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Simulation of flow in a volcanic conduit using a particle method

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The magma flow in the conduit cannot be observed directly. Nor can the results of experiments easily be scaled-up to the natural condition. We have to resort numerical simulation of eruptions to understand the physics of the flow.

The presenter has developed a new numerical method, which is a kind of particle methods. The particle methods are superior in treating of topological change of the fluid interface over the FDM and FEM. In the simulation of gas-liquid multi-phase flow, the ability treating topological deformation is plus one. It allows us to simulate the change of the continuous phase in the multi-phase system. In other words, fragmentation, transformation from a liquid with dispersed gas bubbles to a gas with dispersed liquid drops, can be generated internally in our simulation.

In other simulations, the condition of fragmentation is one of the most difficult problems. In earlier works [Wilson et al., 1980; Dobran, 1992], it is assumed that the magma fragmented when the growing bubbles reach their closest packing state. In later works [Alidibirov, 1994; Papale, 1999], more complicated conditions are presented. However, the conclusive condition has not been obtained yet. On the other hand, our simulation does not require the condition, because fragmentation is generated spontaneously. This spontaneous generation of fragmentation is the unique feature of our method.

In our simulation, rarefaction shock wave-like phenomena have been found. To be more precise, the pressure drops rapidly with the generation of the gas phase and the process from vesiculation to fragmentation occurs rapidly in the pressure drop. The phenomena are similar to Evaporation wave, which is observed experimentally [Simoes-Moreira et al., 1999].

On the basis of our simulation results, we present a new eruption model. In our model, it is assumed that the process from vesiculation and fragmentation is controlled by a shock wave-like phenomenon. Given this assumption, the complicated change of the fluid properties, density and viscosity, is no longer great matter and we can apply a shock wave theory to modeling volcanic eruptions.