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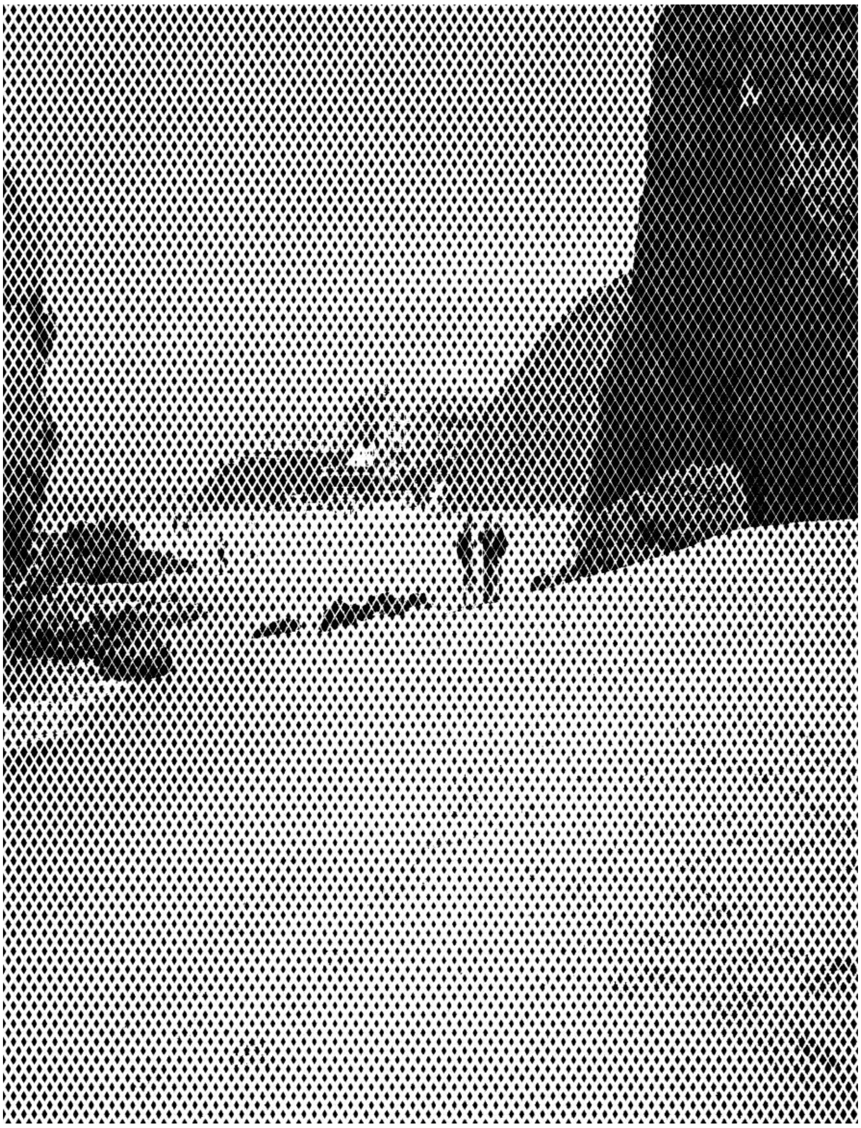
Field-Trip in the Lusitanian Basin



