Geophysical Research Abstracts, Vol. 9, 09329, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-09329

Numerical tests on the relationship between crustal thickness and partial melting in subduction zones

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In subduction zones, petrological studies have shown correlations between Na_6, Ca_6 in lavas and the crustal thickness of the overriding plate. It has been proposed that an increase of crustal thickness is related to an increase (decrease) of Na_6 (Ca_6), respectively. Partial melting starts in a region located at a depth of about one hundred kilometres, which corresponds to the top of the subducted slab under the volcanic arc. The amount of partial melting is expected to increase with the height of the mantle column between the top of the subducted slab and the bottom of the overlying crust, which means that it depends only on the thickness of the overlying crust. In order to test the latter proposals, a numerical code with adaptive mesh refinement is proposed for modelling subduction zones. This code is developed using the finite element code FreeFEM++ (INRIA, France). Conservation of energy is solved using a Galerkin procedure, whereas Stokes equations are solved with a penalty method. Crust and mantle rheologies depend on temperature, pressure, composition and strain rate. Following previous studies, a combination of pseudo-brittle rheology for the crust and a non-Newtonian rheology for the mantle is imposed.

Nowadays, a lot of models study subduction zones using the laws of fluid mechanics, without any geometrical constraint. In our case, a different approach has been chosen because a focus on specific geometries encountered in various contexts is required. In particular, emphasis must be put on the influence of the crustal thickness parameter. Furthermore, the geometry of the subduction zone is fixed accurately.

In the preliminary work that will be presented, the overriding plate is considered at rest and the value of its crustal thickness is fixed. The bending of the subducting plate is also fixed. Meshes are refined considering viscosity gradients in the whole domain when computing the Hessian matrix.

The first application of our code is to study the influence of crustal thickness on the temperature field and rheological properties for different subduction geometry and boundaries conditions. The next step will be to take into account the effect of water on the melting regime.