SIMULATION OF THE SEISMO-ELECTROMAGNETIC FIELD DURING AN EARTHQUAKE

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Summary Reported in this short paper is our recent investigation into the seismo-electromagnetic field during an earthquake due to electrokinetic effect. The rock system is seen as a horizontally layered porous medium with a rupturing fault in it. To model the large rupturing earthquake fault, we stack the wavefields excited by a succession of small-sized slipping faults which are equivalent to double couples. Comparing the snapshots of the simulated electric and magnetic wavefields to the seismic wavefield, one can see electromagnetic signals accompanying the seismic waves, with stronger signals on the slip-propagating edge. Near the surface of the earth, the vertical component of the electric field is two orders greater than the horizontal components. An important feature of the earthquake-induced electric field is the existence of a slowly decaying remanent field near the surface above the fault after the seismic wave has propagated away.

THE ELECTROKINETIC COUPLING IN A POROUS MEDIUM

Electric and magnetic signals have been recorded during many earthquake events in the past 20 years. Understanding these signals is important for prediction and monitoring of earthquakes. Among the many mechanisms for these seismoelectromagnetic signals is the electrokinetic effect, which is due to the existence of surplus ions in the movable part of pore fluid in a permeable rock system. When a seismic wave propagates in a porous rock, the pressure difference between a peak and its neighboring trough of the wave will cause a flow of fluid through the porous rock, and result in a convection current and an electric voltage, which in turn brings about a conduction current opposite to the convection current. Pride[1] derived a set of equations that combines the Biot theory of poroelastodaynamics and the Maxwell equations of electromagnetics, with an experimentally determinant factor called the electrokinetic coupling coefficient. In this study we quantitatively model and analyze the earthquake-induced electromagnetic field due to electrokinetic effect.

THE EARTHQUAKE MODEL AND THE SIMULATED WAVEFIELD

Consider a horizontally layered porous medium with a rupturing fault in it, as in Figure 1. An earthquake event can be modeled as a succession of microfaults, rupturing at a speed from one microfault to another. Each of these microfaults

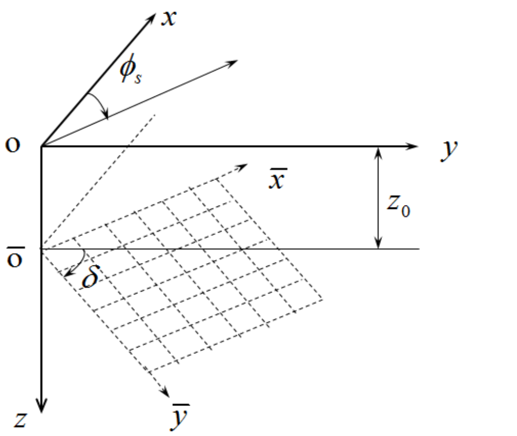

Figure 1. Geometry and discretization of the fault surface in the earth surface Cartesian coordinates. ϕ_s and δ are strike and dip angles respectively.

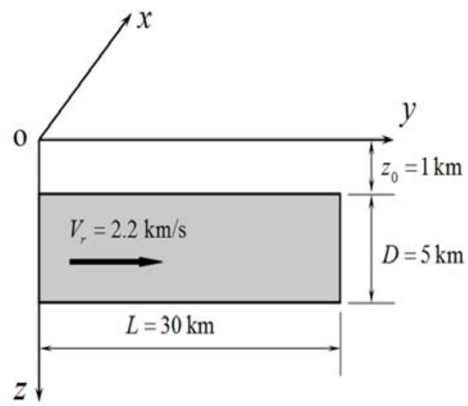

Figure 2. A vertical strike-slip fault in a homogeneous half-space.

can be seen as a point double-couple source. Gao and Hu[2] have derived the Green functions for the seismic,electric, and magnetic fields caused by a double couple in a uniform porous medium with infinite extension in space. In a horizontally layered system, the seismoelectric field can be formulated in the surface harmonic coordinates with a discontinuity vector representing the double couple source [3,4]. Here we give an example to reveal some of the features of seismoelectric field during an earthquake. Let us consider a strike-slip fault in a homogeneous porous half space (Figure 2), with both the strike and the dip angles being 90 degrees. The fault ruptures from the left to right with a speed of 2.2km/s. The rock has a porosity of 10% and is saturated by water with a salinity of 10^{-3} mol/L. The snapshots of the

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simulated electric field are shown in Figure 3. The seismic field and magnetic field are also calculated, but not displayed here due to limited space. There are electric and magnetic signals accompanying the seismic waves, with stronger signals on the rupture propagating edge. Near the surface, the vertical component of the electric field is two orders greater than the horizontal components. An important feature of the earthquake-induced electric field is the existence of a slowly decaying remanent field near the surface above the fault after the seismic wave has propagated away.

