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Dynamics of accretionnary subduction wedges: insights from thermo-mechanical modelling

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Since the discovery of plate tectonics, the increasing precision of global kinematic models and geodesy has led to a good description of the horizontal displacements at the Earth surface. However, vertical displacements are poorly constrained by geodesy and our knowledge of uplift rates strongly depends on the exhumation rates/model taken into account to separate topographic uplift from exhumation. Hence, a better understanding of the mechanisms of exhumation of HP-LT metamorphic rocks within a steady oceanic accretionnary wedge is needed.

We study the evolution of an oceanic accretionnary wedge since the onset of subduction over 20My. For this purpose, we use thermo-mechanical modelling with a visco-elasto-plastic rheology (FLAC-based PARA(O)VOZ code ; Poliakov et al., 1993 ; Burov et al., 1998, 2001). Introduction of passive markers in the original algorithm allows us to follow multiple particles trajectories inside the wedge and to compute synthetic P-T-t paths, which are then compared with data.Besides, realistic progressive density changes of the mineral phases are taken into account by coupling the thermo-mechanical code with thermodynamic algorithm THERIAK (de Capitani, 1994).

We first conducted a general parametric study of the dependence of wedge behaviour on the ductile flow law parameters, thermal conductivity, density of the sediments, convergence rate, and the upper plate rheology.

We applied our approach in the Western Alps on the Schistes Lustrés (SL) complex, which are the remnants of oceanic sediments of the Liguro-Piemontais ocean accretionnary wedge. Our choice was stimulated by the abundance of available P-T-t data

(Agard et al., 2001, 2002) both on the SL and on the surrounding units. Results show that a steady state evolution of the wedge requires (1) the convergence rates to be close to 3cm.yr^{-1}, (2) the continental lithosphere to be strong, and (3) the low density aluminium-rich pelite sediments to have a relatively high viscosity.

In the corresponding experiments, a part of subjacent sediments is irreversibly carried down to mantle depths. Another part of the sediments stays at middle depths and forms the accretionnary wedge. The wedge achieves a steady state at 20 Ma and establishes a burial-exhumation cycle of 10-15 Ma. These oceanic sedimentary units of the wedge reach conditions of blueschist facies (15-20 kbar, 350-450˚C), before returning to the surface with a two-stages exhumation path (10 to 4 mm.yr^{-1} during the first fast exhumation stage, and 1 to 4 mm.yr^{-1} during the second slower exhumation stage). Our study also shows that pressure in the wedge system does not significantly deviate from hydrostatic pressure.