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Experimental evidence for seismoelectric observations at field scale

Julia Holzhauer and Ugur Yaramanci
Leibniz Institut für Angewandte Geophysik (LIAG), Hannover, Germany (Julia.Holzhauer@liag-hannover.de)

In the past decades, seismoelectric has concentrated a growing interest as a promising tool for hydrogeophysical studies. Resulting from an electrokinetic coupling in porous saturated media traversed by an acoustic wave, this method could ultimately offer a direct access to various hydraulic parameters ranging from porosity to permeability or fluids conductivity. In some other aspects it also occasionally showed some ability to thin-layer resolution.

Within the development of the new test-site Schillerslage with typical north-German geology, consisting of two shallow quaternary aquifers separated by a till layer over cretaceous marl, we tested the observability of the seismoelectric signal along with various conventional (seismic, georadar, geoelectric) and unconventional (magnetic resonance sounding -MRS, spectral induced polarisation -SIP) geophysical methods as well as boreholes analysis. The special focus was on the converted seismoelectric signal, an electromagnetic wave acting as a vertical dipole which should theoretically display on the seismoelectrogram as a horizontal arrival. This converted wave appears when the incident acoustic wave meets a hydraulic discontinuity affecting the pore space in any geometrical or chemical manner. This electromagnetic signal fades out rapidly, due to its dipole nature and its weakness, so that its relevance is restricted to the near surface characterisation. In the given setting, such a wave could either initiate at the water table or originate from an abrupt transition from sand to till.

Decision was made to record both seismic and seismoelectric signal concomitantly. To allow the detection of the later signal, the field layout was gradually adjusted. Considering the source, hammer-seismic was chosen for its precision in near surface application and automatic trigger-techniques producing major disturbances in the first 10 ms of the seismoelectrogram were abandoned in favour of manual triggering. To avoid any further noise due to metal displacement in the earth's magnetic field both hammer and plate were chosen non-magnetic. As for the acquisition-chain, it was improved by rejecting the DC component of the electric fields (occasionally saturating the seismic transient-recorders) thanks to new designed preamplifiers. Some recent testing using Vibroseis-seismic yielded encouraging results although some amendments have to be made concerning the optimal distance to the source. With basic processing, we successfully observed both coseismic and converted seismoelectric signals in the field data. The laters were identified by matching their amplitude distributions with that of a vertical dipole with adjustable depth stemming from the first Fresnel zone.
Well-attended column experiments, using sorted glass beads and controlling the nature and depth of the interfaces are undertaken, with special focus on the porosity, the permeability and the pore radii distribution of the pileup. These allow a better understanding of seismoelectric waves with regard to the sensitivity of amplitudes to various hydraulic parameters, and should guide the quantification of those.