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Relamination styles in orogens– a geodynamic perspective of continental collision

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Relamination of the continental crust is a process that can occur during collision of lithospheric plates: a part of the lower-plate material is subducted, emplaced at the base of the upper plate, and eventually incorporated into its crust. This process has not been satisfactorily studied by means of numerical modeling so far and its dynamics is poorly understood. We performed a parametric numerical-modeling study which shows different styles of relamination.

We use a thermo-mechanical numerical model of oceanic subduction and continental collision. The model setup takes into account complex viscoplastic rheology, effect of fluids and melt, and major phase changes that affect the density. We test the role of basic properties of the converging plates such as their velocity, lithospheric thickness and strength, age and length of the oceanic plate, the role of melt-induced weakening and the boundary conditions. The resulting model cases are classified into three main groups according to the behavior of the deeply subducted continental crust: (i) return along the plate interface in a subduction channel or wedge, (ii) flow at the bottom of the upper-plate lithosphere and subsequent trans-lithospheric exhumation near the arc or in the back-arc region ("sub-lithospheric relamination"), and (iii) nearly horizontal flow directly into the overriding-plate crust ("intra-crustal relamination"). Sub-lithospheric relamination is preferred for relatively quick convergence of thin continental plates and strong melt-induced weakening. Return along the plate interface typically occurs if the overriding plate is thick and strong. Conversely, a very thin or weak overriding plate leads to intra-crustal relamination. Each of these modeled styles of evolution has its counterpart in nature, for example, in the Caledonides, Alpes, Variscan belt, Himalaya, and possibly pre-Cambrian orogens.