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A Global Synthesis with implications
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Gonzalez R.*, Lobo F. J. *, Mendes I. *, Dias J. M. A.*

Possible mechanisms leading to the formation of a thick prograding transgressive wedge at the edge of the inner Guadiana Shelf (SW Iberian Peninsula): preliminary results

*CIACOMAR-CIMA, Universidade do Algarve, Avenida 16 de Junho, s/n, 8700-311 Olhão (Portugal),
E-mail: pacolobo@ualg.pt

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Introduction

Transgressive sediment bodies formed during periods of fast sea-level rise are a crucial link between lowstand and highstand systems tracts, reflecting times of rapid environmental changes. On the Guadiana shelf (northern Gulf of Cadiz, SW Iberia) several such sediment bodies have been identified (Lobo et al., 2002). The surface of the most prominent and most recent of these is exposed at the outer edge of the inner shelf, forming a thick prograding wedge in this location (Figure 1).

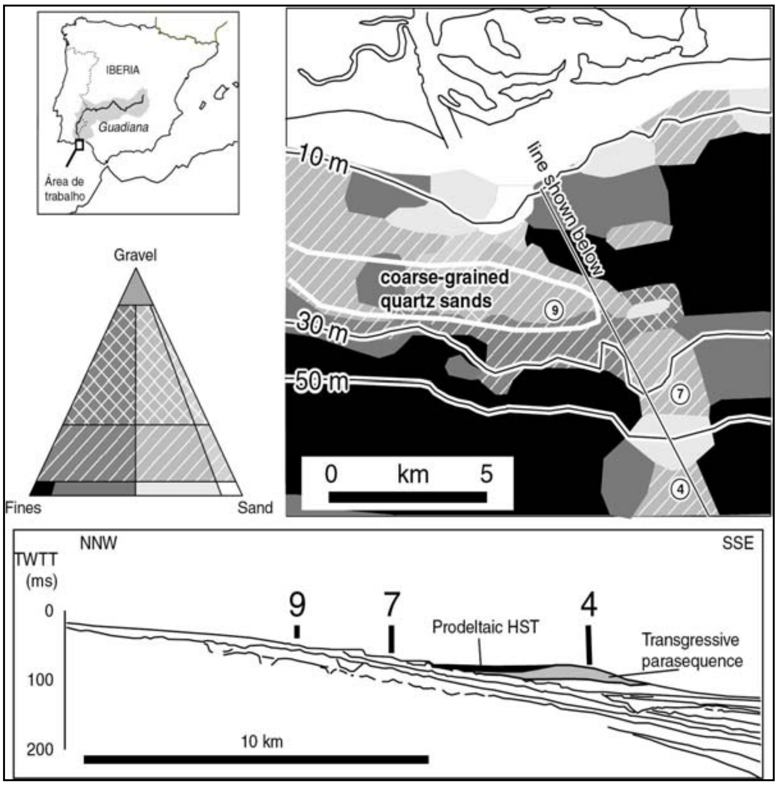

Figure 1. Location of cores on the Guadiana shelf (northern Gulf of Cadiz)

Its origin is thought to be related to a periods of slower sea-level rise or stagnant sea-level during a cold event centred at 8.2 ka B.P (Alley et al., 1997; Bard et al., 1996).

This study aims, using sedimentological data from vibrocores retrieved from the top of the transgressive deposit, and a shallower location, at identifying possible sedimentary mechanisms leading to the formation of this sediment body.

Description of cores

3 Vibrocores were extracted at water depths between 27.5 and 51m, i.e. between the outer border of the inner shelf and the upper middle shelf. All cores are with a length of less than 1m relatively short. While cores 9 and 7 were retrieved from locations where seismic lines indicate that little or no Holocene sedimentation has occurred, core 4 is from the top of the trangressive sediment wedge.

This core was retrieved from a water depth of 51 m. It shows a vertical succession dominated by sand-sized components, with little gravel (Figure 2). The trend is generally fining upward, with fines constituting ~5% at the base and 20-40% towards the top, where it is covered by a thin veneer of mud. However, most of the core shows very little vertical variation in composition. Quartz and bioclasts (mostly shells, gastropods, and sea-urchins) dominate the components. Up to 5% of bioclasts are Foraminifera. Other terrigenous grains of varied origin make up about 8-12% of components.

The sands reveal thin sets of oblique laminations, possibly related to ripples and submarine dunes.

