Seismoelectric Ground-flow
DC-4500 Locator
Introduction

The seismoelectric survey is a new technology combined the electro kinetic potential method and geophysical technology. It is applied directly to locate a groundwater aquifer to deduce the associated petroleum hydrocarbon reservoir fluids with high accuracy, low cost, site access, portability, and simple operational procedures in the field.

The seismoelectric survey is different from the conventional seismic prospecting or the electrical resistivity survey, which separately register either a seismic impulse velocity or electrical resistivity sounding data in the geological structure. Seismoelectric survey uses the different physical characters between the ground-flow (water and oil) and the earth solid (rock or soil) to locate ground-flow directly. Seismoelectric survey can also work with seismic survey. By using the same seismic source, we can get both seismic data and seismoelectric data at the same time. The seismoelectric data can be used as pseduo-well log data and projected to the seismic section.

DC-4500 Seismoelectric Ground-Flow Locator receives both a seismic signal and a seismoelectric signal generated by the same seismic source. The seismoelectric survey depth depends on the power of seismic source. We already got seismoelectric data from a 7000 feet depth reservoir in LA with a Buffalo gun seismic source. We also had seismoelectric data from 30000 feet depth with a special testing.

DC-4500 Seismoelectric survey can avoid a dry hole in water well, indicating groundwater in real time analysis. After further data processing and interpretation with the reference application, we can locate the hydrocarbon reservoirs such as fluids- crude oil or natural gas.

We provide the following services:

- Perform seismoelectric oil & gas and water survey;
- Combined with the seismic survey, additional seismoelectric data can show groundwater directly;
- Provide technical training in the use of seismoelectric survey;
- Research and development of seismoelectric exploration.
To market Seismoelectric Ground-Flow survey. We offer free test to the respected clients in Houston area.

**Seismoelectric Survey Principle**

Seismoelectric effect is associated with charge activities taking place at the mineral-water interface, defined as the electrical double layer (EDL). When a seismic wave passes through a porous rock, it agitates movements of both the rock frame and the pore fluid, not at the same rate. Relative movement between fluid and solid particles disturbs the electrical double layer, which in turn produces electric charge movement. Eventually the variation in electric charge creates an electric potential signal, which can be detected as a seismoelectric signal.

Seismoelectric (SE) survey method is a technology based on the seismoelectric effect. It measures the electric potential signal at ground surface with a seismic source for detecting subsurface water properties. This potential is a function of rock porosity, permeability, fluid contents and their saturation.

Superior to Seismic Reflection method, seismoelectric signals could be screened by proper arrangement of surface probes for vertical transmission. Hence it can reduce the influence of noise from diffraction and out of plane reflection commonly associate with seismic reflection method. Furthermore, since seismoelectric signals are related to fluid properties, the SE method could provide additional parameters for petrophysical properties.
SE signals are sensitive to the permeability of the rocks, therefore SE survey has served as a value-adding tool for the underground aquifer detection for the last five years by Seismo Electronics LLC. in many areas of the world. The principles of seismoelectric water value color strips (SEW) interpretation are shown in the figure below.
SE Surveying Method Vs. Other Traditional Surveying Methods

Seismoelectric (SE) survey method is a technology based on the seismoelectric effect. It measures the electric potential signal at ground surface with a seismic source for detecting subsurface hydrocarbon reservoir. This potential is a function of rock porosity, permeability, fluid contents and their saturation. The successful rate for SE survey in oil reservoir detection is higher than 50%.

Seismoelectric (SE) survey can also work with seismic survey. To use the same seismic source, we can get both seismic data and seismoelectric data at same time. The seismoelectric signal works as pseudo-well log to be projected to the seismic section to give additional ground-flow information to the seismic survey, with lower cost.

Seismoelectric (SE) survey also can detect the hydrocarbon reservoir below the salt dome. In some area, the salt layers sometimes covered reservoir, and the seismic wave is difficult reflected back to the surface. Therefore, it is extremely difficulty for traditional seismic surveying method to detect the hydrocarbon reservoir below the salt. However, salt is a good conductor, hence seismoelectric signals can identify the potential hydrocarbon reservoir below the salt.

<table>
<thead>
<tr>
<th>Surveying Method</th>
<th>Depth</th>
<th>Fluid</th>
<th>Surface</th>
<th>Borehole</th>
<th>Cost</th>
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<td>Poor</td>
<td>Excellent</td>
<td>Usable(low S/N)</td>
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<tr>
<td>EM</td>
<td>Usable (&lt;5% max. Z)</td>
<td>Excellent</td>
<td>Usable</td>
<td>Excellent</td>
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<tr>
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<tr>
<td>Seismoelectric</td>
<td>Excellent</td>
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</table>

Seismoelectric Survey Field Operation

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One set of survey equipment includes signal receivers, one data collector and seismic source. We use two geophones and four electrodes as signal receivers, one Seismoelectric Ground-Flow DC-4500 Locator as a SE data collector, and Buffalo Gun as seismic source. DC-4500 locators have total 4 channels. Channels 1 and 4 are used to connect with 2 geophones: one is placed 5 meters away and the other is 20 meters away. These two channels are in charge to receive the seismic signals. Channels 2 and 3, connecting with two pairs of electrodes spaced with one meter along a line, record the seismoelectric signals. When a seismic wave produced by a seismic source passes through a porous rock, it agitates movements of both the rock frame and the pore fluid, not at the same rate. Relative movement in turn generates an electric potential signal, which can be detected as a seismoelectric signal. After further data processing and interpretation, we can detect the depth location of the hydrocarbon reservoirs and estimate their volume.

