Modeling of fluid-filled crack using boundary integral method

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Volcanic tremors have been observed around many active volcanos in the world. These tremors are considered to be generated by the motion of volcanic fluid like magma and volcanic gases, and the elucidation of these signals is one of the critical keys to understand the dynamics of the volcanic system.

In this study, as a tool to interpret the source process of volcanic tremors quantitatively, we develop a method to numerically simulate the dynamics of a fluid-filled crack which is considered to be one of the most plausible models of the source of volcanic tremors. We formulate the motion of fluid and elastic solid inside and outside the crack using boundary integrals, and develop a numerical scheme most suitable to solve dynamic interactions between fluid and elastic solid. Since the final goal of this chapter is to develop a stable and efficient method to simulate the dynamics of fluid-filled crack over the wide range of material properties and crack geometries, we employ the following computational procedures: First, we derive the expressions of the motion of the medium inside and outside of the crack as integrals over a distribution of the displacement of the crack wall in the frequency domain. Then we expand the unknown distribution of the surface displacement using a set of continuous basis functions (Chebyshev polynomials of the second kind), and determine the weight of each basis function using a point collocation method such that the boundary conditions on the crack surface are satisfied.

The newly developed method is more efficient compared to the conventional modeling method using the time-domain finite difference method, and enables us to study the dynamics of the fluid-filled crack over the wide range of physical parameters. Another advantage of the method is the accurate estimation of the attenuation of crack resonance which is indispensable factor to estimate the properties of the fluid inside the crack. The method is designed to be flexible to many applications which may be encountered in volcano seismology, and the extension of the method to more complicated problems is promising.