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Estructuras de unidades sedimentarias recientes en la plataforma continental de Galicia (NW de España)

Structure of recent sedimentary units in the Galician continental shelf

REY, J. and DIAZ DEL RIO, V.

Los perfiles de sísmica de reflexión de alta resolución en la plataforma continental gallega nos permiten conocer la estratigrafía de los sedimentos holocenos.
De techo a muro se distinguen:

— Un nivel superior de limos holocenos marinos con interestratificaciones de arena.

— Un reflector basal que aflora hacia la zona media y externa de la plataforma continental y formado por varias superficies erosionales debidas a lo reducido de los aportes sedimentarios en ese punto.

— Un basamento acústico de naturaleza ígnea y metamórfica con una fuerte respuesta sísmica.

La plataforma se caracteriza por el desarrollo de dos cuerpos de arena limosa que se extiende hacia mar abierto desde la zona interior de plataforma hacia el sur y una superficie de progradación en la zona externa de la plataforma.
El mapa de isopacas demuestra que los sedimentos marinos holocenos forman generalmente un lecho contínuo que alcanza su máximo espesor delante de las rías.

Palabras clave: Galicia, plataforma continental, holoceno, cuaternario, estratigrafía, sondeos sísmicos.

High-resolution seismic reflection profiles of Galician Continental Shelf show the shallow seismic stratigraphy of Holocene sediments. Three acoustic units can be distinguished from top bottom:

— a continuous upper layer of Holocene marine muds with interstratifications of sand.

— a basal reflector which outcrops towards the middle and outer continental shelf, forming several erosional surfaces due to reduced sediment supply.

— an acoustic basement, of igneous and metamorphic nature; with strong seismic response.

The shelf is characterized by the development of two bodies of sandy mud that extends offshore from the inner shelf toward the south and a progradation surface on the outer shelf.
The isopac map shows that the Holocene marine sediments generally form a continuous layer that reachs a maximum thickness in front of the «rias».

Key words: Galice, continental shelf, holocene, quaternary, stratigraphy, sismic profiles.

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INTRODUCTION

The northwestern continental shelf of Spain is currently the object of a multidisciplinary oceanographic study in a cooperative investigation Program carried out by Spanish and North-American investigators.

The Program includes studies in the fields of biology, physics, chemistry and geology.

The objective of this paper is to present the preliminary results of seismic-stratigraphic analysis of the uppermost sedimentary layers on the continental shelf that border the Galician Massif in front of the «Rias Bajas» (Muros, Arousa, Pontevedra and Vigo). Information also is provided by the correlation of high-resolution seismic reflection profiles with sediment samples collected during the study. The so-called «Rias» are systems of river valleys initiated by the drowning of the continental shelf. The concept of «Rias Altas», «Rias Bajas» and Estuaries», from a geomorphic point of view, considers climatic effect combined with sea level changes and tectonic variations caused by the tectonic revival of Hercynian discontinuities (SCHEU, 1913).

The regional bathymetry (Fig. 1) and the structure of the continental shelf are well known due to the numerous surveys carried out on the continental border as well as in the «Rias» (KOLDIJK, 1968; ARPS and KLUYVER, 1969; DE JONG and POORTMAN, 1970; PANNEKOEK, 1970; LAMBOY and DUPEUBLE, 1971; LAMBOY and DUPEUBLE, 1975; LAMBOY, 1976; AUXIETRE and DUNAND, 1978; MOUGENOT and VANNEY, 1980; VANNEY and MOUGENOT, 1981; DIAZ and NITTROUNER, 1984).

