PS Submarine Canyons and Fans in a Rift-Climax Event: Analysis of Two Contrasting Late Jurassic Systems in the Lusitanian Basin (Portugal)*

Nuno Pimentel[1], Rui Pena dos Reis[2], and Margins Exploration Group[3]

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[1]Geology Dep., Lisbon University, Lisboa, Portugal (PIMENTEL@FC.UL.PT)
[2]Earth Sciences Dep., Coimbra University, Coimbra, Portugal (PENAREIS@DCT.UC.PT)
[3]Margins Exploration Group, Lisbon & Coimbra Universities, Portugal

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Abstract

The Lusitanian Basin in Western Iberia is related with the Cretaceous North Atlantic opening. A previous late Jurassic rifting event, related with the seafloor spreading in the Central Atlantic between Morocco and Nova Scotia, is recorded by transitional to coastal sedimentation, with high TOC in restricted areas (Oxfordian source-rock). A late Oxfordian increase of subsidence and accommodation space promoted deep marine carbonated sedimentation.

An abundant and wide detrital input marks the latest Oxfordian rift-climax, corresponding to an intense structuration of the basin, driven by transtensional faults, together with extensive salt motion. Fluvio-deltaic inputs from NE, W and E, were carried by a longitudinal drainage towards SW, into the depocentric areas, where shallow to deep-marine turbiditic deposits accumulated over 2,000 m thick, with rates of 1500 m/my. In these areas, coarse deposits coming from inland and platform scarps were also delivered into the marine basin submarine fans, by feeding canyons and talus debris-flows.

On the western border, a Paleozoic basement rift-shoulder delivered coarse granitic and quartzitic clasts, as seen in Santa Cruz outcrops very close to a piercing diapir. Here, as a result of the coeval salt motion, the rift-climax sequence is only 100 m thick, with broad and thin sandy channels and shallow turbidites, followed by a deeply incised conglomeratic feeding canyon, showing good reservoir characteristics. This sequence is overlaid by progading deltaic lobes.

On the eastern border, late Jurassic carbonates have been salt domed and uplifted in rift-shoulders, as seen at Montejunto area, delivering extremely coarse calciclastic sediments with olistholits, followed by later siliciclastic turbidites coming from the basement. The rift-climax sequences attained around 600 m thick, and present multiple broad coarse-grained feeding channels, showing poor reservoir characteristics.

These two contrasting and contemporaneous submarine fans systems and the resulting characteristics of the incision and infill, show the influence of source-area composition and of coeval diapiric activity, in the reservoir properties. The proximity between the late Oxfordian source-rocks and the early Kimmeridgian submarine fans reservoirs, as proved by several oil-shows and oil-seeps, promoted the development of an efficient upper Jurassic rift related petroleum system, in the Lusitanian Basin.

SUBMARINE CANYONS AND FANS IN A RIFT-CLIMAX EVENT:
ANALYSIS OF TWO CONTRASTING LATE JURASSIC SYSTEMS IN THE LUSITANIAN BASIN (PORTUGAL)

N. PIMENTEL &
R. PENA DOS REIS

SUMMARY

The Late-Jurassic rif-climax at the Lusitanian Basin (Portugal), promoted the development of submarine fans related with the up-lift of bordering rift-shoulders.

The two borders of the intensively subsiding through present distinct tectonic control, producing different responses, regarding canyon incision, channel geometries and facies.

As a result, reservoir characteristics observed in outcrop show different properties, allowing to correlate it with the paleogeographic position in the rift-climax evolution.

KEY-POINTS:
- rift-climax signature in siliciclastic marine basins;
- tectonic influence on submarine fans development;
- paleogeographic influence on geometries and facies;
- paleogeographic control on reservoir properties.

GEOLOGICAL FRAMEWORK

The Lusitanian Basin in Western Iberia is related with the **Cretaceous North Atlantic opening**.

A previous **Late Jurassic rifting event**, related with the seafloor spreading in the Central Atlantic between Morocco and Nova Scotia, is recorded by a **regional inconformity and block-tilting**.

Post-unconformity sedimentation started with transitional to coastal sedimentation, with high TOC in restricted areas (**Cabaços Formation**, an Oxfordian source-rock).

A late Oxfordian increase of subsidence and accommodation space promoted increasingly deep marine carbonate sedimentation (**Montejunto** Formation).