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INTRODUCTION

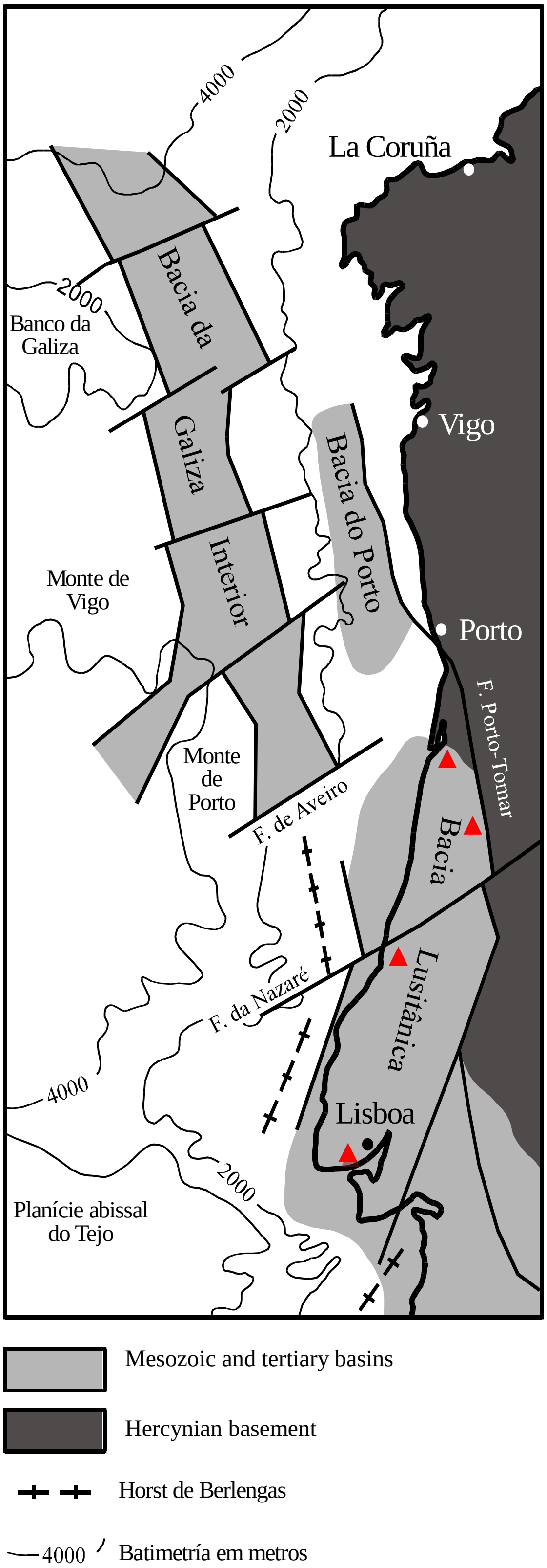

Fig. 1 – The Lusitanian Basin and the West Iberia margin. The four positions indicated on the Stratigraphic Chart of figure 2 are indicated with ▲

The Lusitanian Basin was initiated during a late Triassic rifting phase and belongs to a family of periatlantic basins (e.g. Jeanne d'Arc Basin, Scotian Basin). It is located on the western border of the Iberian plate (Fig. 1) and extends some 250 km in a NNE-SSW trend and up to 100 km East-West. The axis of maximum subsidence follows a general NNE-SSW structural orientation.

The basin is located between hercynian basement rocks, namely, in the east the Iberian Meseta and to the west a marginal horst system (the Berlenga and Farilhões islands are emerged parts of this system).

In the Mesozoic sedimentary record of the Lusitanian Basin five major stages of infill are identified (Wilson *et al.*, 1989). They are represented by the following sequences, bounded by unconformities: UBS1) upper Triassic - Callovian; UBS2) Oxfordian - Berriasian; UBS3) Valanginian - lower Aptian; UBS4) upper Aptian - lower Campanian; UBS5) upper Campanian - Maastrichtian.

During the Mesozoic and part of the Cenozoic the structures with a NE-SW and NNE-SSW direction had a distensive behaviour. But after the end of the Cretaceous and mainly during the Betic orogeny, the western rim of the Iberian Plate suffered a compressive deformation that led to a progressive inversion of the central axis of the basin, uplifting and bringing to the surface the thick layers of the Mesozoic.

MESOZOIC BASIN EVOLUTION

The geodynamic evolution includes two major rifting episodes, a passive margin interval and an inversion process.

