§Exploring links between mantle wedge flow and observables: Examples from NE Japan

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In this study, we explore factors that affect mantle wedge flow patterns through three-dimensional numerical experiments and examine the modeling results against a range of geophysical observations, using Northeast (NE) Japan as an example. Key observations include the orientation of volcanic cross-chains, volcano clustering, surface heat flow, seismic velocity and attenuation structures, and seismic anisotopy. Seismically polarized fast direction in the mantle wedge varies spatially beneath Hokkaido, where subduction direction is oblique to the trench. Our modeling results indicate that oblique subduction results in out-of-plane mantle inflow and outflow streamlines that are symmetric about the down-dip direction. The predicted complex mantle flow pattern may explain the observed spatial variability in seismic anisotropy. The orientations of volcanic cross chains are normal to the trench in Tohoku and oblique to the trench in Hokkaido. They are sub-parallel to the model-predicted mantle inflow directions, possibly indicating the role of mantle inflow in controlling the location of melt generation beneath the arc. Volcanos occur in clusters in Tohoku, beneath which narrow low seismic velocity zones (LVZs) extending from the back-arc into the sub-arc mantle. These LVZs are interpreted as regions of high temperature and/or presence of free fluids that provide melts to the arc. The mantle beneath volcanic arcs is brought in from the backarc region, and the thermal state of the backarc has a direct impact on sub-arc mantle temperatures. Our models that incorpoate small backarc thermal perturbations indicate that vigorous inflow of hotter mantle and subdued inflow of colder mantle occur beneath the arc due to strong temperature dependence of the mantle viscosity. This results in a complex 3-D mantle flow pattern that amplifies the along-arc temperature variation of the sub-arc mantle and can provide a simple mechanism for volcano clustering. Between the regions of vigorous and subdued inflow, margin parallel flow occurs, possibly contributing to the observed trench-parallel fast direction beneath Tohoku.