The analysis of the seismic reflections profiles has provided a spatial view of the upper layer of the Holocene sediments as well as the variation in thickness and the character of the seismic response. The track lines include transects in the shelf as well as one transect in each of the three Rias; Arousa, Pontevedra and Vigo. In addition, three sonograph profiles were made using a side scan sonar system in the Rias (Fig. 1). The analysis of the sonographs shows that the

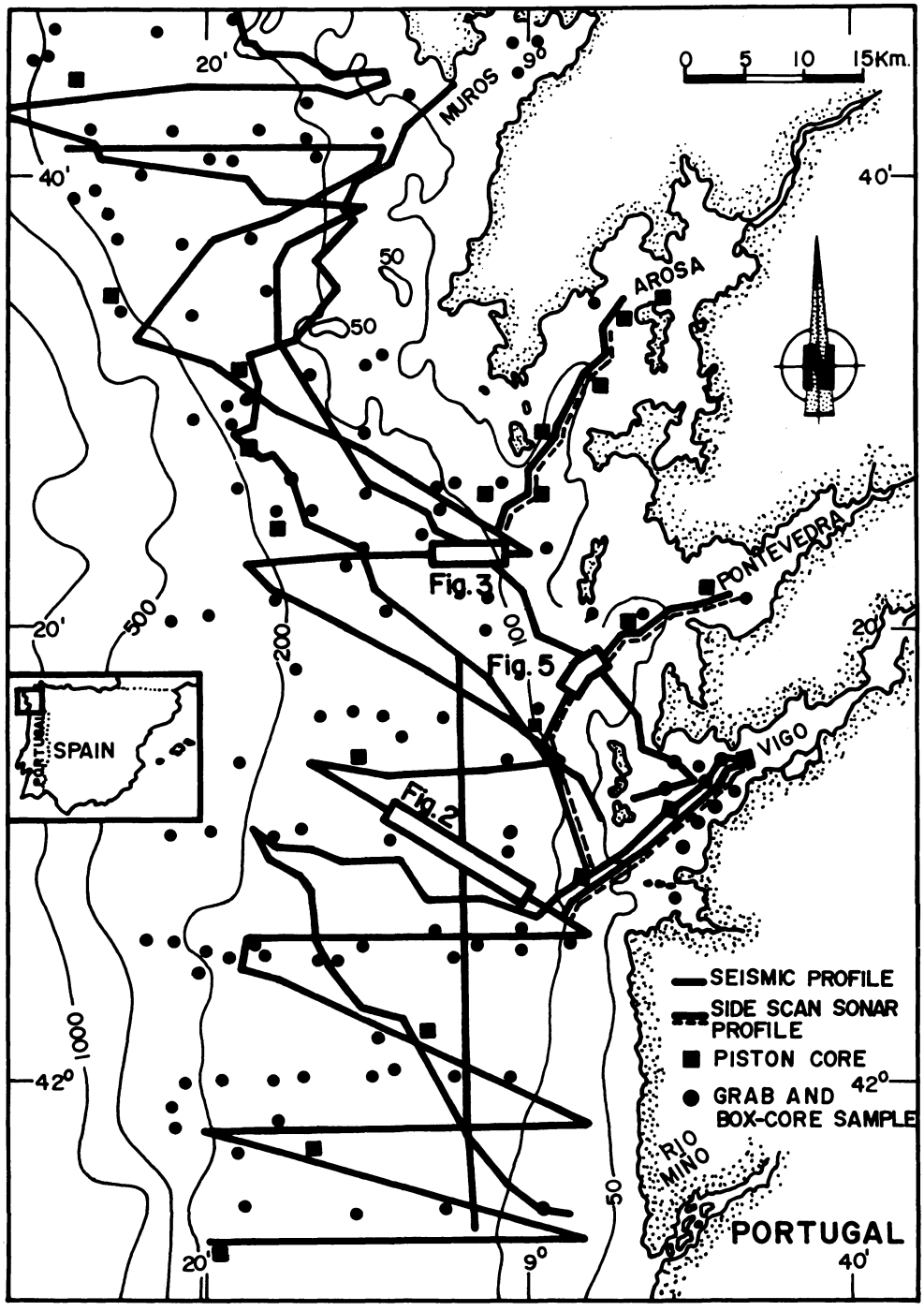

Fig. 1. Map showing generalized bathymetry of the shelf in front of «Rias Bajas» and location of the seismic profiles and samples collected. The thicker lines show the location of the profiles depicted in Fig. 2, 3 and 5.

bottom is accoustically soft in the inner part of the Rias, whereas in the mouth sand-patches and rocky outcrops have been detected. This event is in part due to the existence of a regionally continuous layer of Holocene sediments composed of sandy mud with several interstratified sandy layers.

