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Transportation of H_2O and melting beneath Japan arcs

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Recent knowledge concerning the phase relationships of hydrous peridotitic and basaltic systems allows us to model the fluid generation and migration in subduction zones. Here I present a numerical model, in which the aqueous fluid migrates by permeable flow and interacts chemically with the convecting solid, including melting. The model results and the observations show good agreement, suggesting that the differences in the structure are mainly controlled by the age (hotness) of the subducting slabs.

Material recycling in subduction zones, including the generation and migration of aqueous fluids and melts, is key to understanding the origin of volcanism in subduction zones and is also important for understanding the global circulation of materials. Recent knowledge concerning the phase relationships of hydrous peridotitic and basaltic systems allows us to model the fluid generation and migration in subduction zones. Here I present a numerical model, in which the aqueous fluid migrates by permeable flow and interacts chemically with the convecting solid, including melting. The calculation results suggest that nearly all the H_2O expelled from the subducting slab will be hosted by serpentine and chlorite just above the slab, and is brought down by up to 150km, depending on the temperature along the slab. Breakdown of serpentine and chlorite at these depths results in the formation of a fluid column through which H_2O is transported upwards. The fluid reaches a depth corresponding to a cusp of the H_2O-undersaturated solidus of peridotite (minimum at 2.5GPa) and initiates extensive melting whose depth and the lateral extent toward the trench side is nearly fixed, irrespective of the age of the slab. This is because the flux of H_2O and the depression of the practical solidus temperature in the mantle wedge are similar for models with different slab ages. Exceptionally, for very young slabs (e.g. less than 10m.y. when the subduction velocity is 6cm/y), different melting regimes occur, such as melting in the forearc region and slab melting. If the aqueous fluid released from the slab migrates upwards in disequlibrium (e.g. through fractures), significant melting occurs in the forearc region, since the serpentinite layer, an effective H_2O-absorber, is not formed. However, this is not the case in most subduction zones. The model results are compared with seisimic images for beneath the Japan arc (NE Japan, central Japan, and Kyushu). The model results and the observations show good agreement, suggesting that the differences in the structure are mainly controlled by the age (hotness) of the subducting slabs.