V080-P008 Time: May 29 17:15-18:45

A hierarchical permeable flow model for degassing process from volcanic conduits

Yoshiaki Iwamuro[1], Hiroaki Niimura[2], Takehiro Koyaguchi[3]

[1] Complexity Science and Engineering, Univ. of Tokyo, [2] Univ. Tokyo, [3] Frontier Sciences, Univ Tokyo

Water-rich silicic magmas may erupt explosively, giving rise to massive columns of ash, or effusively as viscous, bubbly lavas to form lava domes. One of the important factors that lead to the different eruption types is degassing, which means escape of gas from conduit. The most important process for degassing is considered to be relative gas flow through liquid magma. A magma carrying many bubbles connecting each other is regarded as a porous media, where high viscosity magma and connected bubbles play roles of obstacles and flow paths, respectively. Bubbles may deform under the shear stress in the magma flow, which affects the anisotropy of the permeability of the liquid magma. We numerically investigate the effects of bubble deformation on the degassing process.

Generally speaking, it is difficult to calculate the whole gas flow through many small bubbles (approx. 1 mm in diameter) in a conduit with radius of approx. 10 m. Therefore, we developed a hierarchical permeable flow model for 2-dimensional conduits. In the microscopic model, we calculate percolation probability and anisotropic permeability tensor for variable porous structure of liquid magma with deformed bubbles. Gas flow through connected bubbles is calculated by the lattice Boltzmann method in order to determine the anisotropic permeability. In the macroscopic model, macroscopic gas flow inside the whole conduit is calculated by the finite difference method for the system where the permeable tensors are arranged. In the macroscopic model, various pressure boundary conditions were set along the side wall as well as at the top and bottom of conduit; typically it is assume that the pressure along the side wall is as low as that of the vent.

Our results of the microscopic calculations suggest that elongation of bubbles affects connectivity of bubbles and permeability. The percolation probability in the direction of the major axis increases and that of the minor axis decreases, as the aspect ratio of bubbles increases. As the aspect ratio of bubbles increases, the permeability in the direction of the major axis increases, because tortuosity of the gas-flow path decreases in that direction. As the aspect ratio of bubbles further increases, however, the permeability in the direction of the major axis decreases, because the individual flow paths become narrower. Our results of macroscopic calculations suggest that two important factors, elongation and rotation of bubbles, control the direction of gas flow. In the case of circular bubbles, the permeability tensor is isotropic. Gas efficiently escapes toward the conduit wall due to horizontal pressure gradient. In the case of elongated bubbles, the permeability in the direction of the major axis becomes higher than that of the minor axis. Because flow of liquid magma elongates bubbles in the direction along the conduit, vertical gas flow straight to the vent is enhanced in spite of the horizontal pressure gradient. The elongated bubbles rotate due to velocity gradient of liquid magma flow. Such rotation has two opposite effects for the gas flow. Gas flow concentrates toward the center of the conduit along the direction of the major axis as it rises through the liquid magma. Under some conditions, horizontal connectivity of bubbles increases due to rotation, which can enhance horizontal degassing. Elongation and rotation of bubbles depend on magma viscosity, flow velocity of magma, radius of conduit, bubble size and surface tension. It is suggested that the efficiency of degassing varies depending on these factors.