# Magma transfer processes in the NE Japan arc: insights from crustal ambient noise tomography combined with volcanic eruption records

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Subduction zone magmatic budgets and crustal growth processes depend on poorly constrained intrusive : extrusive ratios of arc magmas. Published ambient noise tomography data from northeast Japan reveal upper crustal low-$V_S$ bodies, indicating elevated temperatures of plutonic rocks, beneath most sites of active arc-front volcanoes, with the exception of Zao volcano. Strikingly, when small eruptions (VEI 1 to VEI 3) from arc-front volcanoes in the last 2 kyr are considered, Zao has erupted most frequently and has produced a more than three times greater tephra volume than any of the other volcanoes. We propose that the frequent low-volume volcanism at Zao is fed by dikes that traverse the crustal section rapidly, fracturing through brittle lithologies. Beneath the other volcanoes, hotter and more ductile plutonic bodies have developed through repeated intrusive activity, hindering magma transport to the surface. This positive feedback mechanism ultimately results in cataclysmic caldera-forming events. We show that the number of late Cenozoic calderas is higher above the imaged low-$V_S$ crust, consistent with this interpretation. We propose that generation of plutonic bodies is facilitated by volcaniclastic materials buried in a Miocene rift graben, which dampen fracture propagation and promote repeated sill intrusion. In contrast, transcurrent faulting has moved cold Cretaceous basement of the fore-arc range into the arc-front beneath Zao. These brittle rocks instead provide fracture pathways explored by magmas rapidly rising to the surface. The combined data imply that millions of years of crustal growth and tectonic history have a direct control on present-day volcanic eruption style.

Keywords: heat incubation, crustal magma ascent, crustal growth history, volcanic eruption style, Tohoku volcanism, brittle-ductile transition