Phase Stability and Metastability in Deep Slab Structure and Dynamics

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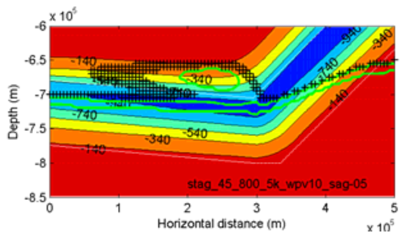
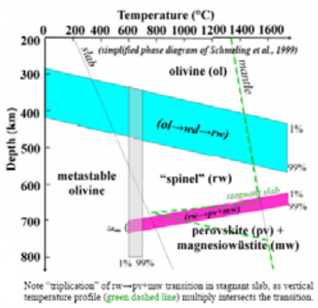
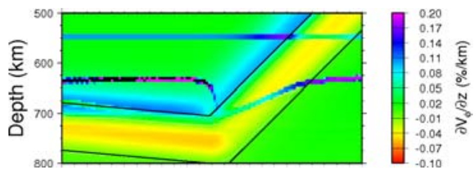
Deep subhorizontal extensions of subduction – or "stagnant slabs" – constitute unusual thermobaric environments, in that subducted material may gradually undergo nearly isobaric thermal assimilation. The petrological consequences, in terms of equilibrium or metastable phase relations, should affect both apparent seismic velocity structures and slab morphology [*e.g.*, Bina, 2006].

Evidence for slab stagnation may appear in several forms. Seismic extensions of stagnant slabs may appear as shallowing in apparent dip angles of deep seismicity distributions [*e.g.*, Chen *et al.* 2004]. Aseismic extensions may appear as subhorizontal deflections of fast velocity anomalies in P-wave and S-wave seismic tomography [*e.g.*, Fukao *et al.*, 2001, Suetsugu *et al.*, 2006]. Lateral depth variations along the 660-km seismic discontinuity in migrated receiver functions [*e.g.*, Kawakatsu and Watada, 2005] may be mapped into thermal anomalies by assuming correspondence to equilibrium deflection of the perovskite-forming transition in ringwoodite. Fine structure in the deflected discontinuity will depend upon details of slab deflection angles and depths. Any metastable persistence of low-pressure phases within the cold slab [*e.g.*, Kubo *et al.*, 2008, Chen *et al.*, 2008] – potential contributors to buoyancy forces favoring slab stagnation – may give rise to steeply dipping seismic reflectors within the slab [*e.g.*, Kawakatsu, 2008].

We have constructed kinematic thermal models [*cf.* Bina *et al.*, 2001, Negredo *et al.*, 2004] of stagnant slabs and undertaken thermodynamic modeling [*e.g.*, Fei *et al.*, 1991, Akaogi *et al.*, 2002] of the consequent thermal perturbation of high-pressure phase transitions in mantle minerals. For such models we have estimated seismic velocity anomalies, as might be imaged by seismic tomography, and corresponding seismic velocity gradients, as might be imaged by receiver-function or boundary-interaction-phase analysis. We have also calculated associated thermo-petrological buoyancy forces and bending moments which – along with other factors such as viscosity variations and rollback dynamics [Christensen, 2001] – may contribute to slab deformation and morphology. We have considered effects of variations in depth of stagnation, post-stagnation dip angle, phase transition sharpness, transition triplication due to multiple intersection of stagnant-slab geotherms with equilibrium phase boundaries, and potential persistence of metastable phases due to kinetic hindrance. Japan is our primary study area.







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