Ciências da Terra (UNL)	Lisboa	Nº 12	pp. 35-43 4 figs., 4 phot.	1993

Synthesis of the Piacenzian onshore record between the Aveiro and Setúbal parallels (Western portuguese margin)

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ABSTRACT

Key words: Piacenzian; Mondego and Lower Tagus basins; lithostratigraphy; correlation; depositional model; tectonic.

Onshore, the Piacenzianof the Mondego and Lower Tagus Tertiary basins comprises siliciclastic sediments deposited in shallow marine to continental environments. The outcrops of the deposits are relatively widespread in the Aveiro and Setúbal region. A lithostratigraphic synthesis based on the correlation of geological sections, is presented for the two basins. In general, the Piacenzian sediments display a regressive sucession. The Late Tortonian-Zanclean (?) confined drainage pattern changed at the beginning of Piazencian, to fluvial systems draining to the Atlantic, and capturing the drainage of the inner parts of the Hesperic Meseta.

The Piacenzian sedimentary sequence post-dates one of the uprising phases during Neogene compression, recorded by a strong regional unconformity. Some local active faulting — as in Lousã, Rio Maior and Setúbal - Pinhal Novo — allowed the local thickening of the sedimentary record. Later compressive tectonism continues to generate reverse faulting and diapiric reactivation, affecting those sediments. Currently, the Piacenzian deposits culminates the marginal piedmonts, widely eroded by the Quaternary fluvial dissection.

INTRODUCTION

The Mesozoic and Cenozoic sedimentary record of the portuguese western margin is, approximately, 5 km thick. In the Lutetian distensive faulting, related to the Pyrenean Orogeny defines two Tertiary basins (Fig. 1): the Northern Mondego Basin and the Southern Lower Tagus basin. Onshore, the Tertiary infill consists of mainly continental siliciclastic deposits, nearly 370m thick in the Mondego Basin, and reaching a maximum thickness of 1 200m in the Lower Tagus Basin.

Onshore, the Upper Pliocene is composed of terrestrial sediments (conglomerates, coarse sandstones), nearshore sediments (mudstones with lignites and diatomites) and shallow marine sediments (micaceous fine sandstones). The sediments are mainly composed of quartz and quartzite clasts; the clay fraction contains predominant kaolinite, some illite and rare vermiculite.

Weathering features, including kaolinization and hidromorfization (leaching conditions) are seen in these deposits and its substratum. This can be compared to the "ocre alteration" of the alluvial terminal Neogenic platforms and their substrata, which culminates the marginal piedmonts of the Douro Basin Western border (Martin-Serrano, 1988). The general persistence of water mechanisms is evinced in the alluvial systems by several factors such as: predominance of weathering resistante clasts, intense yellowish alteration of the slaty clasts, kaolinite and illite associations. This is confirmed by the fossil data, facies associations and the spatial extension and gradients of the alluvial systems (0.15% for the Lower Tagus Basin and 0.40% for the Mondego Basin). The faunistic (Dolfus & Cotter, 1909; Zbyszewski, 1959; Brébion, 1970; Cardoso, 1984; Cachão & Silva, 1990) and floristic data (Teixeira, 1979; Diniz, 1984; Diniz & Cachão, 1987; Cachão, 1989) in the marine and nearshore sediments point out to relatively warm and humid climate; colder conditions occur in the final Pliocene. Although the available fossil data indicates a Piacenzian age, the chronological limits are yet not well established (Antunes & Pais, 1992).

