Geophysical Research Abstracts, Vol. 9, 08577, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-08577

Density structure and buoyancy of the oceanic lithosphere from integrated geophysical-petrological modelling

J. C. Afonso (1), G. Ranalli (2), M. Fernàndez (1)

(1) Inst. Earth Sci. "J. Almera", CSIC, Luís Solé i Sabarís s/n 08028, Barcelona, Spain (jafonso@ija.csic.es), (2) Dept. Earth Sci. , Carleton University, Ottawa, Canada

The oceanic lithosphere (OL) is not only a thermal, but also a chemical and a mechanical boundary layer. How these layers interact, as well as their respective thermophysical properties, depend on the major-element composition and equilibrium mineral assemblage of OL, which in turn depend on temperature, pressure, composition of the original source, and degree of melt depletion experienced at the mid-ocean ridge. Here we present an up-to-date assessment of the thermal, compositional, density, and seismological structure of the lithospheric and sublithospheric oceanic mantle. We use a new integrated modelling approach that combines the latest data on mineral physics, geochemical and petrological models of OL, and geophysical observables. All pertinent equations are solved simultaneously and self-consistently using a finite-element formulation. Compressibility, partial melting, phase changes, and compositional heterogeneities are explicitly considered.

Results indicate that plates with asymptotic thermal thicknesses (depth to the 1300 °C isotherm) of 105 $\pm$ 5 km are consistent with all the available geophysical and petrological data. Thinner plates (e.g. GDH1 model) are difficult to reconcile with available seismological information in OL. A clear low-velocity zone is always present, even in the absence of partial melting. The "anomalous" positive velocity gradient with depth observed in the first $\sim$ 30 km of some sections of mature OL can be interpreted in terms of an incomplete spinel-plagioclase phase change.

Contrary to the general belief, the average density of mature OL ($\sim$ 3310 - 3315 kg m^{-3}, including the crust) never exceeds those in the underlying mantle. Moreover, average density contrasts between mature OL and the adiabatic mantle ($\overline{\Delta\rho}$, used in

buoyancy calculation) are constrained to values $\lesssim$ 40 kg m^{-3}, significantly smaller than commonly assumed in many geodynamic models ($\gtrsim$ 70 kg m^{-3}). These estimates are only slightly dependent on different isentropic melting models and/or source water contents. The average viscosity of OL, on the other hand, can be drastically affected by these two factors (increased by more than two orders of magnitude), making OL more resistant to deformation.

The above results suggest that the roles of $\overline{\Delta\rho}$ and intrinsic viscosity in triggering/assisting processes such as subduction initiation may not be as critical as others factors such as localized rheological weakening, compression, thickened oceanic sections, and/or lateral density contrasts.