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# RECENT EVOLUTION OF THE BAY OF LAGOS AFTER A HEAVY ANTHROPOGENIC INTERVENTION

**ANA RAMOS PEREIRA**

*Ana Ramos Pereira -Centro de Estudos Geográficos and Departamento de Geografia, Universidade de Lisboa.*

Abstract

The Bay of Lagos is a good example of a complex small coastal feature with the well preserved evidences of its Holocene evolution, after the sea reached its present level. The built of heavy structures to settle the inlet of a small lagoon inside the bay (Alvor lagoon), allowed us to do this study as the coastline is retreating.

**Key words**: coastal lagoon; Little Ice Age; heavy structures; coastline retreat.

## 1. INTRODUCTION

The bay of Lagos is located on the Portuguese southern coast between Ponta da Piedade and Ponta do Facho (near Alvor, Fig. 1). These capes are both cut into Miocene carbonated rocks, while the more recessed central part of the bay is cut into relatively poorly consolidated Plio-Pleistocene sandstone and conglomerates.

Today the coastline of the bay of Lagos (with the exception of its extremities) is perfectly regular with a total sandy beach shoreline length of about 12 km. The beach has a width ranging from a few tens to over one hundred metres. It is bounded internally by a longitudinal dune ridge and a sandy plain. These are affected and partially disfigured by footpaths, restaurants, parking yards not to mention the Torralta buildings, on the eastern side. As for the plain, it is dominated by a step, which never surpasses 30 metres height with variable slope values. This step is cut into either Miocene or Plio-pleistocene formations.

Three small rivers flow into the bay of Lagos. The Bensafrim river margins the City of Lagos and flows directly into the bay, while the Odiáxere and Alvor rivers flow into the Alvor lagoon. The estuaries of these rivers have been submitted to an heavy infilling. In the harbour of Lagos, efforts to regularise the stream channel date back to the 17$^{th}$ century and are still going on up to this day. The attempts to control the unstable Alvor inlet started with the building of two jetties in 1989 (Fig. 1).

Facing South, the bay lies in a shelter position from the Atlantic waves, which explains its wave height (≤1 m in 80 % of the year). Nevertheless, it is widely exposed to the more morphogenetic, though less frequent, SW and SE (“levante”) wave directions. The annual resultant of the longshore drift is not well known. It is even possible that the drift resultant is westward in some years and eastward in others.

The bay of Lagos displays a whole of landforms that stand as a proof of its evolution since the sea reached its present level[1]. In 1992, the ocean has shaped a cliff in the Alvor-Torralta beach, revealing evidences of the Holocene progradation of the Alvor lagoon. This erosion dynamics has prevailed since then, threatening part of the Torralta tourist complex.

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[1] Evidences of that stabilization were found on the Bay of Armação de Pera, 23 km East of the bay of Lagos – a consolidated beach-dune system which is now partially fossilized by an identical though active system. The old system based on $^{14}C$ analysis dates from 3 300 BP (aeolianite: ICEN – 1052 = 3 540 ± 100 BP and ICEN – 1051 = 3 450 ± 60 BP; beach rock: ICEN – 1050 = 3 290 ± 70 BP) (*Pereira & Soares*, 1994).

