

Development of experimental apparatus for P-V-T measurement of crustal fluids at high pressure and temperature

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The compositions of crustal fluids can be characterized by H₂O-gas (CO₂, CH₄, N₂ etc.)-salt (NaCl, KCl, CaCl₂ etc.). Especially, NaCl and CO₂ are most characteristic solutes in the crustal fluids. The ternary system H₂O-CO₂-NaCl is one of the most important fluids in geochemistry. Many studies on fluid inclusions indicate that CO₂ and NaCl concentrations of crustal fluids vary over wide ranges. The condition up to 200MPa and 400°C is very important state for water-rock interaction as the bright layer and ore deposition. However, there is little information on the thermodynamic properties (pressure (P)-volume (V)-temperature (T)-chemical composition (X), phase equilibrium and so on) of these systems at high CO₂ concentration and salinity up to 200 MPa and 400°C. We cannot exactly estimate thermodynamic properties of solutes and solvents in the crustal fluids under these conditions which most important water-rock interaction occurs. Therefore I developed new experimental devices to measure P-V-T of crustal fluids continuously and synchronously up to 200 MPa and 400°C.

The new devices are composed of a mini piston-cylinder system, differential transformer, and a temperature measurement system set inside a pressure vessel of the tri-axial apparatus, as well as a CO₂ injector set outside. Simulated crustal fluids are confined in the cylinder, and pressurized CO₂ (liquid) is injected into the cylinder, and eventually the mixture can be pressurized and heated up to 200 MPa and 800°C in the pressure vessel of the tri-axial apparatus. The pressure P nearly equal to confining pressure is realized since the piston can move smoothly as confining pressure changes. The volume V is measured by detecting the motion of the piston of the handmade differential transformer. The temperature T is measured by thermocouples set between heater and cylinder. The P and T dependence of the differential transformer were calibrated, and the difference in T between the inside and the outside of the cylinder were estimated. The V and T are recorded continuously and synchronously at constant pressure in PC. The procedure is repeated with different pressure of the same sample.

I verified the performance of my new devices by comparing my experimental data for pure water over the T range up to 400°C at 100 MPa with those in equation of state, SUPCRT92. The deviation of the former from the latter is within 5%, and the main cause of the deviation is attributed to the overestimation of T about 30°C or less. My apparatus inherits a high potentiality to offer an innovative method for investigating the equation of state of fluids at high P-T conditions.