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The Influence of H_2O on Mantle Wedge Melting and Some Consequences for Island Arc Magmatism

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Recent laboratory studies of the melting and crystallization behavior of mantle peridotite and subduction zone lavas have led to new insights into melting processes in island arc settings. Melting of the mantle wedge in the presence of H_2O begins at much lower temperatures similar to those determined by Mysen and Boettcher (1975). The solidus of mantle peridotite at 3 GPa is $\sim$ 800 ^oC, which is 200 ^oC below estimates determined in the 1968 – 1973 era. At pressures greater than 2.4 GPa chlorite becomes a stable phase on the solidus and it remains stable until 3.6 GPa. Therefore, melting over this pressure range occurs in the presence of chlorite, which contains $\sim$ 12 wt. H_2O. Chlorite stabilized on the peridotite solidus by slab-derived H_2O may be the ultimate source of H_2O for subduction zone magmatism. Thus, chlorite could transport large amounts of H_2O into the descending mantle wedge to depths where it can participate in melting to generate hydrous arc magmas.

Our ability to infer the characteristics primitive mantle melts at subduction zones has led to the following observations. 1) Primitive mantle melts show evidence of final equilibration at shallow depths near the mantle – crust boundary. 2) They contain variable amounts of dissolved H_2O (up to 6 wt. %). 3) These melts record a range of melting extents (up to $\sim$ 20 - 30 wt. %). To produce melts with such variable characteristics requires more than one melting process and requires consideration of a new type of melting called hydrous flux melting. Flux melting occurs when the H_2O -rich melt initially produced on the solidus near the base of the mantle wedge ascends and continuously reacts with overlying hotter, shallower mantle. The mantle melts and magmatic H_2O content is constantly diluted as the melt ascends and reacts with

shallower hotter mantle. Anhydrous mantle melts are also found in close temporal and spatial proximity to hydrous flux melts. These melts are extracted at similar depths near the top of the mantle wedge when mantle is advected up and into the wedge corner and melted by adiabatic decompression.

In light of these new insights into the chemical processes that lead to melt generation in subduction zones, further study of the influence of mantle dynamics and physical processes on melting is crucial. Variations in mantle permeability near the base of the wedge may exercise important controls on the access of fluids and/or melts to the overlying wedge. The presence of chlorite in the wedge may also influence rheological properties and seismicity in the vicinity of the slab - wedge interface. Knowledge of rheology and permeability will help us to develop more robust models of mantle flow and temperature distribution in the mantle wedge are crucial for refining melting models.