The Piacenzian sediments show a regressive evolution that might be correlated to the 3rd order global sea level cycle nº 3.7 of Haq *et al.* (1987). The penetrating early Piacenzian transgression was responsible for the building up of a marine abrasion platform situated in the onshore from 5 to 130m (from West to East, also affected by faulting and diapirism) (Teixeira, 1979; Barbosa, 1983;

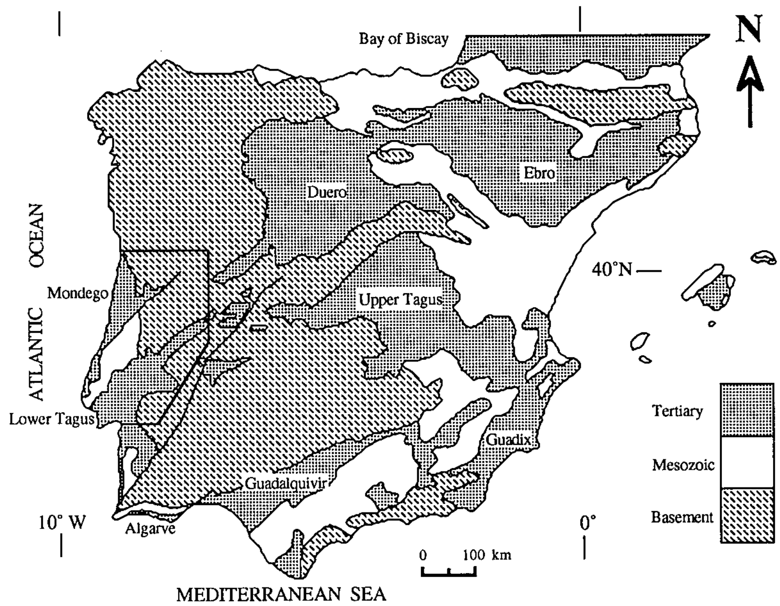

Fig. 1 — Simplified geological map of Iberia, showing location of the main Tertiary basins and the location of the studied area.

