SEAFLOOR CARTOGRAPHY AND CHARACTERISATION OF THE BASQUE COUNTRY INNER CONTINENTAL SHELF

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Introduction

igh quality information about geomorphology and seafloor characteristics of the Basque continental shelf is scarce. Since the first bathymetric charts were performed by the Spanish Marine Hydrographic Institute in the late sixties, little research has been done. Only in the early nineties, seafloor characterisation was conducted to locate and characterise sand disposal places for beach regeneration [1], [2]. Due to a growing interest in cartography of the traditional fishing sites, studies were carried out in 2000 for the Agricultural and Fisheries Department of the Basque Government [3]. These studies show an initial approach to seafloor classification using the Acoustic Seafloor Discrimination System, RoxAnnTM and a sidescan sonar.

In 2003 the Biodiversity Direction of the Environmental and Territory Management Department of the Basque Country agreed to establish a permanent observatory of the Natura 2000 Network in the Basque Country in order to guarantee fulfilment of its objectives and its formulation. This situation highlighted the necessity of cartographic information from the continental shelf and the identification and characterisation of the most significant marine habitats in the Basque Country. To solve these requirements, a three year project started in 2005 with the principal aim of generating seafloor cartography and seafloor characterisation of the continental shelf, the definition and delimitation of marine habitats and the identification of the main species of flora and fauna associated to each habitat type.

The Basque continental shelf (NE of Spain) borders to the East with France (1º46’50”W) and to the West with the autonomic community of Cantabria (3º9’13”W). The total surface of the study area is approximately 936 km2 (between 5 m and 100 m water depth) and the total length of the coast is 150 km.

Bathyemtric data

Bathymetric and seafloor backscatter information has been acquired using high resolution multibeam SeaBat 7125 and SeaBat 8125 systems, having both equipments similar characteristics. Most of the work has being carried out with the latest SeaBat 7125 model. Its operation frequency is 400 kHz, produces 256 beams in 128º angle swath and up to 50 swaths per second. Beam width is 0,5º along track and 1º across track producing very small footprints which produces very high horizontal resolution Digital Elevation Models (DEM). Instead of interpolating between a series of survey tracks, dense soundings can be collected from the entire seafloor and virtually no interpolation is required to produce the details of the physiographic surface [4]. Its vertical resolution is 6 mm and it is fully operative in a range of depths between 0 m and 100 m. All these characteristics make the system fulfil the IHO’s special order requirements [5]. Apart from the multibeam echosounder, the system is composed of a gyrocompass and motion sensor Octans III, a Trimble DGPS, a sound velocity profiler and a surface sound velocity sensor.

Bathymetric data were acquired and processed using specific software PDS2000. Tide correction was applied using the nearest tidal gage (six stations along the Basque coast) and 1 m resolution seafloor DEM was produced for all the continental shelf (higher resolution DEMs are possible to produce in shallow waters if required). Finally, the DEM was exported into ESRI grid format and integrated into a Geographic Information System (GIS) for further topographic features interpretation and analysis.

Main seafloor features

The Cantabrian continental shelf is characterised by its narrowness. In the Basque Country, it ranges from 7 km off Cape Matxitxako, to 20 km off the estuary of the river Oria. The Cantabrian (Basque) inner shelf is covered by a quasi continuous belt of rocks, which constitutes an extension of the rocks of the continental cliffs. The continuity of this rocky substrate is interrupted regularly by the presence of river mouths, beaches, etc., further offshore the shelf is covered by sandy sediments; these, in turn, isolate the exposed rocky areas of the seabed. Exposure to wave energy appears to determine the distribution of sediments. The coast consists of a succession of capes and embayments, which have been developed by the continuous action of the waves and rivers within the region. The resistance to erosion of the different materials has controlled the actual morphology.

Rocky seafloor

Flysch type formation of rocky substrata is recognisable in subtidal areas. A shallow and high roughness bedrock belt, associated to coastal topography is dominant. It presents approx. a 10% slope, after an inflexion point approximately at 32 – 37 m water depth. Further offshore the platform again extends with a milder slope (oscillating between 1,5 % and 2 %). In this area, seafloor roughness is lower and sand patches are common between rock strata.

Rippled scour depressions

Ripples appear distributed along all the study area. They are well developed in subtidal sandy pocket beaches or in sandy areas sheltered by rocky outcrops. The crests appear well developed and they maintain continuity during tens of meters. They present low undulation with occasional bifurcation, reflecting their wave origin. Crests are oriented mainly in NO – SE according to predominant wave direction. Rippled fields backscatter signal indicate that they are composed by coarser sand than the seabed around.

Sea-level change evidences

Previous studies indicate that, during the last glacial maximum, sea-level was lower than 120 m than present. The main physiographic features that evidence eustatic changes are paleochannels and abrassion platforms. The use of only multibeam data is not enough to describe paleochannels because most of them are covered by recent material. In cases where hydrodynamic processes are energetic enough or places where erosion processes are dominant paleochannels are possible to identify. In general terms, they present S - N orientation. Actual estuaries associated paleochannels are the largest ones identified but other smaller channels can be also distinguished. They have continuity in land with small creeks, which indicates that in former times their water discharge was significantly higher.

Conclusions

Due to the high resolution of multibeam system, new seabed features can be now be identified and described. This project will produce base knowledge and the results obtained will be of special interest for integrated coastal management, decision makers, habitat mapping, description of seabed processes, and studies of climatic change and related impacts.

