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HOLOCENE INCISED-VALLEY FILLS AND COASTAL EVOLUTION IN THE GULF OF CÁDIZ (SOUTHERN SPAIN)

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Several estuaries along the coast of the Gulf of Cádiz are reinterpreted as incised valleys. They are at present partly enclosed by spits forming estuarine barriers where a holocene chronology of events of progradation and erosion was deduced using radiocarbon dating of shells (Zazo *et al.* 1994, Goy *et al.* 1996). In the most complete case found in the Atlantic-Mediterranean linkage area, each spit barrier system is formed by four coastal morpho-sedimentary units (spit barriers) that Zazo *et al.* (1994) named H_1 to H_4. Beach crests and swales on the surface of each unit are arranged in sets separated by erosional surfaces and/or particularly large swales that Zazo *et al.* (1994) called a gap. Numerous radiocarbon measurements allowed to deduce the age of the four spit units (Zazo *et al.*, 1994, 1996 a; Goy *et al.*, 1996; Rodríguez-Ramírez *et al.*, 1996, Lario, 1996). In this paper we use the ages of this units expressed as cal. BP: H_1 (6500-4700 cal. BP), H_2 (4400-2700 cal. BP), H_3 (2400-700 cal. BP), and H_4 (500 cal. BP-present).

The spit barrier systems closing the estuaries offer favourable settings for human settlements owing to their proximity to the littoral and natural harbours. For this reason, archaeological remains are relatively frequent. In contrast, the infill of estuaries has remained poorly understood.

This paper presents the results of the study of drill cores from two of these incised-valley fills: the wave-dominated Guadalete estuary and the mixed tide- and wave-dominated Odiel-Tinto estuary. We have related the filling of the estuarine basins with the accumulation of estuarine spit barriers, and interpreted their sedimentary evolution as a function of the glacio-eustasy factor (global sea-level rise) and the response to the relative changes of sea level after the maximum of the Flandrian transgression. We use these data to refine the present knowledge about the coastal evolution of the Gulf of Cádiz during the Holocene.

The incised-valley fills record a fourth-order depositional sequence, still incomplete. At present, both estuaries are largely filled with sediments deposited during the TST and HST phases of the eustatic cycle.

The lower limit of the depositional sequence is a type-1 boundary surface produced by river incision during the lowstand of the Last Glacial period ca. 18 000 ^{14}C yr BP. The absence of lowstand fluvial deposits, and the modest development of transgressive fluvial-to-marine deposits overlaying the erosional surface evidence high rates of sea level rise between 14 000 and 10 500 ^{14}C yr BP.

The maximum advance of estuarine barriers into the estuarine basin occurred ca. 6500 ^{14}C yr BP. There is no evidence of sea level rising appreciably above the present MSL during the Flandrian transgression. However, a small positive oscillation of sea level may have occurred ca. 5500 ^{14}C yr BP, as suggested by isotopic values in the Guadalete estuary.

A large part of the estuary fills is of H_1 age (ca. 6550--4400 ^{14}C yr BP). In contrast, no subaerial parts of the H_1 estuarine barriers are preserved. In the Odiel-Tinto estuary, the dominance of tides was unfavourable for spit development. In the Guadalete estuary, the absence of estuarine barriers results from the concurrence of reduced input of fluvial sands to the bay mouth, and of erosion by laterally shifting tidal inlets. Indirect evidence from the Las Madres peat bog indicates that deposits of H_1 age did accumulate. Therefore, the only remains of H_1 estuarine barriers are found at the base of the sequences close to the thalweg of the incised valley. It is most unlikely that H_1 deposits will ever be found in the emergent parts of spit barrier complexes.

During the H_2 phase (ca. 4200--2550 ^{14}C yr BP), most of the estuarine sedimentation was concentrated in tidal meanders (Odiel-Tinto estuary) and intertidal to supratidal flats (Guadalete estuary) of the axial zones. Restrictions on life conditions increased during this stage. Estuarine barriers grew noticeably; although continued shifting of tidal inlets destroyed a large part of the subaerial barrier in the Guadalete estuary.

Between the H_2 and H_3 phases (ca. 2550--2300 ^{14}C yr BP) a change in prevailing winds from W to WSW strongly affected the estuarine barriers causing partial erosion and spits growing to the east and south-east prevailed over the ones accreting in the opposite direction.

During the H_3 phase (ca. 2300--800 ^{14}C yr BP) estuarine deposits in the mixed tide-and-wave-dominated Odiel-Tinto estuary are largely tidal meanders and tidal sand flats. Rapid growth occurred at Punta Umbría spit and Saltés Island in contrast to more modest rates in Punta Arenilla. In the Guadalete estuary, rapid seaward progradation accumulated a wide estuarine barrier mostly fed by the axial distributary channel. Tidal flats were covered by flood-plain deposits starting at the innermost parts. As the accommodation space in largely filled estuaries had been greatly reduced by this time, most of the sediment by-passed them and was delivered to the coast.

