SEDIMENTARY PROCESSES CONTROLLED BY THE MEDITERRANEAN OUTFLOW AND ATLANTIC INFLOW CURRENTS IN THE GULF OF CADIZ CONTINENTAL MARGIN

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Abstract

The Late Quaternary pattern of sedimentary facies on the Spanish Gulf of Cadiz continental shelf results from an interaction between a number of controlling factors that are dominated by the Atlantic inflow currents flowing southeastward across the Cadiz shelf toward the Strait of Gibraltar. This currents generate depositional processes which develop large prodeltaic bodies prograding southeasternwards. The slope processes, in contrast, are dominated by the Mediterranean outflow flowing under 300 m northwesternwards. Variations in the current speed gives way to the existence of different sedimentary processes on the continental slope. The southeastmost region is characterized by erosive processes as a consequence of an increased current speed northwards. The depositional processes generate, however, large contourite sediment bodies in the areas protected of the current by the diapiric ridges. These depositional processes take place in the southern region of the Gulf of Cadiz.

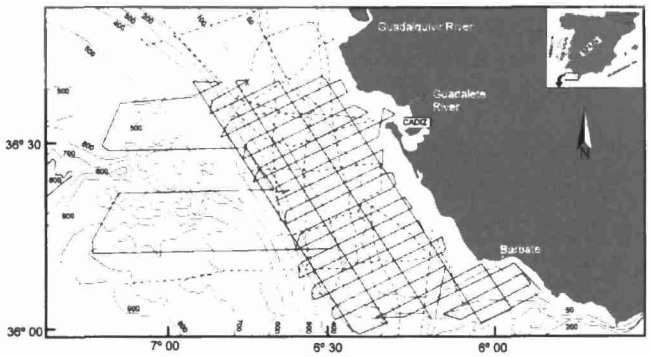
Key-words : sedimentation, Strait of Gibraltar

Introduction

Recent studies have demostrated that echograms recorded on high-frequency precision provide a valuable tool for the study of near-bottom sedimentation processes in the Gulf of Cadiz continental margin (1; 2; 3). However, these studies are orientated toward a study of the continental shelf or continental slope as a independent sedimentary environments. This paper focuses on the Atlantic surface water effects on the entire Spanish continental shelf and integrates new data with the Mediterranean outflow effects on the Spanish continental slope area in the southeastern Gulf of Cadiz.

Methods

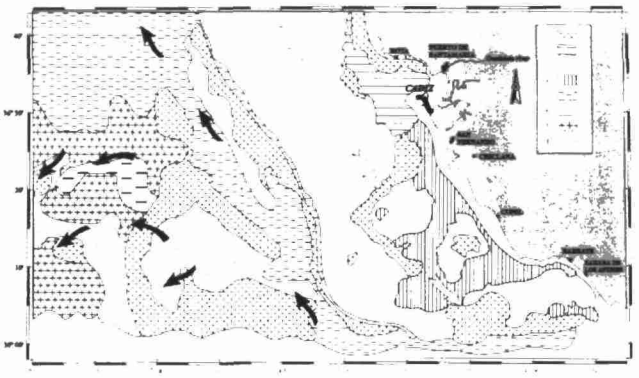
A total of 3.400 km of tracklines of high-resolution 3.5 kHz, Geopulse, and single channel 20-40 cu. in. airguns seismics profiles, taken in the GC-86-1 and G-86-1 seismic surveys, have been analyzed (fig. 1) (4; 5). In addition, 700 subbottom including dredges, rock cores and gravity cores were taken from the Gulf of Cadiz continental shelf and slope, at water depth ranging from 15 to 959 m. Grain-size analyses were conducted with the SEDIGRAPH 5000D (<63 microns), and by sieving (>63 microns). The sand fraction composition was studied with the binocular microscope.



1.- Area of study and simplified bathymetry. Map showing 3.5 Khz, Geopulse and single-channel airgun tracklines. Continuous line: G-86-1; Dashed line: GC-86-1.

Oceanographic setting

The Gulf of Cadiz is located west of Strait of Gibraltar forming a reentrant of the eastern Atlantic Ocean (fig.1). Above 300 m water depth there is a strong southeastward inflow of North Atlantic Surficial Water (NASW- hereafter called Atlantic inflow) that intensifies toward the Strait of Gibraltar (6; 7). Atlantic surface current flows eastward to southeastward over the Gulf of Cadiz continental shelf (fig.2). Extensive sand dune fields across the entire southeastern end of the shelf indicate that current speeds accelerate significantly toward Strait of Gibraltar (8). Between 300-1200 m water depth there is a significant development of bottom-current deposits with bedforms because the deep Mediterranean Outflow Water (MOW-hereafter called Mediterranean outflow) shears northwestward from Gibraltar along the Cadiz continental slope as the Mediterranean undercurrent (9; 10). Because of density differences with respect to the surrounding Atlantic water, the warm and dense (>12° C; salinity (36.2%) Mediterranean



2.- Maps with the distribution of the currents and sedimentary proceses in the Gulf of Cadiz, showing the Atlantic inflow current (white arrows) and the Mediterranean outflow (black arrows) modified from (10, 7). Sedimentary processes: 1, erosive; 2, litoral; 3, fluvio-deltaic; 4, Atlantic inflow processes; 5, slope depositional processes; 6, gravitatory; 7, mixed processes; 8, Mediterranean outflow processes.

outflow progressively sinks as it flows northwestward at varying depths between 300 and 1800 m as an independent stream, the geostrophic Mediterranean undercurrent (fig.2)(7; 11). The Mediterranean undercurrent maintains contact with the seafloor up to 1000 m water depth on the eastern region of the Gulf of Cadiz and approximately to 1400 m depth on the western side of our study area (10; 12).

Maximum undercurrent speeds are 80 cm/s in the eastern part of our study area (10; 7) but decrease to 75-40 cm/s on the central slope (13). Current ribbons splay southwestward through the valleys producing faster channelized bottom-current flows downslope that average 80 cm/s in a region where the contour-parallel currents of the Mediterranean outflow average only 40 cm/s (13; 14). Along the western Cadiz slope, current speed decreases to 10-20 cm/s and speed in channels declines to 25 cm/s (15). Current speeds at the southern fringes are considerably slower than inmediately upslope because the Mediterranean outflow has higher speed cores there (7). Previous studies recognize the variability of current speed east to west, upslope to downslope and valley to intervalley areas in the patterns of bedforms observed on the Cadiz continental slope (4; 10; 11).

Distribution of sedimentary processes

Previous studies show the existence of three main sectors in the study area of the Gulf of Cadiz. The southwestern sector contains dune field and outcrops of acoustic basement (8). Recent deposits of the northwestern area is characterized by the existence of an extensive prodeltaic body developed from the Guadalquivir river. Between these regions there is a transition zone with intermediate characterics (5).

A series of sedimentary processes have been established for each physiographic region of the continental margin (fig. 3). The shelf is dominated in the northern area by fluvio-deltaic depositional processes, affected by the Atlantic mass water crossing the shelf northwest-southeastwards. Large prograding bodies are developed by terrigenous fine-grained materials derived from river inflow in the Gulf of