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Upwelling flow in the mantle wedge beneath Hokkaido and Tohoku, NE Japan, and its implications for arc magmatism

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The mantle wedge beneath Hokkaido and Tohoku, northeastern Japan, has been shown to be highly heterogeneous in structure through seismic tomography studies. At depths shallower than ~150 km in the mantle wedge, studies have identified an inclined zone of low velocity and high attenuation orientated sub-parallel to the subducted slab, probably corresponding to the upwelling flow of subduction-induced convection. Seismic studies have also shown that the temperatures in this zone may be higher than the wet solidus of peridotite, with melt inclusions making up a volume fraction of 0.1-1% within this upwelling flow. This partial melting is thought to be caused by the supply of aqueous fluids from the underlying slab, which meet this hot upwelling flow at depths of 100–150 km. The inclined low-velocity zone reaches the Moho immediately beneath the volcanic front, suggesting that the volcanic front is formed by this hot upwelling flow, which transports aqueous fluids from the subducted slab to shallow levels along the volcanic front. Observations of heat flow and seismic anisotropy also support the existence of the upwelling flow.

Seismic tomography study for the mantle wedge beneath Tohoku has further revealed along-arc variation of the inclined low-velocity zone: very low velocity areas periodically appear every ~80 km along the strike of the arc. Clustering of Quaternary volcanoes, topography highs at the surface are located immediately above these very low velocity areas in the mantle wedge, and low-frequency microearthquakes, perhaps caused by rapid movements of fluids in the lower crust, occur also right above them. This close correlation between very low velocity areas in the mantle wedge,

distribution of Quaternary volcanoes at the surface, and deep, low-frequency microearthquakes in the lower crust suggests that the spacing of Quaternary volcanoes at the surface is determined by along-arc variation of melt contents within the low-velocity zone in the mantle wedge.This level of interpretation demonstrates the value of three-dimensional modeling in the analysis of arc magmatism.