Slab stagnation depth: Buoyancies and seismic velocities

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We have constructed kinematic thermal models of subducting slabs [Negredo et al., 2004], for both stagnant (non-penetrative) slabs and deep-mantle (penetrative) slabs [Fukao et al., 2001]. For these cases, we have calculated equilibrium phase assemblages (olivine polymorphism), along with the resulting buoyancy forces and seismic velocity anomalies. Beyond the well-known thermal dependence upon subduction rate, dip angle, and lithospheric age [Kirby et al., 1996; Yoshioka et al., 1997; Tetzlaff & Schmeling, 2000; Bina et al., 2001], we have focused upon the stagnation depth (of the base of the slab) as a primary independent variable.

We find that several important factors exhibit significant dependence upon stagnation depth. These include: the extent of a basal buoyant layer supporting the stagnant slab, the presence of driving forces for subsequent partial uplift of recumbent material, the associated buoyant bending moments, and the development and extent of a low-velocity zone beneath the stagnant slab.

For example, for a given subduction zone, stagnation of the slab at greater (below 660 km) depth induces greater depression of the Rw to Pv + Mw phase boundary, due to the imposition of lower temperatures at greater depths, thereby stabilizing a larger volume of Rw at depth. However, the resultant deep Rw is actually less positively buoyant (per unit volume), because the Rw is both colder and more compressed and therefore denser, than in the case of shallow stagnation.

Finally, we examine the consequences attending the possible metastable persistence of olivine to stagnation depths, both in terms of buoyant bending moments and in terms of anomalous latent heat release [Green & Zhou, 1996; Bina, 1998].

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