Geophysical Research Abstracts, Vol. 8, 08879, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08879

Slab surface temperature in subduction zones: Paradoxical effect of upper plate thinning processes

D. Arcay (1), M.-P. Doin (2), E. Tric (1)

(1) Laboratoire Géosciences Azur, France, (2) Laboratoire de Géologie, Ecole Normale Supérieure, France (arcay@geoazur.unice.fr/Phone:+33(0)4-92-94-26-06)

In subduction zones, the thermal state of the subducting slab surface is affected by the mantle wedge structure. Near the subduction plane base, a high thermal gradient appears because of the traction-driven mantle wedge flow. For a temperature-dependent rheology, this favors the uprising of hot asthenospheric material in the mantle wedge tip, and locally warms and thins the overlapping lithosphere and the slab top. The mantle flow influence on the slab surface thermal state can be described by the interplate decoupling depth, z_{eq}: The interplate decoupling depth corresponds to the minimum depth where rocks overlying the slab surface become carried along by the subducting plate. The z_{eq} value is thus intimetely related to mantle wedge flows.
To study it, we perform 2D numerical simulations of oceanic subduction. The modelled rock behavior is pseudobrittle or ductile, for mantle rocks as well as for the crustal layer that covers the subducting plate and fills the interplate region. The rheology depends on temperature, pressure, deformation rate, and composition. Because the decoupling depth corresponds to the transition from a brittle behavior to a ductile rheology, in our modelling z_{eq} depends on both mantle and crustal rock deformations. Besides, we develop a water transfer model based on accurate phase diagrams in order to dynamically compute the water content evolution in all nodes discretizing the subduction zone. In our simulations, the subducting plate dehydration corresponds to (1) oceanic crust eclogitization, and (2) the progressive destabilization of the serpentinite layer located under the oceanic crust. The water released by deserpentinization, between 100 and 200 km depth, instantanously water-saturates the overlying asthenospheric rocks. The remaining water is then absorbed by the upper lithosphere. We parameterize the water content effect on rheology, and test the influence of the water weakening degree (f_{ν}) by progressively increasing its value, between 1 and 100. The

mantle softening induced by hydration strongly enhances asthenospheric flows in the mantle wedge tip. This process thins the upper lithosphere near the subduction plane, and significantly decrease z_{eq}. Cold materials removed from the thinned upper plate are dragged along the corner flow, and slightly thickens the viscous blanket forming at the slab surface. For a high hydrous strength reduction ($f_\nu > 20$), the convective destabilization of the hydrated upper lithosphere is triggered. This localized convection in the hydrated mantle wedge further decreases z_{eq}. Cold blobs detaching from the lithospheric lid fall on the slab and strongly increase the viscous blanket thickness that thermally isolates the slab surface from the mantle wedge.

By computing (1) thermal profiles across the slab, and (2) pressure-temperature-time ($P-T-t$) paths followed by crustal rocks during subduction, we quantify the influence of upper plate thinning processes on the slab surface thermal state. First, slab surface temperatures depend on the water weakening amplitude, f_ν. Second, at depths greater than 100 km, the hydrous strength reduction induces two opposite thermal effects. On one hand, the backarc is all the more hot as f_ν is high. On other hand, the more efficient the hydrated upper plate thinning is, the colder the slab surface becomes. At depths shallower than 100 km, the f_ν influence on crustal $P-T$ paths is more contrasted. If $f_\nu < 20$, the corner flow efficiency increases with f_ν, and crustal $P-T$ path get hotter as f_ν is risen. If $f_\nu \geq 20$, the convective removal of the hydrated lithosphere strongly cools the slab surface, and counterbalances the heating effect of the enhanced corner flow. As a result, crustal $P-T$ paths for $f_\nu > 20$ are uniformely cold, whereas the overriding lithosphere is significantly warmed.