Prospectivity of the Portuguese Deepwater Areas

within the context of the Afro-European East Atlantic Province

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INTRODUCTION

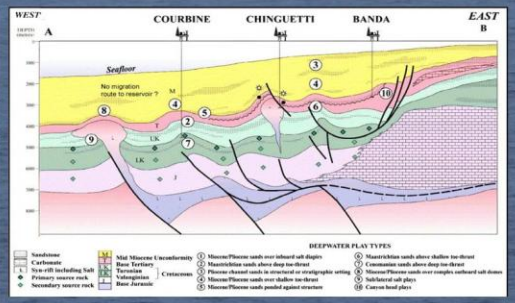
The Eastern coasts of the Central and North Atlantic are being looked by several companies as a promising region for deepwater oil and gas exploration, including the deep offshore areas of Mauritania and Morocco, in Northern Africa, and Portugal and Spain in Western Europe.

This contribution presents a **regional overview** of this province, starting with the NW African basins and detailing the Western Iberian Margin's basins. Similarities and differences are discussed within a prospectivity approach.

NW AFRICAN BASINS

In **Mauritania**, the Coastal Basin extends into deep offshore, presenting important Tertiary leads, with some producing areas (Chingueti Field) and several prospects with significant oil and gas shows.

In **Western Morocco**, several deep offshore leads have been identified, considering two main source rocks (Toarcian and Aptian) and Lower Cretaceous reservoirs.



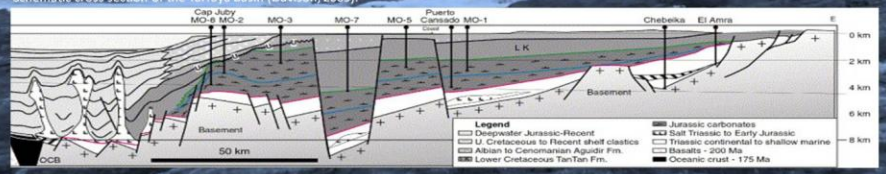
MAURITANIA
SOURCE-ROCKS – Mainly Cenomanian-Turonian
RESERVOIRS – Mainly Late Cretaceous to Miocene siliciclastics
TRAPS – Salt related anticlines and toe-thrusts

MOROCCO

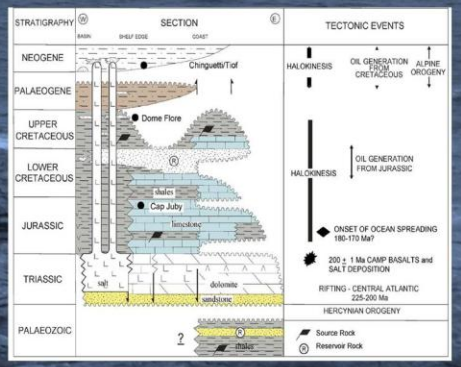
SOURCE-ROCKS – Mainly Toarcian and Cenomanian-Turonian; also Late Jurassic and Aptian-Albian ?
RESERVOIRS – Mainly Early Cretaceous siliciclastics; also Jurassic carb. ?
TRAPS – Roll-over and salt-related strucutres

Schematic cross section of the Tarfaya Basin (Davison, 2005).

Regional geoseismic section of the Tarfaya Basin (www.Serica-Energy.com)

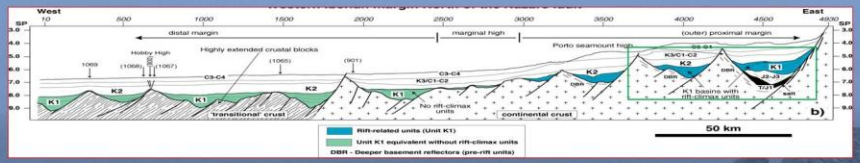


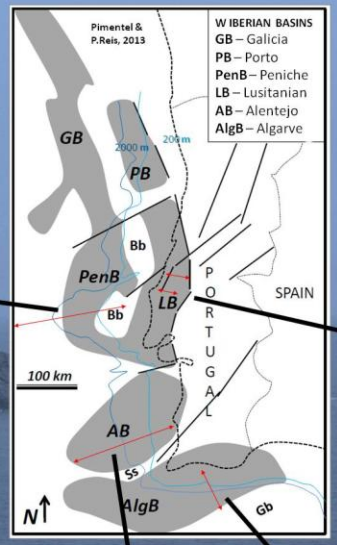
Summary diagram showing the common stratigraphic and tectonic features which are present along most of the NW African margin (Davison, 2005).

