Geophysical Research Abstracts
Vol. 14, EGU2012-6792, 2012
EGU General Assembly 2012
© Author(s) 2012

2-D FDTD computation of seismoelectric fields excited by an underground double couple in a horizontally layered formation

Z. Wang, W. Guan, Y. Gao, and H. Hu
Harbin Institute of Technology,Harbin, China (guanw@hit.edu.cn)

Electromagnetic signals have been recorded during earthquakes (e.g. Karakelian et al., 2002). One important mechanism for the coupling between the elastic and the electromagnetic energies is the electrokinetic effect. Gao and Hu (2010) simulated the electromagnetic fields excited by a double couple by solving analytically the set of equations derived by Pride (1994), which combines the Biot equations with the Maxwell equations. However, analytical solution is not available when the geological structure is complex. Numerical methods are thus needed to solve for the seismoelectric fields.

In the present work, seismoelectric fields excited by an underground double couple in a horizontally layered geological structure are computed by solving the Pride equations with a finite-difference time-domain (FDTD) algorithm with 2-D grids. A double couple source represents a small fault, and it has no axisymmetric nature. However, as the layered formation is axisymmetric, we only need to solve a 2-D problem by Fourier transforming the seismoelectric fields from the azimuthal angle θ domain to the corresponding wavenumber m domain in cylindrical coordinates. Further, we can prove that $m \leq 2$ for a double couple source. 2-D FDTD grid is developed, and the perfectly matched layer technique (Guan and Hu, 2008) is applied to truncate the computational region. The radiation pattern of the double couple is computed. The seismic and the electromagnetic fields on the surface of the layered formation are obtained and compared to the analytical results given by Hu and Gao (2011). Good agreements between the FDTD results and the analytical solutions show the validity of our FDTD algorithm. Extension to a general 3-D problem is under way.

A key issue involved in our modeling of the earthquake source in a porous medium is to find out the body forces in the Pride equations. We point out that if Biot (1956) theory (which is one base of Pride equations) is used, no equivalent force should be loaded on the fluid phase, and the equivalent double couple is loaded only on the solid phase. That is because in the constitutive equations used by Biot (1956) the shear stresses due to the rate of the shear strains of the fluid are neglected.

This study is supported by the Natural Science Foundation of China by project No.41174110.

References

Gao, Y., and Hu, H., 2010, Seismoelectromagnetic waves radiated by a double couple source in a saturated porous medium, Geophys. J. Int., 181, 873-896

Guan, W., and Hu, H., 2008, Finite-difference modeling of the electroseismic logging in a fluid-saturated porous formation, Journal of computational physics, 227, 5633-5648

Hu, H., and Gao, Y., 2011, Electromagnetic field generated by a finite fault due to electrokinetic effect, Journal of geophysical research, 116, B08302, 1-14

Karakelian, D., Beroza, G. C., Klemperer, S. L., et al., 2002, Analysis of ultralow-frequency electromagnetic field measurements associated with the 1999 M7.1 Hector Mine, California, earthquake sequence., Bull. Seism. Soc. Am., 92, 1513-1524

Pride, S. R., 1994, Governing equations for the coupled electromagnetics and acoustics of porous media, Phys. Rev. B., 50, 15678-15696