A simulator of volcanic activity usable in eruption prediction: fundamental principles for its development

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One of the most important problems for volcanic eruption prediction is how to evaluate the possibility of eruptions with their natures based on observation of some anomalous activity at volcanoes. For a useful approach to the prediction, I propose to develop a simulator of volcanic processes, assuming that eruptions should be induced by gravitational instability of underground magma. Namely, we predict an eruption when it is inferred from the simulation that the gravitational instability can grow enough. The simulator can be constructed using some phenomenological parameters that describe the properties and behaviors of magma.

The gravitational instability that has been introduced above is actually caused by vesiculation of volatile components and resultant bubble formation in magma. Namely, bubble inclusions expand the magma volume and contribute to the driving force of magma ascent. If ascending magma returns additional bubbles through pressure reduction, magma motion is accelerated with enhanced instability. Such a positive feedback between ascent motion and bubble formation may lead to a surface eruption.

Ascent of bubbly magma may be suppressed, however, by degassing and cooling of magma. If these effects are stronger, the ascent is decelerated and finally stopped without causing an eruption. In this way, an eruption may or may not follow some anomalous activity in the volcano, depending on if the cooperation between magma ascent and bubble formation can or cannot overcome the degassing and cooling effects. In this context, the volume of unstable magma determines the scale of the eruption and the explosiveness of the eruption depends on if the gravitational instability grows enough to result in magma fragmentation.