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Effects of rising velocity of magma changing its intruded shape

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We employed software PFC 2D (Particle Flow Code in 2 Dimensions) based on discrete element method and studied effects of which rising velocity of magma would control shape of intruded magma. Although behaviors and shapes of the intruded magma would be controlled by various factors, here we paid attention to the rising velocity of intruding magma because the velocity would reflect directly overpressure from deeper magma chamber.

In the discrete element method, all materials are approximated by assembling of many particles, and one particle and other particles are connected by elastic 2 springs (normal and shear stiffness). If necessary, we can set parameters, bond, for connecting particles. By trial and error, these parameters are determined by biaxial test in a computer. In this study, we assumed Young's modulus of 16 GPa and Poisson's ratio of 0.21 as elastic constants of basaltic crust near the surface, and we estimated the normal and shear stiffness of 50 GN/m and the normal and shear contact bonds of 3 kN, to satisfy the mentioned elastic constants, by the biaxial test. The normal and shear contact bonds of intruded magma were set to 0 kN for keeping fluidity.

In this study, we considered the model of which width and depth are 5 km and 1.6 km. We assumed that the intrusions of magma would be pushed out from bottom of the model by an arbitrary rising velocity, and we evaluated effects of the rising velocity changing shape of the intruded magma. In the model, radius and density of particles constituting the crust were assumed to be 4.8˜6.4 m and 2500 kg/m^3, and radius and density of particles constituting the magma were assumed to be 0.8˜0.96 m and 2000 kg/m^3. The final volume of the intruded magma was set to 2e^5 m^3 in all simulations, and we changed the rising velocity from 5e^{-4} m/step to 0.16 m/step.

As a result, it was found that the shape of the intruded magma was circular in an initial stage of intrusion and that they were irrelevant to the rising velocity. However, the final shapes were dependent on the rising velocity. If the velocity was slow, the intruded magma grew up as the elliptical shape elongating upward. On the other hand, if the velocity was fast, the intruded magma grew up as the circular shape of which lower parts were elongated sideways or the triangle shape with blunt corner. In addition, the slow rising velocity deformed widely the surface, because the magma having slow velocity grew up more upward than the magma having fast velocity.