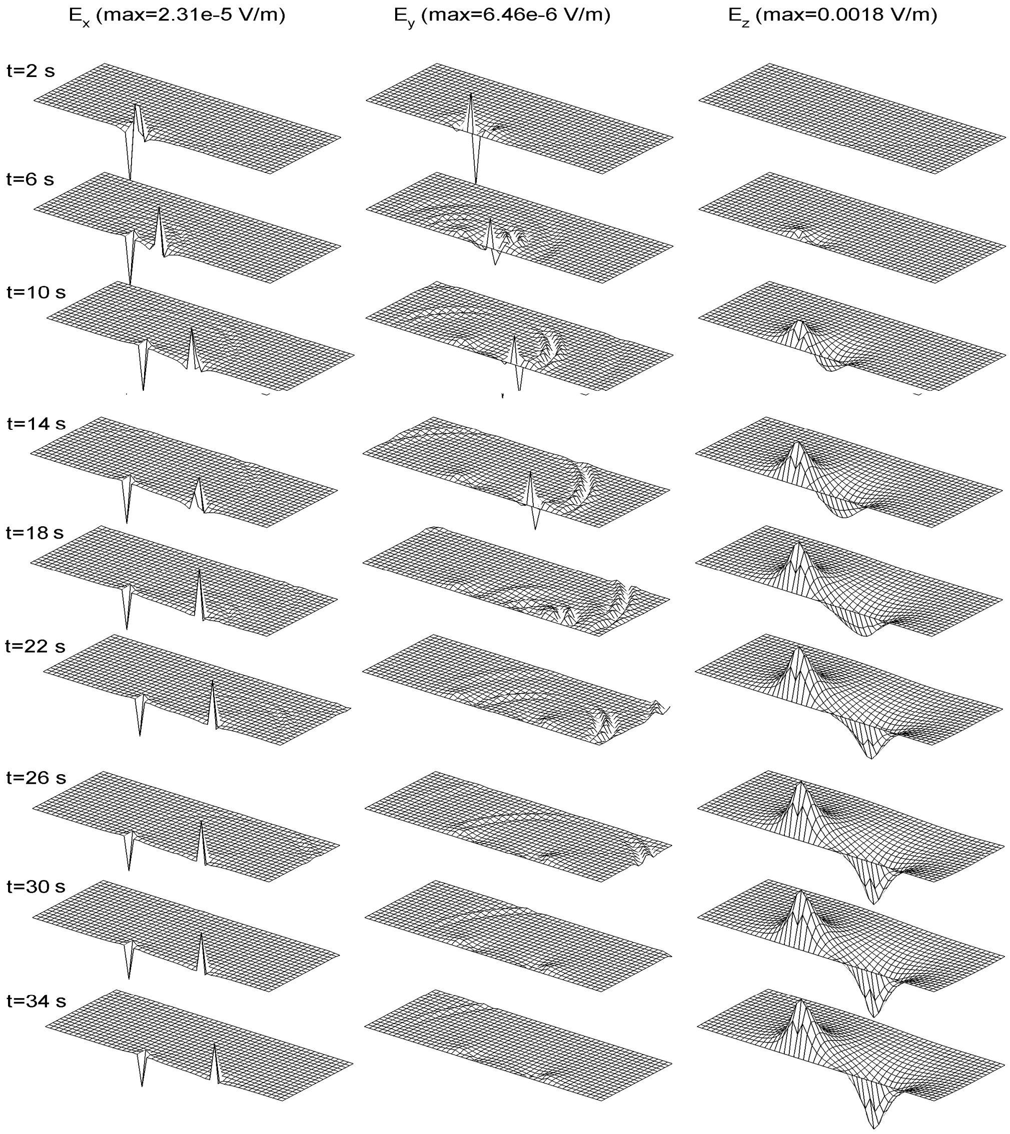

Figure 3. Snapshots of the electric field generated by the strike-slip fault in a homogeneous half-space. The receiving positions are in the domain ($x \in [0\ \text{km}, 38\ \text{km}]$, $y \in [-40\ \text{km}, 58\ \text{km}]$, $z = 1\ \text{m}$)

CONCLUSIONS

We have performed seismoelectromagnetic calculations based on the Pride equations. From the simulated field, we see electric and magnetic signals traveling with seismic waves. The vertical component of the electric field is two orders stronger than the horizontal components. And there is a remanent electric field that decays very slowly. This study is supported by the Natural Science Foundation of China by project No.41174110 and the Special Research Funds of Seismology in China (No.200808072).

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