The nature of subduction-derived metasomatism in the upper mantle: Dehydration melting of hydrous basalt from 3–12 GPa

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It has been shown experimentally that hydrous minerals such as lawsonite and phengite are stable in hydrous basalt to pressures up to 10–12 GPa (Pawley and Holloway, 1993; Poli and Schmidt, 1995 Schmidt, 1996). Given the broad diversity in the geodynamics of subduction, a great variability in the P-T paths of subducted slabs ought to be expected, such that complete dehydration of the oceanic crust may not occur until depths of greater than 300 km are reached. This implies that basaltic crust in subducted slabs is an important source of hydrous fluids that would presumably metasomatize the upper mantle in the back-arc regime. Whether this slab-derived phase is vapour, silicate melt, or super-critical fluid will depend on the relative positions of the wet basalt solidus and the dehydration boundaries of the primary high-pressure hydrous minerals. We provide constraints on the nature of the slab-derived fluid for situations in which dehydration is accompanied by the formation of a silicate melt phase, in multi-anvil experiments at 3–12 GPa on a natural, hydrous alkali basalt. From these and other experimental studies we have constructed a composite phase diagram (Fig. 1) for hydrous basalt showing the relative positions of the wet basalt solidus (WBS) and the phase boundaries of important

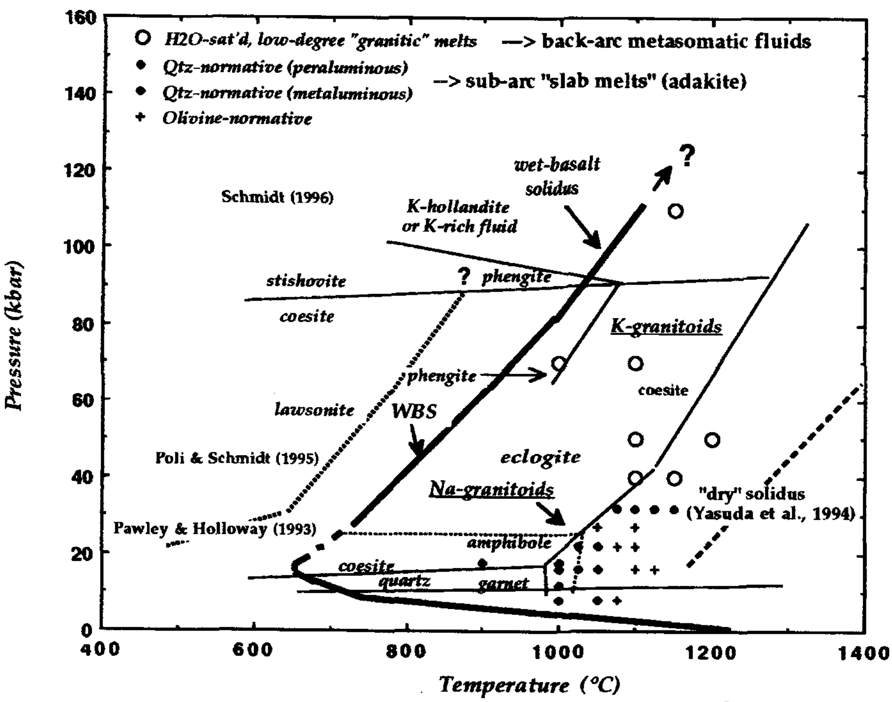

FIG. 1. Composite phase diagram for basalt-H_2O.

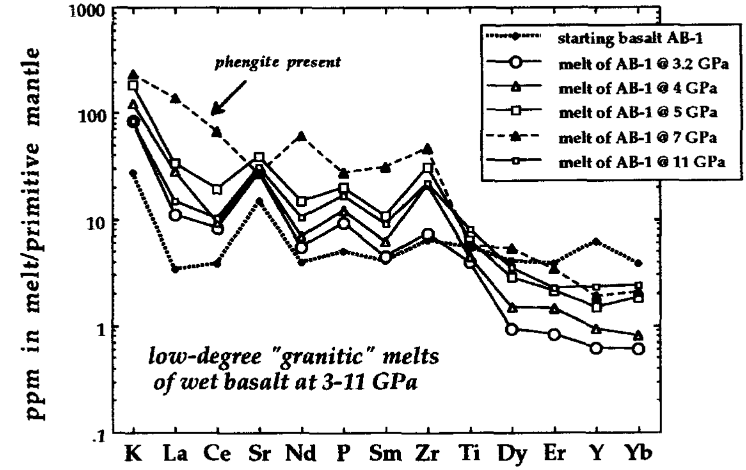

FIG. 2. Trace-element composition of first-formed melts of hydrous basalt at 3–11 GPa, normalized to primitive-mantle abundances.

hydrous minerals. First-formed melts at < 4 GPa are Na-rich granitoids akin to adakite magmas found in the island arc regime and attributed to 'slab melting'. At pressures of 4–12 GPa, first-formed melts are K-rich granitoids (which at 7 GPa are in equilibrium with phengite), because clinopyroxene in the eclogitic residue of melting is becomes increasingly jadeite-rich with increasing pressure.

We have analysed these melts for a range of trace elements by secondary ion mass spectrometry (SIMS), and find that the geochemical characteristics of low-degree melts of subducted oceanic crust are remarkably similar from 3–11 GPa, except when phengite is present. It is these first-formed melts, with the trace element characteristics signature of the granitic melts in Fig. 2, that constitute the slab-derived metasomatic component in the back-arc regime. Under circumstances in which slab geotherms intersect the wet basalt solidus above 4 GPa, these K-granitoid melts are THE agents of mantle metasomatism in subduction zones.

References

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