

Study on phase change process of high viscous fluid

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The deposition of volatile substance from viscous magmas is one of the most important processes to achieve volcanic eruptions. Analogue experiments are conducted to investigate the phase change behavior such as the bubble nucleation and growth. It is necessary for investigating the volcanic phenomenon to reproduce eruptions. In the present study, volcanic eruptions are simulated by using the visible shock tube apparatus and simulant materials.

The visible shock tube apparatus is mainly composed of the visible acrylic test section, the vacuum tank (volume 2 m³), the diaphragm and the plunger pump. The test section is consisted of 6 visible hollow test blocks(size 100*100*150mm, inner diameter 40mm), 7 pressure transducers, and the diaphragm. Sudden decompression from up to 20 MPa can be carried out in the test section. And the height of the test section is 1065 mm. The diaphragm of stainless thin film divides a high-pressure part from a low-pressure part. The rupture pressure of the diaphragm is controlled by changing the thickness. The plunger pump injects the simulant materials and compresses it to the rupture pressure. In these experiments, the phase change behavior is observed by a high-speed video camera (recording speed 10000-50000 fps) and 7 pressure transducers (sampling rate 10-50 kHz). In this experiment, the mixture of silicone oil and acetone is used as simulant material. The velocity of the simulant materials is 0.7 to 80 Pa s. The vapor pressure of acetone is 20kPa at 290K. Acetone is 6% in total mass.

A series of rapid decompression experiments are conducted. The initial pressure in a high-pressure part is 1 to 12 MPa. The pressure in a low-pressure part is 0.01 MPa. As results, these decompressions completed about 3.5 ms in spite of various initial pressures. The decompression wave propagates from the lower pressure part to the higher pressure part through the diaphragm. The propagation speed is estimated about 1000 m/s. This value is close to the sound velocity in the silicone oil. In the process of the rapid decompression, bubbles nucleation and growth in the viscous fluid are observed. In low viscosity, bubbles are deformed remarkably in a vertical direction. However in high viscosity, the deformation of bubbles is suppressed. In addition, the number of nucleated bubbles increases with the initial pressure in a high-pressure part.

The nucleation doesn't occur simultaneously. At first, a bubble nucleates at some location, and the nucleation of bubbles propagates from the location. This propagation speed is estimated about 1500 m/s. When the nucleation occurs, the pressure is much higher than the vapor pressure of volatile substance acetone. So in future, it is necessary to invest this point carefully and in more detail.