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火山岩組成から推定されるマントル温度構造
Comprehensive geochemical model for the melting of mantle metasomatized by slab-derived fluid

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The chemical composition of a relatively undifferentiated volcanic rock in arc has the integrated information of the processes occurred beneath a volcano in the mantle wedge, such as material infiltration from the subducting slab and subsequent melting of the mantle. Here, we aim to reveal how the whole rock composition including isotopic ratios and trace element abundances can be quantitatively explained by a series of the relevant processes in the mantle, based on which we constrain the geochemical cycling and thermal structure in subduction zones.

We apply a mass balance model to the Quaternary volcanic rocks of Central Japan where the two oceanic plates obliquely subducts. The compositions of slab-derived fluids can be estimated starting from subduction and dehydration of oceanic crustal materials. Then the composition of fluid-metasomatized mantle, including the amount of slab-derived fluids, is estimated based on isotopic systematics as in Nakamura et al. (2008). The composition of subsequent product (i.e., primary arc magma) is then predicted from that of the estimated metasomatized mantle as a forward model. Finally, by optimizing two important parameters involved in the melting equation (i.e., degree of melting and garnet/spinel lherzolite ratio involved in the melting), we have been successful to inverse these parameters based on the observed compositions of volcanic rocks.

As a result, the condition of magma genesis beneath the Central Japan arc is characterized by relatively high fluid fractions, low melting degrees of melting and high proportions of garnet lherzolite in the melting source region, compared to those of neighboring arcs with single subducting plates. The low melting degree and high garnet contribution may imply a low geothermal gradient and near-solidus melting over the spinel-garnet transition depths, semi-quantitatively constraining the thermal structure beneath Central Japan. The results are consistent with the independent numerical modeling of the region, suggesting a cold environment due to overlapping subduction of the Pacific and Philippine Sea plates.

In spite of the cold environment, adakitic rocks commonly occur in the investigated region. The mass balance model of this study demonstrates that the high fluid fraction, low melting degree of garnet lherzolite (plus subsequent crystal fractionation that shifts the overall abundances without modifying the characteristic patterns such as Sr/Y ratio) may explain the adakite signature in the cold environment. We suggest that the mass balance model is a promising approach to constrain the fluid and melting processes as well as the mantle thermal structure in subduction zones.

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