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Magma decompression experiments with Decompression Speed Controller

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[I. Introduction: `quenching' of water content in magma]

The essential materials of the recent phreatomagmatic eruptions (the Usu 2000 and the Miyakejima 2000 eruptions) seem to be `quenched' at rather high pressure, deduced from microbubble-rich texture (Tomiya et al., 2001; Miyagi et al., 2001) and high water content of matrix glass (2-3 wt.%; Miyagi et al., 2000). The timing and place of the `quenching' process in the eruptions, however, have not yet been known well. (Note: Here, we use the term `quench' for `fixing of water content' in magma due to suppression of bubble formation, where `cooling' is not necessary.)

Tomiya et al. (2001) proposed the possibility, based on the Miyagi (1995)'s calculation, that the `quenching' of water content in the Usu 2000 volcanic glass occurred because decompression rate was too high for water dissolution process to follow, and that the acceleration point was deeper than the assumed aquifer. In order to check this proposition, a series of decompression experiments (e.g., Gardner et al., 1999) for the eruptive product are necessary to investigate the relation between decompression rate and water dissolution process.

[2. Method: the decompression speed controller]

An internally heated gas-medium high-pressure apparatus with quenching device and decompression speed controller (Tomiya and Miyagi, 2001) was used for the experiments. This machine was installed on Geological Survey of Japan, AIST, last year, and characterized by its unique decompression speed controller. The controller can provide wide range of decompression rate (ca. 0.0001 MPa/sec to 10 MPa/sec). The rate is continuously variable by micrometer-ring valves, so that change of pressure is smooth.

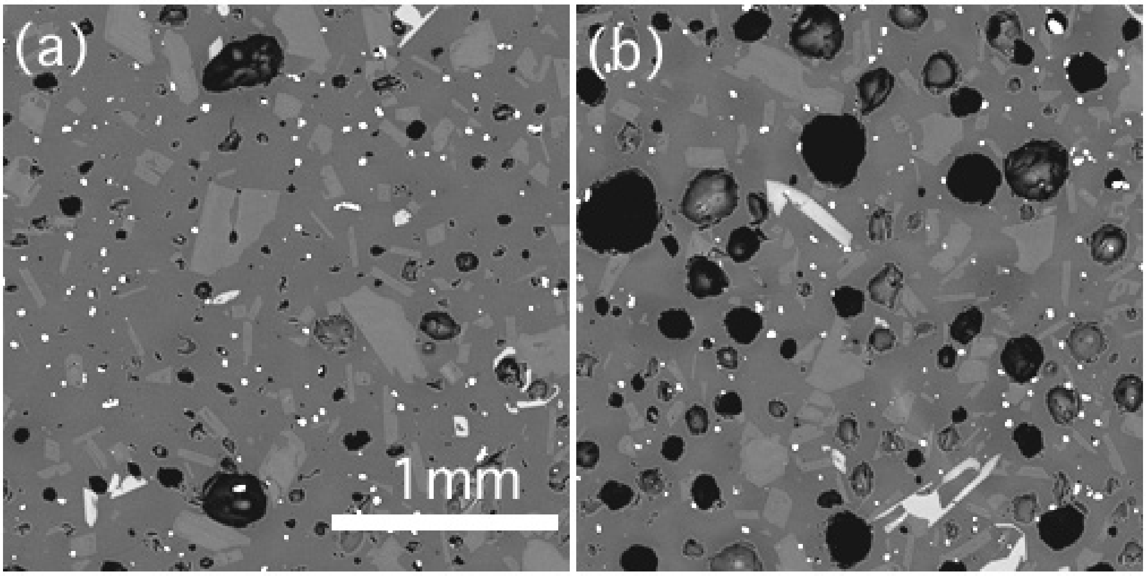
The sample we use is the 2000 pumice of Usu volcano (Us-2000pm; Tomiya et al., 2001). The pumice was ground and sealed in noble metal capsule with weighed water. The sample was once kept at certain temperature and pressure (To, Po), then decompressed at various rate (dP/dt), and finally dropped to quench at a planned pressure (Pe). The water content was set enough to saturate at the initial pressure Po.

[3. Results: relationship between decompression rate and texture]

In Fig.1, we show examples (Back-scattered Electron Image) of run products for Po = 98 MPa, Pe = 50 MPa and To = 900 C. Fig.1a is very high rate (1.5 MPa/sec; decompression duration is 30 sec), and Fig.1b is rather low rate (0.0030 MPa/sec; decompression duration is 4 h 16 min.). These two are different in texture. Bubble fraction is small in the former (ca. 7-8 %) and large in the latter (ca. 20 %). Water content in glass, estimated by difference between 100 wt.% and total (wt.%) in EPMA analysis, is high in the former (4.4 +- 0.6 %; similar to the solubility at Po) and low in the latter (2.7 +- 0.6 %; similar to the solubility at Pe). Thus, at the rate of 1.5 MPa/sec, water dissolution and bubble formation are not effective during decompression, although small amount of microbubbles appear. That is, the water content just prior to the decompression (at Po; the `acceleration' point) is `quenched' at this decompression rate. Furthermore, it is also seen that variation of bubble fraction in magma can be explained by variation of decompression rate.

In future, we will investigate the `critical decompression rate' above which `quenching' of water content can occur during magma ascent, its dependence on temperature and pressure, effect of crystallization during decompression, and so on. In addition, reproduction of the texture of Us-2000pm/g by experiments is expected to provide some constraints on the decompression rate at the Usu 2000 eruption.

Figure 1



1.5 MPa/sec 0.0030 MPa/sec