Hybridization-melting beneath arcs: Consequences for the formation of continental crust

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Hybridization-melting is a concept that emerged from high-pressure experimental studies by P.J. Wyllie's group in the 80's [1, 2]. The experiments have highlighted that liquidus phase relationships of tonalite-peridotite mixtures from 1.5 to 3 GPa are characterised by (orthopyroxene ± garnet)-rich mineral assemblages. Recent data from the lithosphere beneath the Western Pacific (WP) oceanic and continental arcs have shown that the mantle peridotites are enriched in SiO_2 (and thus orthopyroxene) relative to primitive mantle melting trends [3]. It is suggested that these rocks were formed from hybrid sources during ancient mantle wedge melting events [4]. Here we use thermodynamic modelling to show that the most likely physical process forming these peridotites is melting of depleted mantle sources hybridized by hydrous, SiO_2-rich tonalite-trondhjemite silicate melts. Such a petrological nature is typical of a mantle source with addition of a mobile component produced at 700-800°C and 2.5-3 GPa from the subducted plate [5]. Radiogenic isotope data for the peridotites suggest that the hybridizing agent formed by partial melting of subducted sediments rather than oceanic crust. Our models imply that continuous hybridization-melting processes in small-scale, isolated convective cells stranded in the mantle wedge ('Richter Rolls' [6]) progressively leads to the formation of more SiO_2-rich primary mantle melts in equilibrium with orthopyroxene-rich spinel harzburgites. These primary mantle melts are subalkaline and range from basaltic andesite to andesite equilibrated at 1 to 1.5 GPa ; they likely play a role in the formation of continental crust in arcs. We also explore the physical nature of melting processes leading to the formation of WP arc magmas in the mantle wedge, and discuss models of hybridization-melting versus mélange diapir melting [7].

[1] Johnston & Wyllie CMP (1989) ; [2] Carroll & Wyllie JPET (1989) ; [3] Herzberg JPET (2004) ; [4] Bénard *et al.* GCA (2017) ; [5] Hermann & Spandler JPET (2008) ; [6] Davies *et al.* G-CUBED (2016) ; [7] Marschall and Schumacher NAT GEOSCI (2012).