Experimental constraint on the fluid connectivity in an olivine–H_2O–CO_2–NaCl system in subduction zones

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In subduction zones, the circulation of slab-derived aqueous fluid through a mantle wedge plays a key role in arc magma genesis and global material cycling. Their presence can be detected by geophysical observations because of their remarkable influence on the physical properties of overlying plate. Recently, high electrical conductors have been detected by magnetotelluric observations beneath some fore-arcs and are believed to store voluminous slab-derived fluids. This implies that the mantle wedge at fore-arc depths is permeable for aqueous fluids. At high temperature and high pressure condition, dihedral angle is an important parameter to control the fluid connectivity in a fluid-bearing rock. The subduction zone fluid is now gradually recognized as a multicomponent fluid that is composed of the H_2O, salt (NaCl), nonpolar gas (CO_2) and dissolved solid components. However, the effect of multicomponent fluid on dihedral angle is still unclear, which restricts our understanding for realistic fluid circulation model in subduction zones. In this study, we experimentally constrain the dihedral angle in olivine–H_2O–NaCl–CO_2 systems at 1–4 GPa and 800–1100 °C to understand the combined effect of salt and nonpolar gas on the connectivity of aqueous fluids in the mantle wedge. Results in H_2O–CO_2 system show that CO_2, contrast to NaCl, tends to increase the dihedral angle at 1 GPa and 800–1100 °C, and 2 GPa and 1100 °C. However, it can reduce the dihedral angle even below 60° at relatively high pressure and low temperature conditions where olivine partly reacts with CO_2 to form magnesite and orthopyroxene. Results in the multicomponent system suggest that the effect of NaCl on dihedral angle is much more significant than that of CO_2. In addition, strikingly, the dihedral angles in the multicomponent system are the smallest among all investigated systems and much smaller than 60° under the presence of magnesite and orthopyroxene. Therefore, the multicomponent fluid can infiltrate into the forearc mantle wedge through the interconnected fluid network, which can account for the high electrical conductivity anomalies detected in the forearc region. This work was supported by the JSPS Japanese-German Graduate Externship.

Keywords: Subduction zone, Multicomponent fluid, Fluid connectivity, Dihedral angle

