Microstructure evolution of aqueous fluid-bearing wehrlites

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The distribution of geological fluids and its connectivity affect effective viscosity of mantle, seismic attenuation, and material transport. These macroscopic physical properties of the fluid and solid mixture are greatly influenced by grain-scale connectivity and spatial distribution of fluid. Spatial distribution of fluid in rocks has been discussed only in terms of static mechanism, which is controlled by dihedral angle between fluid and mineral. Recently, dihedral angles between rock forming minerals and fluids have been measured in fluid-bearing monomineralic rocks. However, there are few studies which discuss fluid distribution and its connectivity in multi-phase rocks. Toramaru and Fujii (1986), and Nakano and Fujii (1989) proposed percolation models of the melt phase in multi-phase rock, and they showed that melt (fluid) connectivity depends on grain fraction of minerals whose dihedral angles are lower than 60 deg. These models assumed that grains and melt (fluid) were randomly distributed (Toramaru and Fujii, 1986), or the presence of the melt (fluid) phase at the grain boundary is determined by the configuration (dihedral angles) of randomly distributed grains (Nakano and Fujii, 1989). However, it is not evident that these discussions are appropriate, because dynamic mechanisms such as grain growth, grain boundary migration, and pore drag inevitably occur in fine-grained rocks at high temperature.

Evolution of spatial distribution of pore fluids, so to speak, dynamic fluid distribution occurs in pore drag process which is inevitably caused by grain boundary migration. To investigate the evolution of fluid distribution in multi-phase (bimineral) rocks, experiments were carried out in synthesized wehrlites having various Fo/Di ratios at 1200 deg C and 1.2GPa. The pore fluids were classified into two types : those surrounded only by forsterite or diopside single phase (G-type pore), and by both of them (I-type pore). The former are connected only to monomineralic grain boundaries, whereas the latter are connected to more than one interphase boundary. In the short-time annealed wehrlites, the relative volume fraction of I-type pores in all the pores, F , coincided with a simple theoretical model in which all the pores are randomly distributed. The F increased with average grain size and annealing duration. F or example, F of Fo20Di80 wehrlite increased from 45% to 85% in 140h run. Most of the pore fluids (80-90%) exist as I-type pore in 140h-annenaled wehrlites with various Fo/Di ratios. The increase of F is caused by the interphase boundary effect : velocity of G-type pore is faster than that of I-type pore, and then number of G-type pore trapped into the interphase boundary per unit time is larger than that of I-type pore escaping from the interphase boundary per unit time.

These experimental results show that large fraction of pore fluids may be distributed at multi-phase grain junctions as a result of grain growth and pore drag process. This means that connectivity of the fluid network is strongly influenced by dihedral angle between fluid and two different solid phases, and the dihedral angle between fluid and the most abundant phases plays a subsequent role in fluid connectivity of multi-phase rocks.