Direct observation of immiscible aqueous fluid and silicate melt using X-ray radiography

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Direct observations of immiscible aqueous fluid and hydrous silicate melt have been conducted using X-ray radiography technique together with Kawai-type multi-anvil high pressure apparatus (SPEED-1500) installed at BL04B1, SPring-8, Japan. 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. Previous studies for direct observations of complete miscibility between aqueous fluid and silicic magmas were conducted using hydrothermal diamond anvil cell (HDAC). However, it is difficult to obtain enough temperature to observe complete miscibility in hydrous mafic systems using HDAC. Our main purpose is to develop a new method for the direct observations of complete miscibility in hydrous basalt and hydrous peridotite system at high pressure and temperature.

Hydrous Sr-plagioclase (mixtures of oxides and hydroxides) and hydrous CFMAS-basalt (mixtures of hydroxides) systems are used as starting materials in order to obtain better contrast in radiographic images. In addition to the water in hydroxides, deionized water is added to the sample. The sample container should not react with hydrous samples, but should be x-ray transparent. We, therefore, developed a new sample container, which is comprised of a metal (Pt or AuPd) tube and a pair of single crystal diamond lids put on both ends of metal tube. The sample, which is put inside of the container, can directly be observed through the diamond lids and an aperture of the metal tube.

First of all, we should observe two phases coexisting under relatively low pressure and temperature conditions in order to examine if we can really distinguish two phases in radiographic images. The experimental conditions are at pressures of around 3 to 6 GPa and at temperatures up to about 1400 deg. C. Pressure is applied first, and then temperature is increased slowly.

At around 800-900 deg. C and 3 GPa in both systems, we observed some light-gray spherical bubbles (100-500 microns diameter) moving upward in the dark-gray matrix. The light-gray spherules that absorbed less X-ray are considered to be aqueous fluid phase, whereas the dark-gray matrix is silicate melt. With further increasing temperature, we observed some small bubbles coalescing to form a larger one. In most cases, the larger bubbles became hemispheres wetted on the upper wall of the metal tube. At least up to 1400 deg. C in hydrous Sr-plagioclase system and 1200 deg. C in hydrous system, immiscible two phases (i.e., both aqueous fluid and silicate melt) were observed at 3 GPa. One preliminary experimental result at 6 GPa in hydrous basalt system showed that there appeared no bubbles up to 1000 deg. C.

Our new technique could be applied to the direct observations of various kinds of 2-fluids coexisting under deep mantle conditions that could not be achieved by HDAC.