Manufacturing of gas permeameter to investigate permeability of vesiculating magma

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Gas permeability of magma is an important factor to control volcanic eruptions. For example, Melnik and Sparks (1999) showed that the gas permeability of magma controls degree of degassing in conduit flow and influences generation of excess pressure in shallow conduit. However, it is not well known how gas permeability varies with decompression and vesiculation in magma ascent processes.

Measurement of gas permeability of run products produced in experiments of vesiculation is effective to investigate the variation of gas permeability in vesiculation processes. However, the scale of run products is too small to measure their gas permeability by using a ready-made gas permeameter. In addition, there is no ready-made gas permeameter to cover the wide range in permeability inferred from the permeability measurement of erupted materials (zero to 10^-11 m2; Klug and Cashman, 1996). In this study, we tried to manufacture a gas permeameter capable to measure the permeability of small-scale samples.

In our instrument, N2 gas in a steel cylinder flows in vinyl tube and is permeated to a sample sandwiched between acrylic plates. Differential pressure between ahead and behind the sample is measured by using a manometer of water column. The manometer can measure the differential pressure up to 1.5*10^4 Pa. Cumulative gas volume is measured by using graduated cylinder in water bath. Then, gas flow rate is calculated from the cumulative gas volume and elapsed time of the experiments. Applying these data to the Darcy""s law, we obtained the permeability of sample.

In order to confirm precision in the measurement, we examined permeation in metallic capillary tube (0.1 mm inside diameter and 1.5 cm length) mounted in resin. As a result, the flow rate was estimated at 0.3-4*10^-2 ml/s for differential pressure of 1-14*10^3 Pa. Since the difference between the measured and theoretical values, which is calculated assuming Poiseuille flow, is within 11 %, our measurement has enough precision to measure the flow rate.

Preliminarily, we measured permeability of a pumice sample erupted in 1977 at Mt. Usu. A disc sample of the pumice with 9.9 mm diameter and 4.7 mm thickness was mounted in resin to seal its lateral face. The disc sample was sandwiched between acrylic plates. Six times of measurements were repeated. The orientation of sample and differential pressure were changed in each measurement. In these measurements, the flow rate was 2-16*10^-2 ml/s and the elapsed time to accumulate gas volume of 100 – 200 ml was 20-150 minutes. Consequently, we obtained the permeability of 1.3*10^-14 m2 for the pumice sample. The six times of measurements has reproducibility within the standard deviation of 1.4*10^-16 m2.

In conclusion, we obtained the permeability within an order of magnitude of precision by using our hand-made gas permeameter. For the future, we try to make a device to remove fluctuation in differential pressure, and construct a system to measure automatically the differential pressure and cumulative gas volume during measurements. Then, we will investigate the relationship between the permeability and vesiculating texture of the pumice sample produced in vesiculation experiments.