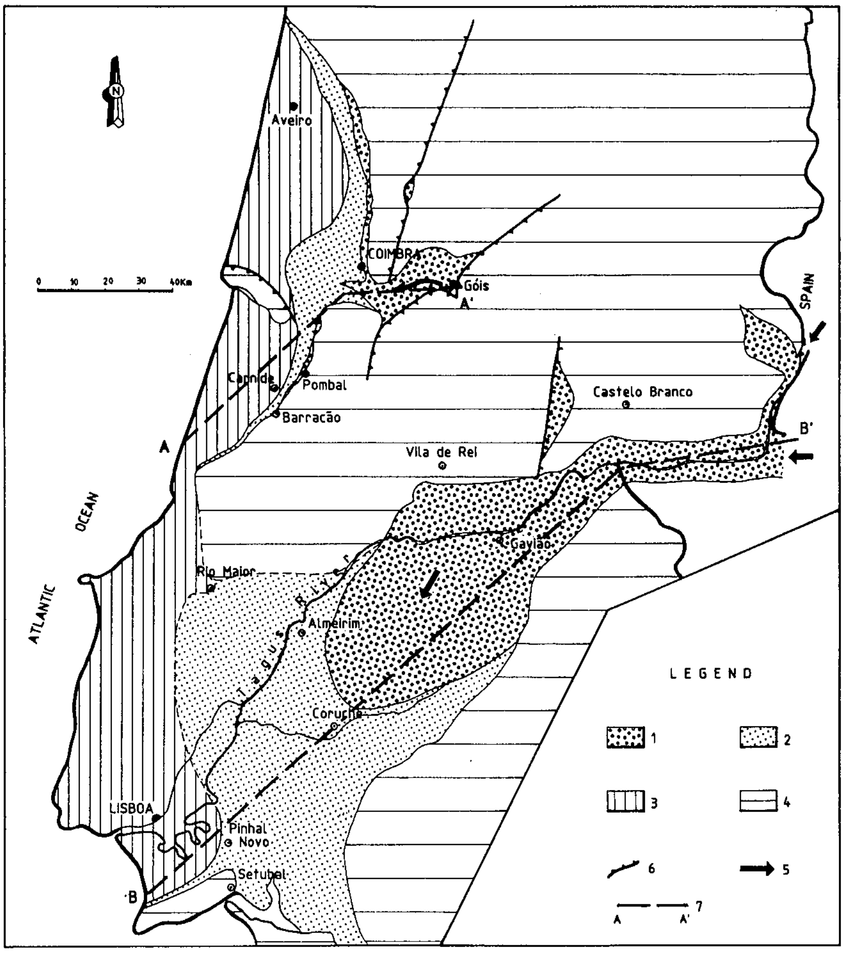

Fig. 2 — Palaeogeographic reconstruction, at maximum flooding, of the Early Piacenzian transgression. 1 - alluvial conglomerates; 2 - alluvial sandstones; 3 - marine sandstones; 4 - no sedimentation area; 5 - main fluvial flux trend; 6 - main active faults; 7 - geological section location. Inland transgression border after Antunes (*in* Ribeiro *et al.*, 1979), modified. Some non marine reliefs (Sintra, Candeeiros and Montejunto hills) inside marine sandstones area, are not represented.

Cachão, 1989). During the maximum flooding, the shoreline reached the vicinity of the line Pombal - Leiria - Rio Maior - Lisboa - Setúbal (Teixeira & Zbyszewski, 1954; Antunes *in* Ribeiro *et al.* (1979) (Fig. 2). The following sea-level fall was accompained by an important progradation of the alluvial systems.

Near the Atlantic shoreline, the sediments were remobilized by the probable Early Pleistocene marine incursion (Teixeira, 1979; Ferreira, 1978, 1980; Azevedo, 1982; Azevedo *et al.*, 1982; Daveau *et coll*, 1986).

Some authors (Zbyszewski, 1943b, 1948; Zbyszewski & Faria, 1967; Cunha, 1987a, 1987b; Reis & Cunha, 1989; Cunha & Reis, 1991; Cunha, 1992) related these deposits to a compressive tectonic event which took place at the begining of the Piacenzian, giving rise to an uplift of the Portuguese Central Range, Estremenho Massif and Western Mountains (NW of Portugal). The Late Pliocene sedimentary record precedes another compressive reactivation of the NNE-SSW and NE-SW faults and, in the coastal platform it is affected by several fault systems and diapiric remobilization (Ribeiro, 1984, 1988; Cabral, 1986, 1989; Cabral & Ribeiro, 1988; Cachão, 1989; Ferreira, 1991).

These alluvial siliciclastic sediments have characterized the Hesperian landscape prior to the Quaternary fluvial dissection and presently culminate the marginal piedmonts in most of Hesperian Tertiary basins (Fig. 3).

A synthesis of the Late Pliocene in the onshore, between the Aveiro and the Setúbal parallels will now be described (Reis & Cunha, 1989; Barbosa & Reis, 1989, 1991; Cunha & Reis, 1991, 1992; Cunha, 1992; Cunha *et al.*, 1992; Reis *et al.*, 1992).