METHODS

The surveyed area comprises a part of the continental shelf between parallels 42° 42' N and 41° 53' N and includes the Rias of Muros, Arousa, Pontevedra and Vigo. The present study consists mainly of sub-bottom profiling (900 Km) from the inner and outer shelf, to a water depth of 200 m (Fig. 1).

The seismic profiles and samples were collected aboard the O/V «Cornide de Saavedra» during the oceanographic cruise «Breogan-485» on April 1985 and «Breogan-586» on May 1986. For recording seismic profiles an ORE 3.5 kHz high resolution profiler and a 100 kHz KLEIN side scan sonar (150 m slant range scale) were used in the survey. Seismic records were complemented with gross-lithologic data from gravity cores (2 m long), Shipeck grab samples, drags and box-cores collected in the study area.

Although sedimentological analysis of the samples are still underway, visual examination has helped to interpret the sedimentological facies recorded in seismic reflection profiles as well as sonograph profiles.

The navigation systems consisted of radar, satellite an Loran C.

REGIONAL FRAMEWORK AND MORPHOLOGY

The continental margin in the Northwestern Iberian Peninsula surrounding Galicia and Northern Portugal is an Atlantic passive type (HEEZEN, 1974). The continental shelf and break are slightly variable in depth. Bathymetry shows that the shelf in front of «Ria de Muros» is 35 Km wide and towards south progressively narrows to 25 Km in width in front of «Ria de Pontevedra». From this point, the shelf widens to 35 Km off the mouth of Miño River.

The shape of the shelf is generally flat and slopes gently seaward. Small irregularities are present due to the existence of rocky outcrops and coarse-sandy benches. The inner shelf is characterized by proximal sediments produced by coastal erosion and littoral drift, but in the mouth of the «rias» profluvial sediments occur as submarine «beaches». From the Hydrographic Charts it is possible to infer numerous bathymetric irregularities related to a rocky belt which borders the entire littoral. In the mouth of the «rias» the sedimentary units cover these rocky outcrops. The middle and outer shelf are characterized by little to no relief. To the south, there is a consolidated outcropping unit related to subaerial erosion following a fall in sea level (VANNEY and MOUGENOT, 1981).

This area is an example of a continental shelf molded by an erosion surface of Oligocene age, which was later modified during the Quaternary period. The origin and orientation of the main morphological features are structurally controlled (AUXIETRE and DUNAND, 1978). At the Shelf-break, the sedimentary units are represented by distal progradational units (MOUGENOT and VANNEY, 1980). The source of sediment forming the depositional units of the shelf are basically the igneous and metamorphic rocks which constitute the adjacent emergent region. Littoral transport is to the south and produces sandy shoals down-drift from rocky outcrops, islands and river mouths (FRAGA and MOURIÑO, 1982).

RESULTS

Seismic stratigraphy

From the analysis of the 3,5 KHz seismic-reflection records, three main geological units are identified: (1) a very reflective acoustic basement; (2) a coarse sand unit corresponding to a Holocene basal level; and (3) Holocene deposits.

The acoustic basement composed of igneous and metamorphic rocks is very reflective and clearly differentiated from the other two geological units. Seaward, the continuity of the reflector is progressively less distinct due to the increase in the thickness of the sedimentary layers, as well as in the limitations in penetration of the seismic equipment. The acoustic basement outcrops in the inner shelf, forming a rocky belt near the coast line.

