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2.5D numerical modelling and seismotectonics in the alpine arc: constrains on late-stage post-collisional evolution

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Stress inversions of a synthesis of 389 focal mechanisms and an original regionalization of seismotectonic informations (using an original interpolation method) reveal that core parts of the Alpine belt are in an extensional mode of deformation (Delacou et al., 2004). A zone of extension is mapped all along western Alpine arc, following closely the overall crest line of "smoothed alpine topography" which in turn is closely correlated with the alpine crustal root. Extension, large scale topography and Bouguer anomaly show a very similar pattern, suggesting a causal relationship between stress regime and overthickened crust. Shortening is observed in narrow zones along the western external units. Here too, a close correlation seems to exist between stress state and change in topography from mountain to lowland. Thermomechanical models using a 2D finite element approach (ADELI code (Hassani, 1994)) were used in order to test various geodynamic scenarii against these observations. We model a simplified cross-section along the ECORS-CROP profile, 300 km long, 100 km deep, taking into account a smoothed topography, the associated crustal root, the Ivrea buttress and the Po plain sedimentary basin. The rheological stratification of the lithosphere is described by an elastoplastic upper crust, an elastoviscoplastic lower crust and Ivrea body, and a viscous power-law type mantle. Boundary conditions are varied between overall convergence, extension or "fixed". The best fit between model and observations is found with fixed boundary conditions (no convergence or extension). The system tends to equilibrate itself with internal extensive areas, correlated with topography and crustal root reequilibration whereas compressive areas are found at transition

between alpine relief surrounding lowlands in response to the extension in the core of the belt. We were unable to model convergent models with extensional core areas, even if only minimal convergence rates were applied. The alpine topography seems to be too low to justify extensional collapse and simultaneous overall compression. In models with overall extension, the system undergoes widespread generalized extension everywhere and we were unable to obtain localized areas of compression due to topographic changes. Another finite element modelling study has been conducted in 2.5D. (thin plate assumption), with the code SHELLS (Bird, 1989; Bird, 1999).The first model has been constructed with the assumption of isostatic equilibrium. The calculated stress field is characterized by radial fan-shaped extension in the regions of high topography in the core of the belt and by radial fan-shaped compression in external zones. This pattern corresponds to GPA equilibration between regions of positive GPA in the inner areas, where high topography is correlated with high crustal thicknesses (according to the isostatic equilibrium assumption) and regions of "normal" GPA (near zero) in external zones, with little topography and the Moho close to a normal position (around 30 km). This configuration results in an extensive stress state in the core of the belt, that tends to reduce overthickened crustal material, and in a compressive stress state in external regions in response to the extension of the inner areas. To infer a more realistic 3D crustal structure, we have constructed a second model with a Moho geometry interpreted from wide angle seismic experiments (Waldhauser et al., 1998). This result in a more complicated 3D geometry than in model A in which the highest topography is not directly overlying its crustal root. The resulting stress field appears to be more complicated than in the first model. However, the general trend, that is to say inner extension vs. external compression is still present, but regional variations can be observed.

In summary, the contrasted tectonics of the western/central Alps, with simultaneous, present day occurrence of both extension and compression, is best modelled without large-scale relative plate motion. Internal body forces tend to gravitationally equilibrate the Alpine belt. This result may be interpreted as a post-collisional isostatic response of the alpine arc subsequent to the cessation of convergence between European/Apulian plates.

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