Water in the NE Japan fore-arc mantle: An estimate based on Vs-T-Rock structure with Perple_X thermodynamic model

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Water dehydrated from the downgoing slab beneath island arcs migrates into the mantle wedge and forms 1) serpentinized forearc mantle and 2) hydrous basalt magma. These processes have been petrologically confirmed by natural rocks and experiments. However, how much water is incorporated into these two different processes and how water is transported through the mantle wedge has been a matter of debats. Water can be transported as an isolated phase via cracks or porous flow. Water can also be transferred as bound H2O in the lattice of hydrous silicate minerals by dragging down into the deep mantle via convection or conversely transferred upward via diapir due to buoyancy driven instability. Any process physically possible in the mantle wedge beneath arcs is difficult to constrain. The spatial distribution and extent of water in the forearc mantle wedge has been suggested by a precise mantle tomography for the northern part of NE Japan arc (Tsuji et al., 2008 GRL). Given the high sensitivity of S-wave velocity (Vs) to water content in the mantle wedge, we attempted to calculate the water content in the downgoing Pacific Plate slab and the overlying mantle wedge in the depth range between 30 and 100 km. The temperature structure in the wedge was calculated by the latest geodynamic model using a temperature-dependent olivine rheology. Water was assumed to be fully bound in mineral lattices. Vs was calculated for slab sediment (SED), altered oceanic crust (AOC), and mantle peridotite (PEID) at H2O contents 0-5 wt.% for SED/AOC and 0-10 wt.% for PERID using Perple_X version 7 thermodynamic model at given P-T conditions (0.5-6 GPa at 0.1GPa step and 100-1400 C at 10 C step). The 3km X 3km grid of Vs values estimated by mantle tomography were then converted to bound XH2O based on the Rock-type, Temperature, and Pressure in each cell. The result indicates that 1) 1-5 wt.% water is accumulated in the fore arc mantle down to 50 km depth, 2) as much as 5 wt.% water is hosted in the hydrated slab SED/AOC and maybe in the uppermost PERID layers of the slab to the depth of 100 km, and 3) this slab water is dehydrated almost completely at 100 km depth. The hydrated shallow forearc mantle and deep-slab dehydration regions appear to be isolated by a water-free, low-Vs mantle zone. Therefore the dehydrated forearc mantle may not be the major water source for arc basalt magmas. Instead, water in the slab dehydrates immediately beneath the volcanic arc forming focused dehydration zone. This suggests a greater role of the slab hosted water in the origin of island-arc magmatism.