The H_4 phase (ca. 500 ^{14}C yr BP to the present) records further advance of bay-head deltas and flood plains over large areas of the estuaries, particularly in Guadalete. The residual estuarine basins act as by-pass tracts for fluvial transport and large volumes of sand have been supplied to the longshore drift, enhancing the longitudinal growth of spits under prevailing winds from the south-west. Increased rates of coastal progradation suggest stable or slightly falling mean sea level (Zazo *et al.* 1994), but human impacts have triggered rapid modifications of the shoreline such as in the Valdelagrana spit complex. Three large washovers, breaching one of the older spits are the result of the 1755 Lisbon earthquake Dabrio *et al.*, 1998).

A variety of other, man-induced processes also played an important role in triggering, or at least magnifying, catastrophic floods caused by heavy rains and enhanced aeolian-dune generation in SW Spain.

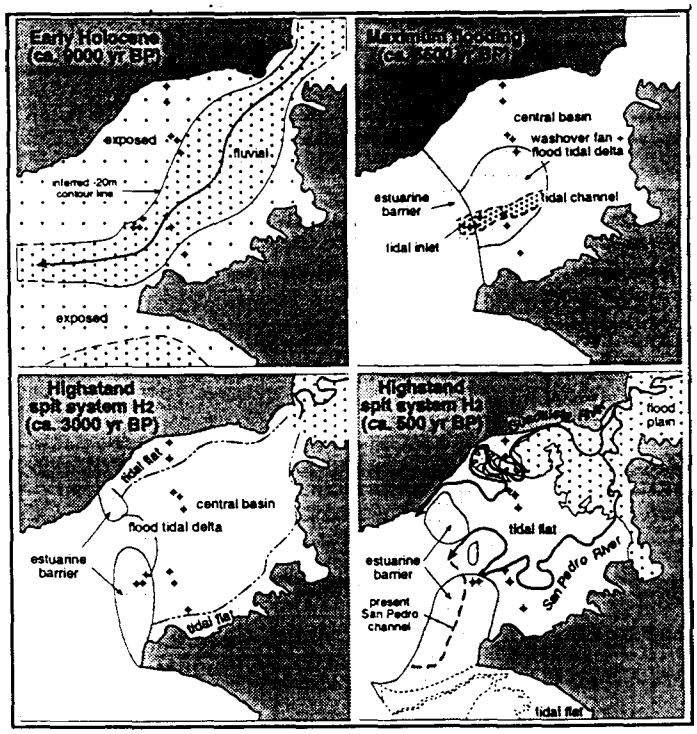

Figure 1. Schematic maps showing the changing palaeogeography of the Guadalete incised valley (the limit between "exposed" and "fluvial" is meant to represent an inferred contour line 20 m below present MSL).

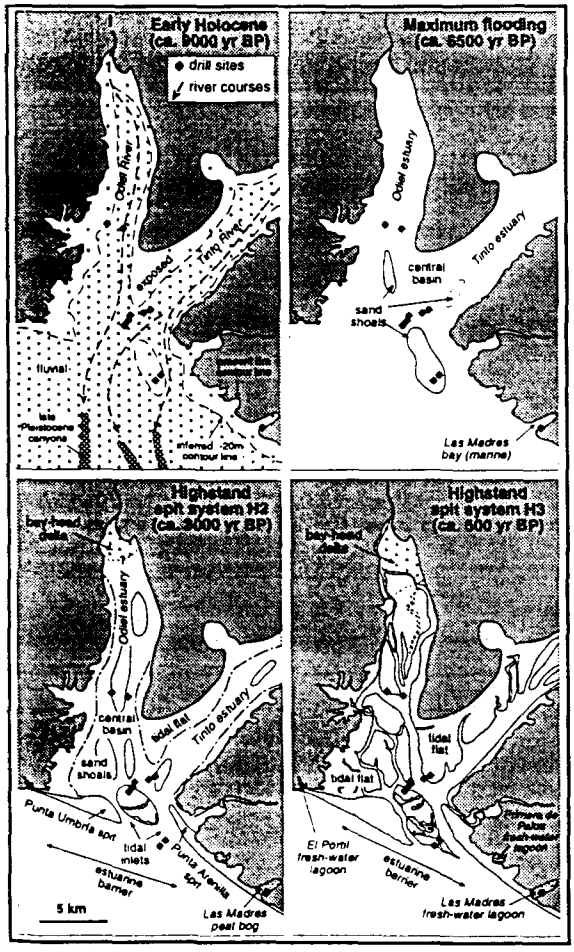

Figure 2. Schematic maps showing the changing palaeogeography of the Odiel-Tinto incised valley. The limit between exposed and fluvial is meant to represent an inferred contour line 20 m below present MSL.

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