Induced electromagnetic field by seismic wave in earth's magnetic field: a 2D layered case

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Because the earth crust is conductive, ground motions in the ambient geomagnetic field can produce an electromotive force as well as a motional induction electric current, which then gives rise to electromagnetic (EM) fields. Such a phenomenon is called the motional induction effect. Our previous study based on a full-space model has proven that the motional induction effect is an efficient mechanism for the generation of the earthquake-induced EM signals. The present study aims to reveal the properties of the motional-induction electromagnetic fields in a layered model. For simplicity we consider a 2D structure, and use a set of governing equations that couple the 2D elastodynamic equations for the P-SV waves and the Maxwell equations. We first transform the governing equations to a system of first-order ordinary differential equations and then solve the seismic and EM fields using the general reflection and transmission matrix method. A moment tensor line source is applied to represent the earthquake source. After the line-source seismic and EM responses are achieved, we finally convert them to the point-source responses to obtain the correct amplitudes. The results show very clear coseismic electric and magnetic signals accompanying both the P and S waves as well as the Rayleigh waves. We simulate an Mw6.1 earthquake, and find that the seismic acceleration at a receiver of epicentral distance of about 100 km is on the order of 0.1 m/s^2. The electric and magnetic fields are respectively on the orders of 1V/m and 0.1nT. The amplitudes of the synthetic seismic and EM signals agree with the observed data, proving again that the motional induction effect is an effective mechanism for the generation of the earthquake-induced EM fields. Our simulations also show that the azimuth of the wave propagation (or ground motion) with respect to geomagnetic field has great impact on the EM fields. That is because the motional induction effect arises from the action of cutting the magnetic line of force.

This work is supported by National Natural Science Foundation of China (grants 41474038, and 41774048).

Key Words: earthquake, seismic wave, electromagnetic field, motional induction effect