THE PERMANENT SEAFLOOR GEOMAGNETIC OBSERVATORY

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1. Introduction

Earth's magnetic field fluctuates over a wide range of spatial and temporal scales. These variations contain fundamental information about both the solid earth and the environment outside the planet. Detailed study of the geomagnetic field addresses a range of first-order problems in the deep mantle and core, lithosphere, oceans, and the solar-terrestrial environment. In addition to these basic research themes, geomagnetic measurements have practical applications in navigation, resource assessment and exploration, hazard mitigation, and control and protection of the telecommunications and power grids.

The mechanism for generating the geomagnetic field remains a fundamental problem in physics and geophysics [1]. Studies of the geodynamo require the comparison of theory and numerical models with long term observations of the geomagnetic field on a global scale. In order to improve our models we need to extend the existing observatory network into the ocean basins [2].

We have built a Seafloor Geomagnetic Observatory (SGO) that can provide some of this functionality.

In addition to geomagnetic field data, geoelectric field data find application in electromagnetic induction and studies of the core. In particular, geoelectric data can be used to provide a constraint on the size and variability of the toroidal magnetic field at the core-mantle boundary. The geoelectric field also contains information about the large-scale oceanic velocity field C-2 through the motional induction effect [3; 4].

In this paper we present our Seafloor Geomagnetic Observatory that will be part of the geomagnetic network soon.

2. The components of a Seafloor geomagnetic Observatory

The components of a SGO consist of five separate systems: sensors, packaging, data recording/transmission, observatory timing and control, and power. The sensor component is divided in a geoelectric sensor and a geomagnetic sensor system.

The SGO that we have built was going to be installed on the Hawaii-2 Observatory site (H2O)[5], which provided power (48 V at 100 W), timing (1 msec accuracy) and two-way communications (80 kbits/s using RS-422 protocol). Thus only the sensor and packaging issues were considered in the design.

The geoelectric system consists of fully redundant, three-component (north, east and vertical) sensors contained in a non-metallic frame. The electric potential is measured at the Ag-AgCl electrodes at the end of mutually-orthogonal, 6 m long salt bridge pipes which connect to a set of water switches or choppers [6]. In order to minimize corrosion-induced electric fields, the entire geoelectric assembly is fabricated from fiberglass and plastic, while the electronics are contained in a glass instrumentation housing.

The geomagnetic sensor system consists of a fluxgate magnetometer, a set of suspended magnet variometer sensors, an Overhauser scalar field magnetometer, a gyroscope, tilt sensors, and data control electronics. These components are mounted on a triangular titanium sled which is placed on a heavy concrete anchor base at the seafloor. The concrete base serves to provide a maximally stable monument which yields rough azimuthal and vertical orientation of the geomagnetic sled through a set of locating pins.

The commercially-produced ringcore vector fluxgate sensor is currently used in land observatories and is manufactured by B. Narod. This system requires about 1W for three component running continuously. We also include a suspended magnet sensor that measures magnetic field fluctuations relative to an arbitrary reference [6]. The absolute measurements on the ocean bottom are done using a scalar magnetometer . All these systems follow the INTERMAGNET standards [7].

The key to obtain the absolute declination measurement is to achieve an absolute azimuth reference (usually to true north) at the seafloor. For this we use a gyroscope and the magnetic field sensors, previously calibrated against a standard observatory.

Tilt sensors provide local vertical reference for the magnetic field sensors, and measure high frequency motion of the sensors caused by either seafloor movement or vortex shedding in near-bottom currents.

The physical design and packaging of the SGO required careful thought to avoid corrosion problems and allow for ease of installation and maintenance. Corrosion is easily dealt with by using titanium, glass, and plastic for all components of the observatory in contact with sea water. The major issue includes the construction of a monument base to hold the observatory in order for it to remain as stable as possible on the seafloor, and it has to allow for easy deployment and recovery of sensors without appreciably altering their orientation or location.

The system also contains a PC104 that is programmed to switch on and off instruments, gather data from different sensors, time stamp them and deliver them through the cable, so they can be monitored in real time.

This system was completed in summer 2003. After, we ran a series of tests in two geomagnetic observatories: Chambon-La-Foret (France) and Victoria (Canada). These led to measurements of the angles between the two vectorial sensors (fluxgate and suspended magnet) with respect to the gyro. Initial deployment on the H2O cable was scheduled for October that same year, although because of technical problems the H2O cable is down and the deployment had to be cancelled.