In the middle shelf, two morphological provinces are defined in relation to the outcropping basement; (1) the northern sector, where the existence of outcrops produces scarps and other discontinuities in the relief of the shelf; and (2) the southern sector, which is unaffected by the outcrops (Fig. 2). A regionally continuous reflector is characterized by layering on the acoustic basement. This reflector has an angular discordance with the uppermost unit and because of its high reflectivity and continuity, is easy to detect in the seismic records (Fig. 3). The deepest point of the reflector is reached in the middle shelf, having a slightly convex geometry. It outrops on the outer shelf and produces an irregular surface, where it can be defined as a hardground (Fig. 2).

The texture of the reflector in the outcrop area is composed of gravels and coarse sands, corresponding to an erosional surface that originated in a transgressive interestadial period. An overlying stratified unit is acoustically translucent composed of parallel internal reflectors. This unit belongs to the Holocene, and is characterized by profluvial accumulation surfaces in two different sedimentary facies: proximal inner shelf, and distal middle and outer shelf.

The Holocene unit is composed of deposits with a low acoustic impedance, and can be interpreted as fine-grained sediment (mud to fine sand). The internal reflectors of the unit have a greater acoustic impedance, and are interpreted as interstratified layers of coarse sediments (gravels and sands) with lateral changes in seismic character. Locally, near the basement outcrops in the inner shelf, the seismic response increases in acoustic impedance. In consequence; the general translucent character is progressively less due to the presence of sand and gravel mixed with bioclastic sediments.

Holocene unit isopachs

Figura 4 shows the thickness of the Holocene deposits. The isolines are in metres, based on a sound propagation velocity assumed in 1.8 Km/s. Although the Holocene deposits are widley distributed in the study area, local discontinuities occur (MOUGENOT and VANNEY, 1980).

The thickness of the Holocene unit, therefore, is variable over the shelf with maximum thickness of 15 m northward the mouth of Miño River and minimum thickness of 2 m in the outer shelf. Elsewhere, thicknesses are 6 m in front of «Ria de Pontevedra»; 5 m in front of «Ria de Arousa» and 8 m in front of «Ria de Muros».

From the isopach map, it is possible to infer two axes of maximum thickness orientated in a N-S direction subparallel to the coastline, and separated by a non-deposition surface. The first sedimentary body is located northward of the shelf, related to contibutions of «Ria de Muros». The second one with larger thickness is related to Arousa, Pontevedra and Vigo «Rias». Maximum thicknesses are associated with proximity to the mouths of the «Rias» where the outcrops trap (Fig. 5).

