Petroleum Systems and Thermal Modeling of the Western Iberian Margin – From the Onshore Lusitanian Basin to the Deep Offshore Peniche Basin*

Rui Pena dos Reis[1], Nuno Pimentel[2], Fátima Cardoso[1], and Bernardo Teixeira[3]

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Abstract

The Lusitanian Basin is one of the Western Iberian Margin's basins, all related with the opening of the North Atlantic and having their counterparts in eastern Canada's Jeanne D'Arc and Whale Basins. In the Lusitanian Basin, pre-rift, rift and drift phases, with its associated deposits, may be studied in detail, including a whole range of lithofacies, from continental proximal infills to distal deep-marine condensed sections. In addition, the structural style and the importance of basement, diapiric structures and other evolutionary aspects can also be investigated. This paper deals with the sedimentary and thermal evolution of the mainly onshore Lusitanian Basin and its petroleum systems, establishing an analogue for the nearby offshore Peniche Basin, aiming to contribute to a better regional framework for exploration in this region. Petroleum systems of the Lusitanian Basin are well known from outcrops and wells, with abundant data about the elements and processes of its petroleum systems. In the Peniche Basin, a seismo-stratigraphic approach, based on the analysis of 28 seismic lines (courtesy of PETROBRAS), allowed the identification of broadly the same sedimentary packages and some extrapolation about its petroleum systems. Subsidence and thermal maturation modeling (PetroMod) has been conducted on 10 wells of the Lusitanian Basin and 13 pseudo-wells of the Peniche Basin. A comparative analysis shows that both Jurassic potential source rocks - marine lower Jurassic shaly marls and lagoonal upper Jurassic marly limestones - reached oil-window in both basins. The lower SR entered the oil-window between late Jurassic and early Cretaceous times, whereas the upper SR entered the oil-window mainly in late Cretaceous to early Tertiary times. However, some lateral variations may be identified in regional maps, related with the

inner/outer position of each basin, as well as with each basin's depocenters. Several thick reservoirs, including late Cretaceous and Tertiary siliciclastics, may have accumulated oil, migrated along faults and diapiric structures, related with Mesozoic extension and with Alpine compression. These reservoirs are well sealed by clayey units, expected to thicken distally towards the outer basins. Alpine inversion structures may have promoted good trap geometries, but also seriously affected seal-integrity. All these interpretations are still to be validated by a wildcat well, constraining stratigraphic and thermal assumptions.

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Ziegler, P.A. (1999) - Evolution of the Arctic-North Atlantic and the Western Tethys. AAPG Memoir 43, p. 164-196.

Petroleum Systems and Thermal Modeling of the Western Iberian Margin

from the onshore Lusitanian Basin to the deep-offshore Peniche Basin

Funding: Project SAGRES

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(3) galp energia

PRESENTATION OUTLINE

Petroleum Systems and Thermal Modeling of the Western Iberian Margin – from the onshore Lusitanian Basin to the deep-offshore Peniche Basin

Pena dos Reis, R.; Pimentel, N.; Cardoso, F.; Teixeira, B.

I. GEOLOGICAL FRAMEWORK

1. Western Iberian Margin (WIM)
2. Geodynamic Evolution
3. WIM Atlantic Basins
4. Stratigraphic Chart
5. Seismostratigraphy

II. PETROLEUM SYSTEMS

1. PS Chart
2. Lower Petroleum System
3. Upper Petroleum System

III. THERMAL MODELING

1. Lusitanian Basin
2. Peniche Basin
3. Maturation Timings
4. Traps & Seals

IV. KITCHENS vs. RESERVOIRS

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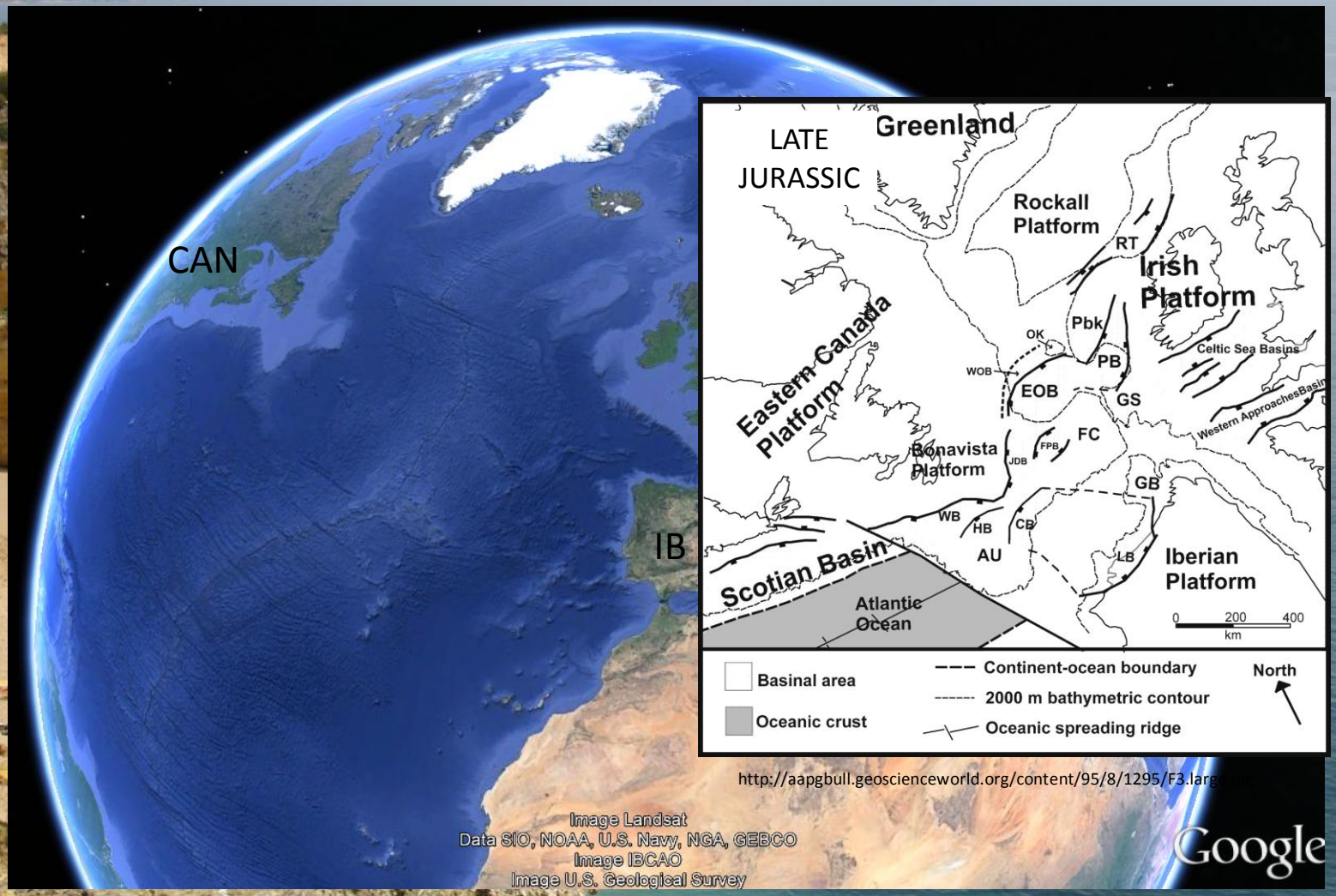
V. CONCLUSIONS