Bibliography
[1] Iberinsa. 1990. "Estudio geofísico marino entre la frontera Francesa y Ondárroa". Ministerio de Obras Públicas y Urbanismo.
[2] Iberinsa. 1992. "Estudio geofísico de la Costa de Bizkaia". Ministerio de Obras Públicas, Transporte y Medio Ambiente. Dirección General de Costas.
[3] I. Galparsoro. 2005. "Elaboración de una cartografía sedimentológica detallada y de mapas de biotopos marinos del litoral vasco." Informe inédito de AZTI-Tecnalia para la Viceconsejería de Desarrollo Agrario y Pesquero, Depto. de Agricultura, Pesca y Alimentación, Gobierno Vasco. 28 págs.
[4] J. V. Gardner, P. Dartnell, L. A. Mayer and J. E. Hughes Clarke. 2003. "Geomorphology, acoustic backscatter, and processes in Santa Monica Bay from multibeam mapping." Marine Environmental Research. Integrated Assessment of an Urban Water Body: Santa Monica Bay, California 56 (1-2): 15-46.
[5] IHO. 1998. "Normas de la OHI para levantamientos Hidrográficos". Publicación especial Nº 44. 4ª Ed. Publicado por el Bureau Hidrográfico Internacional. Mónaco.

USING CONTROLLED SOURCE EM METHODS TO CONSTRAIN PHYSICAL PROPERTIES OF THE UPPERMOST SEAFLOOR: AN EXAMPLE OF INSTRUMENTATION AND A CASE STUDY FROM A GAS POCK-MARK OFFSHORE IRELAND

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1. Introduction
The shallow section of continental shelf is a key interface between Earth and the ocean. This part of the seafloor provides a record of sedimentary history through the Holocene that can be interpreted in terms of changes in sediment supply and re-working. Important chemical fluxes pass through shallow sediments and into the ocean, including groundwater in coastal settings and fluxes of methane in deeper water.

In this paper, we outline how measurements of electrical resistivity are able to contribute to an understanding of the shallow seafloor. Resistivity provides a first order measure of seafloor porosity in sedimentary settings, allowing facies maps to be constructed, or changes in lithology to be identified. In unconsolidated sediments porosity is a key parameter to understanding fluid transport. Resistivity is sensitive to the salinity of pore-fluid, allowing identification of fresh groundwater. And finally, in areas of active gas seepage, there are often changes in pore-fluid salinity and temperature that resistivity measurements can identify, while accumulations of massive gas hydrate are thought to cause an increase in seafloor resistivity [1].

3. The towed EM system
The towed-electromagnetic (EM) system discussed in this paper consists of three main components, the deck electronics, a transmitter, and the receiver string. The seafloor components of the system (transmitter and receivers) form a 40 m-long array which is towed in contact with the seafloor at speeds of 1-2 knots.

The EM transmitter, a horizontal magnetic dipole, generates harmonic magnetic fields over a range of frequencies (~200 Hz – 200 kHz), and the three receivers, tuned to measure these magnetic fields, are towed at fixed distances behind (4m, 12.6m and 40m). At a given frequency the strength of magnetic fields decays away from the transmitter as a function of the conductivity of the seafloor (i.e., according to the skin depth), decaying more rapidly in more conductive media. The sensitivity of the magnetic dipole-dipole system, along with the physics of the propagation of the fields through the seafloor was presented in [2]. Further details of the system are given in [3].

Because the system maintains a fixed distance between source and receiver, it can be regarded as a mapping tool. In order to build up a map of sub-seafloor structure only relatively sparse coverage is needed [4]. The resulting maps provide superior spatial coverage than conventional coring techniques and can measure porosities in regions where coring techniques fail to recover samples, but more importantly provides a means of interpolating between discrete core locations. Finally, the method provides estimates of physical properties where seismic reflection profiles are contaminated by strong bottom multiples or the presence of biogenic gas [5]. The system is, however, perfectly complementary to seismic methods and is best used in concert with high resolution seismic reflection techniques which define the stratal geometry while the EM data define the physical properties [7].

3. The Malin sea experiment
In 2006, we ran the system across an area of gas seepage in the Malin shelf area, offshore Ireland. Within the survey area, which generally has very flat bathymetry, more than 220 pockmarks, related to gas transport through the seafloor, are distributed in clusters around the main structural lineaments. Seismic data show disturbances in the sediments beneath pockmarks to depths of about 80m. The objective of the project is to use a combined acoustic and electromagnetic geophysical approach to study the near-seabed composition in a known shallow gas bearing area. The combination of these various methods should enable us correlate the main geophysical signatures and the geological properties of the seabed, providing a unique tool for geohazard identification, seabed classification, fluid flow migration paths and sediment porosity.

As an example of the type of data collected, we show EM coverage across a major depression and pock mark field in Figure 1. The data are presented as apparent porosities using Archie's law to convert half-space inversions of the raw data on each receiver – this is how data appear in real-time on board the ship. Porosities across the region are remarkably consistent, with very little variation. However, there are subtle changes observable as the system enters a pockmark. The transition into the basin is marked by an increase in porosity, most likely representing looser unconsolidated pelagic sediments. More detailed examination of the porosity profile shows a complex structure as the system enters a small pockmark. The 40m and 13m receivers show opposite behaviours, with data on the 40m receiver dropping slightly in value while the 13m receiver records slightly higher values.