Electromagnetic fields generated by an earthquake due to the motional-induction effect

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When seismic waves propagate in the conducting crust, they make the crust material move and cut the ambient geomagnetic field, and hence product electromotive force and induction electric currents, which give rise to variations of electromagnetic (EM) field. The coupling between the seismic waves and EM disturbances is called motional induction effect and it is a possible mechanism for the anomaly EM disturbances that were observed during earthquake events. In this work, we study the properties of the EM field generated by an earthquake due to such a mechanism. By solving the governing equations that couple the elastodynamic equations with Maxwell equations, we derive the seismoelectromagnetic wavefields excited by a single point force and a double couple source in a full space. Two types of EM disturbances can be generated, i.e., the coseismic EM field accompanying the seismic wave and the independently propagating EM wave which arrives much earlier than the seismic wave. Simulation of an M_w 6 earthquake shows that at a receiving location where the seismic acceleration is on the order of 0.01 m/s^2, the coseismic electric and magnetic fields are on the orders of 1 μV/m and 0.1nT, respectively, agreeing with the EM data observed in the real earthquake, and indicating that the motional induction effect is effective enough to generate observable EM signal. The motional induction effect is compared with the electrokinetic effect, showing the overall conclusion that the former dominates the mechanoelectric conversion under low-frequency and high-conductivity conditions while the latter dominates under high-frequency and low-conductivity conditions.

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