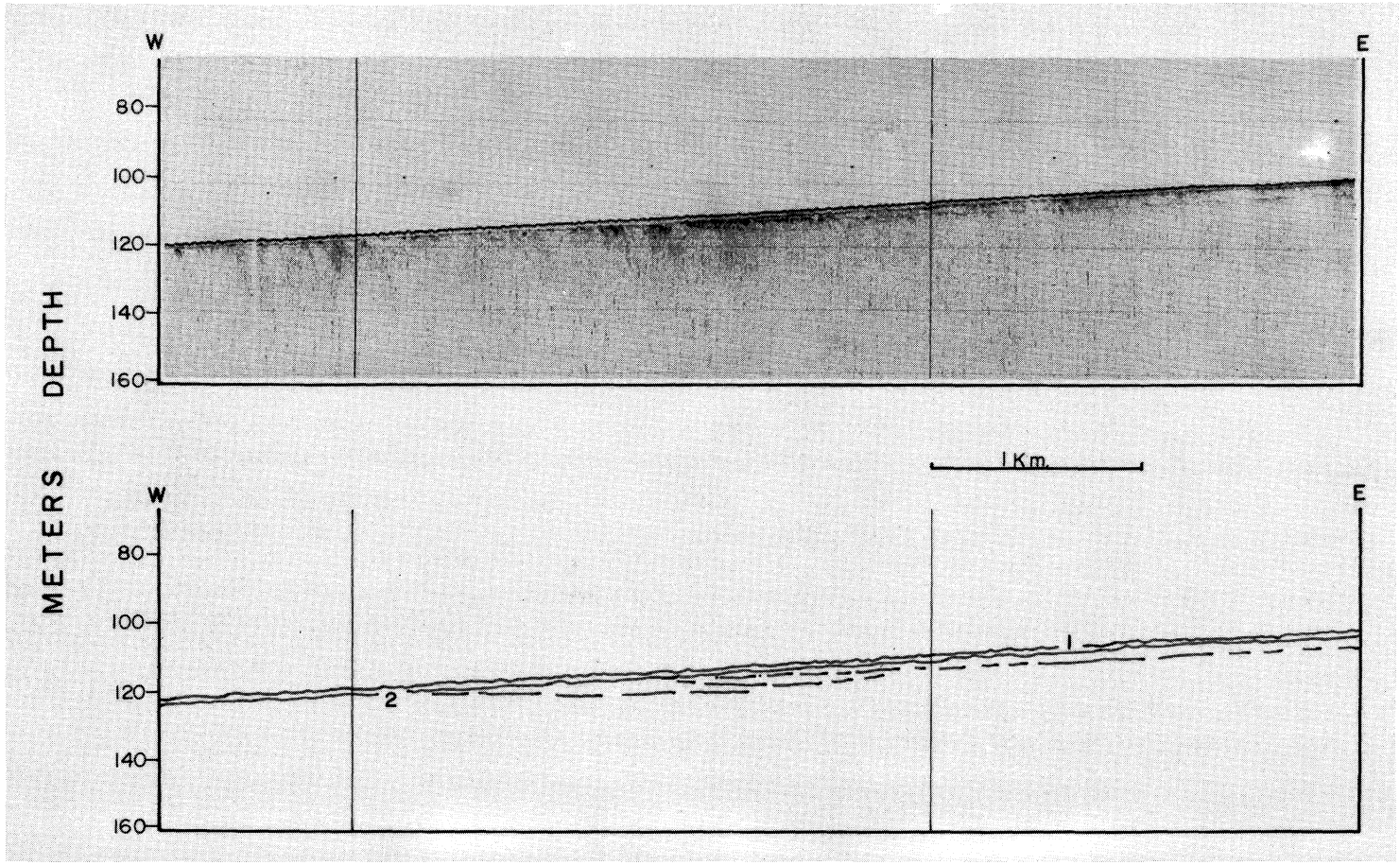

Fig. 2. 3.5 kHz seismic record showing the outcropping of the Holocene basal surface. (1) Translucent unit; (2) Holocene basal level; (3) non deposition surface. See Fig. 1 for location.

