Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04786, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04786
EGU General Assembly 2008

A closer look at magmatic fragmentation

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Detailed knowledge of fragmentation mechanisms is vital for understanding explosive volcanism. Since roughly a decade, fragmentation experiments have been performed on natural magma and varying analogue materials. These experiments and subsequent field studies have pointed out important correlations between magma properties and fragmentation behavior but also posed new questions.

We constructed a shock-tube apparatus, optimized for visual observation during rapid decompression of a pressurized (natural) sample. This setup allows for the first time to monitor the fragmentation of natural vesicular magma simultaneously with a high speed video camera and up to three pressure sensors. We analyzed products from the 2004 Vulcanian eruption of Asama Volcano, Honshu, Japan, as well as samples from other volcanoes (as Karymsky, Russia, and Unzen, Japan) exhibiting similar eruptive behaviour.

Firstly we investigated the influence of the wall condition on the fragmentation behaviour. Therefore samples were mounted in different ways to the sample holder, by using different glues, compressive confinement or friction. Next we determined the threshold of our sample sets and estimated their permeability. The achieved threshold values are in good agreement with already published data (Spieler et al. 2004, Scheu et al. 2006, Müller et al. 2005). Having characterized our sample sets in that way we were able to have a closer look at the mechanism of brittle fragmentation: we analyzed video and pressure recordings of rapid decompression experiments, conducted at different initial pressure conditions above the fragmentation threshold (as 5 MPa, 7.5 MPa and 10 MPa). It could be shown that the classical understanding of magmatic fragmentation as one fragmentation wave travelling through the sample and causing "layer-by-layer" fragmentation has to be refined. Within the investigated energy range the process of layer-by-layer fragmentation due to vesicle bursting is overriding, but it does not propagate as one fragmentation front through the sample, it rather occurs in several generations. The number of such generations seems to depend on the applied energy and sample properties as permeability. Slightly above the threshold only one generation of layers could be observed, whereas three or even four generations of layers could be traced at applied pressures significantly above the threshold. With higher permeability, both the number of layers and the number of layer-generations are decreased, indicating that the permeability impedes the fragmentation process. This is consistent with the effect of permeability on the fragmentation threshold.