Open-system degassing of flowing and stagnant magmas in a volcanic conduit

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Open-system degassing from magmas ascending in a volcanic conduit is a controlling factor of the explosivity and dynamics of volcanic eruptions. A permeable gas flow through connected bubbles has been considered as a mechanism of effective degassing. However, the changes in bubble microstructure and the development of gas permeability of flowing and stagnant magmas have not been clarified. In this study, we perform torsional deformation experiments to simulate the flowing and stagnant magmas and to investigate bubble microstructures and gas permeability in the magmas.

Before a deformation experiment, a columnar obsidian (dia. 4.7mm x 5mm) was heated at a temperature of 975degC to vesiculate the sample. The vesicular obsidian was twisted at a rate of 0.5 rpm and the temperature of 975degC. After 10 rotations, the sample was held for 10 and 50 minutes at the temperature of 975degC without the deformation. The microstructure of bubbles in the run products was observed by using X-ray CT at BL20B2 of SPring-8. The gas permeability was measured by a gas permeameter.

The results of the X-ray CT analyses show that the deformation enhances bubble coalescence and the 10 rotations result in the formation of bubble networks. The connectivity of bubbles is large at the outer part of cylindrical samples at which the extent of the deformation is large. After 10 and 50 minute retentions, the vesicularity of inner parts becomes larger than that of outer parts. This indicates that the bubble networks of the outer parts shrink due to outgassing and the isolated bubbles of inner parts expand. The expansion of bubbles and the increase in the vesicularity at the inner parts result in the formation of bubble networks at inner parts.

The gas permeability parallel to shear deformation was determined to be more than 10^{-12} m^2 for samples just after the 10 rotations. The permeability decreases to less than 10^{-13} m^2 after the 10 minute retention and increases to more than 10^{-13} m^2 after the 50 minute retention. The decrease in the permeability is induced by the outgassing and shrinkage of bubbles in the outer parts; then, the permeability increases due to the formation of bubble networks at the inner parts.

In a volcanic conduit, the outgassing at permeable zones may induce the expansion of bubbles and formation of new bubble networks. Because the outgassing and the formation of new bubble network are feedback system, it is inferred that magmas become dense and the explosivity of volcanic eruptions decreases once magmas are stagnant in a volcanic conduit.