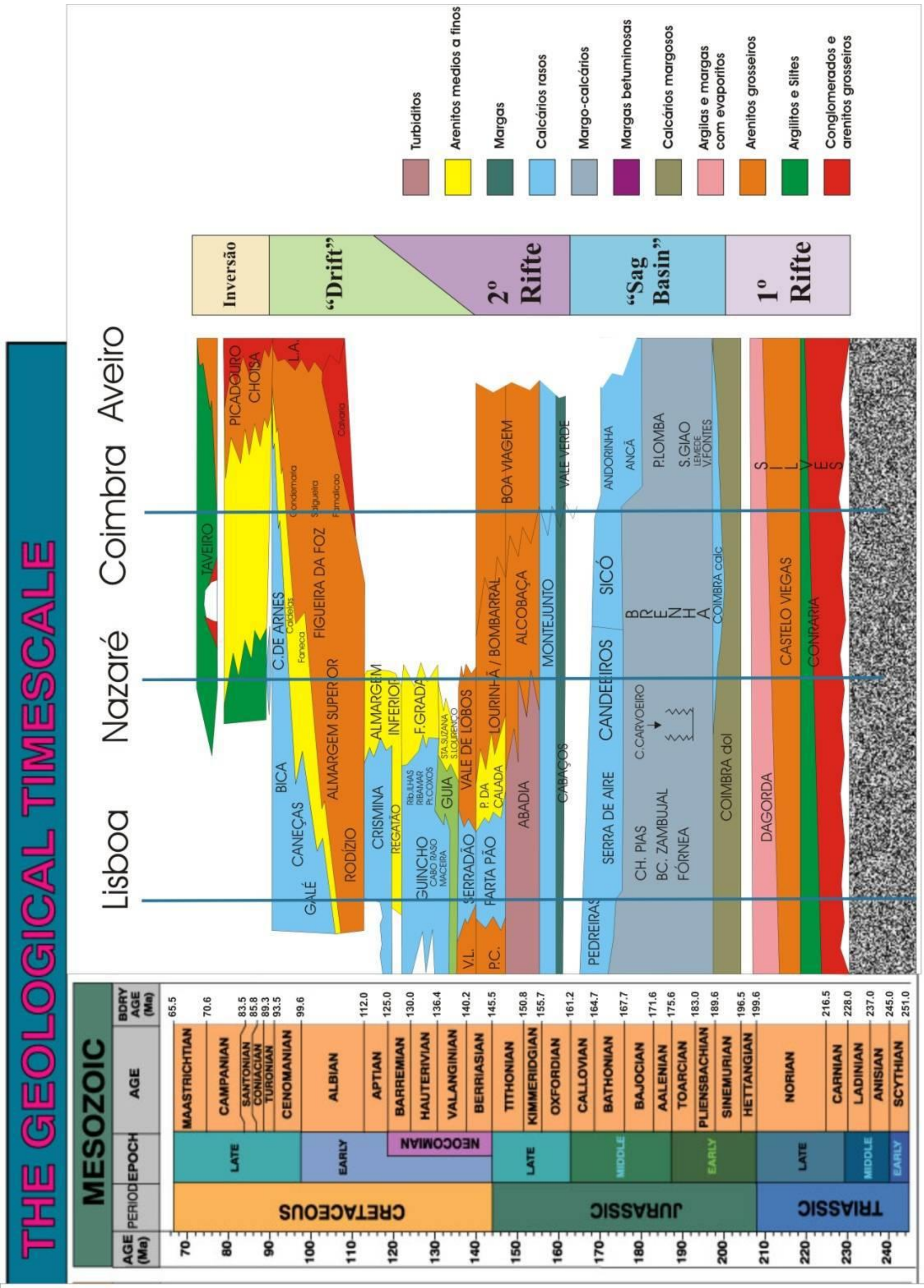

Fig. 2 – Stratigraphic chart of the Lusitanian Basin (Penareis, et al. 2007). This chart is oriented from N (Aveiro) to South (Lisbon).

The first rifting episode in Late Triassic

The first rifting episode that began during late Triassic (Fig. 2) led to the definition of a system of sub meridian grabens and half-grabens, bounded westwards by the Galice bank-Berlengas trend. The sedimentary record includes coarse alluvial fan and fluvial deposits (Palain, 1976), followed by lacustrine and coastal sandstones covered distally by evaporites (Dagorda Fm.).
A transgressive dolomitic limestone unit marks the beginning of a thick sag phase, composed of ramp marls and marly limestones, lower and middle Jurassic in age.

The second rifting episode in Late Jurassic-Early Cretaceous
From the middle Oxfordian to the early Aptian a second rifting phase occurred. This can be separated into three main episodes: Late Jurassic-Berriasian and two Early Cretaceous steps.
The extensional episode activated hercynian faults (Wilson et al., 1990) coupled with moderate halokinesis and also caused intrusive igneous activity towards the south of the Lousã fault.
The Late Jurassic-Berriasian evolution of the Lusitanian Basin is divisible into three tectonic phases. (Pena dos Reis et al. 1999). The initial phase was the onset of rifting which resulted in widespread carbonate deposition. Extensional climax was reached during phase two. This created highly subsident sub-basins and a significant siliciclastic influx. The phase three was a period of thermal subsidence overprinted by sea-level changes of presumed eustatic nature, which resulted in progradation of siliciclastic systems, overall shallowing and infill of the basin.

The passive margin
The changing from the rifting phase to a passive margin regime follows a northward migrating process. It corresponds to three sectors of sea-floor spreading, spanning from Berriasian to Aptian and migrating from the Tagus area(south), Iberia area in the middle and Galicia area (north).

The inversion
The inversion of the Lusitanian Basin begins in the late Cretaceous (Campanian) when the ocean crust spreading ands in the Cantabrian branch, followed by the beginning of subduction and the Pyrenean compression. Later on, the Betic compression, oriented NW-SE, increased the compression reaching the climax during the late Miocene.

THE OUTCROPS

The thick package of evaporites (there are drill evidences of more than 2000 m in the central area) deposited during the final step of the first rift (Hetangian) show strong evidences of motion, in close relation with the activity of major basement faults (NE-SW and NW-SE). There three main episodes of salt diapirism influencing the sedimentation in the basin: Late Jurassic, Late Cretaceous and late Cenozoic.
The field trip will visit three main outcrops: Santa Cruz and S. Martinho do Porto, both on coastal cliffs and Montejunto located inland. The three outcrops show sediments of the late Jurassic rift, in relation with the diapiric activity.

