ELECTROMAGNETIC RECEIVER FOR MARINE GEOPHYSICAL EXPLORATION

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1. Introduction

Electromagnetic techniques for marine geophysical exploration have considerably improved in the last decade. Both Research and Industry benefices of these new data to better understand the structure of the upper crust or to refine the geological setting of natural resources. Both short period magnetotellurics (SPMT) and controlled sources techniques (CSEM) are now increasingly used in offshore studies. While it may be sufficient for CSEM to measuring the vector electric field only, the combination with the vector magnetic field is of great interest. Simultaneous electric and magnetic fields are necessary for SPMT.

A great number of geological targets in marine exploration are below several hundred of metres up to a few kilometres of seawater. Additionally, the frequent very high conductivity of the marine substratum implies that EM techniques must be used at very low frequencies (10 Hz or much less). The magnetic sensors generally used in marine environment to record data at these frequencies are search coils. While these sensors have a remarkable sensitivity at high frequencies (above several 10 Hz), their performance drops rapidly toward low frequencies. Furthermore, their bulk and weight make them difficult to adapt for marine experiments and make them very sensitive to motion on the sea bottom.

Fluxgate magnetometers are different sensors that may be used for marine exploration. While their sensitivity at high frequencies cannot compete with search coils and their power consumption is higher, the new generation coming from space research is increasingly improving and becomes very reliable up to a few 10 Hz. These sensors are very small (a few 10 to 100 g) and hence easily packaged for marine environment. The full vector magnetic field is readily measured.

2. Instrument description

We developed a new patented marine electromagnetic receiver measuring 5 (and optionally 6) components of the electromagnetic field (2 Electric and 3 Magnetic components) (Figure 1). The magnetic field is measured with a 3-component fluxgate magnetometer. The electric field is obtained from the potential differences between either Pb-PbCl2 or Ag-AgCl impolarisable electrodes, placed at the end of 5m-long tubes.

The current version of our system samples the EM field at about 30 Hz. The fluxgate magnetometer gives the instrument orientation, with the help of precise tiltmeters.

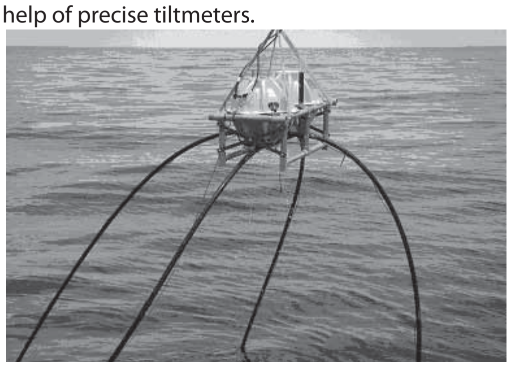


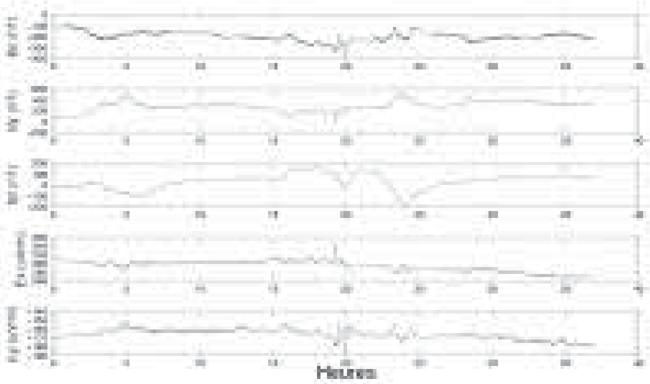
Figure 1 Marine EM receiver

This receiver was originally designed for SPMT but is also fully suitable for CSEM measurements, adding the magnetic information to the recorded signal. The instrument has been designed and recently greatly improved to be small and light, easy to deploy and unexpensive to built, with no compromise on performances. Using glass spheres both as electronics and sensor housing, we managed to get a instrument of only 70kg in air, with all maintenance and configuration done from outside with no need to open the instrument. Energy is provided by rechargeable batteries. Using glass as instrument housing and buoyancy also has no effect on electric nor magnetic measurements. The instrument is deployed on the seafloor, with a concrete anchor. An acoustic release and its natural buoyancy is used to recover the instrument after a few days of measurements (with rechargeable batteries).

3. Performances

Sensors capabilities, integration and management in the system are key issues for the overall performances of the instrument. We paid particular attention to reduce and avoid noise electronics can induce on the nearby sensors.

The figure 2 shows a sample of seafloor magnetic and electric signals recorded with our system. As the signals recorded can be very small, noise level caracterisation is of great importance.



The fluxgate magnetometer has a factory noise level of 20pT/√Hz at 1Hz. The main field can be compensated to increase the sensor dynamics. Electric field is sample via a 24-bit sigma delta converter, with DC-coupling of the electrodes. The preamplifier is rated at 6nV//√Hz at 0.1Hz, with no 1/f noise. This allows to get non distorded data at the lowest frequencies.

We shall present in more details the noise levels and performances measured on the seafloor and in our test facilities, to show the great interest to use such sensors and techniques for electromagnetic measurements.

4. Conclusions

We have developed a reliable new electromagnetic receiver, suitable for magnetotellurics and controlled source electromagnetic soundings, using 3-components fluxgate magnetometer and 2 (optionally 3) electric dipoles.