Geophysical Research Abstracts, Vol. 7, 07078, 2005
SRef-ID: 1607-7962/gra/EGU05-A-07078

Sea-floor undulations on the Guadalfeo River prodelta, southeastern Iberian Peninsula

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Several regions of sea-floor undulations have been identified on river prodeltas of the Alboran Sea northern shelf through extensive oceanographic surveying conducted in the framework of the ESPACE (Estudio Geológico de la Plataforma Continental Española) geological program. The region is characterised by brief, but heavy rainfalls, over relatively small drainage basins surrounded by steep slopes, which cause sudden floods transporting huge sediment loads. The stream power and the flood inertia are often able to erode and largely bypass the delta plain and delta front environments, depositing much of the sediment load in the prodelta environment (Postma, 2001).

EM3000D multibeam echosounder data, TOPAS high-resolution seismic profiles and sediment samples were collected to investigate the surficial morphology of late Holocene prodeltaic deposits, focussing on the description and genetic interpretation of sea-floor undulations. The Guadalfeo River prodelta constitutes a representative example of large-scale sediment body affected by such wave-like morphologies. The Guadalfeo River is 75 km long and its drainage basin occupies an area of 295 km^2. The average value of annual water discharge of the Guadalfeo River is below 12 m^3/s, whereas the erosion rate has been estimated in 200 metric tons per km^2 per year in modern times (Ayuntamiento de Motril, 2002). The delta plain of the Guadalfeo River delta is 6.5 km long and covers an area of 41 km^2. It is composed of Quaternary sandy and gravelly sediments. The subaequous delta extends seaward more than 3 km, reaching the shelf break in a normal direction from the river mouth with an average slope of 1.9º, and laterally it extends about 8.5 km. The sediments composing the prodeltaic

body are mainly muddy sands, although coarser sediments occur in the prodeltaic topsets. The Guadalfeo River prodelta displays a well-defined wedge external shape, as the maximum thickness of about 70 ms in two-way travel time occurs next to the coast, whereas sediment thickness is below 10 ms close to the shelf break.

A series of elongated, subparallel bathymetric undulations are distinguished in the foresets-to-bottomsets of the Guadalfeo River prodelta. Those undulations affect a 6.5 km wide and 2.5 km long area in water depths ranging from 20 to 90 meters. Two main fields of sea-floor undulations can be identified: field A, in the westernmost part, and field B, in the easternmost part, separated by a transitional zone. The location of these fields seems to be related with the position of two mouths (ancient and present-day) of the Guadalfeo River, as field A occurs off the recent mouth, whereas field B occurs off an ancient mouth nowadays abandoned. Those main fields (A and B) exhibit a rougher sea floor and undulations with higher slopes than those occurring in the transitional zone. Typically, the mean slope of fields A and B ranges between 3-4º, whereas the transition zone slope is about 1.7º, being the upslope-side gradient higher than the downslope-side gradient. Undulation wavelengths range between 260 and 50 meters in the whole of prodelta. Undulations of higher lateral continuity and larger wavelengths occur in field A. Downslope variability is also observed, as undulations with larger wavelength occur between 45 and 75 m water depth. This feature is more marked in field A.

Other important geomorphological features identified in the submarine deposit linked to the Guadalfeo River are straight gullies that erode the shel fbreak and can contribute to the sediment transport from the continental shelf to slope. Finally, some evidences of the presence of gas within prodeltaic sediment have been observed.

Undulations similar to those described in this paper have been reported in several Mediterranean shelves (Ercilla et al., 1995; Chiocci et al., 1996; Correggiari et al., 2001; Cattaneo et al., 2004), as well as in other more distant shelves (Christian et al., 1997). Many factors have been proposed to explain the generation of those undulations: gravity-driven deformation, oversteepening driven by rapid progradation, failure or depositional processes, else along- (bottom-hugging shelf-parallel currents) or downslope (underflows, turbidity currents).

According to existing evidences, gravity-driven deformation favoured by rapid progradation is proposed to explain the most significant sea-floor undulations observed in the Guadalfeo River prodelta, on the basis of four main observations: a) sudden floods carrying huge sediment loads do frequently occur in the area, and would cause a rapid progradation; b) the sea-floor undulations display a higher development in field A, which is apparently connected with the most recent Guadalfeo River mouth; c) fields

A and B are located over the steeper zones of the prodelta; d) the occurrence of gas is probably related with the existence of organic matter within the sediment, which also increases the potential for sediment failure.

Acknowledgements

We thank to the project “Estudio Geológico de la Plataforma Continental Española”, funded by the “Secretaría General de Pesca Maritima, Ministerio de Agricultura, Pesca y Alimentación”, for enabling us to study the geophysical information. The second author received finantial support to participate in the present research through the “Programa de Reincorporación de Doctores” of “Junta de Andalucía”, 2003 call.

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