Geophysical Research Abstracts, Vol. 9, 05486, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05486
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Rheology of rocks at convergent plate boundaries: Thermal-mechanical coupling

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We have created a new 2D coupled geochemical-petrological-thermomechanical numerical model of retreating intraoceanic subduction associated with volcanic arc development. The model includes spontaneous slab bending, subducted crust dehydration, aqueous fluid transport, mantle wedge melting and melt extraction resulting in crustal growth. This model allows us to study influence of melt extraction intensity on the dynamics of subduction, mantle wedge plumes development and magmatic arc growth and displacement. In our numerical experiments subduction nucleates across the weak transform fault separating two oceanic plates different age. Subduction rate strongly varies with time. In all studied cases there is a deceleration period of a few Myr after the beginning of subduction, during this period subduction rates decrease from $\sim$ 7 cm/yr to $\sim$ 4 cm/yr. Subsequently, two scenarios can be distinguished: (1) decay and, ultimately, the cessation of subduction, (2) increase in subduction rate (to up to $\sim$12 cm/yr) and stabilization of subduction. In the first case the duration of subduction correlates positively with the intensity of melt extraction: the period of continued subduction increases from 15,4 Myrs to 47,6 Myrs with the increase of melt extraction threshold from 1% to 9%. In scenario 1 the magmatic arc crust includes large amounts of rocks formed by melting of subducted crust atop the thermally relaxing slab. In contrast, in case of stable subduction, magmatic rocks produced by partial melting of hydrated mantle wedge clearly dominate the crust. In several numerical experiments an intra-arc extension is observed during subduction. This process results in splitting of previously formed magmatic arc crust by a newly formed spreading center. The loci of magmatic activity and intensity of crustal growth is strongly dependent on the dynamics of hydrous partially molten upwellings (cold plumes) rising from the slab.