# Potential and limits of Seismo-electromagnetic wave conversions for geophysical imaging

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Conversion between seismic and electromagnetic waves originates from electrokinetic phenomena occurring at the pore scale in wet poroelastic media. There is a reciprocal electro-seismic phenomenon where electromagnetic sources can generate seismic waves due to pore-scale electro-osmotic effects. At the macroscopic scale, electrokinetic phenomenon generates two distinct effects: i) co-seismic local electric and magnetic fields, accompanying P- and S-waves respectively and ii) electromagnetic disturbances created at deep interfaces when seismic waves pass through them. These seismo-electromagnetic couplings, and particularly those occurring at interfaces, have long been recognized as an emerging and original geophysical technique because they theoretically offer the resolution capacity of the seismic reflection technique associated to the sensitivity to elastic and fluid properties contrasts that are generally imaged using low-resolution electric or electromagnetic methods. This interest has considerably grown since the macroscopic governing equations controlling the propagation of seismo-electromagnetic waves have been obtained in 1994. This theoretical work has led to a better understanding of the coupling properties, initially through numerical modelling developments, which have then been pursued by laboratory and field-scale experiments as well as specific signal processing developments. However, despite all these efforts, this method is slow to be operational, mainly because of the difficulty in clearly detecting the deep-generated electromagnetic disturbances, whose amplitude is weak compared to co-seismic signals and to electromagnetic noise.

After a presentation of the phenomena and effects involved in seismo-electromagnetic conversions, we propose first to review the main results obtained through numerical, laboratory and field-scale studies, as well as the difficulties encountered for each approach. In a second step, we will present some recent numerical extensions to unsaturated media and to electro-seismic phenomenon. Finally, we will introduce an original acquisition approach dedicated to seismo-electromagnetic signals, which could pave the way for an operational geophysical tool. This approach takes benefit from multi-electrode arrays, which have been tested both numerically and experimentally, and which could dramatically increase the interface response compared to others electromagnetic signals.