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Numerical simulation of source process for volcanic earthquake consisting of dike and fault

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Volcanic long-period earthquakes or low-frequency earthquakes have variety in observed waveforms. Source mechanisms of these volcanic earthquakes occasionally accompany harmonic oscillations that follow P- and S-waves. This result suggests that such volcanic earthquakes are not generated only from a seismic fault but also from a source that can resonate. In this study, we numerically calculate the dynamic process of the volcanic seismic source consisting of dike and fault for understanding the mechanism of a variety of volcanic earthquakes.

We suppose that a dike and a weak plane are orthogonal and are located close to each other. A fluid motion in the dike and elastic wave propagation are simulated by using the elastic wave equations. The weak plane obeys the slip-weakening law as a constitutive law of friction. We use a finite difference method with staggered grid. We gradually increase the pressure of the fluid. As a result, shear stress increases on the weak plane. When the shear stress exceeds a threshold, a rupture starts. However, the region stressed by the pressure increase of dike is restricted in the tip of the dike, the rupture stops when the shear stress is small. The rupture velocity is almost a half of S-wave velocity of the elastic media. Such faulting process release the pressure in the dike, and the resonance of dike starts when the rupture starts. As a result, P- and S-waves followed by harmonic oscillations are observed at stations around the source region.

We examine the effects of a position of the weak plane, a bulk modulus of the fluid in the dike and a dynamic friction coefficient used the constitutive law of friction. Even when the position of the weak plane is close to the dike, the rupture sometimes doesn't occur. When the length between the dike and the weak plane is short or the bulk modulus of the fluids in the dike is large, the resonance of the dike becomes large. When the dynamic friction coefficient is small, the length of the fault is long and the resonance of the dike is large. These results suggest that the ratio of the amplitudes of harmonic waves to the P- or S-waves can easily change about 10 times by change in these parameters.