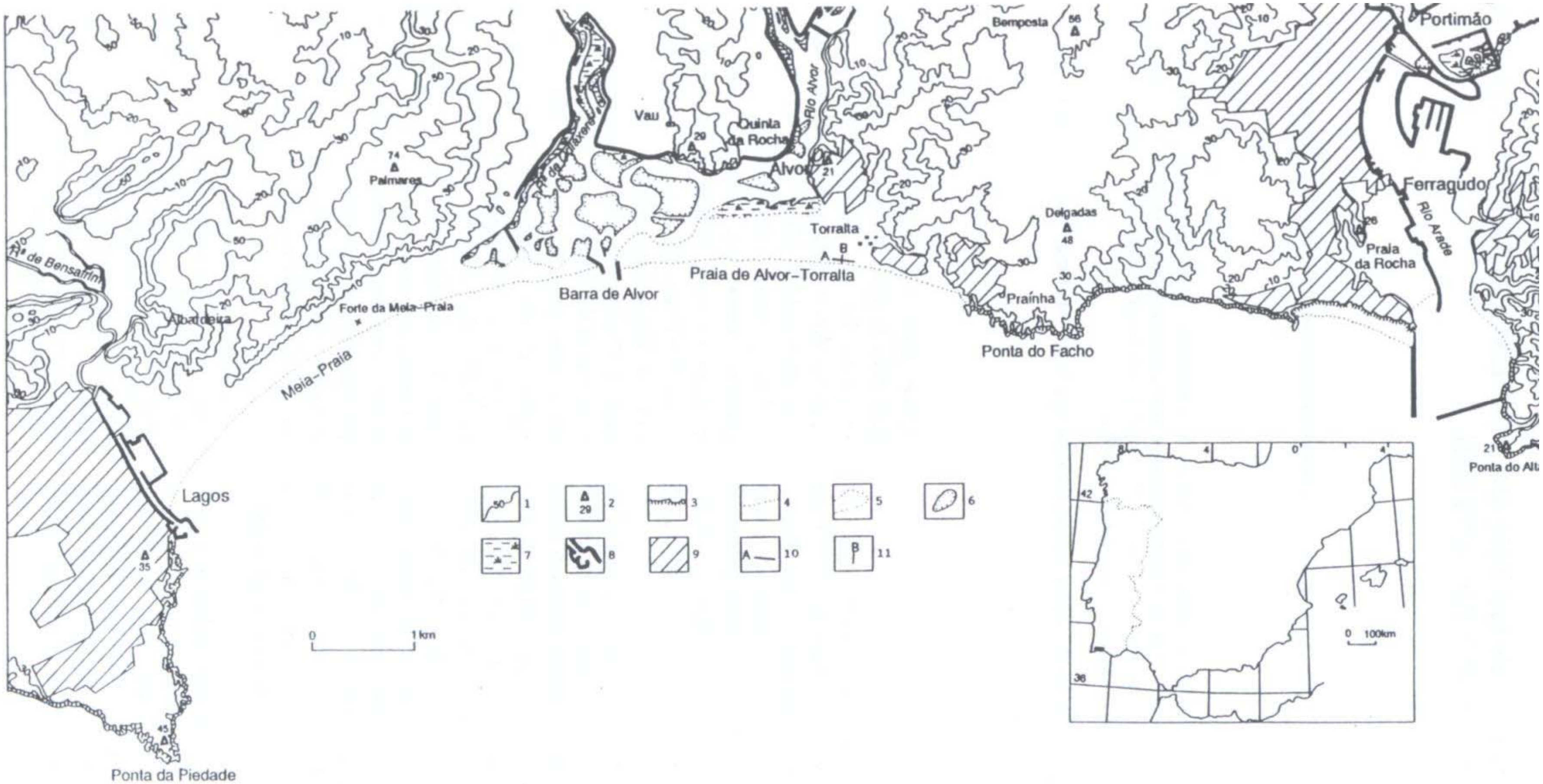


Fig. 1 – The Bay of Lagos. Legend: 1 – line contour; 2 – high; 3 – cliff, 4 – beach; 5 – spit; 6 – sandy shoal; 7 – swamp/marsh; 8 – embankment and jetties; 9 – urban centre; 10 – cliff position in 1990 where the radiocarbon dated sediments were found (*Pereira et al*, 1994).

## 2. THE COASTLINE BY THE TIME THE PRESENT SEA-LEVEL WAS REACHED

Due to its recessed position, the bay of Lagos has been a privileged stored sediment site on the coastline. The area where Odiáxere and Alvor rivers flow into was particularly even more recessed in relation to the whole of the bay (Fig. 2A).

The sand bodies of the bay are dominated by a step only interrupted by the estuaries. This step presents two distinct profiles related to the lithology: on the Miocene carbonated rocks, the shape is regular, vertical, with grottoes on the slope base at the high-tide level, or slightly above it; on the Plio-pleistocene sandstone and conglomerates, the step presents a complex (convex-concave, or more frequently rectilinear-concave) profile with slopes varying from 30° to 90°. Though cut out from the sea by a sandy plain, its position and morphology suggest that it is a cliff correlated with the stage when the sea reached its present level. Assuming this, the mentioned slope's morphology are the cliffs dating back to about 3 000 years (Fig. 2A), when the sea reached its present level.