I. GEOLOGICAL FRAMEWORK

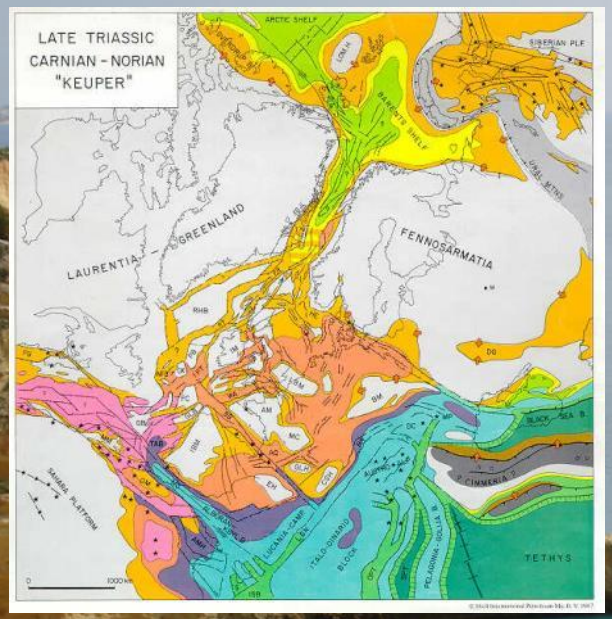
1. WESTERN IBERIAN MARGIN (WIM)

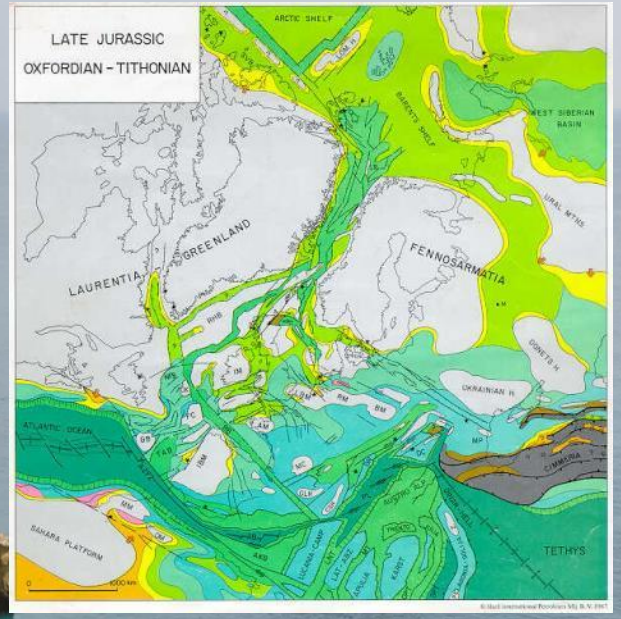


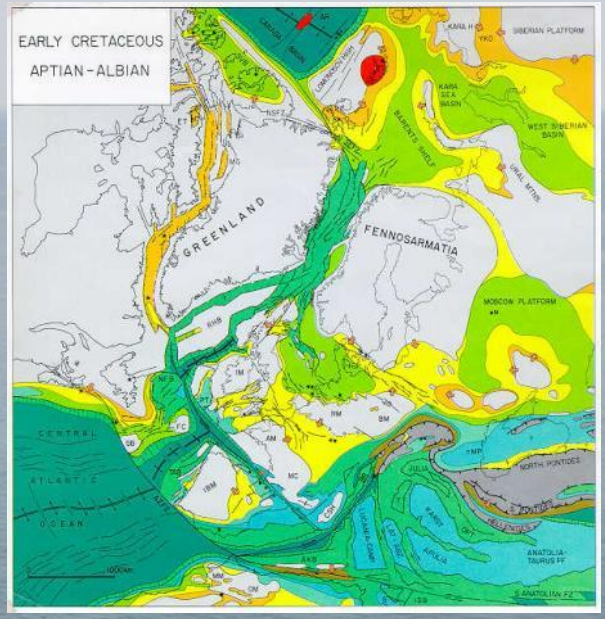
http://aapgbull.geoscienceworld.org/content/95/8/1295/F3.large.jpg

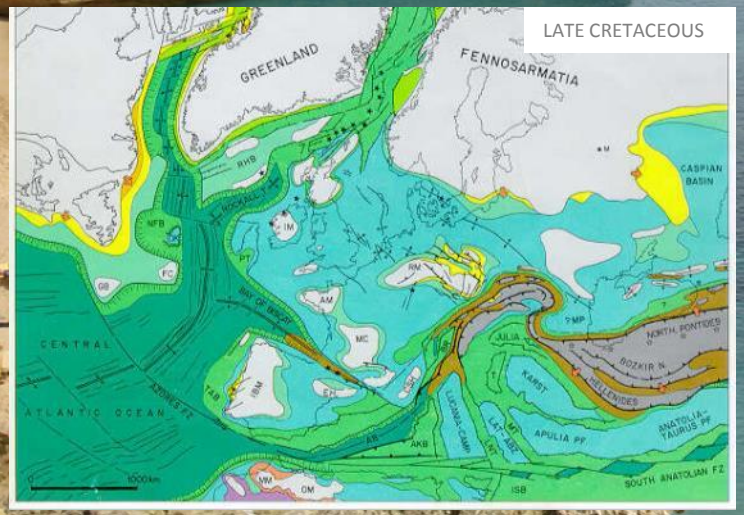
The Lusitanian Basin is one of the Western Iberian Margin's basins, all related with the opening of the North Atlantic and having their counterparts in eastern Canada's Carson (CB), Hibernia (HB) Flemish Pass (FPB) Basins.

