Seismoelectromagnetic conversions generated by a double-couple source in partially saturated media.

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Seismoelectromagnetic conversions of electrokinetic origin have triggered new interest since the theory for the coupled propagation of seismic and electromagnetic (EM) waves was reformulated by Pride (1994). Over the last couple of decades, several modelling programs were developed to simulate seismoelectromagnetic propagation. Most of these programs share in common that they only allow to model point sources, well suited to simulate seismic surveys, but inappropriate when attempting to simulate earthquakes, often described using a double-couple source.

In this work, we present a program allowing to model the seismoelectromagnetic waves triggered by a double-couple source, based on the Synthetic Kennett Bouchon Program (SKBP) developed by Garambois & Dietrich (2002); this program is modified to account for partial saturation conditions (Warden et al., 2013) and high salinities (Vinogradov et al., 2010). We implement both M13+M31 and M12+M21 geometries. We validate our program by comparing its results with those obtained by modelling a double-couple source through a numerical derivative and find excellent agreement between both approaches. We then study the symmetry properties of the waves generated by this new source type for a homogenous half-space.

We then perform a sensitivity study considering a simple tabular medium consisting of a homogeneous layer overlying a homogeneous half-space. When considering a source of frequency fpeak=40Hz of magnitude Mw=1, located 4km below the ground surface and 1.5km below the boundary between both media, we model coseismic electric field amplitudes of the order of several hundreds of μV.m−1. Analyzing these amplitudes in the light of magnetotelluric measurements suggests that even a microearthquake could trigger a coseismic response large enough to be measured at the ground surface.

We also study the characteristics of the interface response (IR) generated at the boundary between the two homogenous media for a M13+M31 double-couple and show that this IR consists of a conversion between an incident S wave and a converted EM wave; its amplitude variations can be approximated by those of a horizontal dipole located at the boundary. We also quantify the contributions of the SH and SV polarizations to the total converted amplitude and find that although the SH waves are coupled to the Transverse Electric (TE) mode, they contribute to the Transverse Magnetic (TM) mode component of the electric field through the IR.

We conclude our study by considering a more realistic model, designed to approximate the context of a geothermal field. We also provide examples of possible coseismic signals observed in electric and magnetic data acquired during geothermal monitoring experiments.

Keywords: Electrokinetic conversions, Seismoelectric imaging, Induced seismicity monitoring