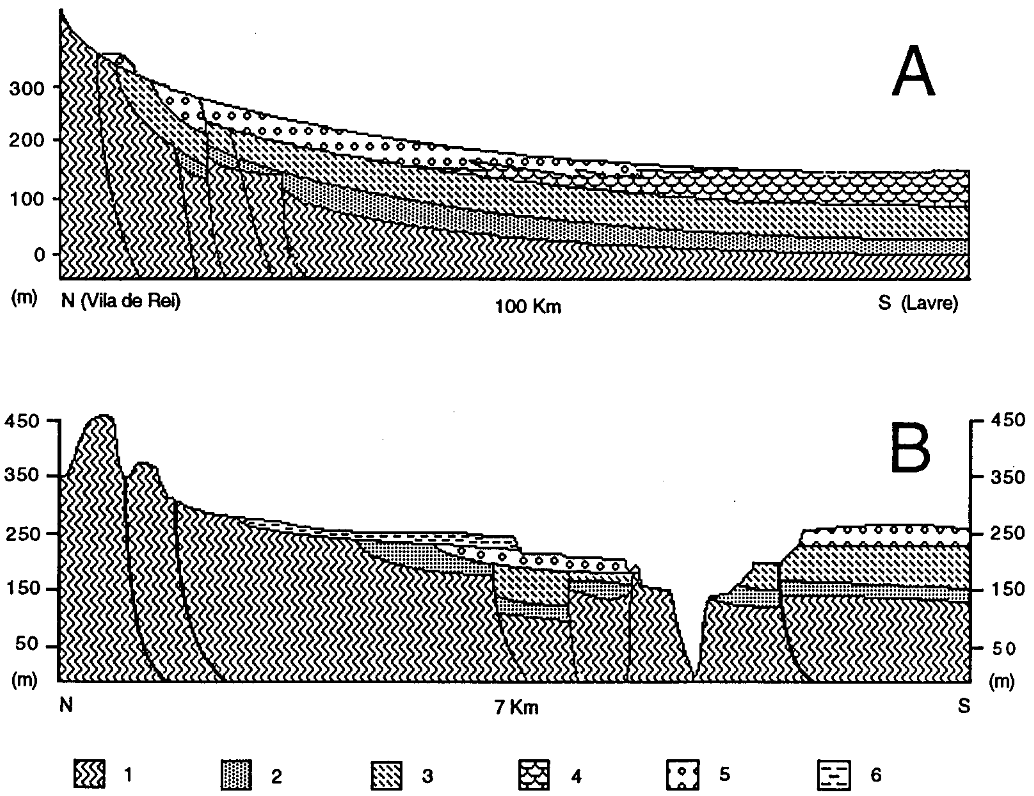

Fig. 3 — Schematic geological sections (N-S) showing the Lower Tagus Basin northern border record (modified from Barbosa & Reis, 1991). 1 - metamorphosed schist/granitic basement (Palaeozoic); 2 - Monsanto sandstones (Paleogene); 3 - Ota and Tomar units (Miocene); 4 - Ulme sandstones (Piacenzian); 5 - Serra de Almeirim conglomerates (Piacenzian); 6 - Vila de Rei conglomerates (Early Pleistocene ?); A - geological section in the Vila de Rei - Lavre region; B - a detailed geological section of the Vila de Rei area.

MONDEGO TERTIARY BASIN

In the Coimbra Southwestern onshore area, the Piacenzian sedimentary record (about 40 m thick) shows, from the bottom to the top the following units (Fig. 4A):

1) A basal conglomerate (photo 1) followed upwards by yellow and white micaceous sandstones (Carnide Sandstones and Roussa Sandstones, respectively; Barbosa, 1983). These were formed in shallow marine environment. The accurate dating of the marine fauna as Piacenzian was clearly stated by Dollfus & Cotter (1909); other authors (Teixeira & Zbyszewski, 1951; Rocha & Martins, 1953; Zbyszewski, 1959; Cardoso, 1984; Müller, 1984) confirmed and/or used this age. Later studies (Cachão, 1989, 1990) in a basal section of the Carnide Sandstones revealed a Discoasteridae nannofossil assemblage indicative of Zone CN12a of Okada & Bukry correlated to the Piacenzian stratotype section.

Photo 1 — The fossiliferous conglomeratic basal section of the Carnide Sandstones, at Carnide. Scale: width of the sheet seen in the photo is 20 cm.

Photo 2 — Barracão Mudstones: marsh and swamp deposits followed up by fluvial sandstones.

2) Marsh and swamp deposits (photo 2), consisting of main sandstones interbedded with lignites (Zbyszewski & Faria, 1967; Dinis & Cachão, 1987).

3) Fluvial sandstones, showing whitish to gray mudstone intercalations, becoming coarser, heterometric and with upwards rubefaction. The lithostratigraphic sequence 2) and 3), was recently defined as Barracão Mudstones (Barbosa, 1983).

To the East of the Coimbra meridian, the deposition was exclusively done in a continental environment. The record — boulder and gravel quartzite conglomerates (Santa Quitéria Conglomerates, maximum thickness 250 m) — corresponds to an alluvial fan, prograding westwards (Cunha, 1992). At the bottom, this alluvial facies passes gradually (from West to Southwest of Coimbra) to marine deposits. The large thickness and the facies existant on the piedmont of the Portuguese Central Range, suggest that the uplift and relief erosion of this mountain system have existed since before and during the Late Pliocene. The Late Pliocene record precedes another compressive reactivation of the Lousã fault (the basement is uplifted and thrusted over the Cretaceous and Tertiary sediments).

