Internal Deformation Fields due to an Isotropic Expansion in an Elastic-Viscoelastic Layered Half-Space

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In the framework of elasticity theory any indigenous source can be represented by a moment tensor. We have succeeded in obtaining general expressions for internal deformation due to a moment tensor in an elastic/viscoelastic multilayered half-space under gravity. First, starting from Stokes' classical solution, we obtained the expressions for static displacement fields due to a moment tensor in an infinite elastic medium. Then, performing the Hankel transformation of the static solution in Cartesian coordinates, we derived static displacement potentials for a moment tensor in cylindrical coordinates. Second, representing internal deformation fields by the superposition of a particular solution calculated from the displacement potentials and the general solution for a layered elastic half-space without sources, and using the generalized propagator matrix method, we obtained exact expressions for internal elastic deformation fields due to a moment tensor. Finally, applying the correspondence principle of linear viscoelasticity to the elastic solution, we obtained general expressions for quasi-static internal deformation fields due to a moment tensor in an elastic/viscoelastic multilayered half-space.

There are many ways to decompose a moment tensor into several independent force systems. It is natural to decompose a moment tensor into two force systems corresponding to isotropic expansion and displacement discontinuity across an internal surface. The displacement discontinuity vector can be decomposed into the normal and tangential components, which correspond to crack opening and shear faulting, respectively. Therefore, we can decompose a moment tensor into three independent force systems corresponding to isotropic expansion, crack opening and shear faulting. This decomposition is natural and always possible by solving the eigenvalue problems of moment tensor.

As for isotropic expansion we may consider two different cases; transformational volume expansion and pressure increase in a spherical cavity. The general expressions include the former case, but not the latter case. In elastic problems we can directly obtain the expression for uniform pressure increase in a spherical cavity by replacing the corresponding factor. In viscoelastic problems, however, the solutions for these two sources have quite different time-dependence from each other if the source is located in the viscoelastic layer, because the source vector in the latter case includes the rigidity, which should be replaced with the Laplace operator.

In this study, we computed the quasi-static internal displacement fields associated with magma intrusion in a two-layered elastic-viscoelastic half-space.