Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SCG15-P01 Room:Convention Hall Time:May 24 18:15-19:30

Towards Seismoelectric Inversion: Sensitivity Analysis using Resolution Functions

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When a mechanical wavefield propagates through a porous, fluid-filled medium, a complex physical phenomenon called the seismoelectric effect can occur. Due to the presence of an electrical double layer at the microscale, coupling between the mechanical wavefield

and electromagnetic fields can occur. Pride (1994) has developed a set of governing equations that describes the seismoelectric effect using Biot's poroelasticity equations coupled to Maxwell's electromagnetic equations. Coupling effectively takes place at two locations:

1) Inside the seismic wavefield, copropagating with the seismic wave velocity and therefore referred to as the coseismic field. This field provides us with local information in the vicinity of the receivers.

2) At locations where contrasts in medium parameters occur (for example interfaces) an independently diffusing electromagnetic field is generated, referred to as the interface

response field or seismoelectric conversion. The seismoelectric method tries to take advantage of this subsurface coupling as a geophysical tool for exploration or monitoring purposes, as well as for borehole applications. Besides providing us with seismic resolution and electromagnetic fluid–sensitivity at the same time, several studies have also shown that seismoelectric fields can provide us with supplemental information about porosity, permeability and pore-fluid properties such as viscosity. The seismoelectric method can potentially be used for the detection and monitoring of oil/water contacts, several (near–)borehole applications and the monitoring of aquifers.

However, the seismoelectric effect is described by a combination of many (often mutually related) subsurface parameters. Therefore, inversion of seismoelectric data for a specific parameter is costly and solving for such a parameter uniquely might be even impossible. By carrying out sensitivity analyses prior to inversion, we can investigate whether the measured fields are actually sensitive to the parameter(s) of interest. In addition, sensitivity analyses can provide information about the optimal acquisition design or help us investigating time–lapse perturbations. We will start by explaining the theory of resolution functions using a seismoelectric example. We will derive the seismoelectric resolution function for inversion for a bulk density contrast. We will compute this resolution function as the least-squares solution to the normal equation. We will demonstrate the effectiveness of this method by first carrying out a purely electromagnetic sensitivity analysis for a point perturbation in conductivity. These results will be compared with literature results. As a next step, we investigate the electromagnetic sensitivity to point scatterers above and below highly conductive layers. Finally, we will present the results of the fully–coupled seismoelectric sensitivity analysis for a bulk density contrast, using single–frequency multicomponent line data.

Keywords: Seismoelectric, electromagnetic, resolution function, sensitivity analysis

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SCG15-P02 Room:Convention Hall Time:May 24 18:15-19:30

Application Prospects of SKZ-1 4-component borehole strain meter

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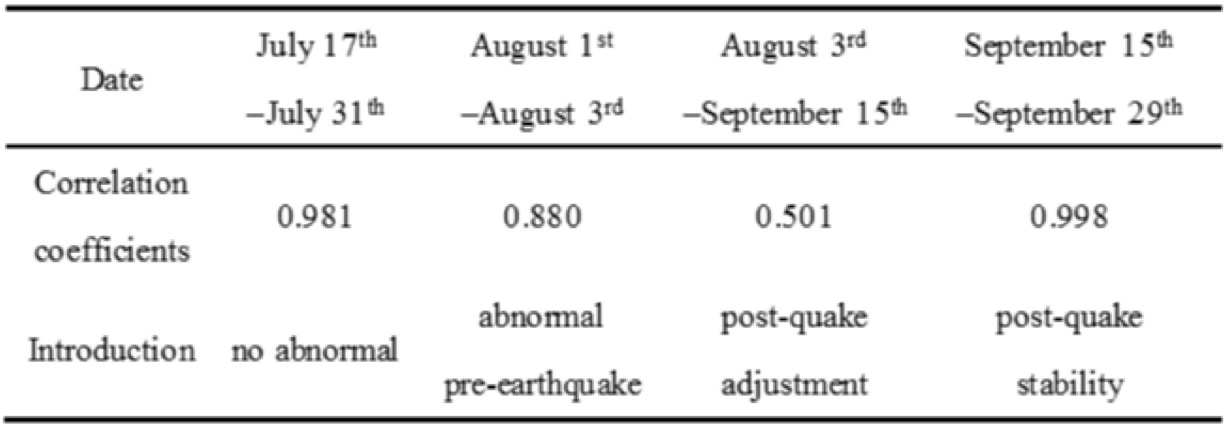
High sensitivity borehole strain meter has good dynamic performance, work stability, anti-interference ability in detecting the regional crustal activity. The structure using four sensing elements that were set at intervals of 45 degree can have a simple ”reliability test formula of measurement data” to realize the real-time inspection of data reliability. This method of work has become an important detection means of multi-component borehole strain observation in Mainland China. The structure of the new model introduced by this paper has been confirmed that it can obviously improve the mutual verification result of strain measurement data because the important improvements have been made on displacement transfer structure of underground instrument, and the borehole strain meter has got two pre-seismic anomaly information in experimental observation in ZhaoTong area, YunNan. Now the types of equipment submitted to this conference is expected participants to consider if it can be used in electromagnetic wave observation station network and become an auxiliary observation means that is matching.

The instrument feature are that it uses four sensing elements that were set at intervals of 45 degree and checking formula is simple and clear: U1+U3=U2+U4. Reliability of observation has been obviously improved because four elements are embedded in the 8 narrow ribs. Cross check degree of the data has reached 0.99.

Preliminary results: 1. M5.7 YiLiang earthquake occurred (longitude 104.00, latitude 27.5) at 11:19 on September 7th, 2012. Seven days before the earthquake, obvious strain anomaly of four directions appeared at the same time in YiLiang Seismic Station which epicenter distance is 15.5km. But in DaGuan Seismic Station which epicenter distance is 30km, correlation coefficient of the two surface strain curve is 0.99 or so, there was no significant association with this earthquake. NS and NW data signals of the borehole strain meter appeared low frequency noise 11-17 minutes before the M5.7 DaGuan earthquake, and the earthquake occurred two minutes after the end of noise. In this earthquake, what is difficult to understand is that the low frequency signal curve shape is different between the NS curve and NW curve. Cycle of NS is about 15s and the cycle of NW is about 60s. But NE, EW data curve did not appear similar situation and the relationship between the low frequency data of four components did not conform to checking formula. The cause of this kind of signal is unclear but it may be a extremely important clue. We suspect that it may be connected with the underground electromagnetic signal because it doesn’t conform to checking formula. 2. The LuDian M6.5 earthquake occurred on August 3, 2014, epicenter was located 26km southwest of LuDian Seismic Station. Except that strain data appeared changes 3 days before the earthquake, the correlation coefficient of surface strain have different values in different stages of earthquake.

Keywords: Borehole strain, Observation technology, Pre-seismic anomaly information



Date	July 17th –July 31th	August 1st –August 3rd	August 3rd –September 15th	September 15th –September 29th
Correlation coefficients	0.981	0.880	0.501	0.998
Introduction	no abnormal	abnormal pre-earthquake	post-quake adjustment	post-quake stability