Development of experimental apparatus for state equations of crustal fluids

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We are trying to grade up our tri-axial apparatus from oil pressure type to gas (argon) pressure type, and to install a new experimental device for investigation state equations of crustal fluids. The graded up tri-axial apparatus can achieve the experimental conditions: 200 MPa confining pressure and 800 degree, associated with a pore pressure system. The axial loading system are reused, and the maximum load of 50 t and strain rate of 10^-3, 10^-4, 10^5/s are available. Axial load and displacement are measured by a load-cell and a differential transformer set outside the pressure vessel. Confining pressure is increased by two-step intensifier, and a strain/stress conversion device, heater, two thermocouples are set inside the vessel. The sample size is 20 mm x 40 mm. Strain gages, electrodes and troidal coils can be set inside vessel so as to enable stick-slip experiments. The signals from these devices are continuously recorded in-sync in a PC at a response frequency of 500 kHz and the maximum sampling rate of 5 MHz.

The new device for experiments of state equations of crustal fluids is composed of a piston-cylinder system and it is set inside the pressure vessel. Simulated crustal fluid is put into the cylinder, and it is fixed to the inside of the vessel. The piston can move following the changes of confining pressure. Therefore, the pressure P, one of the state variables of the state equation, is nearly equal to the confining pressure, but the friction between the piston and cylinder must be compensated. Temperature T is measured by two thermocouples set between the heater and the cylinder. In order to prevent the inhomogeneous temperature distribution, heat insulation material (silica wool) is packed in the space between the heater and the cylinder. The volume of the fluid, which changes as the changes in P and T, is detected by a differential transformer set around the lower part of the cylinder. The differential transformer is handmade but shows an accuracy of 0.05 mm.

Crustal fluids contain NaCl as a solute. This solution is put into the cylinder. Highly concentrated CO2 also is included in crustal fluids. It is a serious problem how to confine this gaseous material in the cylinder. To overcome this problem we developed a new device composed of a CO2 steel bottle, pressure intensifier, and a micrometer of flow discharge. At first CO2 is induced from the steel bottle to the secondary cylinder of the intensifier, and thereafter the pressure in the secondary cylinder is increased up to 200 MPa by pressurizing the primary cylinder using a hand controlled pressure pump. The discharged volume of CO2 is measured by the micrometer of flow discharge at the accuracy of 0.006 cm^3. The pressurized CO2 is injected into the cylinder from its top trough the pore pressure line. CO2 does not run easily into water, so it must be injected under room temperature and a highest pressure attainable (about 200 MPa). Thereafter P and T are changed to a given values. P and T are changed intermittently and P, V and T are recorded continuously in PC.

The errors of the devices are very small, and we assume the total error also is at around 1 %. We can confirm this through the experiments for pure H2O whose state equation has been established already.