Looking for critical endpoints between magmas and aqueous fluids: X-ray radiography with Mibe-cell suggesting too low pressure ?

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We have been conducting a series of high-pressure and high-temperature experiments in order to understand mixing and unmixing behavior between various silicate magmas and aqueous fluids using synchrotron X ray radiography at SPring-8. Mibe et al. (2004 GCA) reported a critical endpoint between Sr plagioclase melt and aqueous fluids at 4 GPa. We called the high PT assembly suitable for X-ray radiography as Mibe-cell. Mibe et al. (2007 JGR) reported a critical endpoint between peridotite and aqueous fluids at 3.8 GPa. Although the manuscript has not yet accepted, Mibe et al. (rejected) suggested a critical endpoint between basalt and aqueous fluids at 3.2 GPa (this preferred value is updated). The pressure values of 3.8 GPa for peridotite-H_2O and 3.2 GPa for basalt-H_2O are much lower than petrologists expected before. Furthermore Kawamoto et al. suggested 2.9 GPa for a critical endpoint between high-Mg andesite and aqueous fluids, and 2.6 GPa between sediment and aqueous fluids. If these values are the case in the nature, the fluids derived from dehydration reactions of hydrous minerals in the subducting slab are in the sueprcritical conditions.

A research group led by Drs. Max Schmidt and Peter Ulmer at ETH has reported experimental works on this subject. Kessel et al. (2005 EPSL) suggested 5.5 GPa as a critical endpoint in the system of basalt-H_2O, and Melekhova et al. (2007 GCA) suggested 11.5 GPa in the system of MgO-SiO_2 peridotite and H_2O. These suggested values are much higher than our preferred values (Mibe et al. 2007 JGR and rejected).

Kessel (2005) and Melekhova (2007) put only 20 weight % water in their experimental charges, and measured the water concentrations of fluids quenched in diamond aggregates by laser ablated ICP instrument. When they found a large compositional change within a small temperature change at a pressure, they suppose that there is a solvus between melt and fluids at the temperature. They judged a critical endpoint when such a large compositional change is not seen and the composition changes constantly as temperature increases. We think that their experimental design is not appropriate to determine the critical endpoints because of the following two reasons. (1) They cannot observe the coexistence of a fluid and a melt at any PT condition. This is because they put only 20 wt % water in their experimental charge, while they suggested the solvus at 60 - 90 weight % water. (2) They suggested the large change of composition during a small change of temperature as a sign of the existence of solvus. However, Nakamura (1974 Yearbook Geophysical lab) reported experiments of SiO_2-H_2O system and showed a similar feature BEYOND the critical endpoint. This means that all experiments reported by Kessel et al. (2005) and Melekhova et al. (2007) are possibly beyond the critical endpoints. This is consistent with our suggestions. Some researchers think that the reality can lie between suggestions by ETH group and us. However, we do not agree with them, because the suggestions by Kessel et al. (2005) and Melekhova et al. (2007) gave no constraint on the location of the critical endpoints.

Mibe-cell with X-ray radiography also has a possible weak point. When we see two fluids with X-ray radiography, we can say there is a solvus at these PT conditions. However, it is difficult for us to deny an existence of possible small solvus when we do not see two fluids. We may have too bad eyes to see the compositional difference between them. Therefore, we have a plan to take an eye test for Mibe-cell with critical endpoints between albite and H_2O system, which has been believed to have a critical endpoint at around 1.5 GPa based on visual observation of solvus at around 1.5 GPa by Shen and Keppler (1997 Nature) and quench experiments by several groups (Paillat et al. 1992 CMP; Stalder et al. 2002 AM). We hope to talk about our first eye test at our presentation.