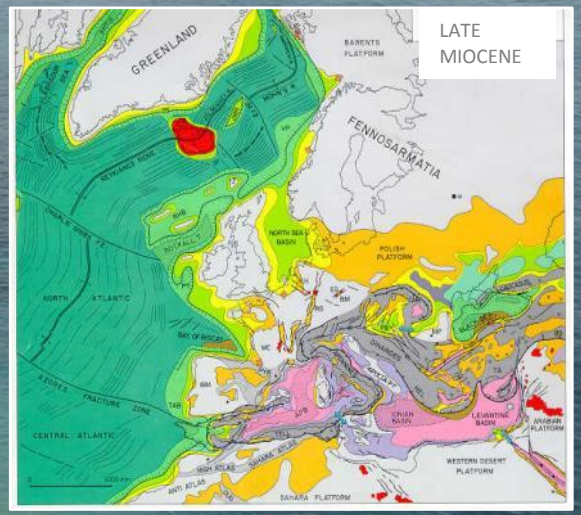
2. GEODYNAMIC EVOLUTION











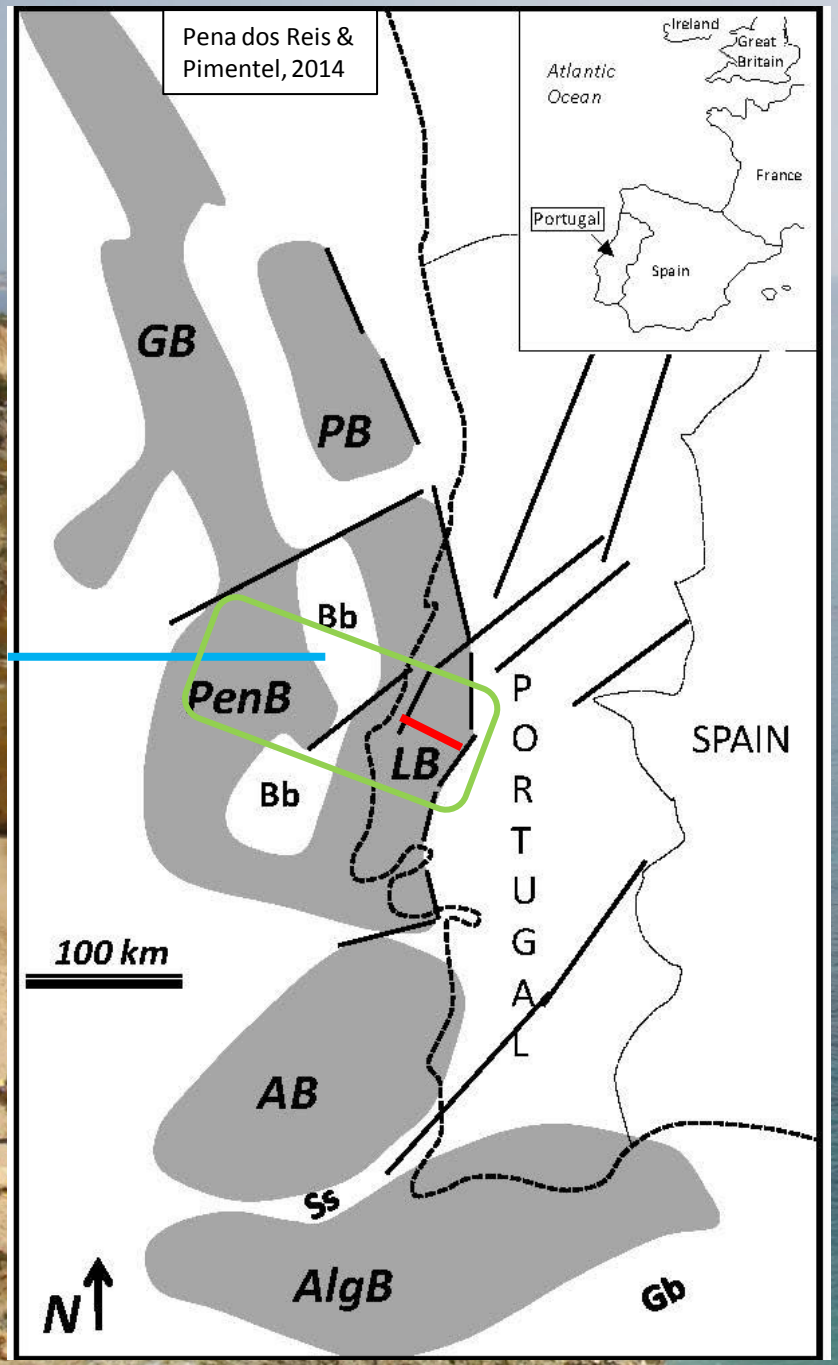
The WIM is related with the Western Tethys closure and opening of the North Atlantic, followed by the Alpine compression.

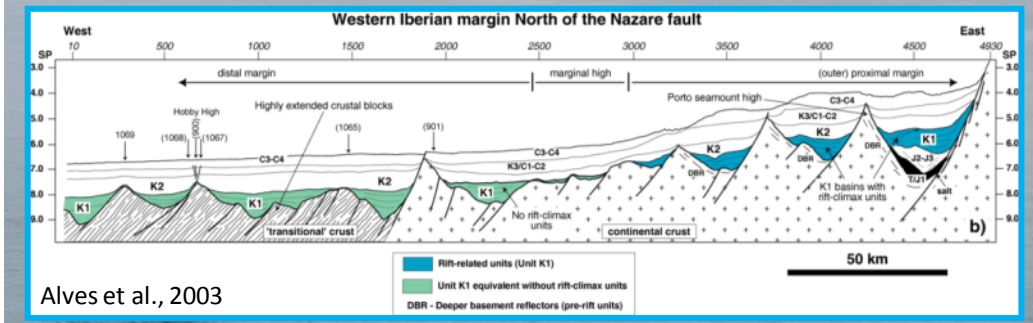
Peter A. Ziegler **1999** Evolution of the Arctic-North Atlantic and the Western Tethys AAPG Memoir 43, p. 164-196.

http://www.searchanddiscovery.com/documents/97020/memoir43.htm

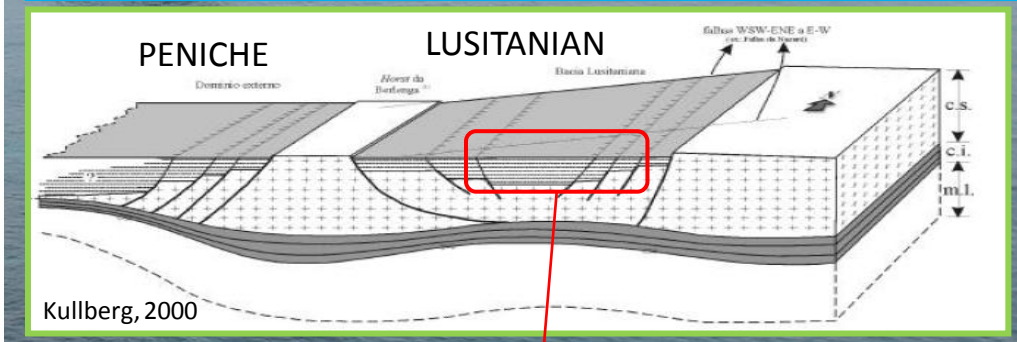
3. WIM ATLANTIC BASINS

From the onshore to the deep offshore, contiguous basins reflect the margins Meso-cenozoic evolution.