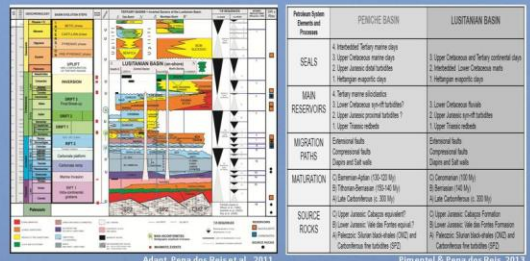


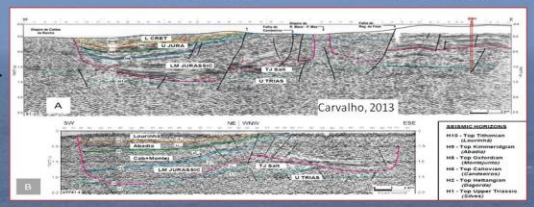
WESTERN IBERIAN MARGIN

The **Portuguese deep offshore** presents two distinct sectors. The Western sector faces the North Atlantic and the North-American coast, including the Porto Basin, Lusitanian Basin and Alentejo Basin. The Southern sector corresponds to the Algarve Basin, along the connection between the Mediterranean and the Atlantic, facing the Northern Morocco coast.

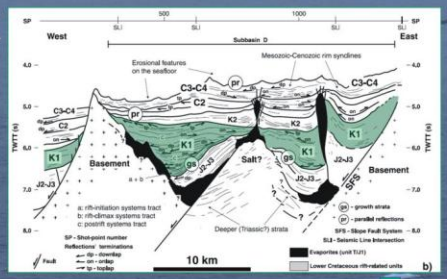




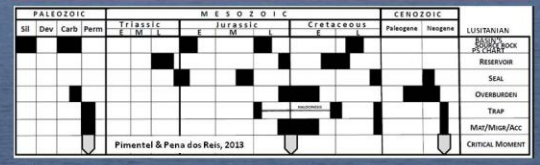




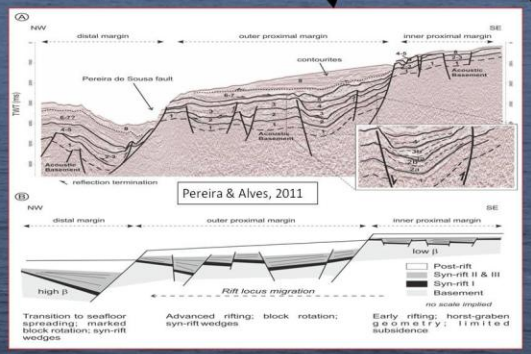
PENICHE BASIN
SOURCE-ROCKS – Sinemurian-Pliensbaquian + Oxfordian + Cenomanian ?
RESERVOIRS – U.Triassic + U.Jurassic + L.Cretaceous + Tertiary
TRAPS – Salt diapirs + Alpine compression anticlines



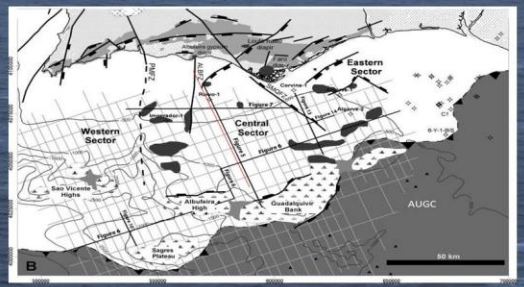
ALENTEJO BASIN
SR – Sinem.-Pliensbaq. + Oxfordian + Cenomanian
RES. – U.Jurassic/Cretac. Silicilclastic (distal areas) + Mid-Jurassic carbonates (proximal areas)
TRAPS – Stratigraphic + Alpine compression



The **Lusitanian Basin** corresponds to the inner proximal margin and most of it is outcropping – it is an excellent analogue for the offshore basins.