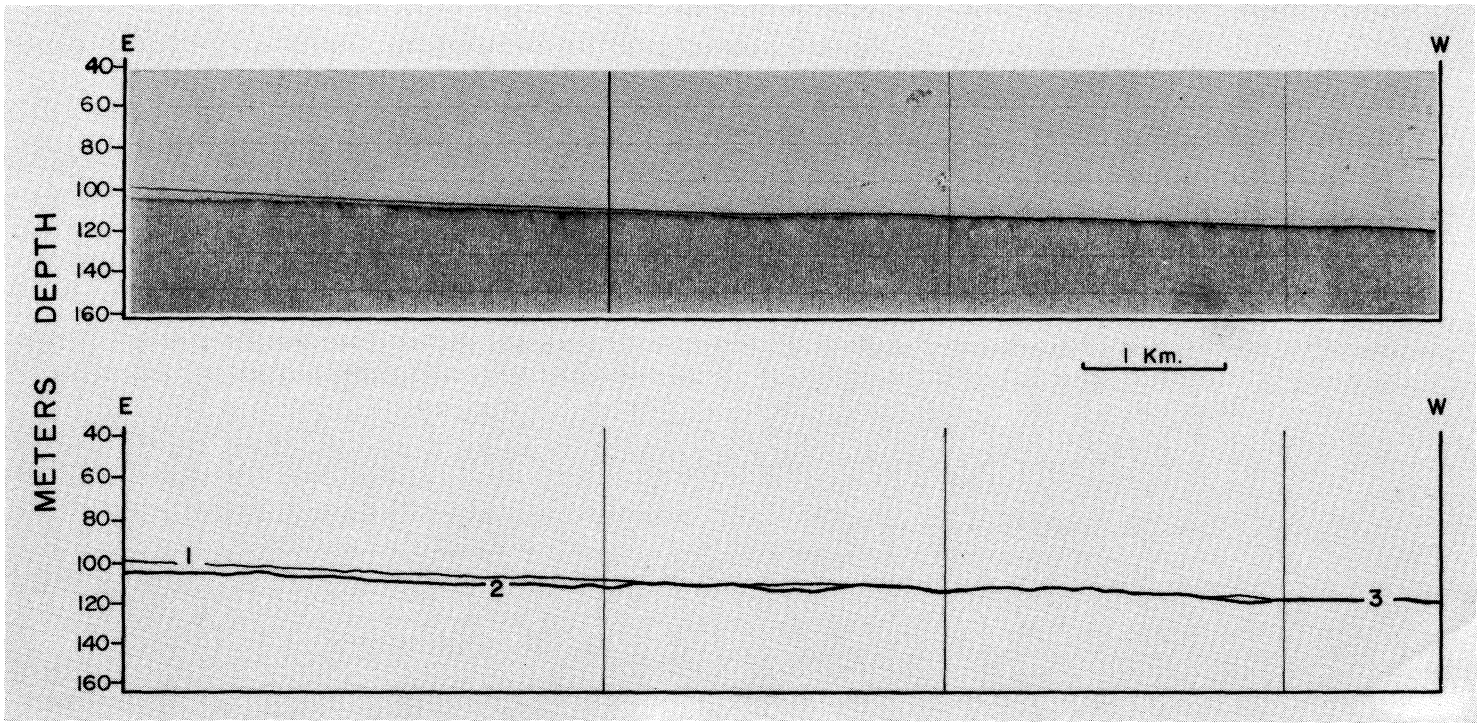

Fig. 3. 3.5 kHz seismic profile, showing the discordance between the transparent unit and basal level. (1) Accumulation surface; (2) Holocene unit with non-continuous internal reflectors. See Fig. 1 for location.

