

Observation of the fragmentation process of the analogous magma in the solid/liquid transition regime

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The fragmentation of vesicular magma is a key phenomenon to determine the style of volcanic eruption. To understand the magma fragmentation, we performed a rapid decompression experiment using an analogous material of magma.

We classify the onset of fragmentation using the brittleness defined by Ichihara and Rubin (2010). The results are as follows: (a) Brittle fracture occurs when the brittleness is from 0.9 to 1.0 only if the differential stress reaches the critical stress, and (b) Ductile expansion occurs when brittleness is smaller than 0.9 even if the differential stress is slightly larger than the critical stress. In addition to the classifications (a) and (b), we find the other class: (c) Delayed fracture occurs when the differential stress sufficiently exceeds the critical stress. We focus our attention to the delayed fracture on this report.

The delayed fracture occurs after the relaxation time of viscoelastic material. Moreover, it causes within the characteristic time of bubble expansion in viscous liquid. This means that the delayed fracture is solid-fracture named brittle-like fracture.

The reasons why the brittle-like fracture occurs when the brittleness is much smaller than 0.9 might be (1) increase of the material viscosity as cooling during the decompression, and (2) inner cracks which are made when the bubbles are mixed into the analogous material.

First, we performed the decompression experiments using two thermocouples, one of which is put on the surface of the material and the other of which is placed in the surrounding gas of the material to check over the cooling effect during the decompression. The gas temperature in the decompression device becomes several tens degrees Celsius lower when the initial value during the experiment. On the other hand, the temperature on the surface of the material remains the initial value in the time scale when the fragmentation happens. This result shows that the cooling effect of the material is not a factor of the delayed fracture happen.

Next, we performed the decompression experiments using the materials having various void fractions and which have a constant brittleness and differential stress. The result shows that the higher void fraction the material has, the easier fracture happens. Thus, the growth of inner cracks during the decompression may lead to the brittle-like fracture.

The brittle-like fracture found in this experiment may happen in specific actual volcanic events in which the onset of explosive eruption is remarkably delayed from the time when the decompression occurs.

Keywords: fragmentation, viscoelasticity, analogous experiment, brittleness