In the Coimbra - Aveiro onshore area (Teixeira, 1979; Grade & Moura, 1980-81; Daveau *et coll*, 1985-1986; Barbosa *et al.*, 1988), the Piacenzian record presents similar vertical and lateral facies changes (more proximal facies to the east and to the top of the series), but a generally lower thickness and lower topographic elevation.

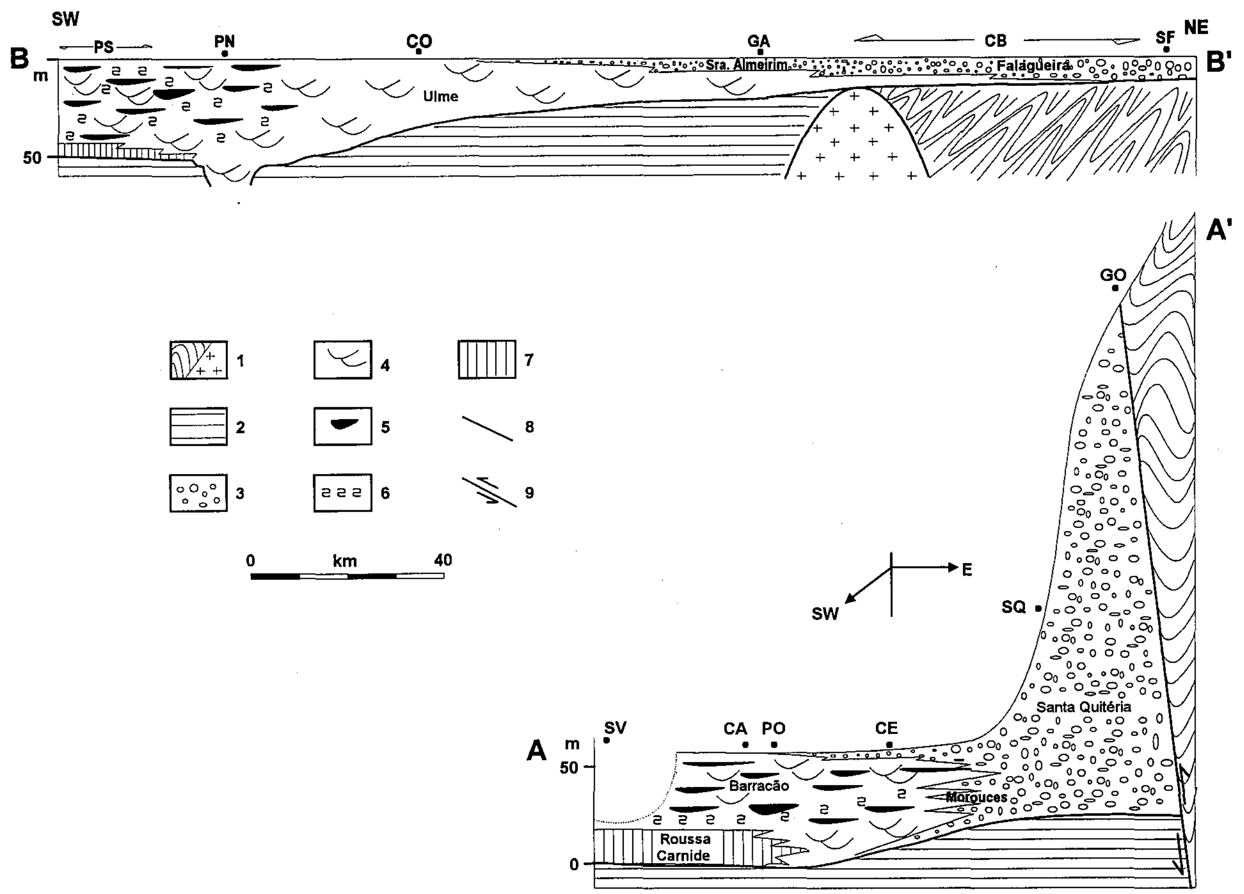

Fig 4 — Schematic geological sections (SW-NE), showing the Upper Pliocene record in the Mondego (A - A') and Lower Tagus (B - B') Tertiary basins. 1 - basement (metamorphosed / granitic); 2 - Mesozoic and Cenozoic substratum; 3 - alluvial conglomerates; 4 - alluvial sandstones; 5 - alluvial mudstones; 6 - marsh and swamp sediments; 7 - marine sandstones; 8 - sedimentary discontinuity; 9 - Lousã fault; SV - Senhora da Vitória beach (S. Pedro de Muel); CA - Carnide; PO - Pombal; CE - Cernache (Coimbra); SQ - Santa Quitéria; GO - Góis (Carvalhal and Sacões sections); PS - Setúbal peninsula; PN - Pinhal Novo; CO - Coruche; GA - Gavião; CB - Castelo Branco region; SF - Spanish frontier.