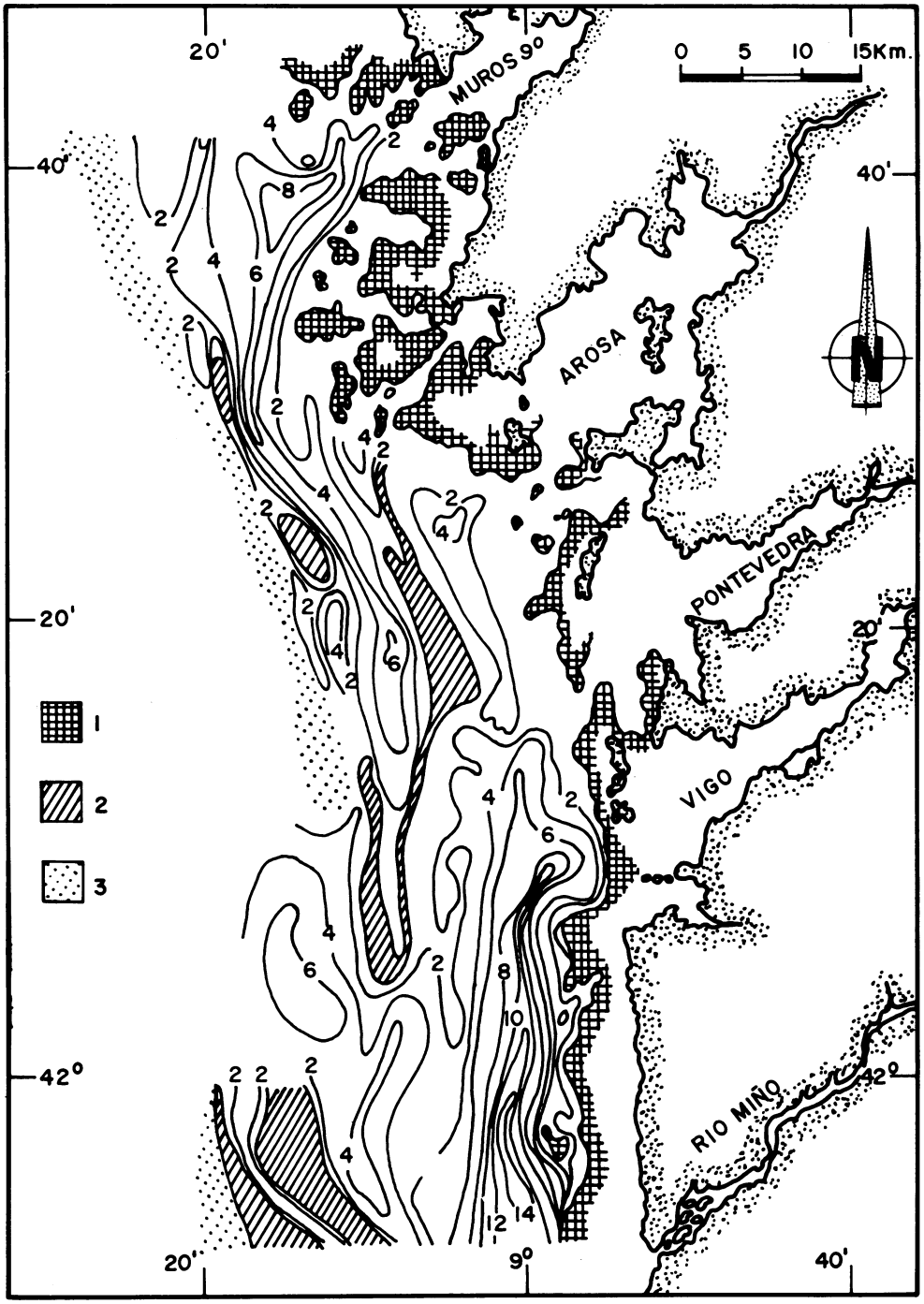

Fig. 4. Map showing the isopach of the Holocene deposits, based on 3.5 kHz seismic profiles. (1) Rocky outcrops; (2) Erosional and non-depositional surfaces; (3) Shelf break deposits (contour lines are in metres).

