Geochemical variation of volcanic rocks in Central Japan with double subduction of the Pacific plate and the Philippine Sea plates

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Arc magmas are thought to originate through the interaction among the subducting slab, the slab-derived fluid, and the mantle wedge. However, the contribution from each source (slab, fluid, and mantle wedge), even the relative proportion, is not well constrained at present. The main aim of this study is to evaluate the contributions from each source to arc magmas quantitatively, based on the geochemical data of volcanic rocks from Central Japan as a test case.

Major and trace elements (417 samples), including REEs, and Sr-Nd-Pb isotope ratios from 28 volcanoes have been analyzed for the Quaternary volcanic rocks in Central Japan. The results show that overall enriched features with a wide compositional range from depleted to enriched (e.g., 87Sr/86Sr and 143Nd/144Nd ratios from 0.7030 to 0.7080 and 0.5124 to 0.5130, respectively). Systematic spatial variations exist in both EW and NS directions. The 143Nd/144Nd ratios decrease gradually from the south to the north (e.g., 0.512959 in Kurofuji, 0.512928 in Azumaya, to 0.512851 in Myoko), and also decreases toward the back-arc side to the west (e.g., 0.512959 in Kurofuji, 0.512786 in Ontake, to 0.512473 in Eboshiwashigatake), suggesting regional variation in the genetic conditions of the magmas.

By using chemical compositions of the Pacific (PAC) and the Philippine Sea (PHS) plate sediments and altered oceanic crusts (AOC), chemical compositions and amounts of aqueous fluids released through a series of dehydration reactions have been estimated by forward models. Then, melting conditions of the fluid-added mantle and the melt compositions generated have been calculated to optimize the composition of primary magmas.

As a result, we obtained (1) the compositions of aqueous fluids released from the two subducting slabs (the PAC plate and the PHS plate), including the proportion of contribution from the subducting sediment and AOC, (2) the fluid proportion from the PAC plate and the PHS plate, (3) the amount of the slab-derived aqueous fluid added to the mantle wedge peridotite, (4) the degree of partial melting of the fluid-added mantle, (5) the proportions of garnet lherzolite and spinel lherzolite involved in the melting. The amount of the slab-derived aqueous fluid added to mantle peridotite is relatively high compared to the Izu-arc, ranging from 0.2 to 6 wt. %. Considering the two overlapping plates seismically observed over the studied area, the overall geochemical enrichment of the volcanic rocks in Central Japan would partly be attributable to the high amount of the slab-derived aqueous fluid.