LOWER TAGUS TERTIARY BASIN

In the Lisbon-Setúbal area (Fig. 4B) the Piacenzian includes, at the base, sandstones, granules and pebble conglomerates ("Alfeite upper unit") with coastal malacologic fossils ascribed to the Piazencian (Roman, 1906 *in* Azevedo, 1982; Zbyszewski, 1943a); it passes upwards to a thick sandy succession ("Pliocene sandy complex") with lignite and diatomite intercalations. This sedimentary record averaging 50 m thickness, with a local maximum subsidence at the graben of Pinhal Novo (325 m, Setúbal - Pinhal Novo fault) corresponds to the vestibular part of a braided fluvial system draining from NE (Zbyszewski, 1943a; Carvalho, 1968; Azevedo, 1982).

This sedimentary record lies on the "Alfeite lower succession" (probable Messinian or/and Zanclean ?), about

Photo 3 — Serra de Almeirim Conglomerates: barforms near Almeirim, with mean maximum particle sizes (MPS) = 20 cm.

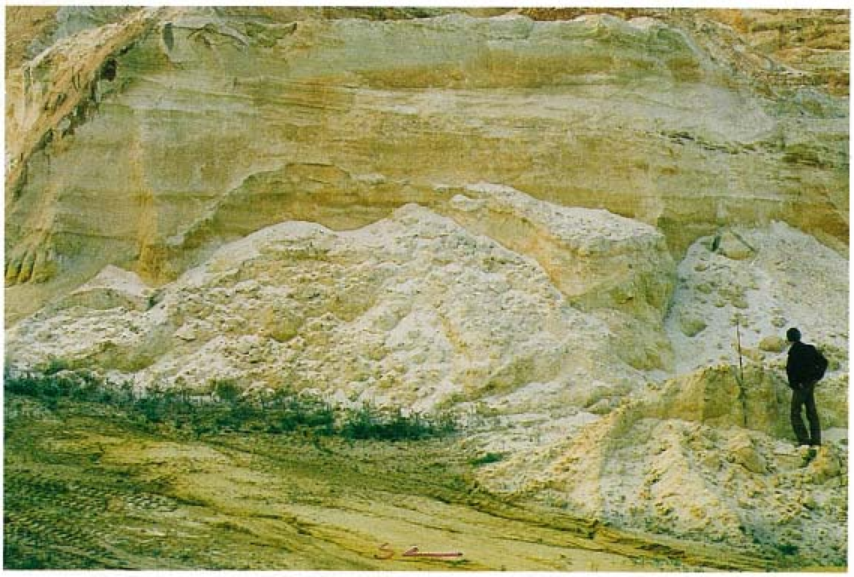

Photo 4 — Coastal whitish sandstones in Rio Maior, sedimentologic and lithostratigraphic equivalent of the Roussa Sandstones.