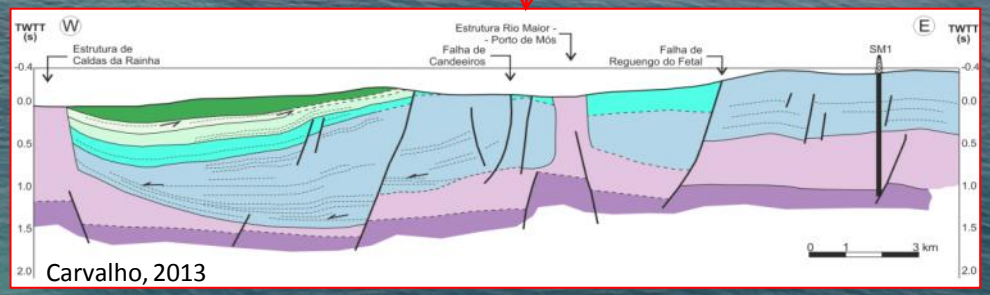




Alves et al., 2003



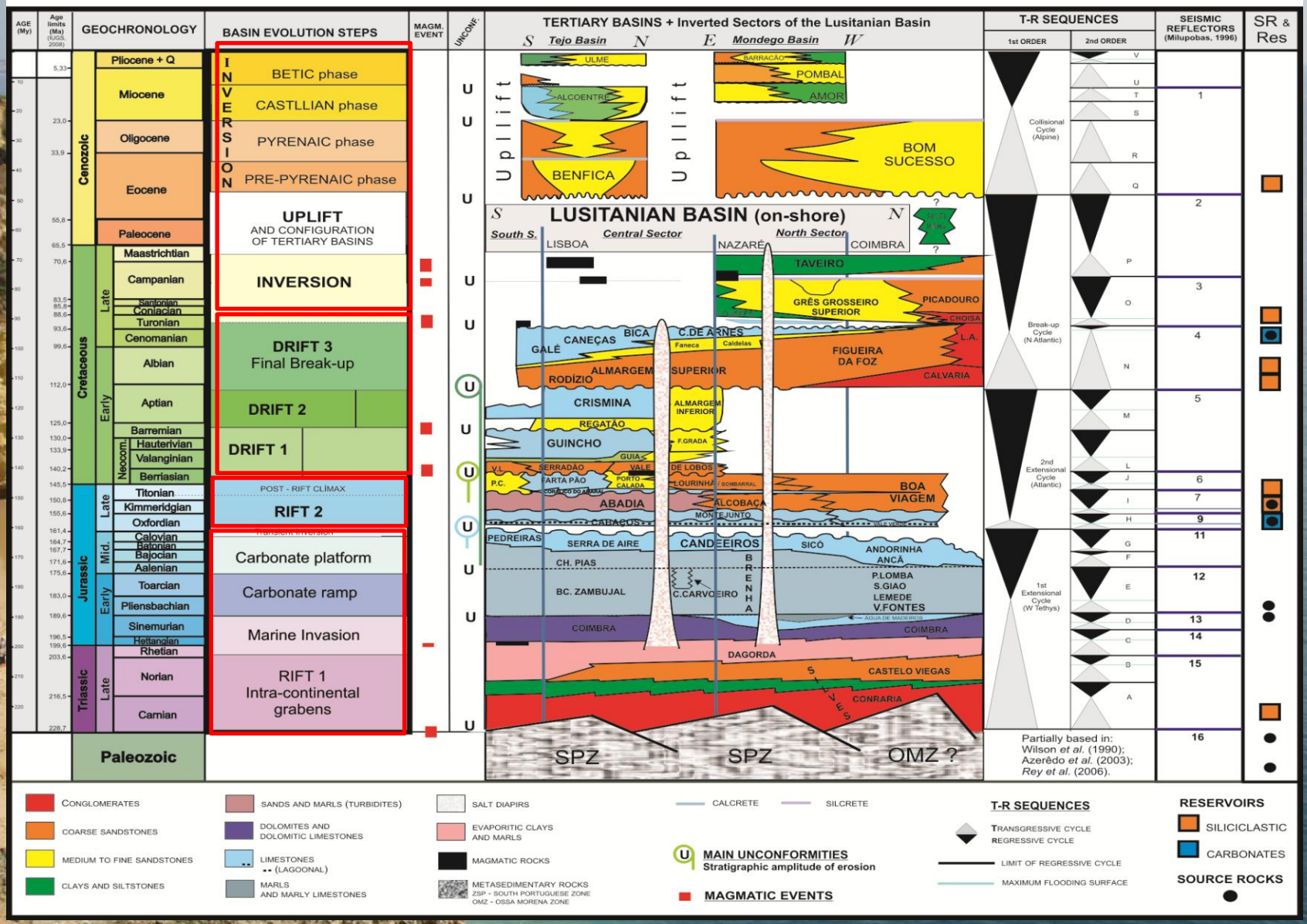
Kullberg, 2000



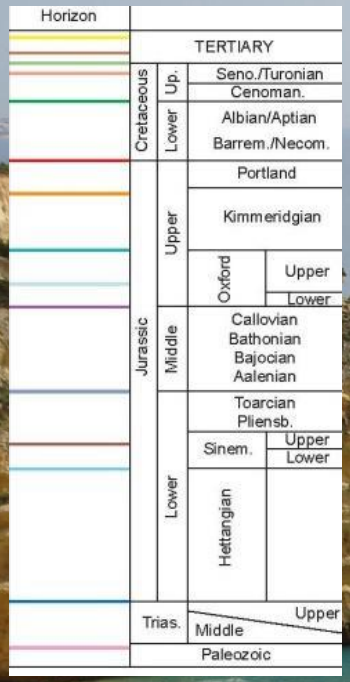
Carvalho, 2013

4. STRATIGRAPHIC CHART

Pena dos Reis & Pimentel, 2014

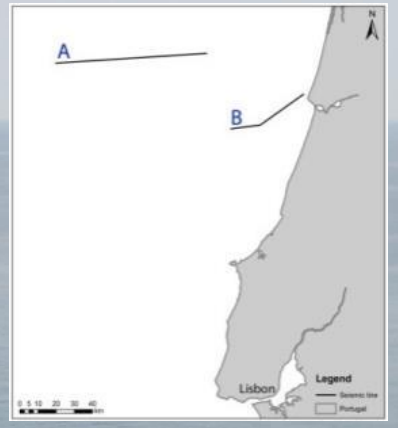


5. SEISMOSTRATIGRAPHY

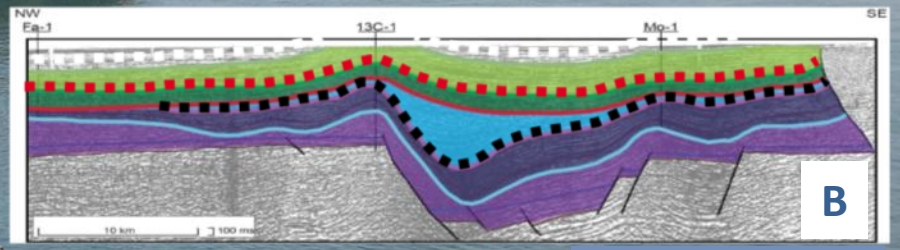


Peniche Basin ⟵ Lusitanian Basin

The main unconformities identified in the Lusitanian Basin may be also identified in seismic lines of the Peniche Basin.

