Effect of seismic oscillation on the bubble detachment from wall of magma chamber

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The bubble detachment or departure from wall of magma chamber is thought to be a candidate as a mechanism of triggering of volcanic eruptions by seismic oscillation, because thereby the advective overpressure or the abrupt vesiculation by convective overturn is expected to bring the rested magma chamber to unstable and overpressurized state. We conducted the laboratory experiments in order to investigate the effects of oscillation frequency, amplitude, and bubble radius on the bubble detachment process. The simple experimental setup consists of an acrylic cylindrical container (diameter 80 mm, height 100 mm) and an underlain oscillator by which we can control the frequency and amplitude of vertical oscillation. Commercially available carbonated water in the container was used as an analogue material to magmas containing bubbles. When the carbonated water (500 ml) is poured in the container, CO2 bubbles form on the wall by heterogeneous nucleation and grow. Even in the oscillation-free state, the bubble detachment occurs when a bubble size exceeds a critical value determined by liquid/gas-, gas/substrate-, and liquid/substrate-interfacial tensions (oscillation-free detachment bubble size). In the case that the oscillation is applied, the critical bubble size of detachment change with the amplitude and frequency of oscillation. In order to understand the relationship among the detachment size of bubble, amplitude and frequency of oscillation, we conducted a series of experiments, bubble detachment experiments and bubble growth experiments. Two video images were taken for a close view and whole view, which were used for the analysis. After the stationary state was achieved in the filled carbonated water, we applied oscillations with frequencies every 10 Hz from 10 to 100 Hz. For a chosen frequency we gradually increase the amplitude until substantial bubble detachment occurred. We measured the minimum radius of detached bubbles as function of the amplitude for the given frequency. As a result we obtained the detachment condition in terms of bubble radius, frequency and amplitude. The minimum amplitude of bubble detachment decreases with increasing bubble radius and with increasing frequency. This relationship can be interpreted by the force balance among the buoyancy force, inertial acceleration and surface tension force, which act on a bubble attaching on the bottom substrate. Applying this relationship to the natural case with seismic frequency, around 1 - 10 Hz, we roughly predict that 1 mm bubbles can detach from the bottom of magma chambers for approximately 0.1 mm displacement by a seismic vibration, suggesting a possible seismic triggering of volcanic eruptions.