ALGARVE BASIN
SOURCE-ROCKS – Lower and Upper Jurassic
RESERVOIRS - U.Jurassic + L.Cretaceous + Tertiary siliciclastics
TRAPS – Mostly salt-diapir related



WESTERN BASINS

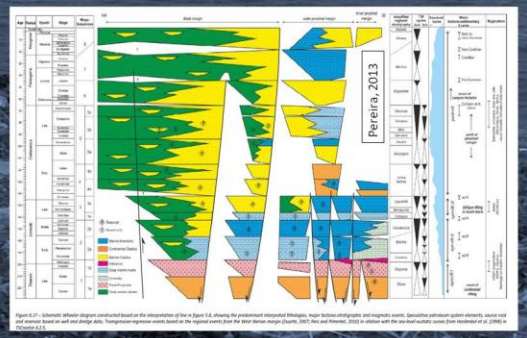
The Western Iberian margin resulted from the Western Tethys and North Atlantic evolution, with a thick **Late Triassic to Neogene infill**.

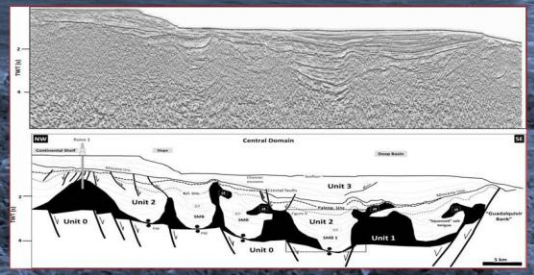
Along its 800 km long N-S section, some important differences may be noted in the **timing of the main rift events** and both Mesozoic and Cenozoic sediment thicknesses. Seismic scale observations suggest an earlier rifting (Late Jurassic) and a more pronounced Tertiary subsidence and infill for the Southern sector (**offshore Alentejo Basin**), whereas the Northern Sector (**offshore Peniche Basin**) seems to have a more recent rifting (Early Cretaceous) and less recent subsidence and infill.

This contrast may point to a better development of the **Cretaceous-Cenozoic play** in the Southern areas, related with the Mediterranean and North African mainly Tertiary play, and of the **Jurassic play** in the Northern areas, related with a North Atlantic mostly Jurassic play. **S**

OUTHERN BASINS

At the southern Portuguese margin (Algarve Basin), two superimposed basins may be considered – a Late Triassic to Early Cretaceous Tethys-related basin and a Late Cretaceous – Neogene Betic/Guadalquivir-related basin. In the deep offshore, both a Mesozoic and a Tertiary play may be active.





REGIONAL OVERVIEW

The Portuguese deep offshore is part of a larger deepwater province, the Afro-European East Atlantic Province. This Province encompasses the **outer sectors of several basins related with the opening of the Central-North Atlantic**, from Mauritania to Northern Iberia (c. 3000 km long).

These basins share many similarities, related with the rifting evolution in a similar geodynamic setting. However, they also show important differences, mainly as a consequence of **different timings and/or intensities of the rifting events**.

Main **Source-rocks** occur frequently at or immediately before the beginning of the Rift Climax, with starved sedimentation and organic matter accumulation, e.g. related with Early and Late Jurassic rifting events.

Maturation of Mesozoic source-rocks is usually not a problem due to the intense subsidence, both rift and post-rift related, suffered by these outer sectors with frequently renewed accommodation space and abundant sediment accumulation. However the alpine compressive up-lift associated to the N-Africa - Iberia collision may have inhibited further Tertiary maturation in the areas closer to that geodynamic area.

