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Magma dike intrusion simulation by Discrete Element Method (3)

Eisuke Fujita[1*]

[1]NIED

Volcanic crustal deformation is usually analyzed using Mogi and Okada models, and they assume the isotropic and homogeneous crusts and isotropic stress fields, so it is effective to identify the deformation source locations quickly. However, the actual crust around the volcano is anisotropic and heterogeneous and the stress field is subject to local and regional stress fields. Furthermore, these models assume the elastic deformation and do not consider the fractures, therefore, the estimated deformation may be over-estimated. In these points of view, we study the crustal deformation simulation using Discrete Element Method. We have simulated isotropic expanding spherical source and square dike intrusions so far, and this report explains the dependencies on physical properties, boundary stress condition, and the subsurface stress field perturbations due to dike intrusion.
In Discrete Element Method, the crust and magma are modeled by discrete elements, and the stresses between elements are formulated by the normal and shear elastic spring coefficients. In addition, we applied Mohr-Coulomb Criterion for the fractures.
Our simulation suggests followings: 1. Basically, DEM models can reproduce the crustal deformation by Mogi and Okada source. However, we get heterogeneous deformation, mainly due the fractures in some local areas. 2. The amount of crustal deformation is dependent on physical properties. 3. We start the simulation from the state after gravity packing. Therefore, even though the spring constants between discrete elements are uniform (i.e., microscopic homogeneous), the whole crusts (i.e., macroscopic) are heterogeneous, therefore the calculated crustal deformation becomes heterogeneous. 4. Stress around dike increases. 5. Stress field is subject to local deformation.

Keywords: Discrete Element Method, simulation, magma, dike intrusion