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An experimental study on the fluid interconnectivity in the amphibolitic lower crust

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Recent advances in magnetotelluric observations have revealed extensive distribution of non-magmatic, low electrical resistivity regions in the arc's lower crusts, leading to the interpretation that aqueous fluids have long-range interconnection laterally of dimension comparable to their depth, i.e., tens of kilometers. However, little is known about micro- and macroscopic structures of the fluid-bearing mafic lower crust, which are also crucial for understanding its transport and rheological properties. In order to constrain the grain-scale pore fluid geometry of the mafic lower crust, we have carried out sintering experiments of aqueous fluid-bearing amphibolites.

The experiments have been performed by using a piston-cylinder apparatus at 0.7 GPa and 600 degreeC for 1 to 2 weeks. Natural fine powder (< 2 micron) of amphibolite from Ichinomegata maar, NE Japan, was used as a starting material. Anorthosite and hornblendite powder was also prepared from the coarsely crushed amphibolite by hand-picking and by using polytungstate heavy liquid. The starting materials were loaded into a Ag capsule with 0.1 to 3.0 wt.% of deionized distilled water. Oxalic acid dihydrate and brine were used to examine the effect of CO_2 and NaCl respectively. The polished cut surface of the run products were observed with a FE-SEM.

At the triple junctions composed of anorthite and fluid, 49% of the junctions were curved-curved (C-C) type, 22% were curved-faceted (C-F) type, and 29% were faceted-faceted (F-F) type. The dihedral angle between anorthite and fluid in the anorthosite systems is 78 degree for H_2O, 84 degree for a CO_2-rich fluid ($CO_2$62wt.%), 70 degree for 6 wt.% NaCl. By contrast, most of the pores (>75%) were (F-F type) at hornblende-hornblende-fluid triple junctions. At the hornblende-anorthite-fluid triple junctions, faceted hornblende and curved anorthite triple junction (C-F type) was dominant (>75%).

These experimental results suggest that grain scale fluid distribution is dominantly controlled by the facets of hornblendes in the hornblenditic lower crust, while by dihedral angles and facets in the anorthite-rich crust. Price et al. (2006) synthesized extensively faceted Fluoro-tremolite rock and showed that its permeability had an apparent threshold at a porosity of 0.04, because facets isolate fluids into plane-faced pockets at the grain corners. Although the dihedral angles between anorthite and fluids obtained in this study were slightly lower than those reported in the previous experiments done at higher pressure and temperature (92 degree for H_2O, 800 degreeC, 0.8 GPa and >120 degree for CO_2-rich fluid, 900 degreeC, 1.0 GPa; Yoshino et al., 2002), they are clearly higher than the threshold value for interconnection at small fluid fraction (ca. 60 degree). Therefore, high fluid fraction is necessary for the grain-scale fluid interconnection in the single mineral phase (hornblenditic or anorthositic) lower crust, as long as crystal orientation is isotropic. However, in the system composed of two mineral phases, pore fluids could be interconnected along the pores surrounded by the hornblende - hornblende - anorthite (faceted - faceted - curved) surfaces or by the hornblende - anorthite - anorthite (curved - curved - faceted) ones. Whether the

fluid is interconnected or not might be strongly dependents on the curvature of anorthite surfaces: if the curvature of anorthite is large, the network would be pinched-off. Thus, the connectivity might depends on the modal composition in the continental lower crust; the connectivity may be largest when the modal component of anorthite and hornblende is 1 : 1.

Keywords: low electrical resistivity, continental lower crust, interconnected fluid, dihedral angle, facet