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SVC50-P10 Room:Poster Time:May 2 16:15-17:30

Formulation of the 1-D magmatic flow including vesiculation kinetics

TORAMARU, Atsushi[1*]

[1]Department of Earth and Planetary Sciences, Kyushu University

In most of existing fluid mechanical modeling and numerical calculations, the equilibrium vesiculation has been assumed according to the solubility relation. However, in order to understand the transient behaviors such as triggering of eruptions and shifts of eruption intensity, we need to examine the effect of vesiculation kinetics on the fluid mechanical behaviors in the conduit. In this study, we formulate the governing equations describing the one dimensional fluid mechanics taken into account the vesiculation kinetics, that is, the nucleation and growth of bubbles, assuming the homogeneous flow.

As we adapt the single fluid approximation, we build upon the advantage of the formulation in which the mass conservation equation about density is converted to the pressure equation through the equation of state. We make the similar procedure to obtain pressure equation while in our case the density is a function of not only pressure but also gas phase fraction. The gas phase fraction is calculated by the vesiculation kinetics. As a result we have four equations; 1) pressure equation (mass conservation), 2) equation of motion (momentum conservation), 3) constitutive equations describing vesiculation kinetics. These partial differential equations consisting of pressure, velocity and gas phase fraction, can be solved numerically.

In order to confirm the validity and fundamental characters of the formulation, we numerically solve the shock tube problem, using modified CIP method for advective terms. In the case that the kinetic effect is negligible due to relatively large initial gas fraction in the high pressure region, we obtain the similar solution to that of single fluid, consisting of shock wave in downstream and rarefaction fan in upstream. On the other hand, in the case that kinetics of vesiculation works effectively, we have different behaviors in the high pressure region in which rarefaction front, nucleation pressure front and nucleation event propagate with different velocities, while the behavior in the low pressure region is basically same as the case without the kinetic effect. Each propagation velocity depends on nucleation pressure (liquid/gas interfacial energy), bubble growth rate, initial gas faction in the high pressure region. The essential difference between two cases, the pressure of bubble formation becomes lower in the case with the kinetic effect than in the case without kinetic effect. If the kinetic effect is dominated, it is expected that the time to the vent from the bubble nucleation is relatively short. On the other hand, in the case that the vesiculation proceeds at equilibrium without the kinetic effect, it needs longer time to the vent, suggesting that the relative motion between gas and liquid, the bubble coalescence and degassing become dominate. Thus, this suggests that the kinetics of vesiculation may control the transition of eruption styles such as explosive and non-explosive eruptions.

Keywords: conduit flow, vesiculation kinetics, bubble nucleation, shock tube