Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC50-16 Room:315 Time:May 2 14:45-15:10

Mechanism of delayed brittle-like fragmentation of vesicular magma analogue

KAMEDA, Masaharu[1*] ; SHIDA, Tsukasa[1] ; ICHIHARA, Mie[2] ; TSUGO, Mitsuaki[1] ; OKUMURA, Satoshi[3] ; UESUGI, Kentaro[4]

[1]Mech. Sys. Eng., TUAT, [2]ERI, Univ. of Tokyo, [3]Earth Sci., Tohoku Univ., [4]JASRI

Magma fragmentation is a key phenomenon controlling volcanic eruptions. The fragmentation is classified into two styles: solid-like brittle fragmentation and liquid-like ductile fragmentation. Brittle fragmentation is more hazardous than ductile fragmentation because violent release of pressurized gas in the bubbles contained in the magma may lead to explosive eruptions

The fragmentation of magma, which is a viscoelastic fluid, occurs through a combination of viscoelasticity and rapid deformation. We conducted a rapid decompression experiment over ten years in order to clarify the viscoelastic effect on the fragmentation using a magma analogue, syrup containing gas bubbles (Kameda et al GRL 2008; Kameda et al. JVGR 2013).

Through the experiment we demonstrated the existence of a transitional fragmentation behavior. This transition behavior, which we refer to herein as brittle-like fragmentation, occurred even if the response of material should be in a ductile manner. Comparing the realistic decompression time with the viscoelastic relaxation time for magma, it is more probable that the fragmentation in the real volcanic system occurs in a brittle-like manner.

Observation by high-speed photography using a visible light-source indicated that the onset of brittle-like fragmentation was triggered by the sudden release of a considerable amount of gas from a crack in the specimen. Further observation (Shida et al. IAVCEI 2013) showed that reducing the volume of the specimen suppressed the onset of fragmentation even if their brittleness (Ichihara and Rubin 2010) was close to unity. In our case, the pore distribution of the small samples was more uniform than that of large samples. This observation implies that the crack is initiated from the interior of the specimen due to non-uniform spatial distribution of bubbles.

Then, we observed the interior of the specimen by synchrotron X-ray tomographic microscopy. The X-ray tomographic microscopy was performed at the BL20B2 beamline of the Japan Synchrotron Radiation Research Institute (JASRI, Hyogo, Japan). Initial structure of the specimen was observed by three-dimensional tomographic imaging. High-speed radiography was performed during the decompression. A digital charge-coupled device (CCD) camera was used as the detector whose imaging area is about 16 mm (horizontal) by 5 mm (height) with spatial resolution of 8 μm/pixel. We took 1800 projections over 180 degrees of rotation for tomographic imaging. The framing rate of radiography is 200 frames per second. We successfully captured a series of images during the brittle-like fragmentation. The reconstructed 3D image of the specimen indicated that the brittle-like fracture was initiated at a notch and a chain of small bubbles in the vicinity of a large bubble.

We propose the following scenario for brittle-like fragmentation: It is initiated from ductile growth of internal cracks by connection of bubbles. The stress concentration and the brittleness at crack tip may exceed the critical level at some moment, which leads to brittle failure of the crack. Rapid decompression due to sudden release of a considerable amount of gas from the crack may increase local brittleness to cause partial fragmentation. Such a sequence from ductile crack growth to partial fragmentation may successively occur in brittle-like fragmentation.

Keywords: Magma, Fragmentation, Viscoelasticity, Decompression, X-ray CT