The coastline must have been rather irregular and significantly recessed when compared with the present-day one (about 400 m near the Meia Praia fortress, about 1 300 m near Casalinho do Vau, about 900 m near Sra. da Rocha and 600 m in Alvor, Fig. 2A). The cliffed coast was then interrupted by three large and recessed estuaries. These estuaries were at the end of a transgressive stage (according to *Curray*, 1964) when their silting up started.

## 3. THE COASTLINE EVOLUTION IN THE LAST 3 000 YEARS BP

The discharge of sediment in the estuaries must have provided an influx of sediments that allowed the formation and growth of spits that finally closed the Alvor - Odiáxere inlet, leading to the genesis of the Alvor lagoon (Fig. 2B).

The origin of the sands that led to the increase growth of these spits is questionable. The alluvial origin seems to be the prevailing one from the four possible ones (including sediments carried by longshore drift, resulting from the coastal erosion of contiguous areas of the bay; local cliff erosion; transport from the continental shelf; and fluvial supply). This fluvial supply appears to have had two different kinds of sources: one from a direct fluvial discharge (Alvor and Odiáxere rivers) into the estuaries' mouths and another from old alluvium previously deposited on the continental shelf, supplied by the Bensafrim and Arade rivers. The latter one, whose estuary is 5 km to the East (Fig. 1) is the most important agent regarding this process. The results obtained in the sedimentological study of the beach sands, especially in its morphoscopic analysis and heavy mineral study (*Cabral et al*, 1989) revealed this dominance of direct and indirect alluvium sources.

Due to the whole set of conditions the coastline has turned into a practically continuous sand accumulation, forming what may be interpreted as a logarithmic spiral section, which indicates a stage close to equilibrium (*Yasso*, 1965; *Silvester*, 1970). It is not known for certain when this coastal section reached this stage. Nevertheless, the first known precise mapping ($18^{th}$ century) already documents this stage, as shown in the Hydrographic Map of the Bay of Lagos in 1791 by Sande de Vasconcelos (Fig. 2C).

In September 1992, the present-day transgressive stage affecting the Portuguese coast, has led to the appearance of a 70 cm high cliff in the backshore of Alvor-Torralta (Fig. 1 and 3). The cliff cuts a complex depositional sequence of various facies that appears to be the prove of a Little Ice Age regressive event (around 500 years BP, ICEN-984, shells: 490 ± 20 BP; ICEN-987, sediments: 490 ± 60 BP; ICEN-988, sediments: 500 ± 150BP).

In the Alvor area the coastline retreat which led to the display of the above mentioned formations seems to be caused by the combination of several favourable conditions:

- the general sea-level rise which is of 1.9 mm/year, in Lagos (*Taborda & Dias*, 1988);
- the heavy structures in the Alvor inlet which prevent the bypassing of sediments between the two sides of the bay (divided by the jetties) and inside the bay itself;

