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The analogue experiment to investigate the condition of bubble detachment from magma chamber wall by seismic wave

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Volatile components, such as SO_2, CO_2 and H_2O, are saturated in magmas. These components are nucleated as bubbles when magmas are further oversaturated. Seismic waves will reduce the nucleation barrier to facilitate the heterogeneous bubble nucleation under a low supersaturation. Bubbles which heterogeneously nucleate on the wall or bottom of magma chamber get buoyancy then detach the wall or bottom and ascent with keeping internal pressure. According to the principle of advective-overpressure, the magma chamber is overpressurized. This overpressure may trigger eruptions and other geophysical phenomena such as low frequency earthquakes at geothermal fields. Thus the detachment condition of bubbles from wall or bottom surfaces is a key factor to control the onset of seismic triggering. In order to evaluate the effect of seismic wave and surface tension on the detachment condition, we conduct the analogue experiment.

Using a carbonated water as magma and experimental vessel as magma chamber, we design the experimental setup to find out that what kind of waves cause the bubble departure. We oscillate the experimental vessel containing a supersaturated carbonated water at various frequency and amplitude. In addition, we conduct the experiment to evaluate the effect of the bubble shape on the detachment condition because buoyancy to drive the detachment is controlled by bubble shape, such as contact angle and bubble radius. The contact angle is decided by surface tension which varies with ethanol concentration in carbonated water. Further, we investigate the effect of oscillation on the bubble morphology such as bubble radius or contact angle.

From a series of experiments, we obtained following results. 1) If the amplitude is small, the bigger CO_2 bubbles are detached and when the frequency is higher, the amplitude is small at the moment of detaching of bubble. 2) The increase in the ethanol concentration decreases the contact angle and detachment bubble radius. 3) When the experimental vessel is oscillated at the same frequency and amplitude, the increase in the ethanol concentration decreases the detachment bubble radius but contact angle is various and has no systematic features.

We consider that the reason why the contact angle has no systematic features is that during vertical oscillation, the contact angle has different value because the contact angle becomes small, when the experimental vessel goes down, whereas when the experimental vessel goes up, the contact angle becomes large.

Integrating experimental results, we summarize the detachment condition as follow: The thresholds of oscillation amplitude and bubble radius at the detachment condition decrease as the frequency of oscillation increases and as the contact angle decreases. In natural systems, it has been reported that the contact angle is small approximately 20 degrees for silicate minerals such as quartz or feldspar in magmas rather than oxide minerals (larger than 90 degrees) such as magnetite. So we can speculate that the seismic triggering for overpressure may occur in the ordinary magma chamber with silicate minerals-rich walls. Furthermore, the addition of other volatile components reduces the surface tension, leading to less threshold of oscillation amplitude and bubble radius.