Permeability measurements of natural and experimental volcanic materials: Toward an understanding of magmatic degassing processes

Shingo Takeuchi[1]; Satoru Nakashima[2]; Akihiko Tomiya[3]

[1] Geological Survey of Japan, AIST.; [2] Dept. Earth & Space Sci., Osaka Univ.; [3] GSJ, AIST

The permeability measurement of quenched volcanic porous materials is an important approach for understanding permeability development in vesicular silicic magmas that controls volcanic degassing. In this study, a gas permeameter to measure the permeability of natural samples and experimental products was developed. The permeameter has broad measurement ranges of pressure difference (10^1-10^5 Pa) and gas flow rate (10^{-9}-10^{-5} m^3/s). These ranges enable us to measure viscous permeability in the range of 10^{-17}-10^{-9} m^2 for 1 cm-scale samples, using the Forchheimer equation, which includes the inertial effect of gas flow permeating through the samples.

In addition, we improved the procedure for performing permeability measurements of small products quenched during hydrothermal decompression experiments. Although Takeuchi et al. (2005) reported the first permeability data for silicic vesicular products of decompression experiments, we found an overestimation in their permeability data due to problems in sample preparation, especially for very low permeability samples. Our improved measurements resulted in decreased permeability than those of Takeuchi et al. (2005).

We evaluated the degree of the inertial effect on apparent permeability calculated using Darcy's law under the conditions of permeability measurement and magmatic degassing. The permeability measurements indicate the apparent permeability of highly permeable samples (more than 10^{-10} m^2 in viscous permeability) is affected considerably by the inertial effect under a high pressure gradient (more than 10^5 Pa/m) and reduced by more than 0.5 orders of magnitude from viscous permeability. Also in magmatic condition, the reduction of apparent permeability may occur during the degassing of highly permeable magmas driven by a high pressure gradient.