Fluid circulation in the forearc mantle wedge inferred from the dihedral angle in an olivine-H_2O-NaCl system

*Yongsheng HUANG[1], Takayuki Nakatani[1], Michihiko Nakamura[1], Catherine McCammon[2]

1. Graduate School of Science, Tohoku University, 2. Byerisches Geoinstitut, University of Bayreuth

In subduction zones, the circulation of slab-released aqueous fluids is crucial to understand the generation of arc magma and recycle of materials, and further to constrain the global geodynamics. The infiltration of aqueous fluids plays an important role in controlling geophysical properties of the mantle wedge such as elasticity, permeability and electrical conductivity. Recently, magnetotellulic studies found a high electrical conductor beneath the fore-arc region which was interpreted as a storage of voluminous slab-derived fluid, implying the presence of permeable mantle wedge at fore-arc depths. By contrast, experimental constraints on dihedral (wetting) angle (θ) in the olivine-H_2O system indicated the fluid is once trapped in isolated pores ($\theta > 60^\circ$) within the down-dragging mantle matrixat fore-arc depths and finally released just beneath the arc volcano where $\theta < 60^\circ$. Here we present the precisely determined dihedral angles in the olivine and NaCl-bearing aqueous fluid (5–27.5 wt% NaCl) system at 1–4 GPa and 800–1100°C to reveal the influence of NaCl on the fluid connectivity because the NaCl is now recognized to be an important constituent of subduction zone fluids. We found that NaCl significantly decreases θ down to below 60° at all the investigated temperature and pressure conditions even at 5 wt% NaCl. Our results suggest that released NaCl-bearing aqueous fluid begins to form an interconnected network in the mantle at relatively shallow depths of ~80 km and can partly penetrate the fore-arc crust without causing mantle melting, which could account for the high electrical conductivity anomalies beneath the for-are region. Our model also emphasizes that partial melting of peridotite triggered by the addition of aqueous fluid can occur more widely than that previously thought, and implies that the release depth of aqueous fluid is not a primary control on the volcanic front position. This work was supported by the JSPS Japanese-German Graduate Externship.

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