*Geologie en Mijnbouw* **77:** 263–281, 1999.



# Sequence stratigraphy of Holocene incised-valley fills and coastal evolution in the Gulf of Cádiz (southern Spain)

Cristino J. Dabrio[1], Cari Zazo[2], Javier Lario[2], José Luis Goy[3], Francisco J. Sierro[3], Francisco Borja[4], José Ángel González[3] & José Abel Flores[3]

[1]*Departamento de Estratigrafía and Instituto de Geología Económica–CSIC, Universidad Complutense, 28040 Madrid, España (e-mail: dabrio@eucmax.sim.ucm.es);* [2]*Departamento de Geología, Museo Nacional de Ciencias Naturales–CSIC, 28006 Madrid, España (mcnzc65@mncn.csic.es);* [3]*Departamento de Geología, Facultad de Ciencias, Universidad, 37008 Salamanca, España (joselgoy@gugu.usal.es, sierro@gugu.usal.es, angel@gugu.usal.es, flores@gugu.usal.es);* [4]*Área de Geografía Física, Facultad de Humanidades, Universidad, 21007 Huelva, España (fborja@uhu.es)*

Received October 1996; accepted in revised form 4 March 1999

*Key words:* estuarine deposits, Flandrian transgression, Late Pleistocene, radiocarbon data, spit barriers

**Abstract**

This first sedimentary interpretation of two incised-valley fills in the Gulf of Cádiz (southern Spain), which accumulated during the last fourth-order eustatic cycle in response to fluvial incision, changes of sea level, and correlative deposition, relates the filling of the estuarine basins and their barriers with four regional progradation phases, $H_1$ to $H_4$. The cases studied are the wave-dominated Guadalete, and the mixed, tide and wave-dominated Odiel-Tinto estuaries. The sequence boundary is a type-1 surface produced during the lowstand of the Last Glacial period ca. 18 000 $^{14}$C yr BP. No fluvial lowstand deposits were found in the area. Due to rapid transgression the valley fills consist of transgressive and highstand sediments. The maximum landward advance of the estuarine barriers occurred ca. 6500–6000 $^{14}$C yr BP during the maximum of the Flandrian transgression, but there is no evidence of sea level rising appreciably above the present. A large part of the estuaries was filled during $H_1$ (ca. 6500–4400 $^{14}$C yr BP) but ravinement by shifting tidal inlets destroyed most of the coeval barriers. During the $H_2$ phase (ca. 4200–2550 $^{14}$C yr BP) sedimentation was favoured by arid conditions and concentrated in the axial estuarine zones and the barriers. Between $H_2$ and $H_3$ prevailing winds changed from W to WSW, increasing spit growth to the east and south-east. Progradation of bay-head deltas and flood-plains during $H_3$ (ca. 2300–800 $^{14}$C yr BP) and $H_4$ (500 yr ago to the present) further reduced the accommodation space in the largely-filled valleys, and sediment by-passed the estuaries and accumulated in the estuarine barriers as fast-growing spits. Arid conditions and increasing human activity have caused rapid coastal modifications.

## Introduction

Several estuaries along the coast of the Gulf of Cádiz are partly enclosed by spits (Figure 1). The Holocene evolution of the coast has been the focus of many papers (e.g. Gavala y Laborde 1959, Dabrio & Polo 1987, Zazo et al. 1992). Radiocarbon dating of shells from the spits suggested a chronology of events of progradation and erosion (Zazo et al. 1994, Lario et al. 1995, Goy et al. 1996, Lario 1996).

In contrast, the filling of the estuaries has remained poorly understood despite a few publications (e.g. Borrego 1992, Borrego et al. 1993, Morales 1993). The first attempts to reconstruct the Holocene sedimentary evolution of an estuary from drill cores were those of Dabrio et al. (1995) and Goy et al. (1996) who concluded that the Guadalete estuary underwent flooding in the Early Holocene followed by a phase of open estuary and a later, relatively rapid filling related to sea-level changes and progradation of the Guadalete