Core 7 was retrieved at a water depth of 36.4 m. It shows a similar dominance of sand-sized

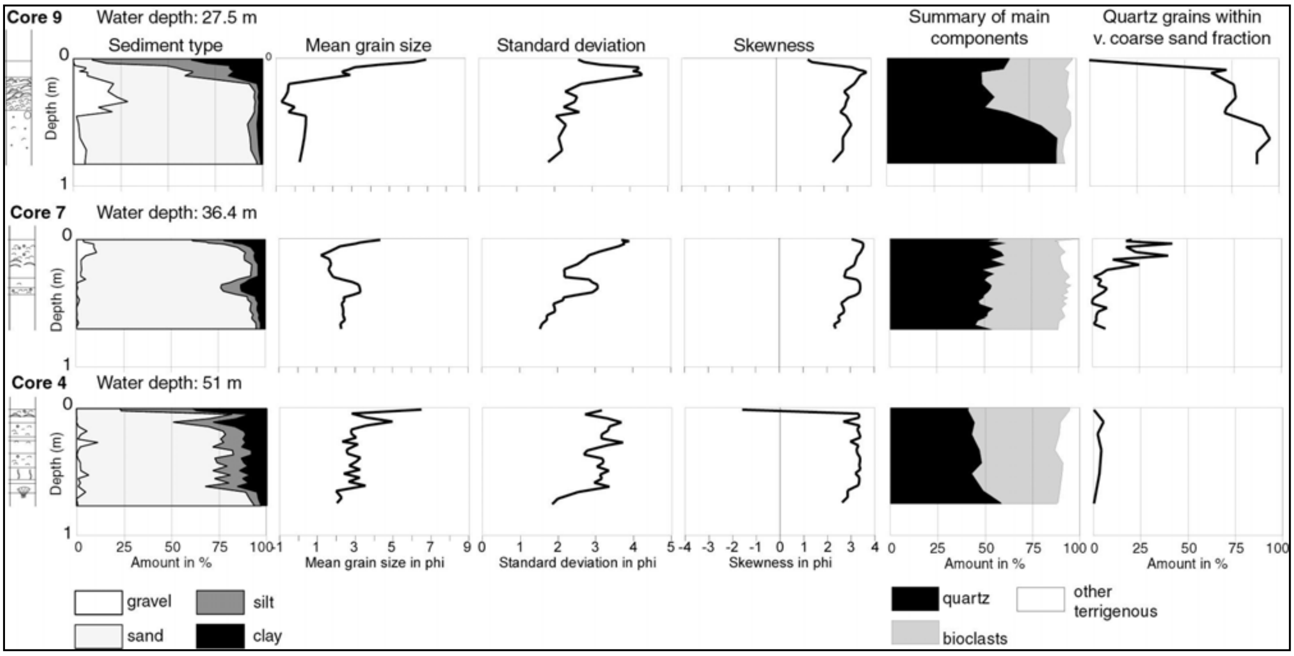

Figure 2. Logs of the three analysed cores, grain size parameters, main components, and vertical v. coarse quartz grain distribution

components as core 4, but has up to 10% of gravel towards the top (Figure 2).

The veneer of mud covering the top of the core is thinner and sandier. The central layers are characterised by a higher percentage of fines (up to 20%), and seem to be bioturbated. Otherwise the same type sets of oblique lamination can be recognised within the sandier units.

The general make-up of components is very similar to that of core 4 and shows little vertical variation.

Core 9 was extracted from the most proximal location, and taken at 27.5 m water depth. It shows a distinct variation between its lower and upper half.

While the base is similar to the two previous cores, dominated sand-sized components with little mud and gravel, the upper half shows a strong presence of gravels (mostly shells). The last 20 cm show a fining upward trend. Also in this core, the sediments show distinct horizontal and oblique layering. The large shells within the upper half of the core are densely packed in horizontal sheets, reminiscent of a shell lag. Of interest is the amount of quartz occurring in the very coarse-grained sand fraction in all cores. It hardly appears at all in core 4, with a maximum of 4-5%. Equally, the amount at the base of core 7 is limited, consistently showing values below 10%. This amount increases in the upper half, and reaches more than 40% in some horizons. Many of these quartz grains show a distinct red ferrugineous patina and bear percussion marks. In contrast to these, the very coarse grained sand fraction of core 9 is dominated by quartz sand.

The values show an upward decrease from amounts as high as 95% at the base of the core to around 70% towards the top. These values are reduced to zero in the top layer. While the grains have no red patina at the base of the core, grains towards the top are strongly stained, and show percussion marks.

However, the skewness of all sediments (with the exception of the most recent mud deposits) is distinctly positive, with values consistently above 2 phi. Although this definitely indicates a high energy environment, which depleted the sediment of fine grained material, it does not lie within the values expected from a beach deposit (e.g. Friedman, 1967).

