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Phase Relations and Magmatism in the Mantle Wedge Above Subduction Zones

David Headley Green[1] & **Wilfred Lus** (wilfred.lus@anu.edu.au)[2]

[1] Director RSES, Australian National University, Canberra, ACT, 0200 Australia
[2] RSES, Australian National University, Canberra ACT 0200, Australia

The mantle wedge is inferred to be of lherzolitic to harzburgitic composition with various models suggesting reactivation of refractory lithosphere, re-circulation of subducted lithosphere and cornerflow of asthenospheric mantle. There is general agreement on introduction of a 'slab component' with supercritical fluids, silicate melt or carbonate melt suggested as the mechanism of transfer of the 'slab component(s)'. Experimental studies of fertile to refractory lherzolite compositions have established solidus temperatures and phase stability as functions of P,T and CO_2 or H_2O contents. The stability field of pargasitic amphibole is sensitively dependent on bulk composition and is limited to pressures <3 GPa. Pargasite compositions will vary with P,T conditions within the wedge such that there are continuous dehydration reactions rather than an abrupt dehydration and water-release situation within the wedge flow.

Application of the experimentally determined phase relations to models for P,T distribution in the mantle wedge allows prediction of melting regions and constrains mechanisms of transfer of the slab-component. Melting within metasedimentary or metabasaltic slab components at high pressures under fluid-saturated or fluid-undersaturated conditions produces rhyodacitic to dacitic melt compositions which are extremely reactive towards overlying lherzolite-harzburgite and normally crystallise to form 'refertilised' phlogopite or pargasite-bearing lherzolite with increased pyroxene:olivine proportions and possibly with minor dolomite and magnesite. H_2O-rich fluids, but not C_2O-rich fluids, may exist in this P,T field in which carbonate or carbonatite melt is stable. Carbonate melt may transfer an incompatible-element enriched, slab-derived component into the overlying silicate melting regime. Petrological and geochemical attributes of convergent margin melts in which carbonatite melts have been agents of enrichment of previously depleted lherzolite to harzburgite are predictable as magnesian ankaramites, with high Ca/Al, Na/Al, Ca/Ti ratios, enriched in LILE elements but not in HFSE. Phenocryst phases would be olivine $Mg^{\#}>91$, low Al_2O_3 diopside $Mg^{\#}>91$ and spinel with Cr#>70.

In contrast, the occurrence of boninite magmas at convergent margins is attributed to unusually high temperatures in the wedge, close to the subducted slab. If a slab-derived, rhyodacitic melt can access overlying harzburgite or lherzolite at T>1000 C then the rhyodacite melt will not freeze but will cause or enhance melting within the enclosing peridotite. The inverted temperature gradient may then cause upwelling, increased melting and melt extraction. The melt characteristics would reflect both a refractory harzburgitic component (and residue) and the enriching rhyodacitic to dacitic melt, i.e. magmas with phenocrysts of olivine with $Mg^{\#}>91$, spinel with $Cr^{\#}>80$, magnesian orthopyroxene ($Mg^{\#}>89$) or proto-enstatite and with low Ca/Al, Ca/Na, Ti/Al and LILE-element enrichment. The characteristics of boninite magmas require the melting of already refractory harzburgite and a ?slab-derived, melt-fluxing agent with Na_2O/H_2O~1. This appears to indicate the role of a silicate melt rather than an H_2O-rich fluid. The model is applied to the Papuan Ultramafic Belt in the Musa-Kumusi area and associated boninitic magmas at Cape Vogel, Papua New Guinea.

In general terms, convergent margin magmatism is a consequence of upwelling, increasing melt proportions and melt segregation from within the silicate melting regime, bounded by the fluid-saturated solidus (peridotite-C-H-O for relatively oxidised conditions).