



What do we learn from extensional tectonics in the Western Alps?

C. Sue (1) and J.-D. Champagnac (2)

(1) IUEM - UMR 6538 place Nicolas Copernic F-29280 Plouzané - France , (2) Universität Hannover, Institut für Mineralogie, Hannover, Germany

The Western Alps' active tectonics are characterized by ongoing widespread extension in the highest parts of the belt and transpressive/compressive tectonics along its borders (Sue et al., 1999; Delacou et al., 2004). We examine these contrasting tectonic regimes, as well as the role of erosional processes, using a multidisciplinary approach including seismotectonics, numerical modelling, GPS, morphotectonics, fieldwork, and brittle deformation analysis. Extension appears to be the dominant process in the present-day tectonic activity in the Western Alps, affecting its internal areas all along the arc. Shortening, in contrast, is limited to small areas located along at the outer borders of the chain. Strike-slip is observed throughout the Alpine realm and in the foreland. The stress-orientation pattern is radial for 3 in the inner, extensional zones, and for 1 in the outer, transcurrent/transpressional ones. Extensional areas can be correlated with the parts of the belt with the thickest crust. Quantification of seismic strain in tectonically homogeneous areas shows that only 10 to 20% of the geodesy-documented deformation can be explained by the Alpine seismicity. We show that Alpine active tectonics are ruled by buoyancy forces rather than ongoing shortening along the Alpine Europe/Adria collision zone. Numerical modeling corroborates this interpretation.

The Neogene extensional structures in the Alps formed under increasingly brittle conditions. A synthesis of paleostress tensors for the internal parts of the West-Alpine arc documents major orogen-parallel extension with a continuous change in 3 directions from ENE-WSW in the Simplon area, to N-S in the Vanoise area and to NNW-SSE in the Briançon area (Champagnac et al., 2006). Minor orogen-perpendicular extension increases from N to S. This second signal correlates with present-day geodynamics as revealed by focal-plane mechanisms analysis. The orogen-parallel extension could be related to the opening of the Ligurian Sea during the Early-Middle Miocene and to compression/rotation of the Adriatic indenter inducing lateral extrusion.

Interactions between the different geodynamic processes control the balance between intrinsic and extrinsic dynamics and explain the late tectonic evolution of the belt (Sue et al., 2007). Numerous geodynamic agents are involved in the Neogene to present evolution of the Western and Central Alps, including boundary conditions (collision, rotation, free boundaries), deep dynamics (gravitational forces, slab dynamics, vertical indentation), and surface processes (erosion, transfert, post-glacial rebound). Three main processes seem to play a fundamental role in the tectonic evolution from orogen-parallel to orogen-perpendicular extension. First, the end of the opening of the Ligurian Sea during Late Miocene times would imply a decrease in orogen-parallel extension. Second, a progressive decrease in the rate of continental collision (Europe-Adria) appears to be critical for the change of tectonic regime. The decrease of convergence rates allows buoyancy forces to develop, and to control gravitational spreading. Third, the Plio-Quaternary increase of erosion implies major mass transfert from inside to outside of the belt and may have deeply changed the alpine tectonics, vertical motions, and denudation structure of the alpine realm (Willett et al., 2006; Champagnac et al., 2007; Vernon et al., 2008).

REFERENCES

- Champagnac JD, Sue C, Delacou B, Tricart P, Allanic C, Burkhard M (2006) Miocene orogen-parallel extension in the inner Western Alps revealed by dynamical fault analyses. *Tectonics* DOI: 10.1029/2004TC001779.
- Champagnac, J.-D., van der Beek, P., Diraison, G., Dauphin, S. (2007) Flexural isostatic response of the Alps to increased Quaternary erosion recorded by foreland basin remnants, SE France. *Terra Nova* 20, 213–220, doi: 10.1111/j.1365-3121.2008.00809.x.
- Delacou B, Sue C, Champagnac JD, Burkhard M. (2004) Present-day geodynamics in the bend of the western and

central Alps as constrained by earthquake analysis. *Geophys J Int* 158: 753-774.

Sue C, Thouvenot F, Fréchet J, Tricart P. (1999) Widespread extension in the core of the western Alps revealed by earthquake analysis. *J Geophys Res B: Solid Earth* 104: 25611-25622.

Sue, C., Delacou, B., Champagnac, J.D., Allanic, C., Tricart, P. & Burkhard, M. (2007) Extensional neotectonics around the bend of the Western/Central Alps: an overview. *Int. J. Earth Sci.* doi:10.1007/s00531-007-0181-3.

Vernon, A.J., van der Beek, P.A., Sinclair, H.D., Rahn, M.K. (2008) Increase in late Neogene denudation of the European Alps confirmed by analysis of a fission-track thermochronology database. *Earth and Planetary Science Letters*, 270 (3-4), pp. 316-329.

Willett, S.D., Schlunegger, F., Picotti, V. (2006) Messinian climate change and erosional destruction of the central European Alps. *Geology*, 34 (8), pp. 613-616.