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Fluid migration in solidifying rhyolitic magmas: insight into three phase coexistence of crystal, melt and fluids

Emiko Nakata[1], Michihiko Nakamura[1]

[1] Inst. Mineral. Petrol. Econ. Geol., Tohoku Univ.

In solidifying rhyolitic magma chambers, fluid phase exsolves from melt with cooling and increasing crystal fraction to form bubble-bearing crystal mush. Further degassing is necessary to the formation of compact granite body by, for example, squeezing fluids out via compaction of the crystal mush. Fluid-phase behavior in a crystal mush is crucial to understand cycle, mode and trigger mechanism of volcanic eruption, because it determines the accumulation of excess pressure in magma chambers. Since crystal mush composes the wall of magma chamber, its permeability may govern the degassing rate of magma chamber, even though crystal fraction in the main magma body is small. The rheological properties of crystal mush control the dike formation conditions, which are important for eruption initiation mechanism.

In order to understand microstructure of fluid bearing crystal mush, we have carried out high-pressure experiments using piston-cylinder apparatus. Crushed powder of granite (from Abukuma plutonic complex, Fukushima pref.; ABK) and pegmatite (Yamanoo pegmatite, Ibaragi pref.; YAM) were used as starting materials. Grain size of the powders was controlled to produce the desired microstructure of solidifying granite in experimental capsules. The powders with 15-30wt% H2O were sealed in a 4-hole and one-hole Pt-lined Ni capsule with the ash-tray method. The temperature was kept at 680-720ºC and 7-8kbar for 45-90 hours, then cooled to 450ºC in 10ºC/hour.

In the ABK run products, coalescence structure of bubbles is often obseved in the interstitial melts. Large bubbles are preferentially distributed on the surface of biotite crystals. This indicates that fluid channels along network of the 'easy to wet' crystals such as biotite may be effective degassing pathway in the crystal mush.

In the YAM experiments, melt and fluid tend to segregate from each other and form two portions in the run products; melt-rich part and fluid-rich part, in which average volume fractions of crystal, melt and fluid are approximately 40%, 50% and 10%; 30%, 20% and 50%, respectively. The volume fraction of bubbles in the melt-concentration part decreases toward the fluid-concentration part, suggesting that melt was filtered out from the fluid-rich portions by coalescence of bubbles in the crystal mush. Occurrence of free crystals without glass coationg in some pumices falls may be indicative of fluid-rich portions in the top of magma chamber prior to eruption. Existence of fluid-rich crystal mush at the top of magma chamber would be important to the dike formation at eruption initiation.