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Portugal: coastal dynamics

Dinâmicas Litorais

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THE PORTUGUESE LITTORAL SETTING

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1. Geological and geomorphological framework

The area visited in this field trip is developed in five main geotectonic domains - Central Iberian Zone, the Ossa–Morena Zone, the South Portuguese Zone, the Lusitanian Basin and the Tagus-Sado Cenozoïc Basin (fig.1.1):

(i) The Iberian Massif consisting of the Central Iberian Zone, the Ossa–Morena Zone and the South Portuguese Zone. Two major fault zones separate them – the Porto-Coimbra-Tomar shear-zone and the Ficalho up thrust (Chaminé *et al*, 2003; Ribeiro & Silva, 1983). The latter is considered a Paleozoic plate tectonic boundary between a continental (the Ossa-Morena Zone) and an oceanic plate (South Portuguese Zone) where the deposition of an accretionary prism of sediments during Paleozoïc age occurred.

Granites and metasediments are the main rocks.

The three geotectonic units cluster the so-called Iberian Massif, Hesperian Massif or Ancient Massif, which is in fact "the Iberian Hercynian Chain, razed at the end of the Paleozoïc" (Ferreira, 1996, p.15-25). The Ancient Massif has been submitted to several episodes of planation during the Cenozoic. The planation surfaces are frequently tilted and uplifted along the alpine and reactivated late-Hercynian faults. The Ancient Massif occupies 70% of the Portuguese mainland.

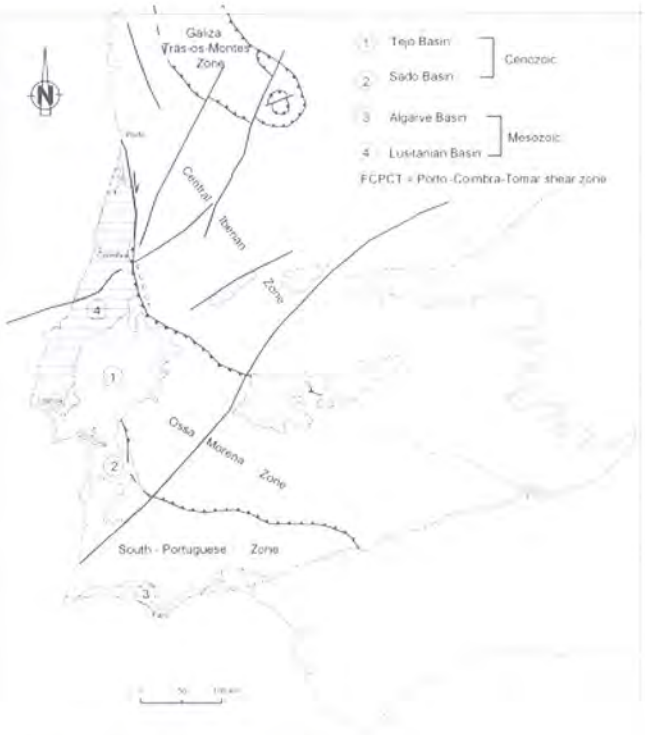

Fig. 1.1 – The geotectonic domains.

(ii) The Lusitanian Basin (and its equivalent – the Algarve Basin) is developed like an aulacogen during Mezo-Cenozoïc times. It is a tectonic depression related to the opening of the Atlantic Ocean. Sandstones, clays, marls and limestones are the result of changing

continental and deep see sedimentation environment in the basin where the subsidence reached 5km deep during Mesozoïc times. However, since the Upper Cretaceous, the geotectonic inversion of the African plate drift creates a convergence boundary and the right movement of the Iberian microplate is responsible for the uplift of the previous basin and the reactivation the late-Hercynian and Alpine faults.

(iii) The Tagus-Sado Cenozoïc Basin is a depression created in the last 50My. Induced by the collision between Africa and Eurasia during the Paleogene, and because of the Iberian drift to the North, a reactivation in distension of the NNE-SSW fault system (Messejana and lower Tagus fault; fig. 1.1) was produced generating this basin (Ribeiro *et al*, 1990). Since then and until the Pliocene this area was filled up with detritic sediments (mainly sand and sandstones, clays and some marls and limestones). Since then, a compressive regime prevails and the upper erosion planation surface cut into the detritic sediments of the basin is considered to be upper Pliocene (Martins, 1999).

