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Evidence for Slab-derived Silicate Melt in the Sub-Arc Mantle

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The sources of arc-related lavas are commonly modified by metasomatic fluids and/or melts believed to be extracted from parts of the subducting slab (e.g., the basaltic crust and/or overlying sediments). Evidence from phase equilibria, trace-element geochemistry, and volatile contents arc-related lavas and melt inclusions strongly suggest that aqueous fluid derived from subducted basalt is one of these phases. In contrast, the properties and even presence of slab-derived melts in the sub-arc mantle are relatively uncertain. Commonly, a role for slab-derived melt is implicated where arc lavas are enriched in sediment-born and fluid-insoluble trace elements such as Th (e.g., Elliott et al., 1997). However, this evidence is contradicted by or fails to address other constraints; for instance: Solvi between water-rich silicate melts and solute-rich aqueous fluids 'close' at T-P conditions within the range of those in the slab and mantle wedge, suggesting that the dichotomy between 'slab fluid' and 'slab melt' may be poorly posed (e.g., Bureau and Keppler, 1999); furthermore, thermal models of subduction zones suggest that no section of the slab should melt except under special circumstances or through generally unexpected physical effects (Peacock, 1991); finally, experimental and empirical constraints on the expected geochemical properties of slab fluids and melts are inconsistent with one another in several respects, adding ambiguity to trace-element arguments for or against the role of slab melt (e.g., Keppler, 1996; Johnson and Plank, 1999).

Resolution of these and related issues will require a variety of approaches; we have made two efforts to understand the role of slab melts in subduction-zone volcanism by using oxygen isotopes as tracers of subducted materials. Results of these studies are summarized below and will be discussed in light of other recent work on this subject:

(1) Values of $\delta^{18}O$ for relatively magnesian, oceanic arc lavas correlate positively with indices of extent of melting of their sources. These trends resemble previously-demonstrated relationships between indices of extent of melting and water contents of back-arc lavas (Stolper and Newman, 1994) and can be fit by models of 'fluxed' melting driven by up to 2.5wt.% of high-$\delta^{18}O$ aqueous fluid. Similar amounts of high-$\delta^{18}O$ melt should obscure these trends because those melts would produce significant changes in $\delta^{18}O$ with relatively small contributions to fluxed melting of mantle sources. Therefore, our results suggest that slab melts are a minor component or are absent in the sub-arc mantle. However, the trace-element composition we infer for high-$\delta^{18}O$ slab-derived fluid (like that inferred by Stolper and Newman for the water-rich component in back arc lavas) has several 'melt-like' trace element characteristics. A simple explanation of this apparent inconsistency may be that slab contributions to the sources of arc lavas are volumetrically dominated by aqueous fluid (which controls extents of 'fluxed' melting and $\delta^{18}O$ variations) but contain a small (though presumably variable) component of highly trace-element-enriched slab melt.

(2) We examined oxygen isotope variations in metasomatized mantle xenoliths from Batan (Philippine arc) and Simberi island ('TLTF' arc) using the ion microprobe. Strongly ^{18}O-enriched silicate melt inclusions ($\delta^{18}O$ of 12 to 15) are identified in both suites, suggesting the presence of a metasomatic silicate melt containing oxygen derived principally from the upper ~1-2km of the subducted slab (although 'normal'-$\delta^{18}O$ melts are also present in both suites, requiring isotopic exchange of some inclusions with mantle minerals and/or multiple sources of metasomatic melts). In one instance (Batan), high-$\delta^{18}O$ inclusions can be successfully modeled as partial melts of subducted pelagic sediments; in the other (Simberi island), extremely low abundances of Zr and other high-field-strength elements in melt inclusions require that high-$\delta^{18}O$ melts are generated from extensively metasomatized and ultra-depleted peridotite or are slab melts that have undergone cryptic secondary differentiation to modify their high-field-strength-element abundances. We prefer the first of these hypotheses because of its agreement with relatively detailed model predictions. Collectively, these studies support the presence of slab-derived melts in the sub-arc mantle and (because of the susceptibility of oxygen isotopes to high-temperature exchange) constrain the time-scales of their transport; however, these studies also suggest that such melts may be difficult to distinguish from chemically exotic melts generated and/or modified within the mantle wedge.

Elliott T, Plank T, Zindler A, White W & Bourdon B, *Journal of Geophysical Research*, **102**, 14,991-15,019, (1997).
Bureau H & Keppler H, *Earth and Planetary Science Letters*, **165**, 187-196, (1999).
Peacock S, *Phil. Trans. Royal Society of London*, **335**, 341-353, (1991).
Keppler H, *Nature*, **380**, 237-240, (1996).
Johnson MC & Plank T, *Geochemistry, Geophysics, Geosystems-G3*, **1**, (1999).
Stolper E & Newman S, *Earth and Planetary Science Letters*, **121**, 293-325, (1994).