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Investigations on Small Scale Targets with Sputnik, a Two Polarization Transmitter System

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SUMMARY

Sputnik is a novel CSEM transmitter system, which is used for small scale investigations. The system is special in the sense that it can excite two perpendicular TX polarizations at each TX location. It can be shown that this generally increases the sensitivity of measurements to the resistivity structure of the seafloor.

This style of experiment requires new approaches for a first pass data interpretation, for which we have adapted the concept of rotational invariants to the marine case. Rotational invariants allow a display of measured data in terms of apparent resistivity sections. They can also be used in the inversion of data. Additionally - using the skew invariant - a dimensionality analysis of the underlying resistivity structure is possible directly from the measured data.

Within the past two years the system has been used in three successful experiments for the investigation of methane hydrates and free gas. First results prove that the system is a useful tool for investigations on small targets.

Introduction

CSEM experiments in the past decade were mainly designed for the exploration of hydrocarbons at larger depth. These systems are not always the best choice for the investigations of smaller targets at shallow depth. At GEOMAR we have taken new approaches to marine CSEM experiments, which have resulted in the construction of "Sputnik", a frame based transmitter (TX) system.

We will introduce the system and show the general style of experiment. In our presentation we will also explain how data may be evaluated in terms of rotational invariants and will show results from experiments of the past two years.

Instrumentation

The Sputnik system (Figure 1) consists of a frame, which holds

- the pressure housings for the TX,
- a pair of perpendicular, 10m long electrode arms,
- an ultra-short-baseline (USBL) ranging system for determination of distances and orientations between the TX and the remote receivers,
- additional attitude sensors (pitch, roll, heading, inclinometers on electrode arms),
- an altimeter,
- and a camera.

The latter are of special importance, because the frame is placed onto the seafloor during measurements, which – for safety reasons – is only possible with real time control over the system.
The Sputnik TX system was successfully used in three CSEM experiments targeting shallow gas hydrates (2012: M87/2, R/V Meteor, Norwegian Shelf / Storegga Slide; 2013: SO227, R/V Sonne, passive and active margin to the SW of Taiwan; 2014: MSM35/2, R/V M.S.Merian, Danube Delta / Black Sea).

Figure 1 *Sputnik transmitter frame.*

Methods

The system allows for a new style of marine CSEM experiment, in which two perpendicular TX polarizations are excited at every TX location. It can be shown that this style of experiment with two polarizations increases the sensitivity of marine CSEM measurements to the resistivity structure of the underground. For the first pass interpretation of such data sets we have adapted the concept of rotational invariants, which was introduced for land based EM measurements by Bibby (1977), to the marine case by using a source normalized E-field tensor (Hölz et al., 2014). We have also used this concept to define a meaningful apparent resistivity, which allows for a quick imaging of measurements (Swidinsky et al, 2014).

One interesting aspect of rotational invariants is the fact that they allow for a dimensionality analysis of a measured data by using the skew invariant, quite similar to magnetotellurics. In Figure 2 we display the skew invariant for an anomalous body of 5Ωm, which is embedded at a depth of 100m in a 1Ωm seafloor. The lateral resistivity contrast, especially at the corner of the anomalous body, has a strong effect on the skew invariant.

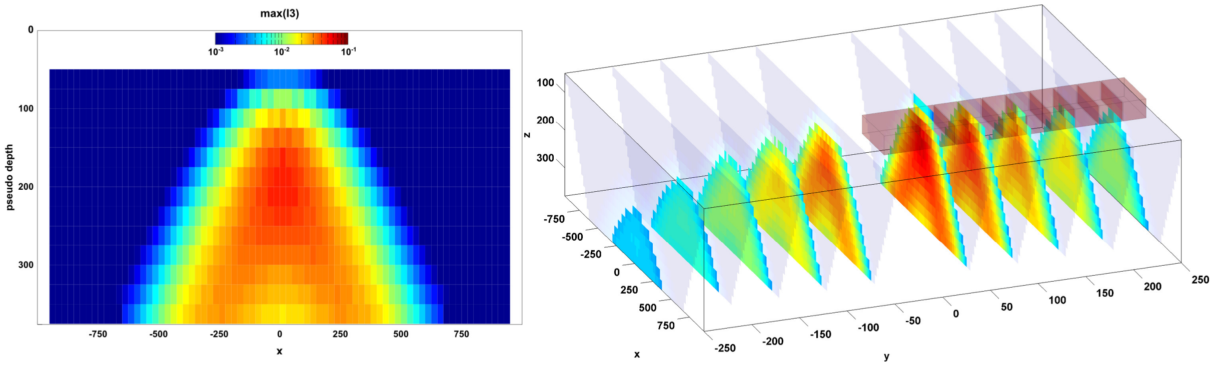

Figure 2 *Skew invariant (maximum of absolute value) for anomalous body (right, block structure), calculated for various TX-RX offsets and positions. For each TX-RX combination the according value is plotted at the midpoint between TX and RX at a pseudo depth of half the TX-RX offset (left: section at y = 25m; right: anomalous body with collection of pseudo sections).*

Results

Using the quick imaging (Swidinsky et al., 2014) we can display first results from our experiment, which was conducted in 2012 on the Norwegian shelf in the Nyegga area on the northern edge of the Storegga slide (Figure 3). The apparent resistivity section shows a pipe structure called CN03 as a resistive structure.

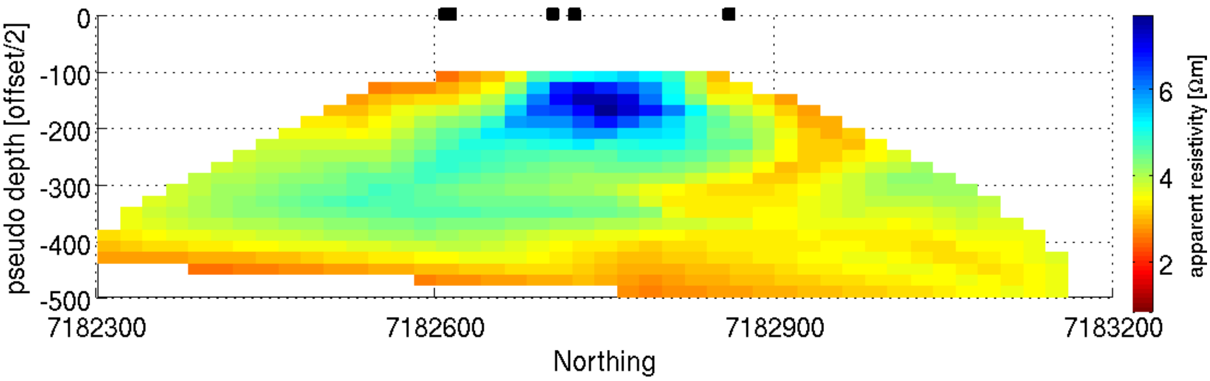

Figure 3 *Apparent resistivity section (interpolated) from measurements conducted on the Norwegian shelf, Nyegga area. Black squares mark the projection of five receivers onto the profile line.*

References

Bibby, H. [1977] The apparent resistivity tensor. *Geophysics*, **42**, 1258-1261.

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