An analysis of foraminiferal populations in core 7 shows a dominance of species associated with a near-shore environment in the lower half of the core, the upper half shows species occurring at the lower portion of the inner shelf (Mendes et al., in press). In this context the lower half of cores 7 and 9, and the entirety of core 4 would be interpreted as a high-energy nearshore environment, dominated by waves and possibly tidal currents. The higher content of fines in core 4 indicates that it was deposited at a more distal location than core 7. It is highly likely that the sediments of both were deposited more or less during the same period. The similarity of sediments indicates the same sediment source for both.

In contrast, the very coarse quartz grains in the upper half of core 7 indicate the influx of a different sediment source.

This layer was deposited in a deeper setting, as evidenced by the foraminiferal populations. These very coarse quartz grains are at present exposed throughout the edge of the inner shelf (Figure 1), but not in the immediate vicinity of the location of core 7. It is not known whether the deposits continue eastwards underneath the surface, and were eroded during high-energy episodes from terraces formed during this period at the edge of the outer shelf.

It is not completely clear whether the sediments found in core 9 are (with the exception of the top layer) recent or of pre-Holocene origin. Seismic lines indicate no significant deposits in this area.

Although sediments in the top half of the core have an intense iron-patina indicating a subaerial exposure, they might be relict deposits resedimented during storms.

Discussion and concluding remarks

At present none of our cores has been dated. Consequently, many interesting questions remain open. One of them is the position of the maximum flooding surface (mfs) within the cores. If the storm deposits within the upper part of cores 7 and 9 prove to be recent, then the maximum flooding surface must be defined at the base of the storm deposits.

Technically, the storm deposits would have to be attributed to an incipient highstand sedimentation phase. On the other hand if they prove to be remains of a drowned outer infralittoral, then they represent the terminal phase of the transgressive episode. The question of whether it is one or another is of some interest, as it gives clues on the force of past high-energy events that affected this part of the shelf:If the deposit is recent in age the coarse grain quartz fraction occurring within the tempestites in the upper part of core 7 would have had to be remobilised at a water depth of 25-30m and transported several hundred metres or even kilometres to the southeast.

Although the remobilisation of such grain fraction can regularly occur during storms with a 10 year return period with estimated significant wave heights of H=6.5m (after Pires, 1998) and periods of T=10s, a current of considerable energy would have to be created to transport these grains to the outer limit of the inner shelf. Something similar is true if the deposits are fossil, although it would be much easier for them to be mobilised in shallow water, even during times of moderate wave energy. Slight vertical variations in composition could indicate that these storm deposits might have been created by several events. Lobo et al. (2002) postulated that the thick transgressive sediment body discussed here was created from material eroded from the edge of the inner shelf forming several generations of terraces during a period of slower sea-level rise or still stand. However, the sediments found in core 4 and the lower half of core 7 are distinctly different from those found in surface samples (and in core 9) throughout the edge of the inner shelf. Only the top of core 7 shows sediment that very probably originated from this area. It can be said that at least during the terminal phase of the formation of the transgressive deposit (unfortunately the two cores only penetrate through its topmost layers), the main sediment source was not the terraces on the edge of the inner shelf. At present there are two main near-shore sediments sources: the littoral drift, with a net transport from west to east, and the Guadiana River. A preliminary analysis of heavy minerals in core 4B (not discussed here) taken just a few metres from the location of core 4 shows that indeed there must have been two different sources of sediment present in the area (João Cascalho, pers. Comm.). Similarly, the amount of other terrigenous material in cores 4 and 7 other than quartz indicates a proximity to the paleo-mouth of the Guadiana River. At present, the terrigenous component transported by the littoral drift is very low, particularly in the grain fractions coarser than 3 phi (<5%).

This component can reach values of 10% in a radius of about 5 km to the south and southeast of the mouth of the Guadiana (but not to the west, due to the littoral drift). For core 7 the values for grains coarser that 3 phi are consistently between 2-5%, and reach 7% in the top 20 cm. It is therefore suggested that the transgressive sediment lobe analysed here was formed in the immediate vicinity (not farther than 5-10 km) of the paleo-mouth of the Guadiana River, very probably to the west of it. The sedimentary environment was probably similar to the present river mouth, where proximal prodeltaic sediments accumulate offshore around the river mouth in subtidal sand banks through the interaction of waves, tides, and river discharge. Only a fraction of the sediments was provided by erosion from the terraces formed to the north through the erosive action of the waves, probably during very high-energy events.

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