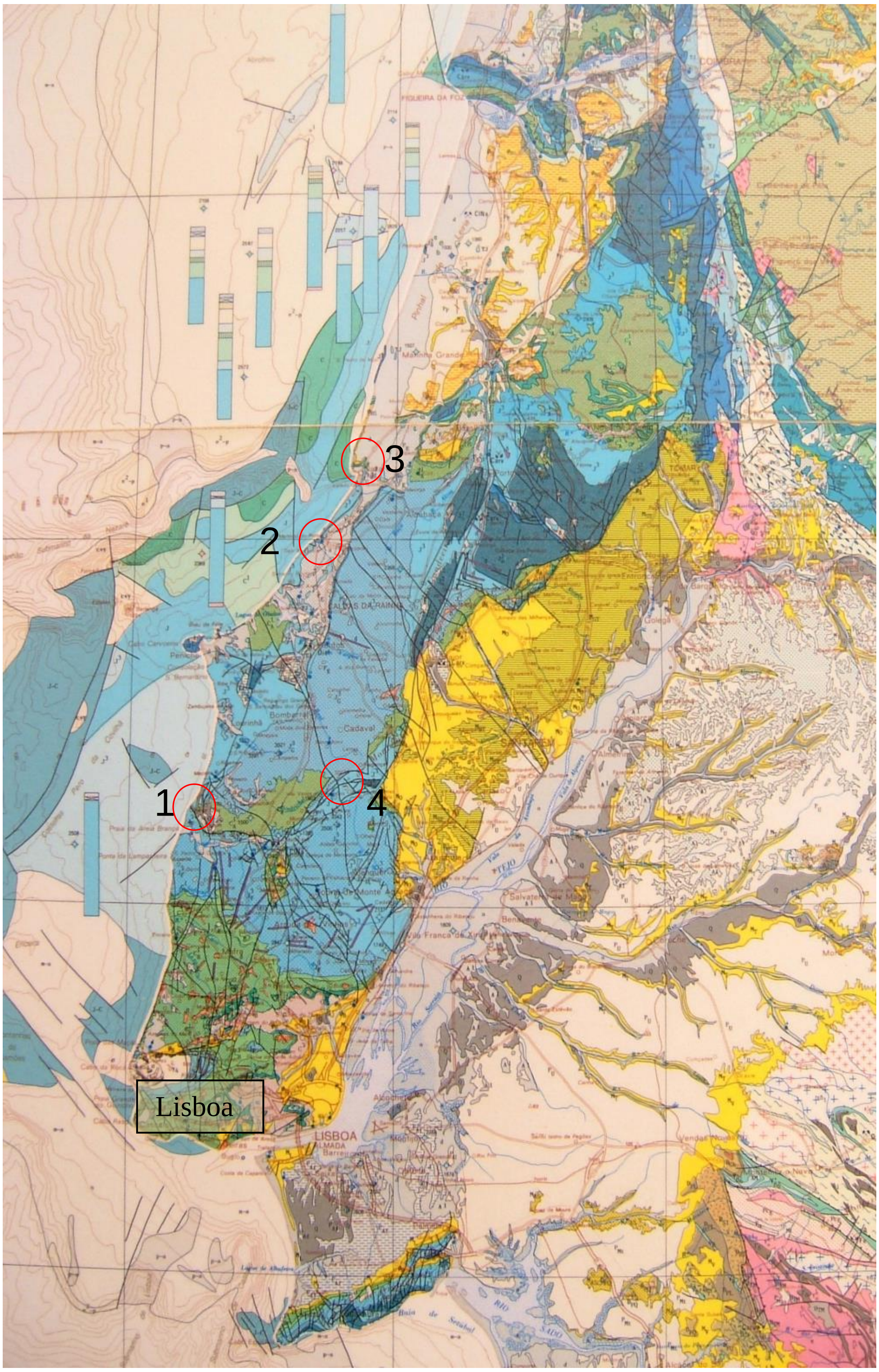

Fig 3 – Geologic map of Lusitanian Basin with the location of previewed stops.
1 – Santa Cruz; 2 – S. Martinho do Porto; 3 – Nazaré; 4 – Montejunto.

STOP 1 - SANTA CRUZ

Main focus - Upper Jurassic rifting sediments in relation with diapiric activity

Introduction

The Santa Cruz region corresponds to the westernmost outcrop of upper Jurassic sediments, likely related to the western basement border of Lusitanian Basin. The sedimentation is mainly siliciclastic, organized in several litostratigraphic units and records the more important conditions of the 2nd rifting ocurrence.
The outcropping diapiric geometries allow the observation of geologic features suggesting the relation between the salt motion and the sedimentation.

Observations

This coastal outcrop presents upper Jurassic sediments related to the second rifting event, including Kimmeridgian turbidites related with the climax, next to a diapir wall (Fig 4 A). These sediments are incised by a submarine flow conglomerate (Fig. 4 B). The package is overlain by coastal and fluvial sands (Ravnas et al. 1997) of the transition to the post climax phase (Amoreira Fm). This succession shows an apparent adaptation geometry going away from the diapir.