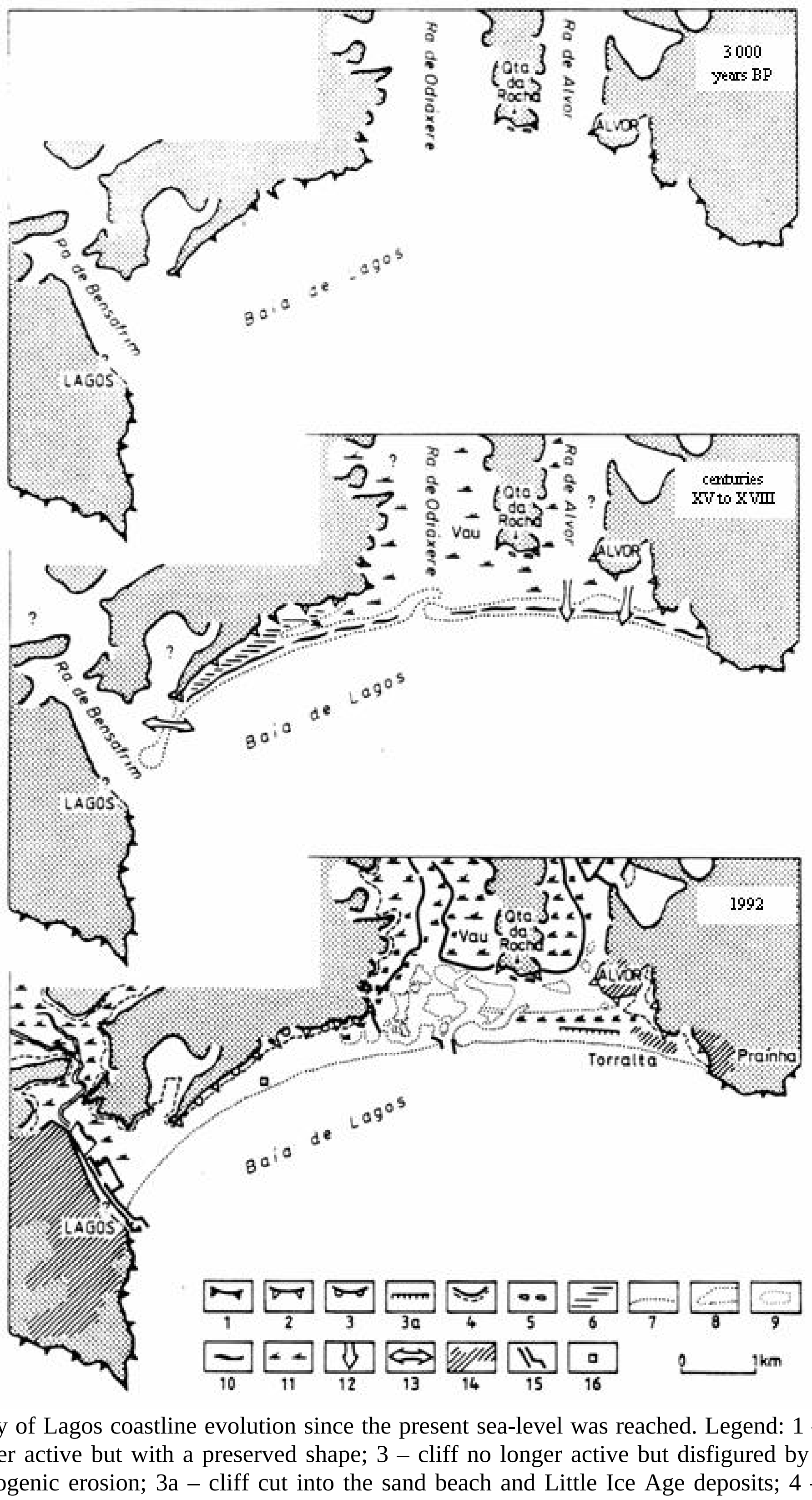


Fig. 2 – The Bay of Lagos coastline evolution since the present sea-level was reached. Legend: 1 – cliff; 2 – cliff no longer active but with a preserved shape; 3 – cliff no longer active but disfigured by later natural or anthropogenic erosion; 3a – cliff cut into the sand beach and Little Ice Age deposits; 4 – slope top and base; 5 – reeef and islet; 6 – coastal plain; 7 – beach; 8 – spit; 9 – sandy shoal; 10 – dune ridge; 11 – swamp/marsh; 12 – torrencial gaps into the sandy barrier correlated to Little Ice Age; 13 – same as 12 plus overwash; 14 – urban centre; 15 – embankment; 16 – Meia-Praia fortress ( *Pereira et al*, 1994).

