Geophysical Research Abstracts, Vol. 7, 00118, 2005
SRef-ID: 1607-7962/gra/EGU05-A-00118

Spinning bodies in mantle wedges

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Using finite-differences and marker-in-cell technique we performed 70 2-D coupled petrological-thermomechanical numerical experiments of intra-oceanic subduction. They indicate that parts of the mantle wedge can be trapped between rheologically weak, hydrated and partially molten upwellings (cold plumes) and the subducting slab. The trapped parts become entrained in spinning motion. The experiments investigated the parameters that control the occurrence and long-term stability of such 'rigid-rotation type' structures (subduction wheels, wedge pin-balls, fore-arc spins). Young, hot subducting slabs enable plume initiation at relatively shallow depth (70-80 km). With a stable depth of plume roots, strong vorticity in the displacement field isolate 20-30 km in diameter rotating wheels of the mantle wedge. At the initial stage of rotation the dynamic viscosity of the isolated body is similar to that of the bulk mantle wedge. With time elapsed the body cools down by 200-300˚C and becomes rigid. The rotation is driven by the moment between the down going slab and the rising plume.

Wedge pin-balls are small rigid bodies ripped off the slab or from the overriding plates and rotating within serpentine channels at 20-50 km depth. These rotating bodies are more viscous than, yet as hot as the surrounding subduction channel material.

Fore-arc spin is a consequence of intra-arc extension that allows the fore-arc lithosphere to be dragged-down at 10 to 20 km depth with the subducting slab.

Computing of seismic velocities demonstrates that spinning bodies may provide an explanation to tomographic anomalies identified in upper mantle wedges.