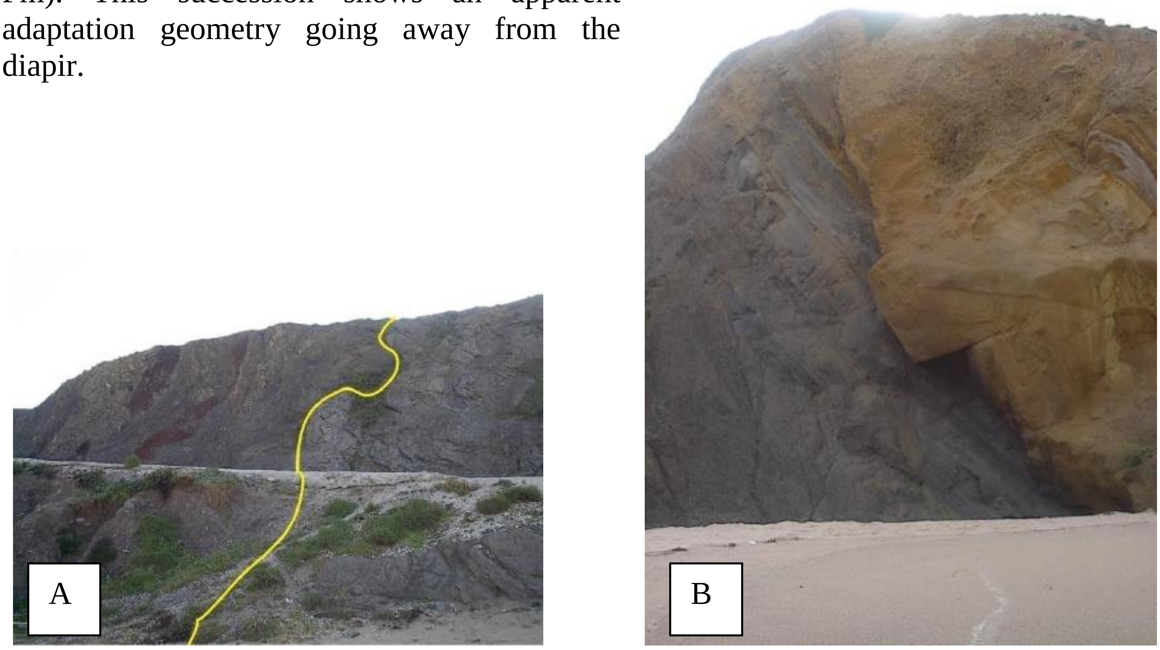

Fig. 4 – Santa Cruz stop. A;. The contact (yellow line) of the Fm Abadia (right) with the diapir wall.(left). B; The Fm Abadia turbidites incised by a submarine channel. C; Deformation in diapiric evaporites.

STOP 2 – S. MARTINHO DO PORTO

Main focus - Upper Jurassic rifting sediments in relation with diapiric activity

Geological framework:

The region belongs to the Estremadura trench, a cortical structure that was formed in the extensional phase of late Jurassic, with a general orientation NNE-SSW. The Caldas da Rainha salt dome is an asymmetric structure in a transversal cross section (with a low tilt in the west flank and a more abrupt tilt in the east) that establishes the pit domains: Peniche's block to the west (where S. Martinho is situated) is characterized by a moderate subsidence and another domain to the East (Bombarral and Ota blocks), where the subsidence is more intense.

The thick clastic succession is organized in fluvio deltaic systems (Bernardes, 1992), infilling a fast subsiding area following the rift climax. To the south, (Montejunto, stop 4), these systems change to deep sea turbidites.

Observations

The figure 5 shows an aerial view of the area. The red line separates the eastern diapiric depression with a half circle sea gulf, from the western coastal cliffs where the fluvio deltaic sediments outcrop. They dip to the West and, as seen in the figure 5, the beds are decreasingly dipping away from the diapir.

Fig. 5 – The area of S. Martinho do Porto. The arrow indicate the view of the figure 6.

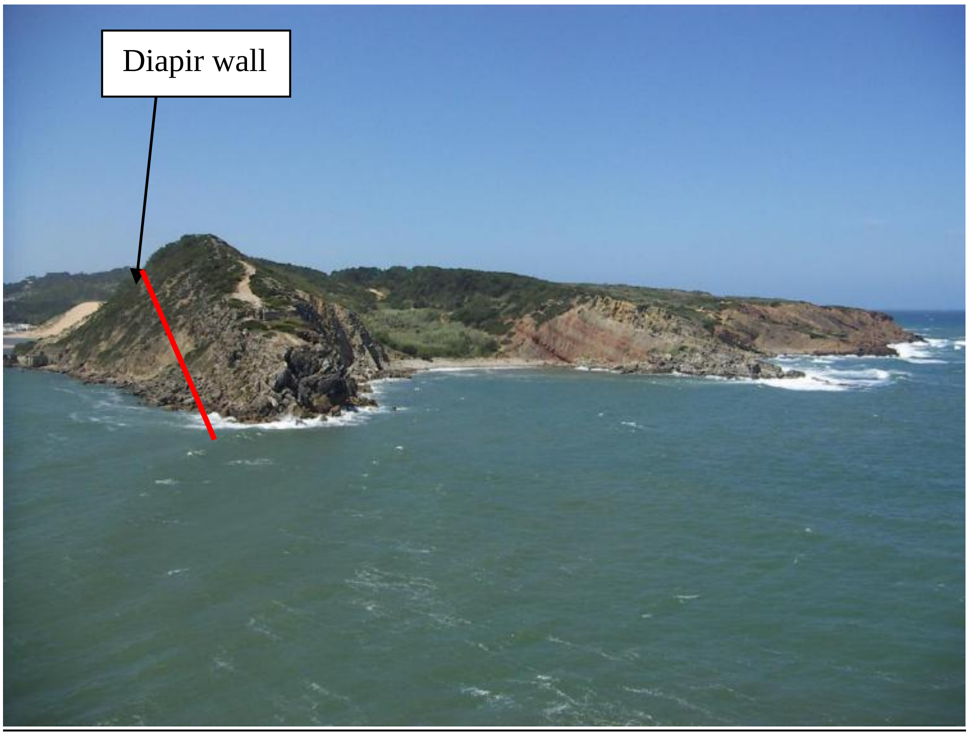

Fig. 6 – The outcrop of S. Martinho do Porto The red line represents the same feature as in the figure 5.

