Bubble growth model in a magma chamber surrounded by elastic medium

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Gas bubble in magma grow and expands the magma volume as confining pressure decrease, hence bubble growth process play important roles on magma ascent and volcanic explosion dynamics. Such bubble growth process has been examined under the melt condition of a constant ambient pressure (e.g., Proussevitch et al., 1993). However, it is natural to assume that magma chamber is surrounded by crustal structure. In this study, we take into account the elasticity of the crust in the bubble growth model to examine pressure recovery and bubble growth in magma chamber.

Magma is assumed to consist of compressible melt and numerous tiny spherical gas bubbles. The melt is saturated with volatiles. When magma is suddenly depressurized, pressure of the melt immediately follows the pressure drop. On the other hand, when growth rate is slow compared with the speed of pressure drop, pressure inside gas bubbles keep the original pressure. As a result, the gas bubbles start to expand to reach a pressure equivalence between gas bubbles, melt and surrounding elastics.

Growth process of gas bubbles is controlled by diffusion equation of gas, mass balance on a bubble's interface, and Navier-Stokes equation for melt. Pressure balance equation is also used between melt and surrounding elastics. We numerically calculate bubble radius and pressure of gas bubbles applying a finite difference method to these equations.

Under the condition of confining pressure of 25 MPa, pressure drop of 1 MPa, initial bubble radius of 10^-5 m, bubble growth process is calculated for rhyolite magma in a dike. When aspect ratio of the dike is very small (10^-5), which corresponds to a constant ambient pressure, the bubble radius increases with time. The growth rate gradually decreases, and the radius converges to a final value, 2.7 x 10^-4 m. The pressure recovery is 7 x 10^-4 MPa. On the other hand, for a large aspect ratio (0.1), the bubble radius converges to 1.3 x 10^-4 m and the pressure recovery is 8.4 x 10^-1 MPa in a shorter time.