This compressive regime is responsible for the major landforms (the Serras – small mountains) not only in the Ancient Massif but also in the Lusitanian Basin. Within this regime, the planation surfaces were faulted and uplifted between 0.13 to 0.3 mm/y inland and 0.1 to 0.2 mm/y in the littoral during the Quaternary (Cabral, 1995) and entrenched by the Quaternary river network. *Cuesta* and mesa landforms were developed in the sedimentary basins.

2. The littoral

In the Portugal mainland, the landscape is characterized by a heritage landform – the so-called coastal platform (equivalent to the Spanish *rasa*). This platform is related to relative sea level changes and their influence on coastal landforms and deposits (fig.1.2). The continuous flattened landform is slightly sloping towards the sea and can be found at different heights. Near Aveiro, the littoral platform is almost at sea level while, in the South sector of the western front, it can reach 150 m (Pereira, 1990). Landward limit isn't always clear; however, the regular presence of tectonic scarps makes the transition to the continental relief's often abrupt.

The littoral platform can be erosion or accumulation dominant (fig. 1.2). In the first case, the levelling took place independently of the local or regional lithostructural framework. The flat morphology and deposits are more or less preserved depending on the intensity of the

posterior local and regional tectonic activity and the density and deepness entrenching the of fluvial network. Correlative deposits locally change in facies so genesis generalizations are not to be made. Littoral and continental sediments, remixed by Pliocene and Quaternary shoreline fluctuations, regularly have no fauna or flora and show the complex evolution of this polygenic littoral feature. The continental shelf has had a Quaternary evolution similar to the littoral platform (fig. 1.2) and its

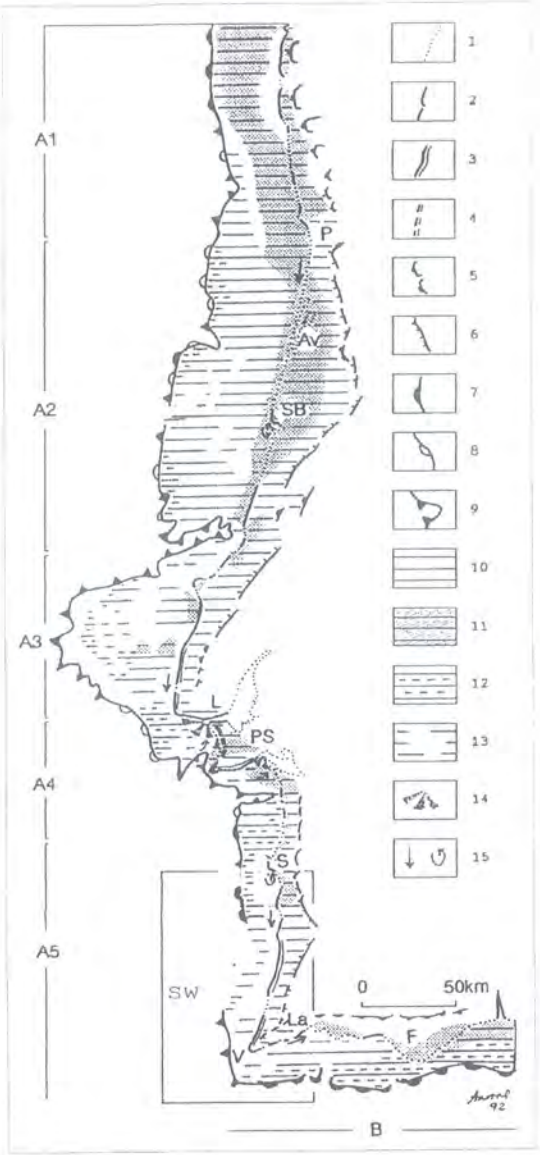

Fig. 1.2 – Geomorphology of the littoral platform and the continental shelf. 1 – sandy littoral; 2 – cliff < 50m; 3 – cliff > 50m; 4 – paleocliff; 5 – erosion edge; 6 – tectonic edge; 7 – progradation edge; 8 – aggradation edge; 9 – regradation edge; 10 – erosion dominant coastal platform and continental shelf; 11 – accumulation dominant coastal platform and continental shelf; 12 – progradation dominant on the continental shelf; 13 – prominent relief's in 10; 14 – profluvial delta; 15 – coastal drift direction. Av – Aveiro; F – Faro; La – Lagos; L – Lisboa; P – Porto; PS – Península de Setúbal; S – Sines; SB – Serra da Boa Viagem. (after Pereira, 2004).

western boundary is a structural one – the continental slope - in the transition from the continental to the marine lithosphere.