STOP 3 – NAZARÉ NIGHT STOP

The Nazaré stop intends to show a Late Cretaceous sedimentation interpreted as the first deposits above the Aptian break-up unconformity. It corresponds to a succession recording the passive margin phase, with the first signs of inversion from the latest Cretaceous on. The changing from alluvial braided systems in the base to the Cenomanian transgressive carbonate platform at the top is very well exposed along the main cliff of the “Sitio de Nazaré. In the light house

Fig. 7 – General view from the Nazaré cliffs.

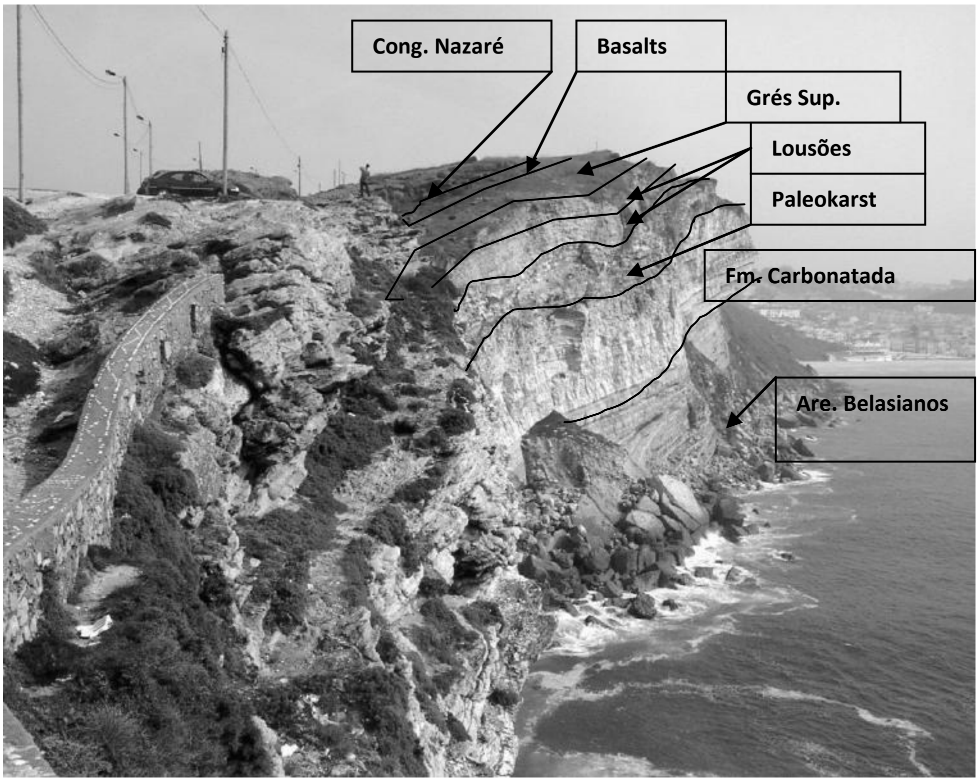

Fig. 8 – View of the Nazaré cliff. The units of the figure are visible.