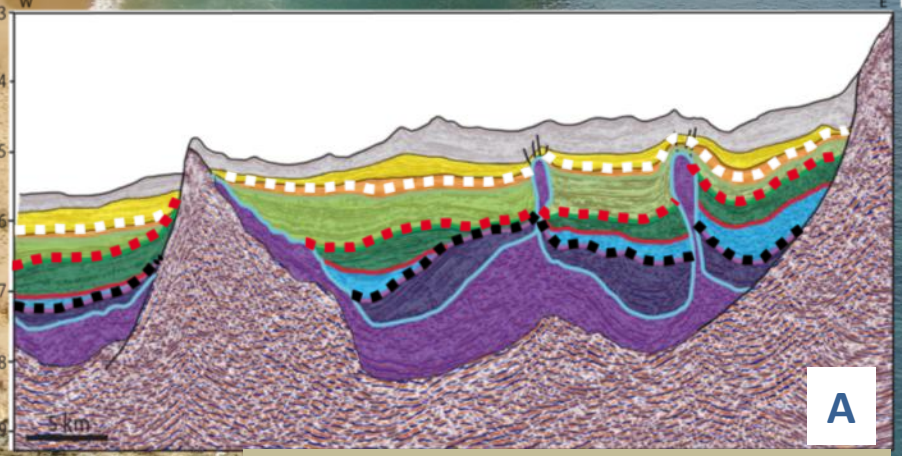


Lusitanian Basin



Rasmussen *et al.* 1998

Peniche Basin



TGS-NOPEC seismic line courtesy from PETROBRAS

Campanian unconformity

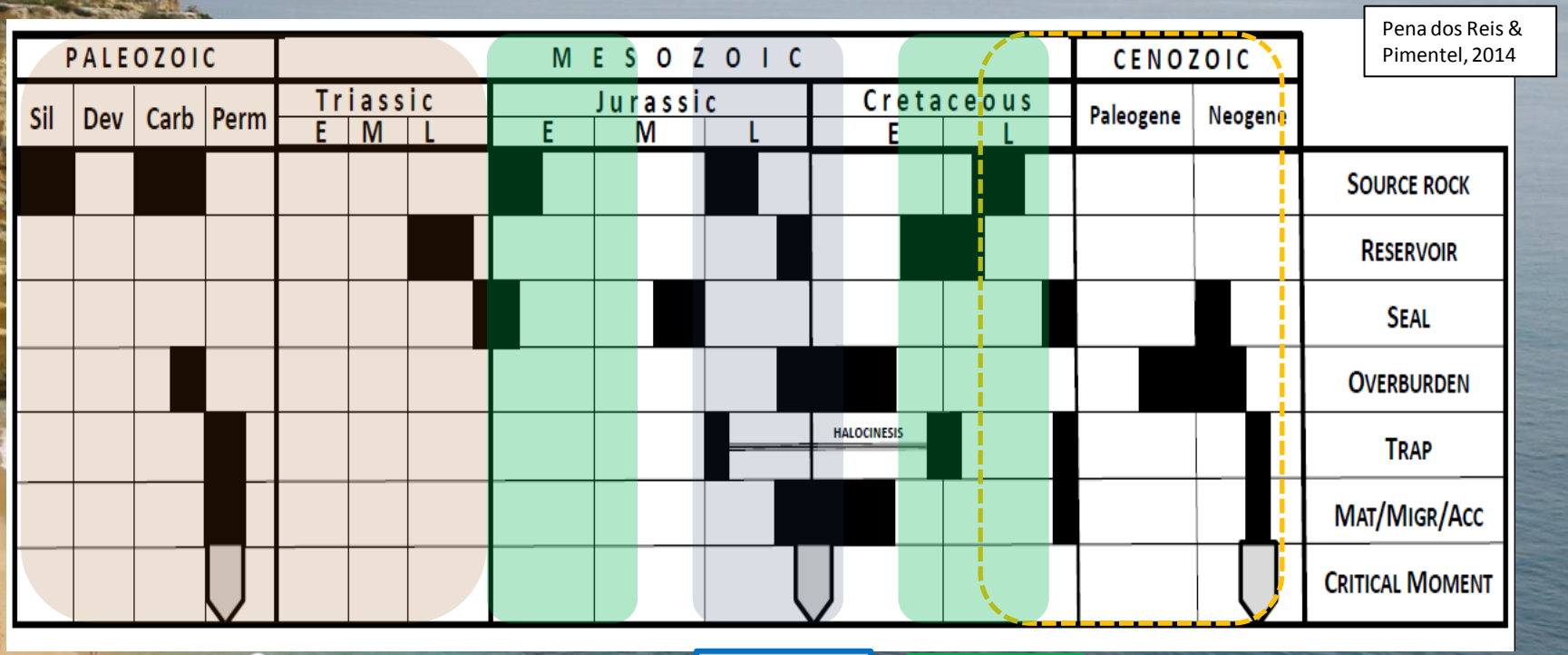
Aptian unconformity

Callovian unconformity

II. PETROLEUM SYSTEMS

Petroleum systems of the Lusitanian Basin are well known from outcrops and wells, with abundant data about its elements and processes.

1. Lusitanian Basin's Petroleum Systems Chart



Pena dos Reis & Pimentel, 2014

PZ - Triassic

L. Jura

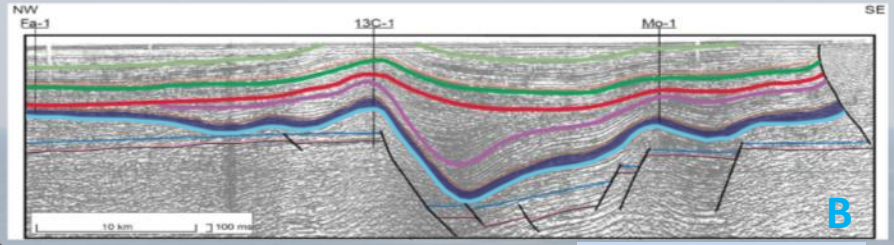
Upper Jurassic

Cretac.

Cret.-Tertiary ?