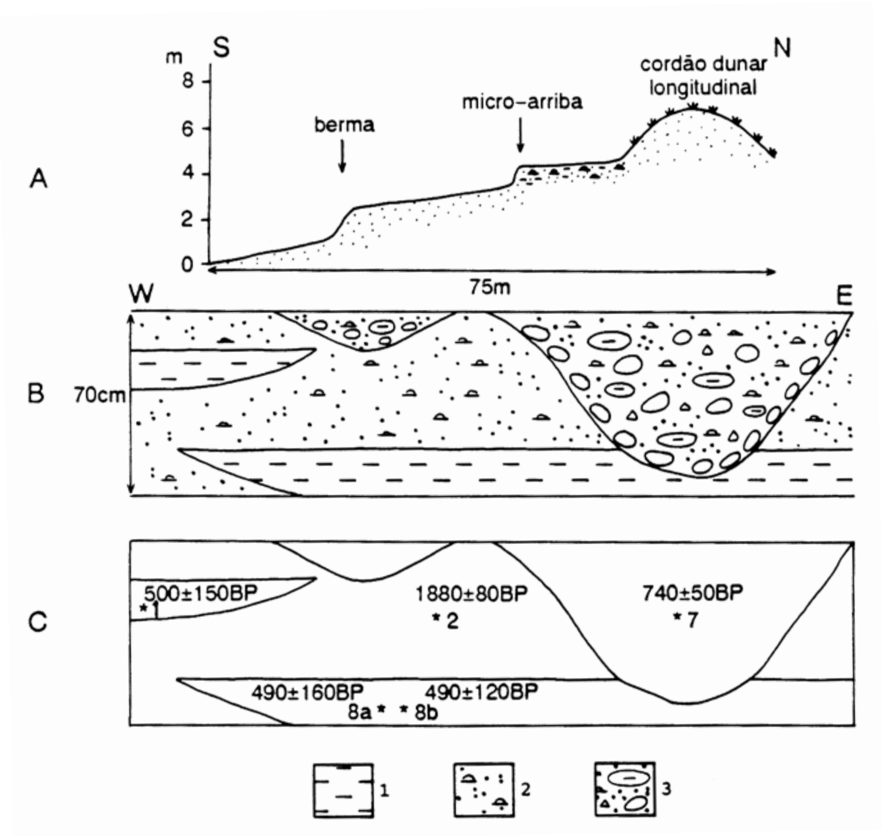


Fig. 3 – Beach profile and the sediments cu tinto cliff in Setember 1992. Legend: 1 – ooze deposit; 2 – sandy deposit; 3 – conglomeratic deposit. The * with a number indicates the position and the munber of the dated sample (*Pereira et al*, 1994). The samples 2 and 7 belong to shells in disturbed deposits, probably took back from the internal section of the lagoon.

- the breaking in the sedimentary exchange system between the beach and the dune, owed to the partial anthropogenic destruction of the latter.

Following the high tides of December 1995 and January 1996, the erosive tendency that had already started in the beginning of the 90’s has progressed and led to a general shrinkage of the beach and a retreat of about 30 m of the before mentioned cliff, reaching the structures of the tourist urbanisation. The swimming pool is already at the risk of being damaged, since its foundations are now functioning as a sea-cliff. The swimming pool juts out about 1 m from the cliff cut into the backshore sands. In the last six years, the Winter eroded sand from the beach was not kept in the submerged beach and left the system, since there has been no sand return in the Summer.

The financial group of the referred urbanisation (which is in financial straits for some years now) may have thought that the inlet settlement, allowing the entrance of recreation boats, would give a “new life” to the area and thus could contribute to its economical viability. However, because of lack of Environmental Impact Assessment of the building of heavy structures and due to the insufficient studies on the coastal dynamics of the bay, the consequences were: the beach erosion; the cliff retreat; and high economic costs (unknown amount) in the nourishment of the beach, promoted by the urbanisation, as the beach is its main tourist attraction.

## References

CABRAL, M. C.; MARQUES, F. M. S. F.; AZEREDO, A. C. & ROMARIZ, C. (l989) – *Caracterização morfo-sedimentológica da baía-barreira de Alvor.* Geolis, vol. III (1 e 2), 196-206.

CURRAY, J. R. (l964) – *Transgressions and regressions. In*: Miller, R. L. (Ed.) – *Papers in Marine Geology* -

*Shepard Commemorativ Volume,* Am. Ass. Petroleum Geologists, Tulsa, Oklahoma, 221-266

DIAS, J. A. (l984) – Evolução geomorfológica das arribas do Algarve. *3º Congresso sobre o Algarve,* vol. 2, Montechoro, 705-711.

LOUREIRO, A. (l9O9) – *Os portos marítimos de Portugal e ilhas adjacentes.* vol. IV, Lisboa, Imprensa Nacional, 36Op.

MARQUES, F. M. S. F. & ROMARIZ, C. (l989) – Evolução da baía barreira de Alvor nos tempos históricos. *Geolis, vol.* lll, (l e 2), 154-163.

PEREIRA, A. R.; DIAS, J. A. & LARANJEIRA M. M. (1994) – *Evolução holocénica da baía de Lagos*. *In*: Pereira, A. R. – *Contribuições para a geomorfologia e dinâmica litorais em Portugal*, CEG, LAGF, 35, 75-89.

PEREIRA, A. R. & SOARES, A. M. (1994) – A estabilização holocénica do nível do mar. Vestígios no litoral de Armação de Pera. *Gaia - Revista de Geociências*, 9, M.N.H.N., Lisboa, 91-93.