Volcanic eruptions are representative of the dynamic activity of the Earth. A striking feature of the volcanic activity is its wide variety of eruption styles. They are different among volcanoes and eruptions of a volcano, and even changes within an eruption event. An important issue of modern physical volcanology is to first find out and define the bifurcation points of eruption styles in the course of magma ascent and emplacement, and then clarify the mechanisms of bifurcations. Besides scientific interests, it provides a basis for predicting transitions of activity in volcanic crises. Among some key processes, we have been focusing on the outgassing mechanism of highly viscous, silicic magmas that often cause violent explosive eruption as well as relatively quiet lava dome growth. In such magmas, shear induced fracturing is believed to be an important process for outgassing. We have carried out for the first time experimental studies on fracturing of a vesicular magma and healing of fractures under high temperature and a confining pressure, and clarified their mechanisms from a viewpoint of material science.

Growing number of evidences from melt inclusions in phenocrysts and obsidian pyroclasts indicate that shallow and H₂O-rich magmatic system is often flushed with relatively CO₂-rich deep-derived fluid. In order to understand the effect of this “CO₂-fluxing” on the volatile behavior in subvolcanic systems, we performed hydrothermal experiments on the reaction between H₂O-rich melt and CO₂-rich fluid. Other projects on the Sakurajima activity, and the microstructure of fluid-bearing rocks have been on-going.

Results:
1. We performed torsional deformation experiments on columnar rhyolites that simulated flow of rhyolites in shallow volcanic conduits. We showed that the deformation was localized and finally resulted in brittle failure, followed by a slip at the fractured interface, which prevented further brittle failure and shear-induced bubble coalescence in the remaining parts of the sample. We infer that repeated fracturing and healing processes are necessary for effective degassing of the entire magma.

2. The healing of magmatic fractures is considered essential to repetitive seismicity and the closure of degassing paths during emplacement of lavas. To estimate the healing time of magmatic fractures, we performed healing experiments of the contact interface of rhyolitic melts at 850°–1000°C. The interface became coherent in atomic scale and finally disappeared, which was characterized by the homogenization of water content across the contact via diffusion. We defined this closure interval as healing time and determined this based on a diffusion model. The microscopic healing time was strongly dependent on temperature and roughness of the interface, being consistent with the period of actual seismicity. It is prolonged sufficiently to permit the formation of millimeter thick bubble-free obsidian layers along fractures in vesicular lavas through bubble resorption due to diffusive degassing.

3. We found chemically-driven bubble growth during the interaction, which has a potential to trigger
volcanic eruptions.

Published Journal Papers:

Symposium Participations: