Geophysical Research Abstracts, Vol. 8, 07693, 2006
SRef-ID: 1607-7962/gra/EGU06-A-07693

Time dependence of negative buoyancy of a mature oceanic lithosphere subducting with varying velocity

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The time history of negative buoyancy of a mature subducting oceanic lithosphere has been studied for various time varying subduction rates and kinematic boundary conditions. The buoyancy force is estimated based on thermal models. The temperature and the resulting negative buoyancy are time-dependent. The magnitude of the negative buoyancy increases with increasing depth of penetration of the slab and subduction velocity. For mature oceanic lithosphere, the buoyancy of a slab reaching the base of the mantle transition zone is approximately 5 x 10^{13} N $m^{-1}$for a peak subduction rate of 5 cm a^{-1}. In all cases considered, the rate of increase in negative buoyancy depends on the convergence rate at a particular period of time during subduction. If the velocity increases exponentially in the initial stages of subduction, the maximum rate of increase is observed when the slab subducts with the peak subduction velocity. If subduction continues with a constant velocity, the rate of increase in thermal buoyancy begins to decrease as the slab penetrates the lower mantle, and the buoyancy approaches an asymptotic value for increasing time. If the velocity decreases exponentially in the last stages of subduction, the negative buoyancy begins decreasing while the slab is still sinking, as its thermal anomaly decreases. After subduction stops, the slab achieves thermal equilibrium with the surrounding mantle in approximately 10-20 Ma depending on its past history.