Eruption due to depressurization: Numerical simulation by VERA code

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Magma and hydrothermal systems are more or less stable under lithostatic and hydrostatic circumstance, however, in case of some pressure condition, the system becomes unstable and even a tiny perturbation can trigger a catastrophic instability, which may lead to an eruption. In a hydrothermal system and shallow volcanic fluid system, the gas-liquid interaction controls the activities, and the instability of two-phase flow dynamics is essential to recognize the eruption mechanism.

There are several candidates as "tiny perturbation", for example, new magma intrusion from deeper part, magma mixing, etc. One of the important triggering mechanisms is depressurization, which occurs in many situations: the opening of a "plug" which is keeping a pressurized gas-water system would disturb a hydrothermal system. For magma plumbing system, magma ascends and reduces the pressure itself, then the bubbling is promoted. Once the volume fraction of gas component overcomes a threshold, the fragmentation occurs and we can detect as an explosive eruption. This series of phenomena from depressurization to fragmentation is controlled by many factors. We developed a numerical simulation code "VERA", by which volcanic eruption is simply simulated as a phenomenon triggered by pressure release due to an opening of a conduit cap at the top. In VERA code, we formulate gas-liquid flow by the expanded two-phase flow model and adopt VOF scheme for free surface evaluation. The subsurface plumbing system is modeled to consist of cylindrical conduit and spherical reservoir with an adequate length and/or diameter. As an initial condition, we assume an initial radius of a bubble in the magma reservoir, bubble number density, and excess pressure in reservoir. Opening of the conduit cap releases fluid pressure and enhances the growth of bubbles. When the void ratio exceeds a threshold, fluid is fragmented. The fluid viscosity is also an important factor, and in case of large viscosity, the fluid is very hard to be fragmented, since the bubbles cannot expand easily. This model is also applied to the Mount Fuji magma system depressed as large as 1MPa due to the enormous ground deformation by Tohoku megathrust earthquake. Our simulation code VERA reveals the details of the fragmentation phenomena, significant heterogeneous distribution of gas and liquid components as well as pressure perturbation in the conduit and reservoir.