An abundant and wide detrital input marks the latest Oxfordian rift-climax, corresponding to an intense structuration of the basin, driven by transtensional faults, together with extensive salt motion. Coarse to fine-grained marly siliciclastics filled-up the subsiding areas, showing important facies variations according to its paleogeography (**Abadia Formation**).

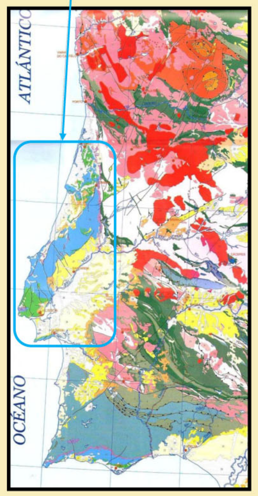
The end of the rifting phase, with the associated decrease in subsidence rate and accommodation space, allowed the prgradation of fluvial siliciclastics all over the basin (**Lourinhã Formation**),

B. LATE JURASSIC TURBIDITES

The **Abadia Formation** has been deposited by fluvio-deltaic inputs from NE, W and E, with a longitudinal drainage towards SW, into the depocentric areas.

Here, collecting those abundant siliciclastics, **shallow to deep-marine turbidites** accumulated over 2000 m thick deposits, with **sedimentation rates up to 1500 m/My**. **Coarser deposits** coming laterally from inland and platform scarps, were also delivered into the marine basin, by **feeding canyons and talus debris-flows**.

This work analyses two contrasting situations of these coarser deposits, related with the western and the eastern **borders of the NNW-SSE through**.



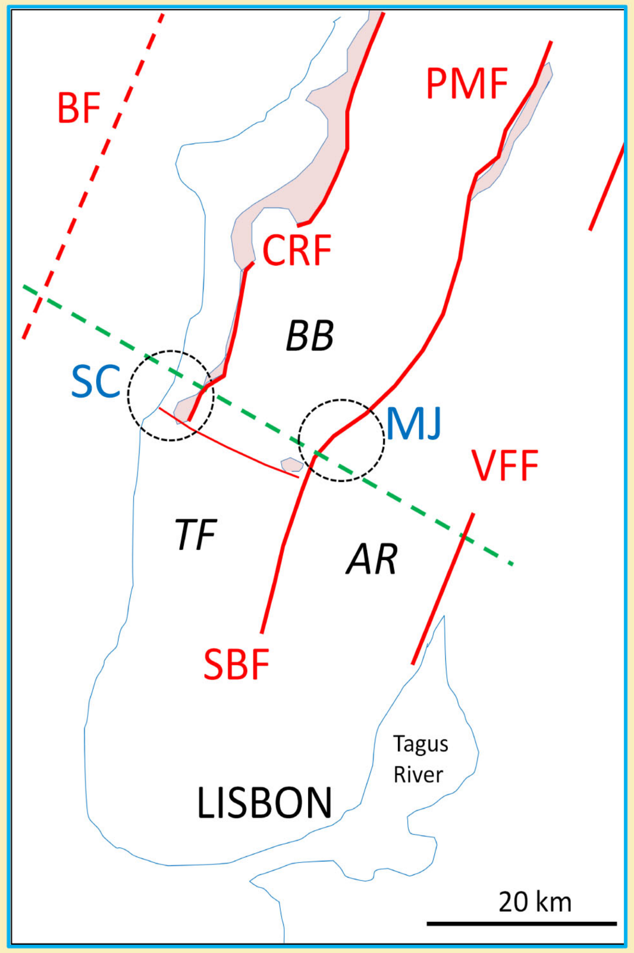


FIG. 1 – The Lusitanian Basin in the Western Iberian Margin.

FIG. 2 – Geological framework of the Lusitanian Basin.

FIG. 3 - Structural control of the two studied locations (**SC** and **MJ**), with indication of the main faults (**red**), depocentric sub-basins (**black**) and diapiric piercing outcrops (**pink**). The **green** line marks the position of the cross-section of Fig. 4.

BF – Berlenga Fault; **CRF** – Caldas da Raínha Fault; **PMF** - Porto de Mós Fault; **SBF** - Sobral Fault; **AF** – Arrife Fault; **VFF** – Vila Franca Fault.
Sub-basins: **BB**–Bombarral; **TF**-Turcifal; **AR**-Arruda.

