

Comparative Geoelectromagnetism of Island Arcs

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Recently, subduction-driven injection of surface water into the mantle and its circulation in the wedge mantle have been a matter of hot debate in various disciplines in the geoscience community. On the other hand, it seems to have become a consensus that the subduction-driven water injection is strongly dependent on thermal states of each subduction regime. Namely, cold and warm subduction zones behave quite differently in terms of the amount and depth of water-bearing slabs to release their volatile content. Here we report an electrical image beneath the back-arc region of northeast Japan as an ocean-locked view of the Earth in addition to a succinct review of crustal resistivity sections beneath southwest Japan as a land-locked view. The intent of this paper is to make a comparative study of two island arcs with difference thermal structures using electrical conductivity. On-going and future plans of seafloor electromagnetic (EM) experiments will be introduced in order to add the ocean-locked view to study of southwest Japan as well.

Northeast Japan can be classified into the cold subduction regime and thus thought to have high potential for water supply to the deep mantle (Iwamori, 2004). Injection of water into the deep mantle seems to produce electrical conductivity anomalies of regional to semi-global scale beneath back-arc regions. Furthermore, those electrical anomalies are present irrespective to whether the subducting slab is stagnant at the 660 km seismic discontinuity (Ichiki et al., 2006) or plunging into the lower mantle (Booker et al., 2004), although their surface manifestations are, naturally, quite different. Arc volcanism in northeast Japan is known to be three-dimensional (3D) as typically depicted by Tamura et al.'s (2003) hot-finger model. A two-dimensional (2D) east-west slice of a 3D P-wave seismic tomography (Zhao et al., 2003) at 39.5N showed a nearly uniform distribution of moderately fast velocity above the subducting Pacific plate within the slice. It can be attributed to the fact that the slice covers a non-volcanic part, viz., a region between the hot fingers, of the well-developed island arc. An electrical section (Toh et al., 2006), which covers the non-volcanic part of northeast Japan, reveals a resistive shallow mantle and a conductive anomaly beneath the back-arc region at depths 150 - 200 km. The electrical conductivity anomaly can be interpreted as a direct manifestation of slab dehydration associated with collapse of the high-temperature type serpentine.

Although the arc volcanism relevant to northeast Japan looks 3D in terms its structure, the magma source can be unique and simple. It stems from the deep mantle behind the mature island arc. On the contrary, that of southwest Japan cannot be thought simple if one studies basalt samples of this area (Iwamori, 1991; Kimura et al., 2003). The alkaline, sub-alkaline and adakite basalts of southwest Japan imply multiple sources for magma production in the mantle including slab-melting of the hot and young Philippine Sea plate. The presence of the adakite magma is a signature of fluid originating from the slab. On the other hand, seismic and EM observations on land have revealed coincidence of deep low-frequency events and lower crustal conductors, which suggests presence of crustal fluid. However, the link between the two kinds of fluid of slab is still missing.

Seafloor EM observations have been conducted since 2006 in the back-arc region of southwest Japan. The objective of the sea experiments is to provide an ocean-locked view of the electrical structure beneath southwest Japan. If an electrical image of southwest Japan is made available, it enables comparison of the two island arcs in terms of a fluid-driven part of the mantle dynamics. A comparative synthesis of the arc dynamics beneath the Japanese Islands can then be argued based on those electrical sections in view of water circulation in the wedge mantle.