The nearly 940 km of Portuguese West and South coastline are characterised by a semi-diurnal mesotidal regime, with 12.30h tidal cycles, which can reach more than 3.5 m of amplitude. The western littoral has a NW dominant wave climate with 2-2,5 m mean wave height, which contrasts with the 1m in the sheltered South Algarve coast (Pires, 1989). This wave climate is highly seasonal and February is the month with more extreme wave heights frequency, with maximum wave height exceeding 12 m.

Coastal systems are diversified but cliffs are predominant. In the western front, granites cliffs are more frequent in the northern sector, sedimentary rock cliffs can be found between

Figueira da Foz and Sines and metamorphic rock cliffs in the southern sector. Seasonal wave climate, abrasion resistance and rock permeability are important factors in cliff dynamics and can distinguish predominant processes acting in different sectors of the littoral.

Beach and beach – dune systems are usually of small dimensions conditioned by cliff morphology or small estuary dynamics. However, the Esmoriz (south of Oporto) - Figueira da Foz coastal sector is an 80 km continuous sandy system composed by two spits that almost close the Aveiro haff-delta (Ria de Aveiro). This coastal lagoon system is the result of the infilling of a *graben*. This infilling regime prevails in the present-day, affecting all Portuguese coastal estuaries. West and southern front sandy systems are in great sediment dependence of the coastal drift. In the western front, southwards coastal drift prevails but it can be reoriented seawards by natural promontories, submerged canyons or heavy coastal structures. This results in regional differentiation of sediment transport dynamics along the coast (fig. 1.2). Associated with Douro, Tejo and Guadiana Rivers, regions A1, A2, A4 and the Eastern sector of region B (fig. 1.2) have a positive sedimentary balance (Pereira, 1992). On the contrary, regions A3 and A5 have a negative one. These regions are in the southern side of two important morphologic structures, the Nazaré and Lisboa Canyons, which stop coastal drift sediment bypassing.

The coastal orientation and the availability of sediments in the continental drift are the main natural factors responsible for the diversity of littoral systems. But the anthropogenic pressure over the littoral has an important role.

Since always the Portuguese have been linked to the sea and see the littoral landscape as a way of subsistence, expansion, development and leisure. During the last decades there has been a population movement towards the littoral (fig. 1.3), not

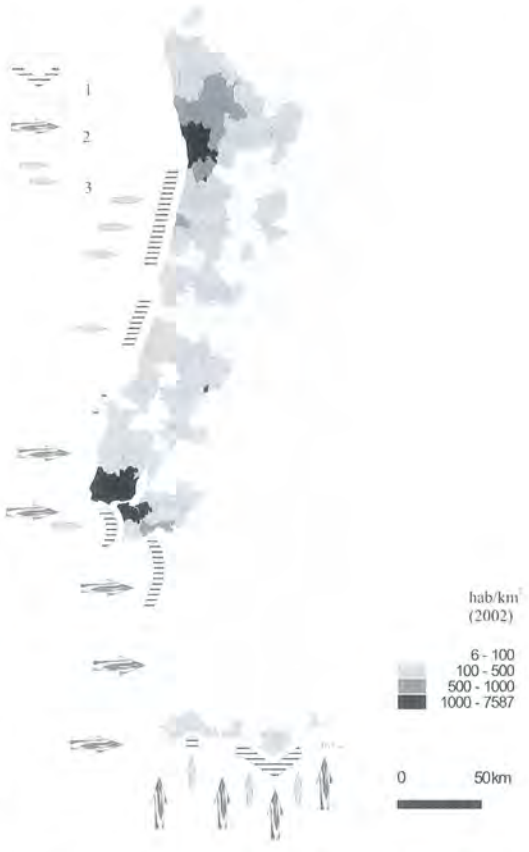

Fig. 1.3 – Vulnerability of Portuguese mainland littoral. 1 – coastline submitted to strong erosion; 2 – sensitive coastline to tsunamis; 3 – frequent overwashes (Pereira, 2004a).

only in the metropolitan areas of Lisbon and Oporto, but along the littoral between than and the Algarve. In the 1970's the unplanned management allowed the construction of tourist complexes in sensitive areas, namely on dune fields and instable cliffs. The result was not only the destruction of the dunes but also the absence of the natural beach feeding, as well as the quick cliffs' retreat. The construction of groins to protect coastal areas submitted to erosion as well as to prevent the infilling of estuaries where the main ports are installed led to a lack of sediments and more erosion leeward (fig. 1.3). The critical areas submitted to erosion are the sandy coasts and cliffs cut into sandstones and marls