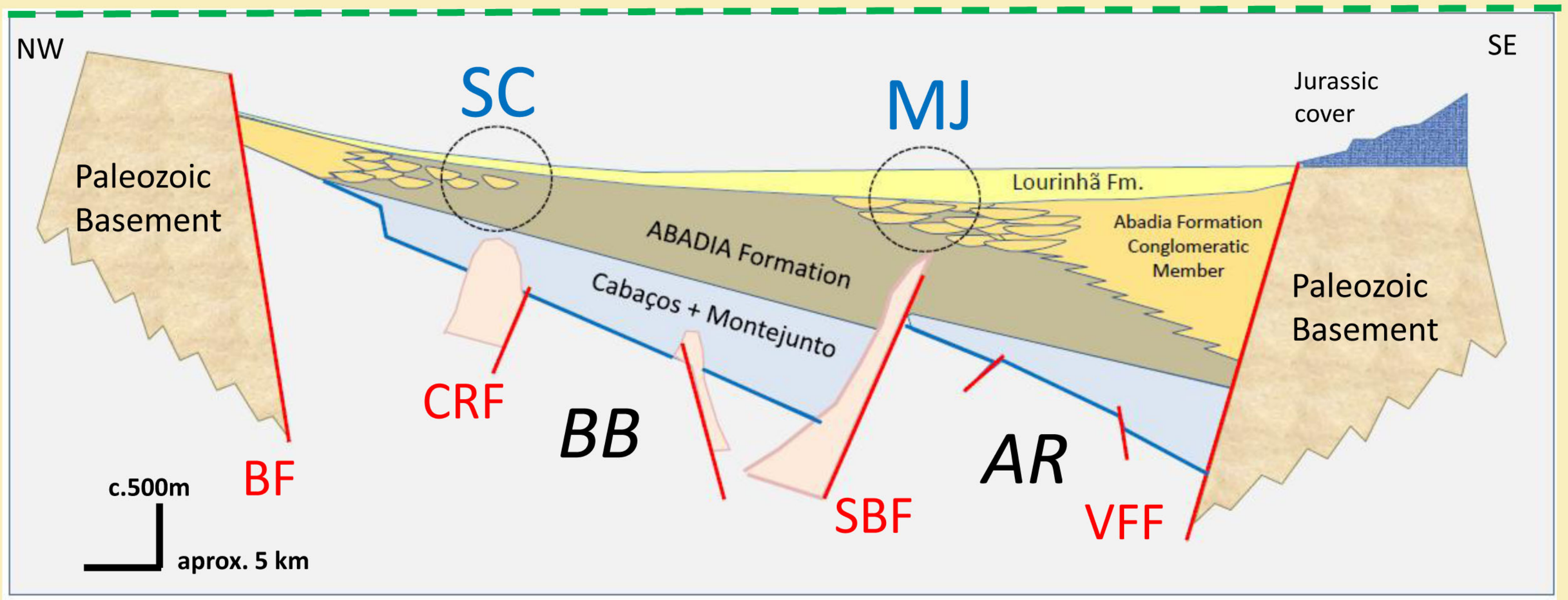


FIGURE 4 - Regional framework of the two studied areas (adapt. from Ravnas et al., 1997); SC - Santa Cruz; MJ – Montejunto.
Notice the strong structural control of the Late Jurassic sedimentary infill in the Southern Lusitanian Basin, namely the assymetric grabens, the two bordering rift-shoulders with Paleozoic basement blocks and the fault-controlled diapiric intrusions.
The Abadia Formation is mainly composed of fine-grained siliciclastics and marls in the central areas (brown), receiving coarse-grained siliciclastics (orange) form both borders.

N. PIMENTEL [2,3] & R. PENA DOS REIS [1,3]

1 - CENTRO DE GEOCIÊNCIAS, UNIVERSIDADE DE COIMBRA, PORTUGAL (*PENAREIS@DCT.UC.PT*)
2 - CENTRO DE GEOLOGIA, UNIVERSIDADE DE LISBOA, PORTUGAL (*PIMENTEL@FC.UL.PT*)
3 - MARGINS EXPLORATION GROUP (*WWW.MARGINSEXPLORATION.COM*)

SANTA CRUZ (Western border)

On the western border of the basin, a Paleozoic basement rift-shoulder delivered coarse granitic and quartzitic clasts, as seen in Santa Cruz outcrops, very close to a piercing diapir.

Here, as a result of the coeval salt motion, the rift-climax sequence is only 100 m thick, with broad and thin sandy channels and shallow turbidites (Photo 4), followed by a deeply incised conglomeratic feeding canyon. These infills show good reservoir characteristics, due to the secondary dissolution of early carbonate cementation.

