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.

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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. <u>Biological production/consumption:</u> During primary production in oceans and lakes CO_2 and nutrients are incorporated by phytoplankton to create organic material (chemically written as $(CH_2O)_{106}(NH_3)_{16}H_3PO_4$). As a result of this process oxygen is produced. Chemically the reaction can be expressed as: $106\ CO_2 + 122\ H_2 + 16\ NHO_3 + H_3PO_4 \rightarrow (CH_2O)_{106}(NH_3)_{16}H_3PO_4 + 138\ O_2$. As written in the equation the approximate atomic ratios between oxygen, carbon, phosphorus and nitrogen are $O_{138}C_{106}:N_{16}:P_1$ 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. <u>Air-water exchange:</u> 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. <u>Pollution induced oxygen consumption:</u> 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 (TCO_2) 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.

2. Planar Optode: A so called planar optode has been used to obtain the oxygenconcentration in two dimensions in the sediment and at the sediment-water interface. A planar optode is like an “inverted periscope” which is gently inserted into the sediment. Through a special optical technique, called luminescence quenching, it is possible to obtain high resolution oxygen images. From the oxygen images oxygen concentration gradients (profiles) can be extracted. About 600 oxygen profiles can be extracted from each image and from the profiles the sediment oxygen consumption can be calculated, which gives an independent estimate of carbon turnover rates.

3. Oxygen gradients in the water: Oxygen optodes have been mounted at different levelsin the water column. These sensors reveal the dynamism of the aquatic environmentand it is possible to extract gradients with lower concentrations for example closer to the bottom and higher close to layers with active primary production. Together with information about the currents we have developed methods that can be used calculate the oxygen consumption/production in different layers.

CUMAS CABLED UNDERWATER MODULE FOR ACQUISITION OF SEISMOLOGICAL DARA FOR GEO-HAZARD MONITORING IN SHALLOW WATER

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1. Introduction

CUMAS is an underwater module developed for the acquisition of geophysical signals in shallow seafloor for geohazard monitoring in volcanic areas. It was conceived for a specific application in the Campi Flegrei Caldera (Southern Italy) where the main features of the present volcanic activity consists of slow soil movements (bradyseism) accompanied by intense and shallow seismic activity. The latest strong episode occurred in the period 1982-84 with a ground uplift of more than 170 cm followed by a slow and continuous subsidence still ongoing with of small amplitude uplift episodes (few centimeters). It is worth noting that the seismic activity only appears during the uplift phase.

CUMAS is the first step toward the extension of the present operating land-based monitoring networks of the Campi Flegrei in the marine sector of the Caldera, roughly covering more than one third of the volcanic area.

2. CUMAS features and functionalities

CUMAS has the aim to

-continuously acquire on the seafloor geophysical and oceano graphic data according to a single time reference;

-transmit acquired data in real time to a acquisition centre on land;

-receive commands from the land centre and accordingly modify its acquisition configuration.

CUMAS is powered through a cable connecting the module to a surface infrastructure; this ensure a long lasting deployment on the seafloor.

All these features make CUMAS fully integrated in centralised monitoring system of the Neapolitan volcanic areas (Vesuvio, Campi Flegrei and Ischia Island) managed by Osservatorio Vesuviano-INGV.

CUMAS consists of a frame of steel with a shape of truncated pyramid of about 1 m high and a square base of 1 m per side. The total weight including the equipment is about 430 kg in air.

In the CUMAS frame the following sensor packages are installed:

1. seismological sensors aimed at recording local earthquakes related to volcanic activity and artificial explosions often caused by fishermen; the sensors include

-a three component broad band seismometer (0.025 s - 40 s) Guralp CMG-40T OBS with auto-levelling platform

- a broad band hydrophone (1 Hz – 65kHz) Sensor Technology SQ03 model

2. physical oceanographic sensors are aimed at the long-term monitoring of the water current regime also useful for seafloor seismic microtremor studies; a further task consists in testing the feasibility of the use of water pressure measurements at seafloor to detect changes in water column pressure potentially related to bradiseismic activity. The oceanographic sensors include

-a single point three component acoustic current meter 3D-ACM Falmouth

-a pressure gauge Series 8000 Paroscientific.

Data acquisition in performed by a Quanterra Q330 digitiser equipped with external hard disk as local mass storage. The digitiser is installed inside a cylindrical aluminium vessel and it is used to acquire the seismological sensors, both sampled at 125 sps.

The data acquistion analog sensors and data acquisition embedded computer for sensors with digital output. The physical-oceanographic sensors with digital output are acquired by an embedded computer with Linux o.s.

Further sensors installed in the vessel are acquired by the Linux PC, namely tilt and heading sensors, for the measure of the real module attitude on the seafloor, and status sensors for the monitoring of the internal status of the vessel (e.g., internal temperature, power absorption, water intrusion).

Both acquisition systems are linked via Ethernet cable to a router connected to an electro-mechanical cable for the real time data transmission to the sea surface. A Wi-Fi communication system ensures the seafloor data transfer to the land acquisition centre in the city of Naples.