Determination of the viscosity of hydrous magma and the second critical endpoint in silicate-H2O systems using X-ray radiography

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H2O plays an important role in the physical and chemical evolution of the Earth. Therefore, the phase relation and the properties of materials in silicate-H2O system have to be clarified. For this purpose, we have developed a new method for the determination of the second critical endpoint and the viscosity of hydrous magma in silicate-H2O systems using X-ray radiography.

Experiments were conducted using high pressure and high temperature X-ray radiography technique, which is the same as the experimental method originally developed by Kanzaki et al. (1987). A Kawai-type double-stage multi-anvil high pressure apparatus (SPEED-1500) installed at SPring-8 was used for generation of high pressure and high temperature. Direct X-ray beam, which passes through the anvil gaps of SPEED-1500 and sample under high pressure, is observed with an X-ray camera. The sample container should not react with hydrous samples, but should be x-ray transparent. Therefore, we developed a new sample container composed of a metal (AuPd or Pt) tube with a pair of lids, made of single crystal diamonds. The sample in the container could be directly observed through the diamond lids with X-ray radiography.

For the determination of the second critical endpoints, the systems Sr-plagioclase-H2O, peridotite-H2O, and basalt-H2O were investigated. H2O in starting materials was added in the form of hydroxides and distilled water. Pressure was applied first by loading. Temperature was increased under the constant load. In runs below the second critical endpoint, two immiscible fluids were observed in the radiographic images. With changing pressure (up to 5 GPa), temperature, and water content of starting materials, we determined the upper limit of pressure (i.e., second critical endpoint) above which the coexistence of aqueous fluid and hydrous silicate magma can no longer be possible.

The viscosity of hydrous magma was measured by the in-situ falling sphere method (Kanzaki et al., 1987). Hydrous kimberlite (mixture of oxides and hydroxides) was adopted as a starting material because melt composition in peridotite-H2O at high pressures becomes kimberlitic (Kawamoto and Holloway, 1997). No free water was added to the starting material. Au and/or Ag sphere(s) were embedded in the sample as a viscosity marker. The velocity of the falling metal-sphere was determined by the radiographic images. Viscosity can be calculated using Stokes formula. Experiments were done at pressures between 5 to 20 GPa.

Detailed experimental results will be presented in the session. Our new technique can be applied to various kinds of studies on materials in hydrous silicate systems.