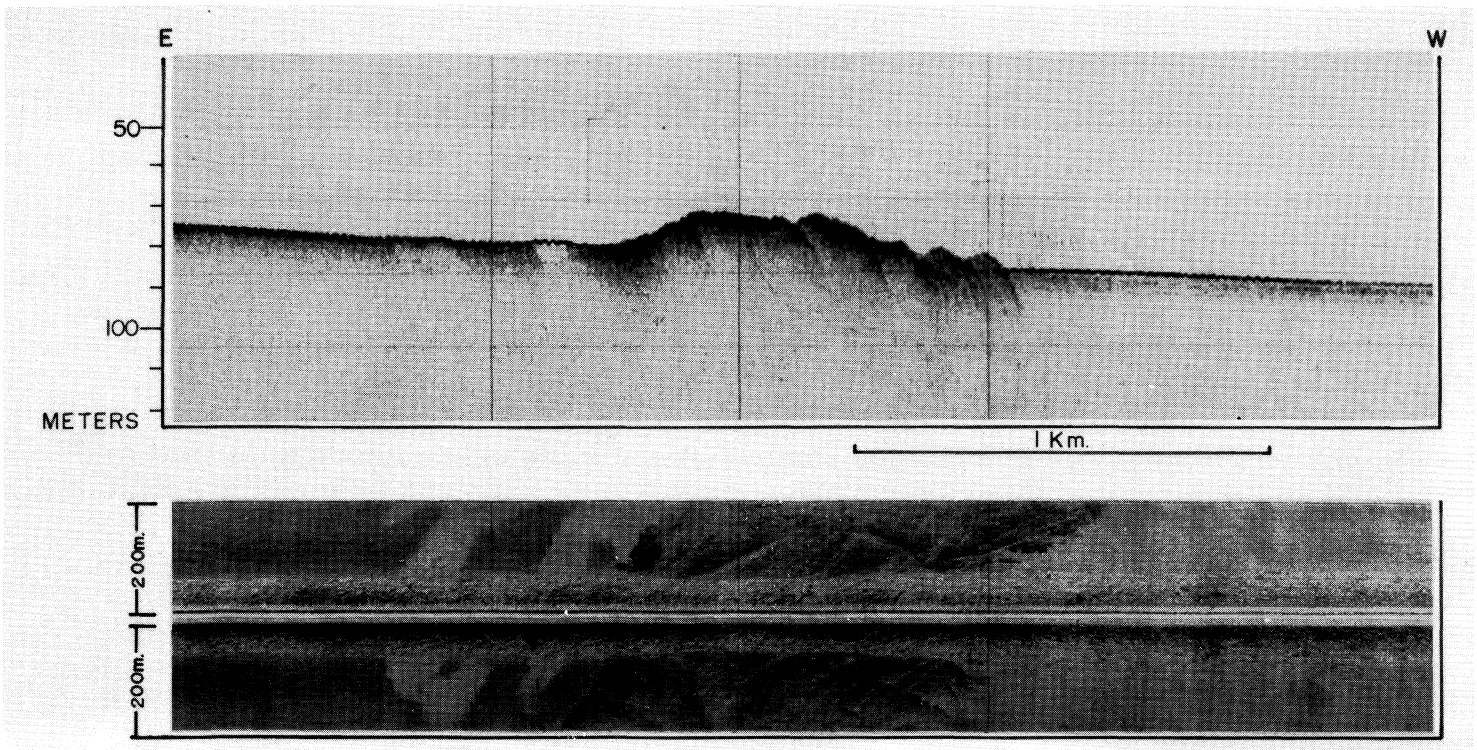

Fig. 5. Seismic profile (A) and side scan sonar (B) records showing a granitic outcrop in the mouth of the «Ria de Pontevedra». Differences in the acoustic response of both sides of the outcrop are detected. See Fig. 1 for location.

CONCLUSIONS

The Galician Continental Shelf in front of the «Rias Bajas» is characterized by the development of a Holocene sedimentary unit, deposited on an erosive base level.

Three main sources have controlled the variations in the amount of shelf deposits: (1) fluvial sediments from the contribution of the rivers of the «Rias». These deposits are mixed with the organic sediments produced inside the «Rias» due to the existence of a high productivity level (LOPEZ JAMAR, 1978; TENORE *et al.*, 1984), (2) distal deposits defined as the suspended, finer sediments removed from the «Rias» to the shelf, (3) local currents, producing a sediment transport in a southward direction (FRAGA and MOURIÑO, 1982).

The reflectivity and the geometrical character of the seismic reflectors in the Holocene unit suggest that the depositional processes have been repetitive during the Holocene period. The unit is not affected by faulting.

The recent geological history of the continental shelf can be reconstructed on basis of results obtained from the survey. Follwing the upper Pleistocene, a transgressive erosional surface was formed composed of gravels and littoral sands. The accumulation of the deposits was thicker in the middle shelf. Later on, during the Holocene transgressive period, a finer depositional unit was deposited because of the confluence of three main contributions: fluvial proximal, fluvial distal and local currents.

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