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The seismoelectric method - examples of successful field studies

M. Strahser (1), K. Iwanowski (1), C. Klein (1), W. Rabbel (1), C. Stadtler (2), U. Werban (1)

(1) Kiel University (mstrahser@geophysik.uni-kiel.de, Fax: +49-431-8804432)
(2) Federal Institute of Geosciences and Natural Resources (BGR)

Summary

The propagation of seismic waves in porous rocks is associated with a small transient deformation of rock matrix and pore space which can cause electromagnetic fields of observable amplitude if the pores are saturated. Seismoelectric field measurements are expected to help localize permeable layers in porous rocks and provide information about anelastic properties such as hydraulic permeability or fluid chemistry. This theoretical potential for hydrogeological applications, however, is so far confirmed only by a very limited number of reliable field studies. In addition, these studies usually show only one example of a successful detection of seismoelectric signals. As a consequence, the seismoelectric method is still far from being routinely used. We present a number of field data examples which prove a successful detection of the seismoelectric wave converted from seismic compressional waves at a layer boundary. Our data include the mapping of a 2D-structure. Seismic, radar or borehole data confirm the validity of the seismoelectric results at several measurement areas, which shows that our successful detections are not isolated strokes of luck.

Introduction

Two main types of seismoelectric waves, named type-I and type-II in the following, respectively, are predicted by theory and can also be detected in the field:

1. Seismoelectric waves carried along the seismic ray path synchronously with compressional waves. These waves are thought to origin from local variations of ion density caused by P-waves through compression and dilatation of the pore space. Also surface waves were observed to cause this type of signals (Garambois & Dietrich, 2001). In homogeneous media no electromagnetic wave is radiated. This electric field is also called the coseismic field.

2. Seismoelectric waves with almost “infinite” apparent velocity (on a seismic time scale) which have their origin in the subsurface at boundaries separating layers of different elastic, electric or hydrological properties (e.g. Haartsen & Pride, 1997). Here, incident seismic waves can cause an unbalanced dynamic charge separation acting as a source of an electromagnetic field (multipole field with a strong vertical dipole component, see Haartsen & Pride, 1997). These electromagnetic waves are also called converted waves and have the potential to provide information about the subsurface. In seismoelectrograms they appear at seismic one-way travel-time and usually have a much lower amplitude than the less informative type-I seismoelectric signals.

Instrumentation

Data were recorded by a 48-channel Bison seismograph, 10 Hz vertical component geophones and steel electrodes. Sensor spacing was 1 m, and the electrodes were coupled to dipoles of 4 m electrode distance. We connected each dipole to a galvanically insulated amplifier in order to keep the relative noise level as low as possible. Seismic signals were generated with a man driven 6 kg sledge hammer hitting a groundplate. For seismic measurements ten shots were stacked, for seismoelectric ones usually twenty.

Measurements and results

The measurement location Menzlin near Anklam in north-eastern Germany is characterized by a dune-like sand layer above a ground moraine. The dipping boundary between these layers was mapped with GPR (200 MHz antenna) and seismic refraction measurements. With the velocity information from the seismic data we were able to obtain the seismic one-way travel-time at which the seismoelectric converted waves (type II) should be detected at the sensors at the surface.

We set up the seismoelectric profile after having removed the geophones in order to avoid crosstalk between the geophones and the dipole sensors. As the location is situated rather remote, the level of background noise was very low and consequently no noise had to be removed from our data. Using a velocity filter in the frequency-wavenumber domain we separated the two seismoelectric wave fields from one another. Data from several shot points do indeed exhibit converted seismoelectric waves at the expected arrival times. We were thus able to map the dipping interface, i.e. a 2D structure, using the seismoelectric method. Successful measurements from other recording locations, some of which are confirmed by borehole data, prove that the detection of converted seismoelectric waves is possible not only in isolated cases.

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References

Garambois, S. & Dietrich, M. (2001): Seismoelectric wave conversions in porous media: Field measurements and transfer function analysis, Geophysics, Vol. 66, No. 5, 1417-1430.

Haartsen, M. & Pride, S. (1997): Electroseismic waves from point sources in layered media, J.Geoph.Res., Vol. 102, No. B11, 24,745-24,769.