction of the orogenic edifice, removing any major topographic divide along the axis of the belt. As a consequence Early Oligocene volcanic rocks that had been erupted in the proximity of the Insubric Line, in the hinterland, could be rapidly eroded and re-deposited in the foreland as flysch. This short-lived episode of lithospheric stretching took place in no more than 5 myr, from ca. 35 Ma to ca. 32-30 Ma.

Continental collision, related to the arrival of the European plate at the subduction zone, was responsible for renewed lithospheric thickening, which is observed in seismic tomography studies.