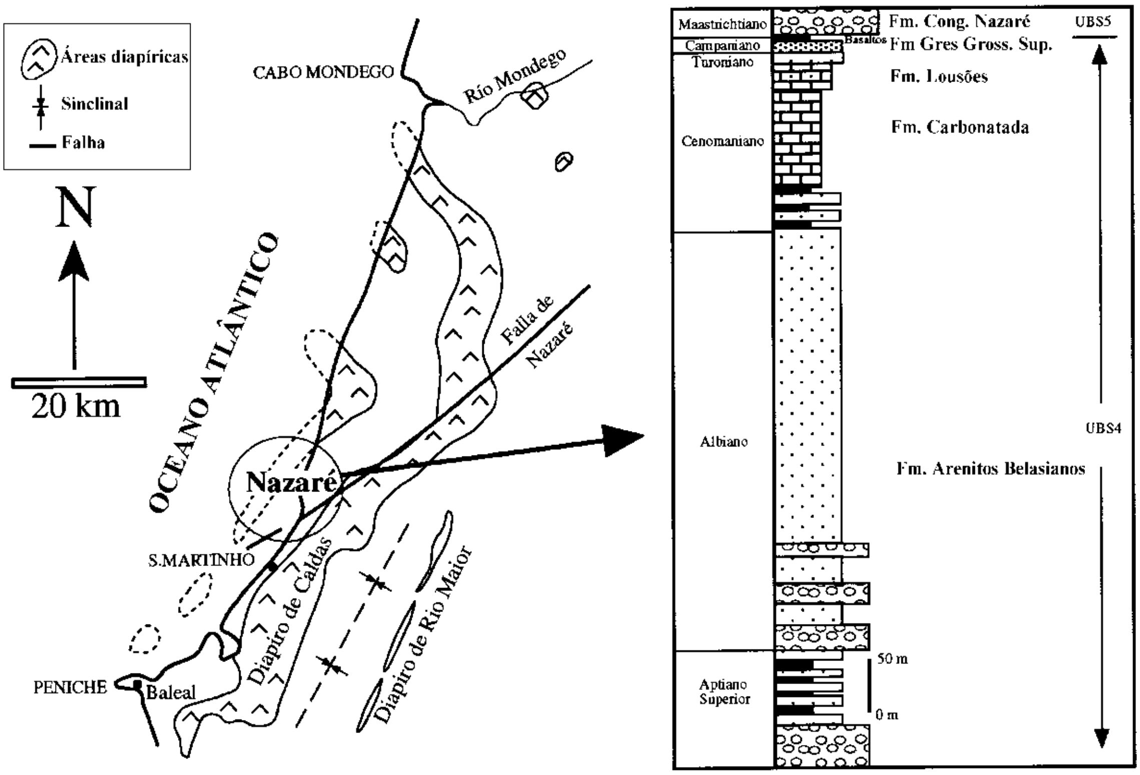

Fig. 9 - Map with the major structural elements in the region. The Cretaceous stratigraphy in Nazaré region is presented .

STOP 4 – MONTEJUNTO

Main focus – Instable talus with deep facies. Thrust anticline related with salt motion

Introduction

With the 2nd rift, between the Caldas da Rainha alignment and the Vila Franca fault, strongly subsident sub-basins are defined (Arruda, Bombarral and Turcifal) whereas some uplifted blocks (Ota, Monte Gordo) remain where the carbonate platform sediments continue to accumulate (Fig. 10).
After the rift climax coarse grained siliciclastic sedimentation is likely to reflect erosion from the borders and subsequent expansion of the drainage basin after the fault movement cessation (Fig. 10). The overall progradation of the siliciclastic systems (Abadia formation) can be interpreted as a highstand-like linkage of depositional systems, created as a response to the tectonic derived relative sea-level rise.
The maximum subsidence occurs in the Arruda depocentre around the structural alignment of Montejunto (stop 4), causing the deepening of the basin, with the rupture of the carbonate platform of the Montejunto Formation (Fig. 11). During this episode, the sedimentation of marls and limestones with ammonites continues in a regime of external platform controlled by NE-SW faults, and represented by the Tojeira member. At the beginning of the Kimmeridgian, the conditions of maximum subsidence are produced (Pena dos Reis *et al.*, 1997; Pena dos Reis and Corrrochano, 1998).

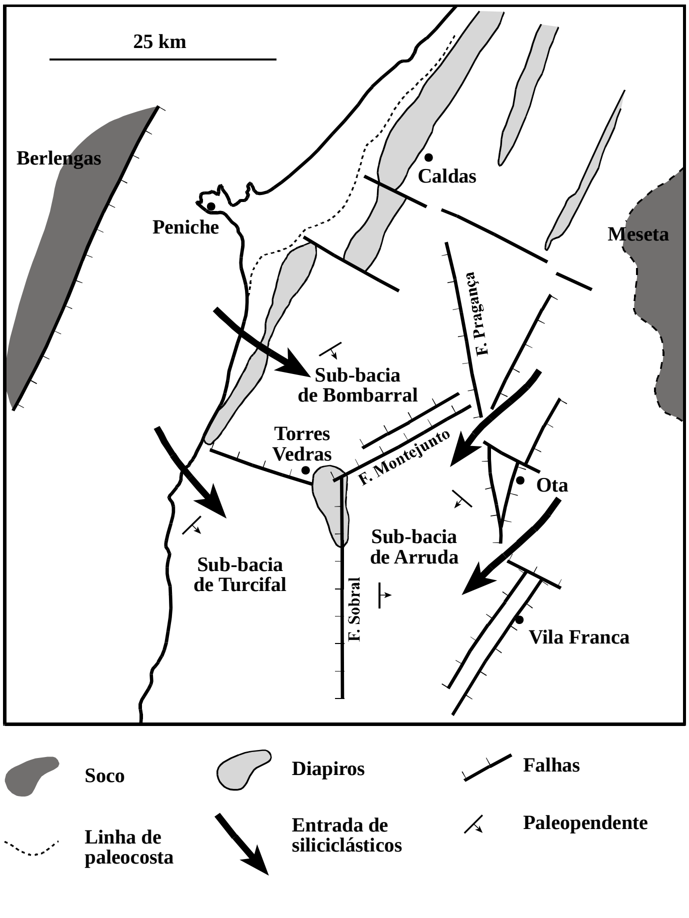

Fig. 10 – Structural framework of the central area of the basin where Montejunto is located. *Soco=basement; entrada de siliciclásticos=siliciclastic input*.