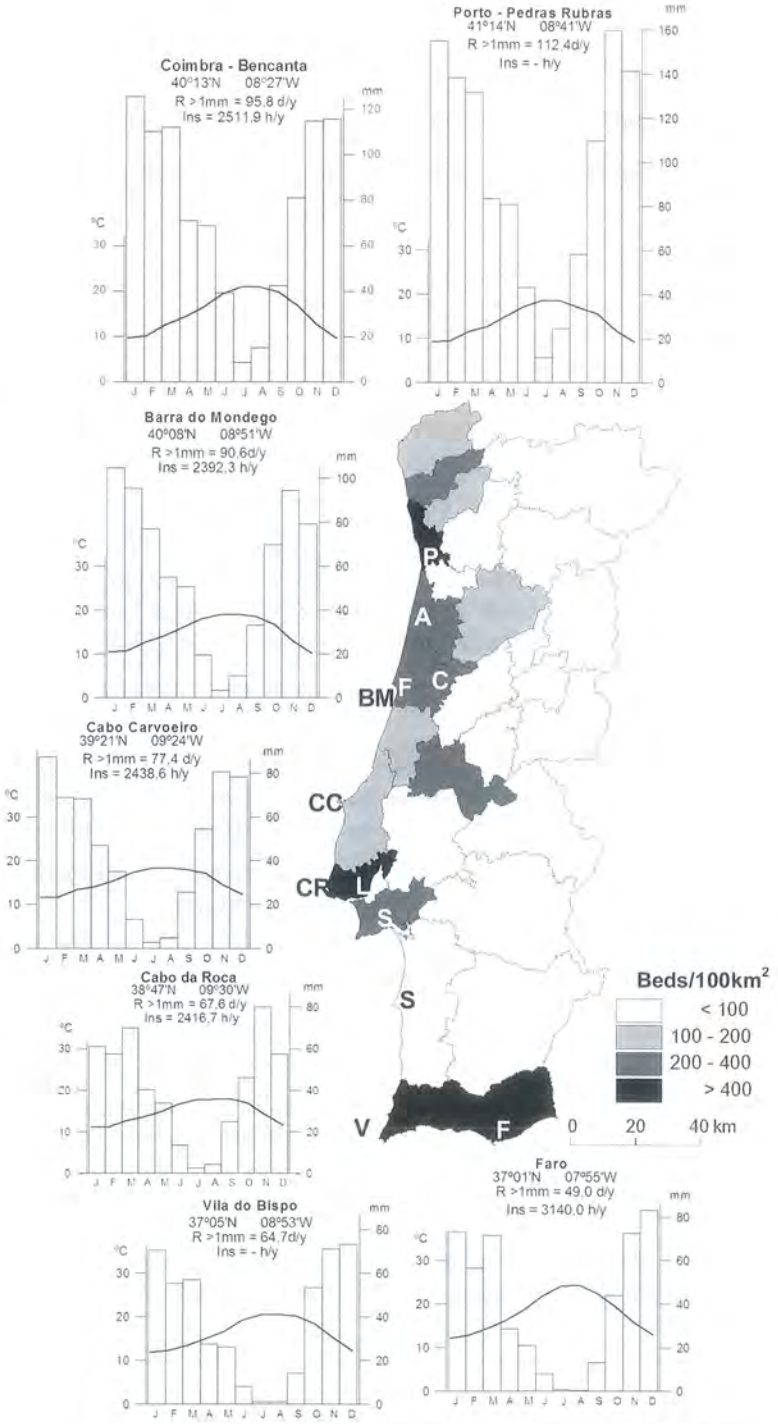

Fig. 1.4 – Climate and hotel capacity. P – Oporto; A – Aveiro; C – Coimbra; FF – Figueira da Foz; BM – Barra do Mondego; CC – Cabo Carvoeiro; CR – Cabo da Roca; L – Lisbon; S – Setúbal; SN – Sines; VB – Vila do Bispo; F – Faro; R>1mm – days per year with at least 1mm of precipitation; Ins – Insolation in hours per year. Source: Normais Climatológicas 1941-1970, Instituto de Meteorologia and Estatísticas Gerais (2002), Instituto Nacional de Estatística.

(fig. 1.3).

The anthropogenic pressure is still growing, related mainly to tourism industry, which is one of the most important of the country. It benefits from a Mediterranean climate with a dry summer and more than 2390 sunlight hours per year (fig. 1.4).

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