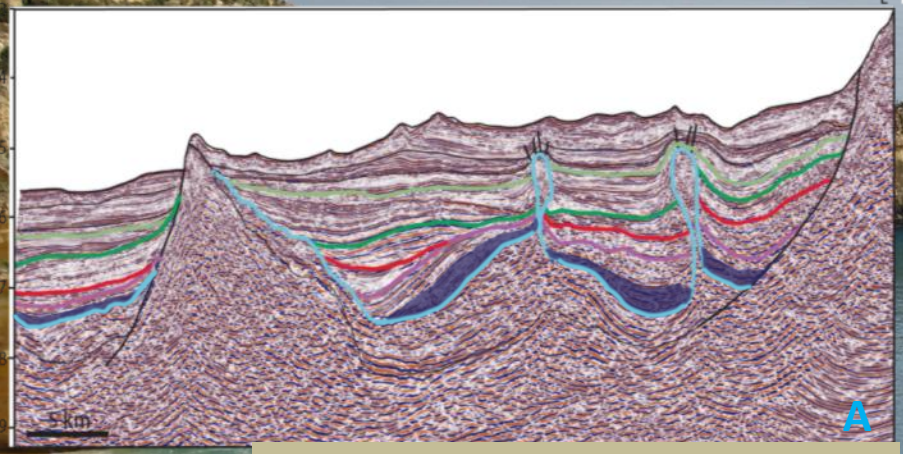
2. Lower Jurassic Petroleum System

Lusitanian Basin



Rasmussen *et al.* 1998

Peniche Basin



TGS-NOPEC seismic line courtesy from PETROBRAS

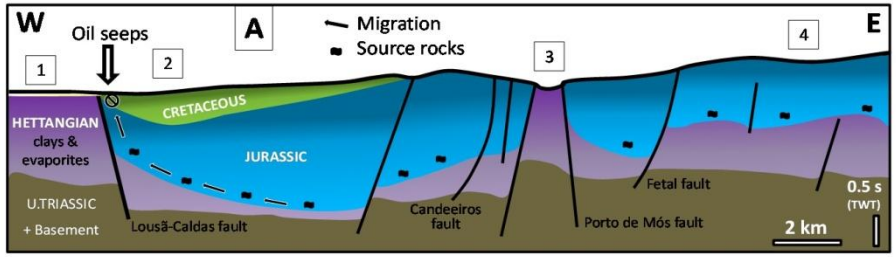
SEAL: Maastrichtian Clays

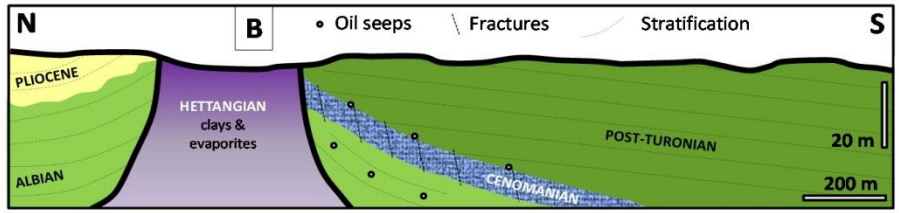
TRAP: Salt Geometries

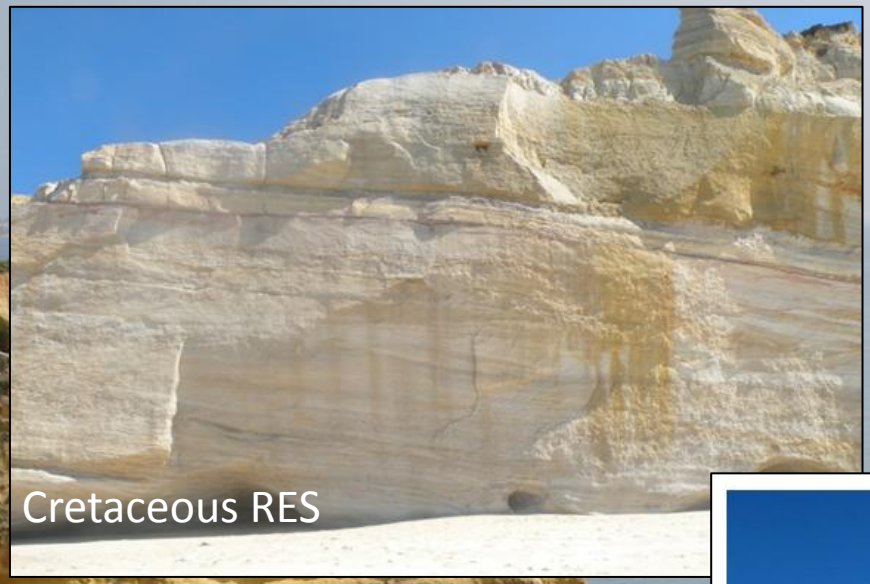
RESERVOIR: Cretaceous Alluvial Sandstones