Main **Reservoirs** are related either with rift-climax siliciclastics – e.g. Late Jurassic and Early Cretaceous turbidites - or with Post-Rift prograding siliciclastics – e.g. Tertiary turbidites.

An overview of these basins shows **two major plays** :

i) a **Mesozoic play** with different source-rocks (Lower Jurassic + Upper Jurassic + Upper Cretaceous ?) and both Jurassic carbonates and Lower Cretaceous siliciclastic reservoirs; diapiric structures and sealing by Tertiary fine-grained deposits are important.

ii) a **Tertiary play** with the same source-rocks and mainly Cenozoic siliciclastic reservoirs; the main factor is the presence of alternating coarse-grained and fin-grained Tertiary siliciclastics, to act as reservoir/seal pairs.

Main **Traps** include many different situations, either related with salt diapirs, with stratigraphic closures and alpine compressive structures.

The influence of diapirs in hydrocarbon **Migration and Accumulation** is very high. Flows are controlled by salt-walls and diapirs mainly aligned along NE-SW structures, which acted initially as lystric faults but later on, during the Tertiary, as alpine inversion faults.

Therefore it may be more interesting to look for **accumulations along these salt corridors,** and not so much on diapir-induced antyclines, which may be intensively fractured, promoting leakage.

	SOURCE-ROCKS	RESERVOIRS	TRAPS
PT - PENICHE	SINEMURIAN-PLIENSBAQUIAN + OXFORDIAN + CENOMANIAN ?	U.TRIASSIC + U.JURASSIC + L.CRETACEOUS + TERTIARY	SALT DIAPIRS + ALPINE COMPRESSION ANTICLINES
PT – ALENTEJO	SINEM.-PLIENSBAQ. + OXFORDIAN + CENOMANIAN	U.JURASSIC/CRETACEOUS SILICICLASTIC (DISTAL AREAS) + MID-JURASSIC CARBONATES (PROXIMAL AREAS)	STRATIGRAPHIC + ALPINE COMPRESSION
PT – ALGARVE	LOWER AND UPPER JURASSIC	U.JURASSIC + L.CRETACEOUS + TERTIARY SILICICLASTICS	SALT-DIAPIR RELATED
W MOROCCO	TOARCIAN AND CENOMANIAN-TURONIAN; ALSO LATE JURASSIC AND APTIAN-ALBIAN ?	EARLY CRETACEOUS SILICICLASTICS; ALSO JURASSIC CARB. ?	ROLL-OVER AND SALT-RELATED STRUCUTRES
W MAURITANIA	CENOMANIAN-TURONIAN	LATE CRETACEOUS TO MIOCENE SILICICLASTICS	SALT RELATED ANTICLINES AND TOE-THRUSTS

CONCLUSIONS

The Portuguese deep offshore areas present basins with different characteristics, resulting from slightly different evolutions within the **same geodynamic context**.

An integrated analyzis of the broader **Afro-European East Atlantic Province** shows some common features of the Portuguese and the NW African basins, allthough with different associations.

A **Mesozoic and a Tertiary play** may be identified in this Province, but its relative importance varies from basin to basin and sometimes even from the proximal to distal part of the same offshore basin.

At the **Peniche Basin** the Mesozoic Play seems to be predominat, whereas at the **Alentejo Basin** both Plays may have equivalent importance. At the **Algarve Basin**, the Tertiary Play is well known in the adjacent Cadiz Basin, but a Mesozoic Play is probably also present.

A **compressive up-lifted sector** may have affected further Tertiary maturation in the areas closer to the Azores-Gibraltar Fault Zone (Algarve and Northern Morocco ?).

In all portuguese basins, **salt-corridors** should be looked at and **salt-related antyclines** should be looked with care regarding compression-related fractures and leakage.

A final remark should be done about the hypothesis of the presence of **Paleozoic source-rocks** feeding Mesozoic and even Cenozoic conventional reservoirs. This hypothesis should be explored and tested in this Province, in which **Silurian and Carboniferous black-shales** are known in many places.

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