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The expressions for deformation fields due to a moment tensor in a poroelastic half-space

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According to the recent studies on postseismic deformation, the top of the crust has poroelastic properties in which the elastic deformation of the crust and the pore fluid flows couple. In order to infer exactly the internal processes such as fault slips from the ground deformation, it is necessary to formulate the effect of poroelastic deformation. So far, solutions on poroelastic deformation have been separately obtained for different sources as displacement discontinuities and water injections. In this study, using a moment tensor as the general internal source, we derived general expressions for poroelastic deformation in a poroelastic layered half-space.

As a beginning, we derived the expressions for displacement potentials due to a moment tensor in an infinite isotropic poroelastic space in cylindrical coordinates. First, displacements due to a moment tensor was easily obtained by differentiating the existing expressions for displacements due to an impulsive force with respect to source coordinates. In general, poroelastic solutions are time-dependent. Thus, we performed Laplace transformation to replace the time-dependent parts by Laplace variable for the later derivation. Next, these expressions were transformed from Cartesian coordinates to cylindrical coordinates for the parallel-layer structure problem. Finally we applied Hankel transformation to the displacements and decomposed them into the expressions for static displacement potentials. In the case of poroelastic problems, we have three displacement potentials for solid displacements corresponding to elastic problems and one potential for pore pressure (Biot potential). As for the potentials obtained here, the three displacement potentials satisfy the Laplace equation, and Biot potential satisfies diffusion equation.

The solution obtained above is the particular solution of the inhomogeneous differential equation in the mathematical context, which corresponds to the direct effect due to the internal source. Adding the particular solution to the mode solution of the layered structure (homogeneous solution) and applying the propagator matrix method, we can obtain the solution for the layered half-space due to the source. We extend the propagator matrices in the elastic problem to those in the poroelastic problem and solved the deformation in the poroelastic layered half-space. The expressions obtained in this study are the Laplace transformed solution and the solution in the time domain can be numerically obtained by the inverse Laplace transformation.

Keywords: poroelasticity, Internal deformation, Layered half-space model, Moment tensor, Mathematical formulation, Pore pressure