SOURCE ROCK: Pliensbachian Marls

Pena dos Reis & Pimentel, 2013






Cretaceous RES


Cretaceous RES

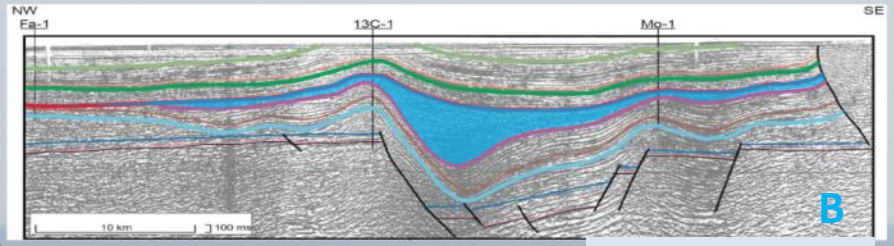

Diapir


Pliensbach. SR


Pliensbach. SR

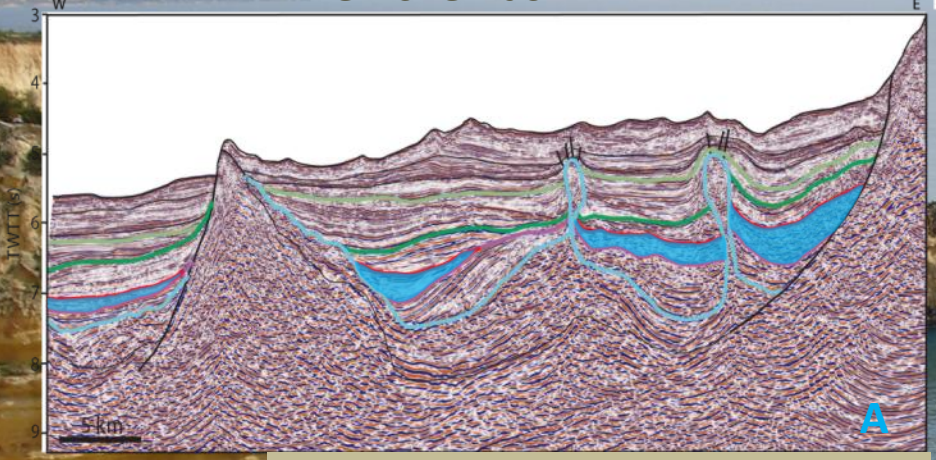
3. Upper Jurassic Petroleum System

Lusitanian Basin



Rasmussen *et al.* 1998

Peniche Basin



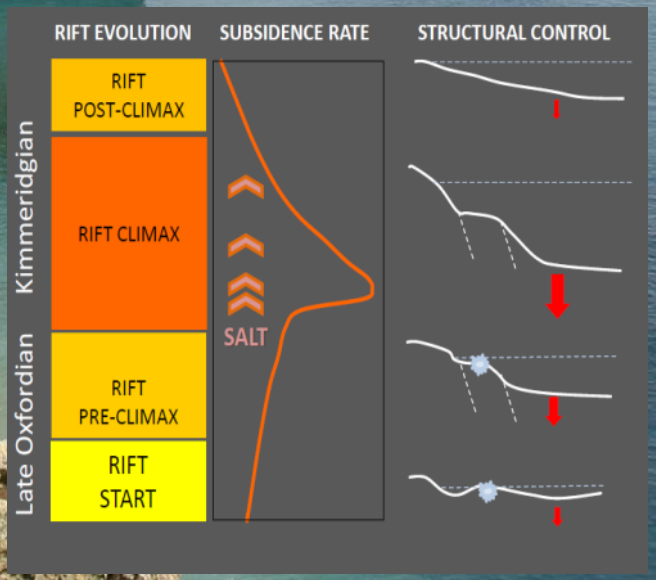
TGS-NOPEC seismic line courtesy from PETROBRAS

TRAP: Inversion Anticlines

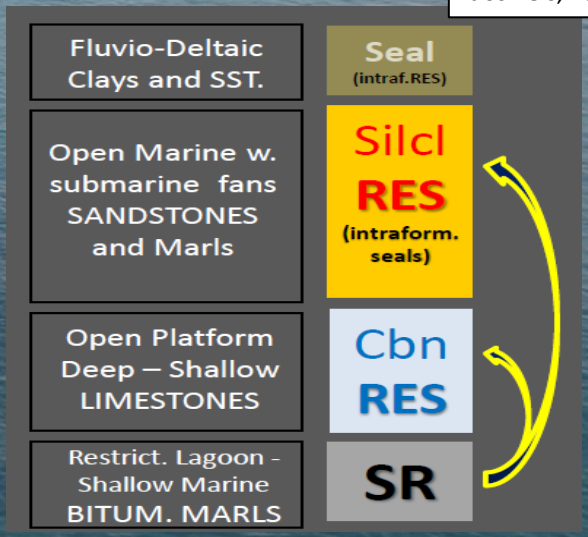
SEAL: Kimmeridgian Marine Marls

RESERVOIR: Oxfordian/Kimmeridgian Fract. Limestones & Deltaic Sandstones

SOURCE ROCK: Mid. Oxford. lagoon. Limest.