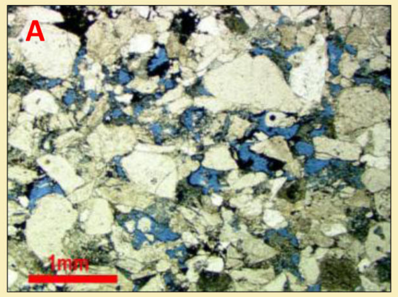
PHOTO 1 – View of the incised canyon coarse grained infill. Dip to the left (orange line) is due to the diapiric intrusion.

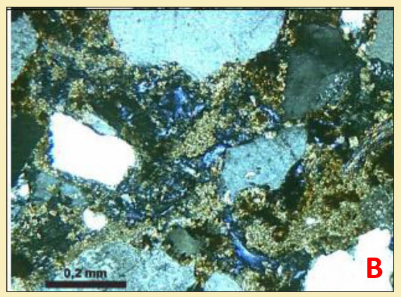
PHOTO 2 – Fine-grained greyish turbidites, covered by coarse-grained incised canyon infill.

PHOTO 3 – Detail view of the coarse-grained massive siliciclastics with clasts up to 15 cm pf quartzite and granite.

PHOTO 4 – Detail view of the turbidites, with fine-grained marly siliciclastics.

PHOTO 5 - View of the coarse-grained deposits, showing crude planar bedding and rapid energy variations.





A - Coarse-grained sandstone, with moldic and intragranular secondary porosity.

B - Coarse-grained sandstone with secondary porosity, resulting from partial dissolution of carbonate cement and grains.

Thin-section photos by A.Garcia, UFS, Brazil

MONTEJUNTO (Eastern border)

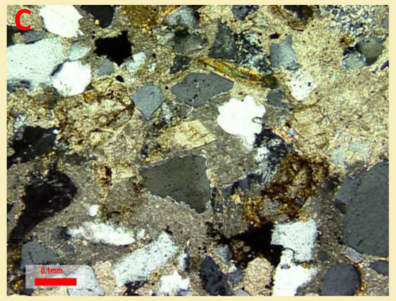
On the Eastern border of the basin, Late Jurassic carbonates have been salt-domed and up-lifted in rift-shoulders, delivering extremely coarse calciclastic sediments with olistholiths, followed by siliciclastic turbidites delivered by the basement's erosion.

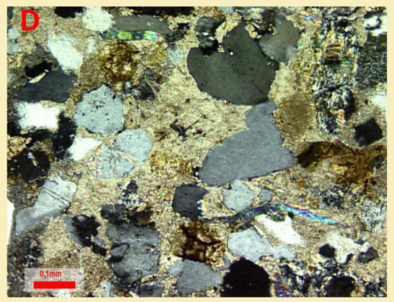
The rift-climax sequences attained 600 m thick, presenting multiple and broad feeding-channels, showing poor reservoir characteristics, due to intense carbonate cementation and rapid deep burial.

PHOTO 6 – Fine-grained turbidites with coarse sandy intercalations, reflecting the influence of submarine fans in deep areas of the basin.

PHOTO 7 – Coarse conglomeratic influx and detail of a coarse-grained layer.

PHOTO 8 - Detail of a calciclastic block, with signs of previous carstification.





C - Poorly sorted sandstone with high poikilotopic carbonate cementation.

D - Poorly sorted sandstone with car-bonate substitution of dissolved grains.

CONCLUSIONS

THESE TWO CONTRASTING AND CONTEMPORANEOUS SUBMARINE FANS SYSTEMS AND THE RESULTING CHARACTERISTICS OF THE INCISION AND INFILL,
SHOW THE INFLUENCE OF BOTH SOURCE-AREA COMPOSITION AND COEVAL DIAPIRIC ACTIVITY, ON RESERVOIR PROPERTIES.

THE PROXIMITY BETWEEN THE LATE OXFORDIAN SOURCE-ROCKS AND THESE EARLY KIMMERIDGIAN SUBMARINE FAN RESERVOIRS,
PROMOTED THE DEVELOPMENT OF AN EFFICIENT UPPER JURASSIC RIFT-RELATED PETROLEUM SYSTEM IN THE LUSITANIAN BASIN, AS PROVED BY SEVERAL OIL-SHOWS AND OIL-SEEPS.

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