**Patent**

The DC-4500 is patented in both the US and in China.
Seismoelectric Ground-Flow DC-4500 Locator

A seismoelectric recording system consists of seismoelectric signal data pre-adjusters and computer control. A military grade computer is used as the control with built-in GPS. In the
general survey, unit obtains both the seismic signals, and the combined seismoelectric signals. The seismoelectric survey monitor receiver is used in a civil engineering groundwater related survey.

**DC-4500 Features:**
- Output Noise: 20VP-P at 90db gain
- Work Time: 5 hours
- Work Temperature: -20 to 60 degrees C
- Stacking Trigger Accuracy: 0.05 of sample rate
- Operating System: Window XP
- Bundled Software: data collection

**Accessories include:**
- Seismoelectric Electrode;
- Geophone;
- Cable;
- Connector, etc.

**Seismic Source**

The nature of generation of the seismic source is critical to the seismic and seismoelectric survey results. The seismic source includes: Sledge Hammer, “Buffalo Gun”, and Weight Drop Seismic
The sledge hammer is popular for most shallow seismic refraction surveys using a multichannel seismograph, but the range of impact is limited.

"Buffalo Gun"

The "buffalo gun" has a wider and deeper impact range of acoustic energy and has been used in the field with great success for the seismoelectric method. The main problem with buffalo gun is its loud sound blast, which may restrict its use in populated areas. We have developed a soundless device in the buffalo gun, and it works very well with the same seismic impact using a 12 gauge shot gun cartridge.

Weight Drop Seismic Source

With some special requirements of our clients, we have also tested a weight drop seismic source methodology of generation in the seismoelectric survey. The tested data shown that one drop energy of A200 P/S Hammer is similar to a 2.5 inch 12 gauge cartridge acoustic impulse. However, the relative cost of this weight drop seismic source is much higher than using a buffalo gun.

Successful Cases

We have tested over three hundred sits, both in the lab and the field. A preponderance of data has shown that DC-4500 demonstrates exceptional accuracy. Five representative survey are
illustrated below:

**Case 1: Fracture Aquifer, Llano Intrusive Project, TX, USA**

In the Blackjack ranch, they got 4 dry holes before we did survey. In April 2011, we designed a seismoelectric (SE) survey along the fracture. After 2 days survey, they drilled a well with 5 gallon/hour.

**Case 2: Aquifer, Haiti**

We already have done over 230 survey sites (with DC-4500) in Haiti with 95% success rate since 2011. More than 230 water wells were already drilled and most of seismoelectric surveys were performed in Port-au-Prince.
Case 3: **Oil, Thrail Oilfield Project, Texas, USA**

In January 2012, we performed seismoelectric survey at 3 sites in Thrail Oilfield. The seismoelectric signals in #3 site indicated that there is no oil reservoir. In April, the drilling company drilled at this point and only got a dry-hole. However, we detected the oil reservoir at #1 and #2 sites based on seismoelectric signals. Then in October, the report from the same drilling company show that they got the oil reservoir at 800 ft depth.

Case 4: **Oil, Lockhard Oilfield Project, Texas, USA**

In April, 2012, we did a SE survey in Lockhard Oilfield to detect the oil reservoir. According to SE signals, we identified fluid existence below 2000 ft, but the drilling company reported they drilled a water well at this location.
Case 5: Oil, Edgerly Oilfield Project, Louisiana, USA

In August 2012, we performed the SE survey in Edgerly Oilfield to detect the oil reservoir below the salt dome.

Case 6: Oil, North of Rockdale Project, Texas, USA

In May 2013, we conducted the SE survey with 8 survey points around the north of Rockdale, TX to identify the depth location for oil reservoir.
**Case 7: Geothermal, Sinopec Project, Texas, USA**

In April 2014, we designed and implemented the seismoelectric survey in south part of Houston, TX to detecting the geothermal resource for Sinopec Group.

**Case 8: Oil, Angelina County Project, Texas, USA**

In May 2014, we implemented the SE survey in Angelina County, TX. This survey took 3 days and included 22 measuring points. The red line is SE survey line. The yellow circle represents the area where the potent oil reservoir located.
Case 9: Aquifer, Beaver Dam Project, Utah, USA

In May 2014, we conducted seismoelectric survey for Willowstick Technologies LLC in Beaver Dam area, Utah, USA. According to our client’s requirement, we designed 3 seismoelectric survey lines, with total 50 measurement stations. After data processing and interpretation, we located 3 layers of aquifers. The red layers are the top and bottom of the first aquifer; the green ones for the second aquifer; the blue ones are the boundary for the deepest water reservoir.
Conclusion

- A new Ground-flow survey technology.
- Lower cost, more efficient.
- Hundreds of successful cases over the world.
- Powerful tools for hydrologists.