10 m thick or on older units, and is composed of red conglomerates and sandstones with mollusks and plant remains (Antunes, *in* Ribeiro *et al.*, 1979; Antunes & Pais, 1992). The thick sandy succession passes upwards, through a disconformity, to the Belverde Conglomerate (Quaternary). According to Azevedo (1982, 1985) the latter unit, composed of well rounded conglomerates and sandstones, consists of fluvial plain deposits reworked by the early Pleistocene marine incursion.

In the Lisbon-Setúbal Northeastern area, the Piacenzian sedimentary record is exclusively of continental origin except in the Rio Maior sector (we interpret the white sandstones of Rio Maior as similar to the Roussa Sandstones, both of shallow marine environment). It can attain up to 110 m thickness ("Ilite-kaolinite Complex" of Carvalho, 1968). It is composed of coarse sandstones with siltstone intercalations, and of a conglomeratic offlapping unit (photo 3) named Ulme Sandstones, Serra de Almeirim Conglomerates (Barbosa & Reis, 1989) and Falagueira Conglomerates (Cunha, 1992) (Fig 4 A-A'). The Northwestern marginal system of coalescent alluvial fans, prograded to SW. From the Southeastern piedmont of the Portuguese Central Range (Vila de Rei, Sarzedas, Monfortinho areas) they supplied a longitudinal Atlantic fluvial system (the pre-Tagus River) which captured the Upper Tagus Basin drainage (from Spain). At maximum flooding during early Piacenzian the sea reached the Rio Maior area (Fig. 3), producing a succession — littoral sandstones (photo 4) passing upwards to diatomites and lignites — similar to the other areas near the present shoreline (Caldas da Rainha, Óbidos; Zbyszewski, 1943b; Zbyszewski & Faria, 1967; Teixeira, 1979; Diniz, 1984). However, according to the palynological studies carried out by Diniz (1984) the lower part of Rio Maior deposits (diatomitic and lignitic units) may represent the Zanclean (by correlation with the NW Mediterranean and North Europe scales). The great thickness of the Rio Maior deposits (ZBYSZEWSKI, 1967) demonstrates an important synsedimentary tectonic subsidence.

Southeast of the Lisbon-Setúbal area offshore, the upper Neogene prograding sequences — of probable Messinian-Zanclean and Piacenzian age respectively — lie erosively on the continental platform substratum and outcrop as two gulfs, close to the Lisbon and the Setúbal submarine canyons (Mougenot, 1989).

CONCLUSIONS

The observation that similar vertical and lateral facies changes developed at the same time in the Lower Tagus and Mondego Tertiary basins suggests eustatic change as an important control on clastic deposition. The interaction of eustatism with local tectonics and sediment supply determined the observed local depositional stratal patterns, facies and thickness.

The Late Tortonian-Zanclean (?) confined drainage pattern changed at the begining of Piacenzian, to fluvial systems draining to the Atlantic. The fluvial systems captured the drainage of the inner parts of the Hesperic Meseta.

Onshore, the Early Piacenzian sediments show a regressive sucession. The late Pliocene sedimentary record of both Atlantic and Mediterranean margins in Spain also show two different units: a lower unit deposited in marine environments and an upper unit deposited under continental conditions (Aguirre *et al.*, 1992).

This sedimentary sequence post-dates one of the uprising phases during Neogene compression, recorded by a regional unconformity. Important synsedimentary faulting is evinced in several places located near active faults (Lousã, Rio Maior, Setúbal - Pinhal Novo). Later compressive tectonism includes evidence of both overthrusting of all Tertiary sediments along NE-SW faults and diapirism.

These siliciclastic sediments characterized the Hesperian landscape prior to its Quaternary fluvial dissection, currently culminating the marginal piedmonts (except in the southern border of the Portuguese Central Range in places, where the Vila de Rei Conglomerates occur).

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support and contributions from other Portuguese researchers. We especially thank M. T. Antunes, J. Pais, M. T. Azevedo and M. Cachão for their helpful suggestions and constructive critiques. Ultimate responsibility for the material presented herein, however, rests with the authors.

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