Earthquake-induced electromagnetic field due to electrokinetic effect

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Electromagnetic fields generated by earthquake events were usually reported and have drawn a lot of attentions. They can be detected before, during and after the seismic arrivals after earthquake rupture started, and are referred to as the co-rupture, coseismic and post-seismic EM signals, respectively. The co-rupture EM signal is of great importance since it arrives earlier than the seismic waves, especially the destructive shear and surface waves and has potentials in earthquake early warning and hazard reduction. The coseismic EM signal arriving simultaneously with the seismic waves are also valuable since it contains the information of the subsurface medium in the vicinity of the EM sensors. However, how these kind EM signals are generated is still controversial. Several possible mechanisms have been proposed to explain the earthquake-induced EM signals, e.g., the electrokinetic effect, the piezoelectric effect, the motional induction effect, etc.
In this study, we present the theoretical simulations of the earthquake-induced EM signals on the basis of the electrokinetic effect. This result shows that due to the electrokinetic effect the earthquake can generate co-rupture EM signal, which arrives immediately after the onset of the earthquake and much earlier than the seismic arrivals. It arrives at different EM sensors simultaneously. The earthquake can also generate coseismic EM field which arrives simultaneously with the seismic waves. Besides, our simulations indicate that when the earthquake fault rupturing stops and the seismic waves pass far away, the magnetic field vanishes while the electric field near the fault remains, decaying slowly and lasting for hundreds of seconds. The near-fault poseismic electric fields hold similar features to some field observations in literature. We apply our theoretical simulations to explain the coseismic EM data observed during the 2004 M_w6 Parkfield earthquake. By using a finite fault source model obtained via kinematic inversion, we calculate the electric and magnetic responses to the earthquake rupture are calculated. The result shows that the synthetic electric signals agree with the observed data for both amplitude and wave shape, especially for early portions of the records after the earthquake. Our simulations supports the electrokinetic effect as the reasonable mechanism for the generation of the earthquake-induced electric fields.
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