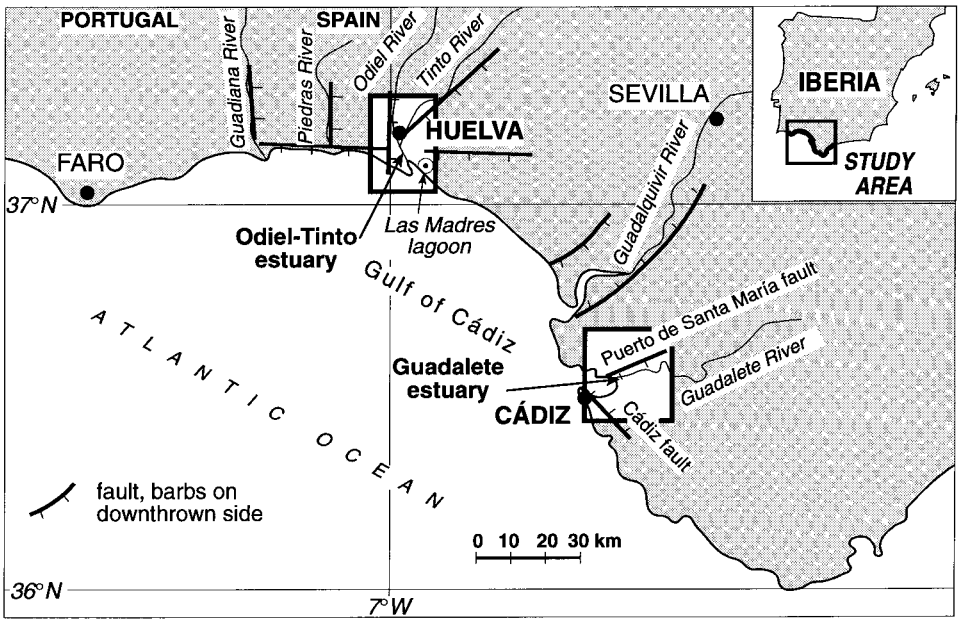


*Figure 1.* Map showing study areas and main faults controlling localities for fluvial valleys and estuary settings along the coast of the Gulf of Cádiz.

river delta after 6450 $^{14}$C yr BP. To obtain a more detailed view of the importance of valley fills as records of coastal evolution and of climate changes, the area has been re-studied in the framework of a project including the analysis of aeolian deposits nearby (Zazo et al. this issue).

The aim of this paper is to present the results of the study of drill cores from two incised-valley fills in the Gulf of Cádiz: the wave-dominated Guadalete estuary and the mixed, tide- and wave-dominated Odiel-Tinto estuary, with its associated Las Madres coastal lagoon and peat bog. The results make it possible to interpret the sedimentary evolution of the incised-valley fills as a function of first the glacio-eustasy factor (global sea-level rise) and then the minor relative changes of sea level after the maximum of the Flandrian transgression. This interpretation also relates, for the first time in the area, the filling of the estuarine basins and the development of spits at the mouths of the estuaries. It proposes a more detailed version of the coastal evolution of the Gulf of Cádiz during the Holocene.

## Geological setting

The Gulf of Cádiz (southern Iberian Peninsula) opens towards the south-west and the Atlantic Ocean (Figure 1). The morphology of the coasts of south-western Europe and north-western Africa, greatly reduces the effective fetch of Atlantic gales, and only wave fronts and surges moving towards the north-east are able to reach the shore of the gulf. Daily winds blowing mainly from the sea also generate wave fronts which progress roughly in the same direction. Most of the wave fronts approach the coast obliquely and induce strong longshore transport. This produces littoral drift directed towards the east and south-east on the Spanish side of the gulf. The drift is demonstrated by direct observation, measurements of sand transport, and the occurrence of spit barriers (Zazo et al. 1992).

The coast of the Gulf of Cádiz can be described as semidiurnal mesotidal with mean tidal ranges of 2.1 m and a variation up to 0.45 m between successive flood or ebb tides (Borrego et al. 1993). Wave energy is medium, because 75% of the waves do not exceed 0.5 m in height. These conditions favour the development of broad littoral lowlands, usually sheltered by spits, where tidal flats and fresh-water marshes extend several kilometres inland.

Two major Holocene phases of coastal progradation have been widely recognised in southern Spain after the transgressive maximum (ca. 6500 $^{14}$C yr BP) in the area (Zazo et al. 1994, 1996a, Lario et al. 1995). In the most complete case (Almería, SE Spain), they include four spit systems currently referred to as $H_1$, $H_2$, $H_3$, and $H_4$ (Zazo et al. 1994). The first major