Figure 1. SGO being calibrated against land observatory in Victoria (Canada).

3. Conclusions

We have successfully created the first ocean bottom geomagnetic observatory. One of the most important and difficult tasks (orientation of measurements) is done using a gyroscope. The system is designed to deliver geomagnetic and geoelectric data in real-time.

4. References

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OBSERVATORIES AND LANDERS TO STUDY OXYGEN DYNAMICS IN THE MARINE ENVIRONMENT

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Introduction:
Most chemical and biological processes result in changes in disolved oxygen concentrations. Oxygen is therefore a prime parameter to measure in marine environmental studies. Because of technological limitations of existing sampling methods and sensors long term monitoring of oxygen was not possible until the introduction of accurate and stable optical oxygen sensors. This technology has revolutionized the possibilities to measure oxygen and has also open the door to obtain two dimensional pictures of the oxygen distribution at the sediment-water interface. In this presentation we will demonstrate new insights in the dynamics of oxygen in the marine environment by giving numerous examples ranging from shallow coastal areas to the deep Arctic Ocean. The presented investigations have been done combining a wide range of instrumentation mounted on both fixed bottom platforms and autonomous landers. The rationale of using oxygen in environmental investigations will be described as well as the techniques. We will demonstrate that such combined measurements will make it possible not only to know more about the oxygen dynamics per se but also to use oxygen as a proxy for the ongoing biological, chemical and physical processes in the water column and at the bottom.

Rationale of using oxygen to monitor the overall water quality: In near shore waters
1. Biological production/consumption: During primary production in oceans and lakes CO2 and nutrients are incorporated by phytoplankton to create organic material (chemically written as (CH2O)106(NH3)16H3PO4). As a result of this process oxygen is produced. Chemically the reaction can be expressed as: 106 CO2 + 122 H2 + 16 NHO3 + H3PO4 (CH2O)106(NH3)16H3PO4 + 138 O2. As written in the equation the approximate atomic ratios between oxygen, carbon, phosphorus and nitrogen are O138C106:N16:P1 which is known as the Redfield/Richards ratio. The phytoplankton can then be decomposed or consumed by zooplankton or fish which will in turn generate organic matter in the form of fecal pellets and dead organisms. The particulate organic matter sinks towards the bottom and on the way it can be further decomposed (by e.g. bacteria) and dissolved before it reaches the seafloor. At the bottom organic matter is subjected to decomposition (mineralization), dissolution, and burial. Through mineralization oxygen is consumed and nutrients can be recycled to the water. This process can approximately be expressed as the reverse of the reaction described above.

2. Water mixing: Oxygen conditions in the aquatic environment are affected by water circulation. Horizontal currents can bring in water which has been more exposed to bottoms with high oxygen demand or to discharge of industrial or urban waste water with chemical (COD) or biological oxygen demand (BOD).

3. Air-water exchange: The dissolution of oxygen in surface water is affected by variations in air pressure according to the common gas law. The role of atmospheric air pressure changes on the total stock of dissolved oxygen is normally minor compared to oxygen variations induced by biological production/consumption. Nevertheless it should be taken into account especially during the less productive parts of the year.

4. Pollution induced oxygen consumption: Pollution from industry (mainly COD) and urban population (BOD) can play a significant role in boosting the oxygen demand. This might lead to serious biological damages and will also significantly influence on chemical equilibrations.

Since oxygen concentrations are coupled to the four above listed factors measuring oxygen in different levels will mirror the sum of these changes. To be able to separate the reasons for oxygen concentration changes from each other it is crucial to measure water circulation, salinity and temperature in parallel. Useful information is also gained by adding sensors for chlorophyll, particles and light (if the water is shallow).

Technology to study oxygen dynamics:
In combination with other measurements, briefly described above, we have used three different techniques to study the oxygen dynamics.

1. Incubations: We have measured oxygen consumption as well as the total carbonate (TCO2) and nutrient production in-situ by making parallel chamber incubations of the sediment and the overlying water. This work has been done with autonomous landers which sink freely to the sea floor. There chambers are gently pushed into the sediment leaving about 20 cm of overlying water. Incubations start when lids are closed and stirrers start to mix the chamber water. During incubations, which generally lasts for 36-48 h the oxygen concentration is continuously monitored in the enclosed water
using oxygen optodes and samples (ten from each chamber) are automatically collected into syringes. The water samples are analysed on-board once the lander has been recovered. The evolution in solute concentrations with time gives information about the degradation and burial of organic matter.