Early Oligocene N-NW thrusting in the external western Alps before the onset of westward indentation

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The Pelvoux cristalline massif (External French Alps) is crosscut by several E-W to NE-SW-trending thrusts, which are classically assigned to the Pyrenean-Provence tectonic history because of their « transverse » orientation. The development of the Paleogene flexural basin marked the propagation of the Alpine orogenic wedge in the Western Alps. These synorogenic sediments make possible to distinguish some older compressive structures, which are sealed by them, from younger deformations which affect those sediments. Only the former structures (D1), which pre-date Alpine flexural subsidence, may be due to the Pyrenean-Provence orogenesis. The latter (D2 to D4) recorded the evolution of the Alpine collision. Among them, two different sets are found in the Pelvoux massif and surrounding areas : (a) the « transverse » thrusts and folds (E-W to NE-SW trending and N- to NW-directed), and (b) structures which are following the curved trend of the Western Alpine arc (N-S to NW-SE and W- to SW-directed in the Pelvoux area). A multidisciplinary study is carried out concerning the transverse structures (a): kinematics, three-dimensional geometry at regional scale, thermobarometry, datation. It is expected to connect the deformation history in the Pelvoux massif with the multistage emplacement of the Penninic nappes.

The large-scale geometry, which can be imaged using geobased maps and a digital elevation model, and kinematic data are consistent and demonstrate that the transverse thrusts and folds (a) are overprinted by (b), thus the corresponding deformation events are named D2 and D3, respectively. The most prominent overprint occurs at the eastern edge of the Pelvoux massif, where a basement bulge was created by the conjugate effects of D1 basement exhumation (pre-Priabonian erosion of Mesozoic series) and D2 NNW-SSE basement shortening. The Penninic nappes stack was transported westwards along the D3 Briançonnais thrust, which is lying directly on top of the basement bulge. The D3 transport directions are divergent on both sides of the bulge.

In the Bourg d'Oisans region, dominantly affected by D3 deformation, the thermopaleomagnetic record in the Liassic rocks suggests that deformation D3 is older than 24 MA since it pre-dates the onset of magnetization process, and that it occurred at elevated temperature (>320°C) (Dumont et al., in press). D3 folds and paleomagnetic vectors are deformed by D4 more recently than 9 MA. In the eastern part of the massif, a thermobarometric study was carried out on a sample taken from the D2 Combeynot thrust, which shows top-NW shear criteria. The method of multi-equilibria of the chlorite-phengite association (Authemayou, 2002) gives the following results : about 300 to 350°C and 3 to 4 KB, which implies the occurrence of a ~10km-thick tectonic lid above this region at the time of D2 deformation. $^{40}Ar/^{39}Ar$ dating of syn-kinematic white micas along the same D2 thrust provides a reliable plateau age at 31.4 +- 0.4 MA (Heymes, 2004).

This D2 age is slightly younger than (1) the volcanic pebbles found in the Paleogene sandstones of the flexural basin : 32.5+-2.2 and 34.3+-1 MA (Féraud et al., 1995), 32.5+-0,3 MA (Ruffini et al., 1994), and (2) the nannoflora content of the olistostrome underlying the Chablais Prealpine nappes (NP21, Early Oligocene ; Mercier de Lépinay & Feinberg, 1982).

Thus we propose that the N-NW-directed deformation D2 observed in the Pelvoux massif is a consequence of the emplacement of the first Penninic nappes (Embrunais-Ubaye, Prealps) during Early Oligocene times, before the activation of the Briançonnais thrust. A southern or southeastern paleogeographic origin of these nappes has been proposed (Merle & Brun, 1984). The D3 structures in the Pelvoux massif can be regarded as shortening in the footwall of the Briançonnais thrust, which is younger (Tricart et al., 2001 ; Ceriani et al., 2001). This out-of-sequence major thrust, which outlines the curved trend of the Western Alpine arc, crosscuts and deforms the proper Penninic Thrust further south (Embrunais-Ubaye nappes). The D2/D3 kinematic change occurred around 30 MA ago, and corresponds probably to the shift from Africa-Europe N-S convergence, to westward extrusion in the Western Alps together with dextral strike-slip motion along the Insubric line (Schmidt & Kissling, 2000).

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