CRONOSTRATIGRAPHY (ATROPS e MARQUES, 1986)				FACIES	SEDIMENTARY MODELS	EVENTS	CLIMAX PHASES OF THE RIFT
KIM	Ac. Div. Hypes.	Fm.	Mb. CABRITO	*Marls *Clastics (sandstones and conglo merates, with breccia	* Shelf and basin facies * canyon-submarine fan (prox turbidites - middle) to NW	Subsidence slowing * infill and shallowing, * Incision and clastics progradation	LATE
	Plat.		Mb. CASAL DE RAMADA	*Marls and limestones. Calcareous breccia; olistolits	* Basin facies. Scree breccia and submarine fan (middle to distal turbidites) to NW	Máximum subsidence * First progradation Diferentiation of a tectonic scarp Deep carbonate sedimentation	MIDDLE
OXFO SU	Plan.		Mb. TOJEIRA	* Marls and limestones	* distal platform	Platform break-up * Subsidência speeding * Basin deepening	EARLY
	Bim.	Fm. MONTEJUNTO					

Fig. 11 – General stratigraphic framework of the Montejunto area (Pena dos Reis and Corrochano, 1998).

Observations

The Montejunto anticline corresponds to a deep salt structure. The assimetric geometry thrusting towards the West, can be seen as in the figure 12. In this area of the basin, this stage begins with the member Casal da Ramada from the Formation of Abadia, formed by facies that are characteristic of a deep sedimentation, including marls and grey lutites with amonnitic fauna. Depending on the active faults, strong levels of breccia and calcareous olistolits (Fig. 12) with evidences of karstification occur, seen as deposits of unstable slope. As in Santa Cruz, submarine feeder channel conglomerate facies can be observed. Above, lutites and sandstones correspond to deep turbidític fans (member Cabrito and higher levels from the Abadia Formation), representing the beginning of the progradation of the siliclastics systems from SW and W, over the facies of the basin.

Fig. 12 – View of the thrust fault bounding the Montejunto carbonate platform from the overlying Abadia turbidits. Large blocks on the left are olistolits.

References

BERNARDES, C.A. (1992) A sedimentação durante o Jurássico Superior entre o Cabo Mondego e o Baleal (Bacia Lusitana): Modelos deposicionais e arquitectura sequencial. Tese de doutoramento (não publicada). Universidade de Aveiro, 261p.

PALAIN, C. (1976) Une série détritique terrigène. Les "Grés de Silves": Trias et Lias inférieur du Portugal. *Mem. Serv. Geol. Portugal*, Lisboa, N.S., 25, 377 p.

Pena dos Reis, R., Pimentel, N. & Garcia, A. (2007). *Curso de Campo na Bacia Lusitânica (Portugal), Roteiro*. Coimbra, 2007. 154 p.

PENA DOS REIS, R.P, PROENÇA CUNHA, P & DINIS J. (1997) Hipersubsident depositional event associated with a rift climax in Late Jurassic of Lusitanian Basin (W Portugal). *IV Congreso de Jurásico de España. Alcañiz.* 101-103.

PENA DOS REIS, R.P.B, CUNHA, P.M.R.; DINIS, J.L. & TRINCÃO, P. (1999) Geologic evolution of Lusitanian Basin during Late Jurassic (Portugal). *in Advances in Jurassic research* 2000, ed. Hall & Smith; GeoResearch Forum, Vol. 6 (2000) pp. 345-356, Trans Tech Pub, Zurich.

PENA DOS REIS, R.P.B. & CORROCHANO, A. (1998) Arquitectura deposicional controlada pela etapa paroxismal do rifting no Jurássico superior da Bacia Lusitânica (Portugal). Caso da região a SO de Montejunto. *V Congresso Nacional de Geología, Livro Guia das Excursões (Eds. J.T. Oliveira & R.P. Dias)*, 15-20.

RAVNAS, R., WINSDELSTAD, J., MELLERE, D., NØTTVEDT, A., SJØBLOM,T. S., STEEL, R. J., WILSON, R. (1997) A marine Late Jurassic syn-rifte succession in the Lusitanian Basin, western Portugal -tectonic significance of stratigraphic signature. *Sediment.Geol.,114*, 237– 266.

WILSON, R. C. L., HISCOTT, R. N., WILLIS, M. G., GRADSTEIN, F. M. (1989) The Lusitanian basin of west-central Portugal; Mesozoic and Tertiary tectonic, stratigraphic and subsidence history. *In* : Tankard, A. J. & Balkwill, H. (*eds*), *Extensional tectonics and stratigraphy of the North Atlantic margins*. American Association of Petroleum Geologists, Memoir 46, 341-361.

WILSON, R. C.; HISCOTT, R. N.; WILLIS, M. G. & GRADSTEIN, F. M. (1990) The Lusitanian Basin of West - Central Portugal; Mesozoic and Terciary tectonic, stratigraphic and subsidence history. *A. A. P. G. Memoir 41,* pp. 341-361.