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Fluid Release, Flow Paths and Melting Systematics in Subduction Zones Predicted by Thermo-kinematic Models and Phase Relations

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We have integrated 2-dimensional thermal models of subduction zones with petrologic phase equilibria data to examine the systematics they impose on the physical locations of dehydration and melting. A range of thermal regimes i.e., different mantle potential temperatures (Tp), convergence rates (v), subducting oceanic lithosphere ages, and the location of appropriate lithologies are considered.

For Tp = 1350˚C and a wide range of subduction velocities (v = ca 4 to 10 cm/year, corresponding to young, hot and old, cold oceanic lithosphere) hydrated mafic crust undergoes complete dehydration at 100 to 200 km via continuous reactions driven by garnet growth in the transition to eclogite. Moreover for these conditions vertical paths from the slab intersect the wet melting regime wedge in the region directly below where active arcs are observed. Whereas for hotter background mantle (Tp = 1450˚C) v $<$ ca. 5 cm/year yields thermal conditions in which the slab cuts mafic (75 to 100 km) and ultramafic (100 to 175 km) wet solidi but little water is available to trigger melting as complete dehydration of mafic crust and slab serpentinites occurs shallower at 40 to 80 km. For hotter mantle (Tp = 1450˚C) a more narrow range of v (6 to 8 cm/year) leads to devolatilization in the slab and mantle melting directly below modern arcs. Cooler conditions accompany faster convergence (v $>$ ca. 9 cm/year; older, cooler slabs) and water is subducted deeper to be released much later due to phase transitions at $>$ 300km or descending slabs heating up mantle temperatures at

660 to 1200 km depth.

Experimental observations on the peridotite wet solidus vary by ca. 200˚C at 3 GPa (e.g. Green 1973; Mysen & Boettcher, 1975; Kawamoto & Holloway 1997; Grove et al. 2006). Consequently the location of melting in the mantle wedge is extremely sensitive to choice of wet solidi. Lower temperature peridotite wet solidi imply a greater melting interval and higher melt production rates for arc crust than for initial melting at a higher temperature and lower pressure. Lower temperature peridotite wet solidi also intersect the slab surface for v $<$ ca. 5cm/year where Tp $\geq$ 1450˚C, however, the lack of implied large-scale melting above slabs for a large range of ages suggests water availability is very limited or modern Tp $<<$ 1450˚C. Higher temperature peridotite solidi rarely intersect the slab surface (except for very hot situations, e.g. $>$ 170 km for v = ca. 1 cm/year, Tp $\geq$ 1450˚C). This implies that slab-derived fluxes are more likely undergo modification via subsolidus metasomatic reaction in the mantle prior to entering higher temperature melting regimes for a wider range of subduction ages and Tp.