Pimentel & Pena dos Reis, 2012




Kimmeridg.RES


Kimmeridg.RES

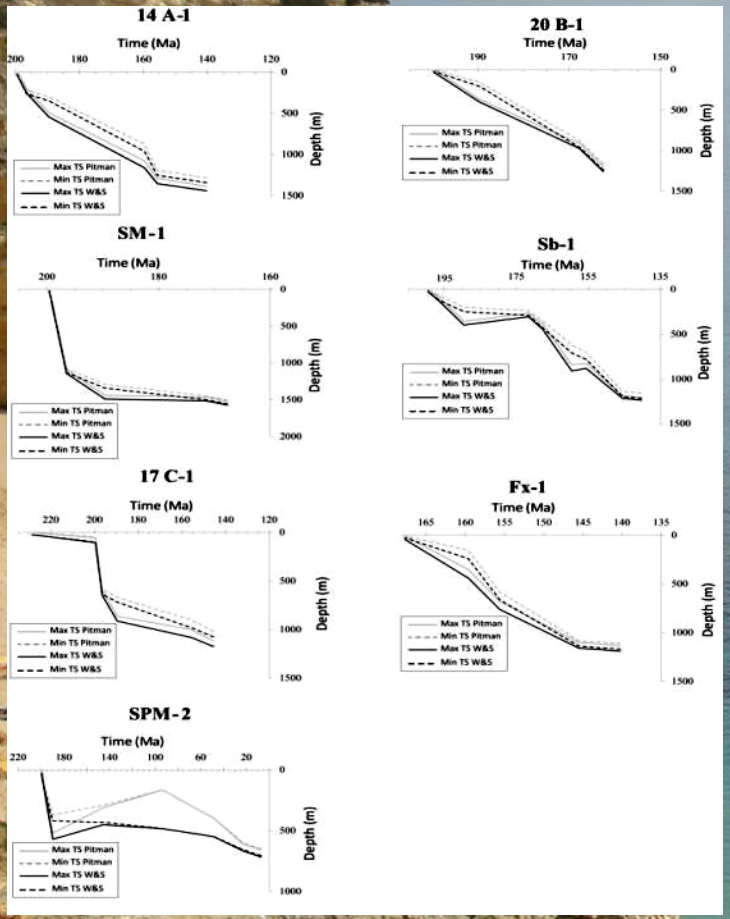

Oxfordian SR


Oxfordian SR

III. THERMAL MODELING

1. Lusitanian Basin

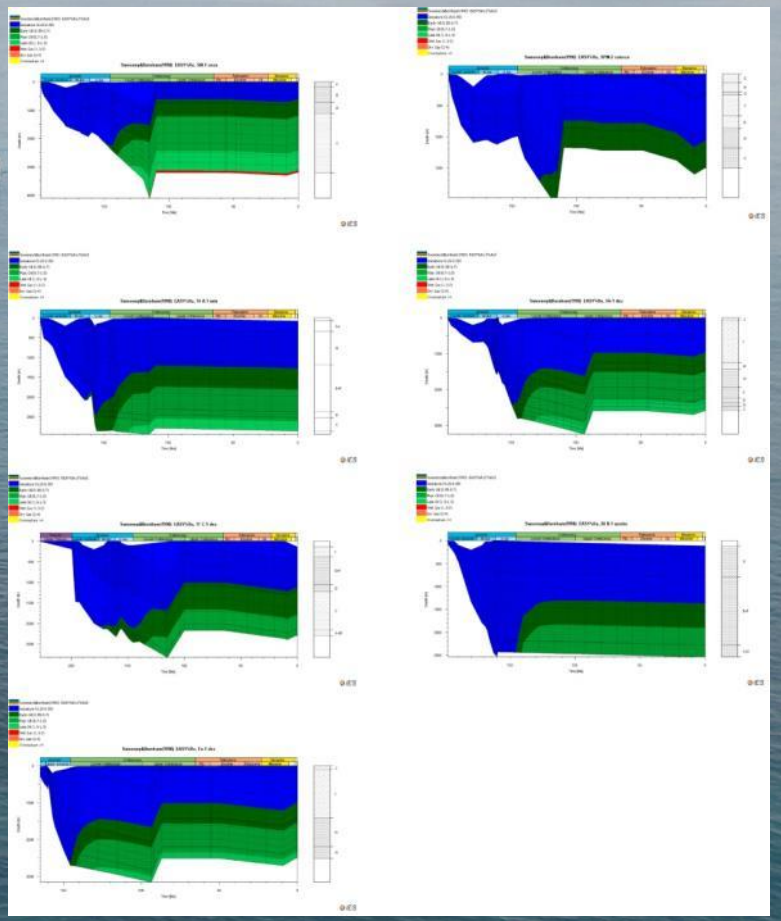
Backstripping



Pena dos Reis & Pimentel, 2013

WELL LOCATION HAS BEEN REMOVED FROM THE ORIGINAL PRESENTATION

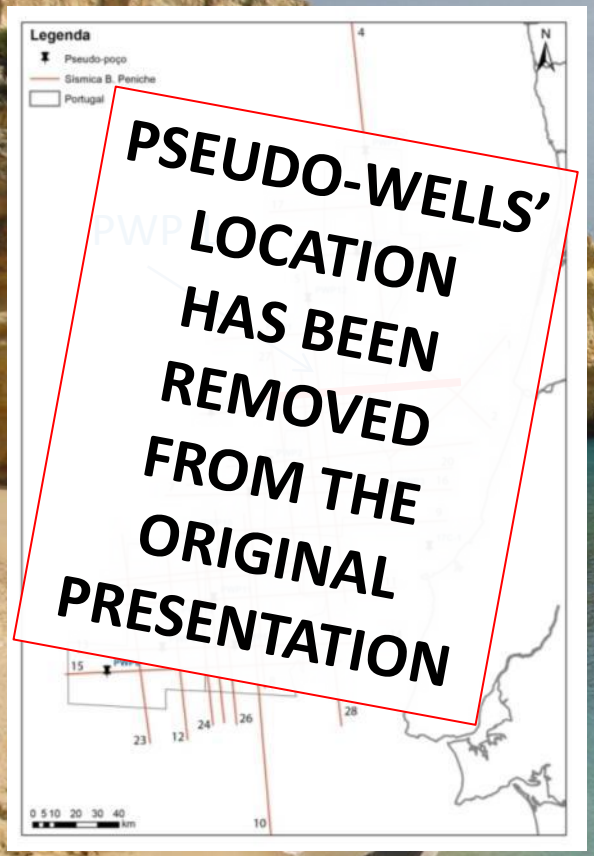
PetroMod

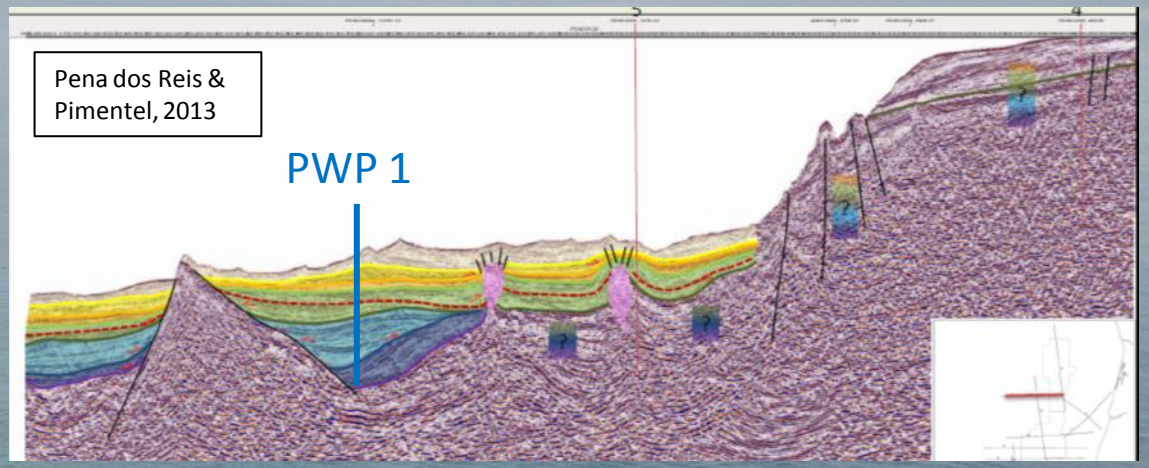


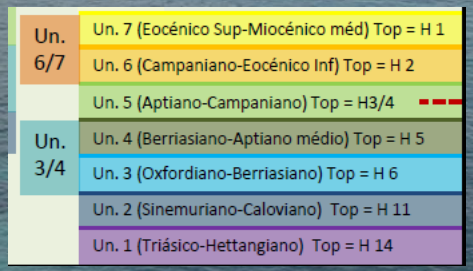
2. Peniche Basin

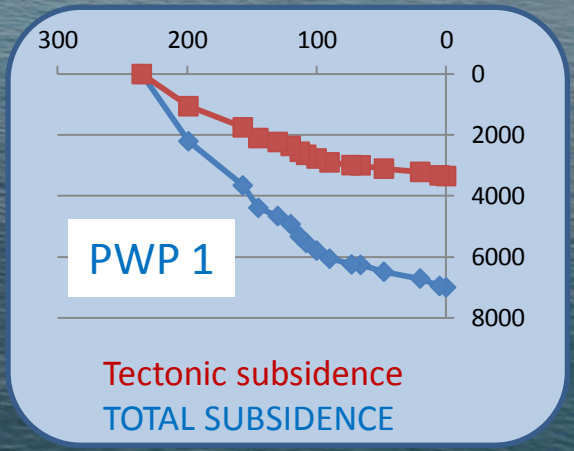
a) SEISMIC LINES & PSEUDO-WELLS

In the Peniche Basin, a seismo-stratigraphic approach, based on the analysis of 28 seismic lines (courtesy of PETROBRAS), allowed the identification of broadly the same sedimentary packages and some extrapolation about its petroleum systems.



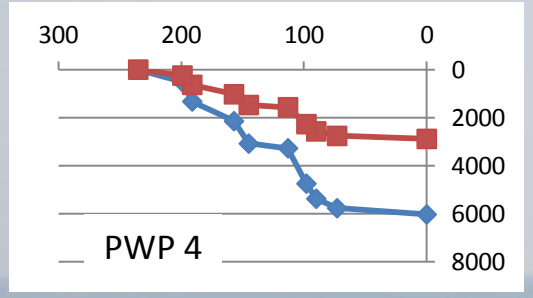


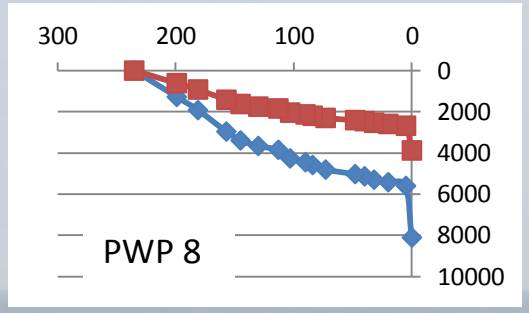


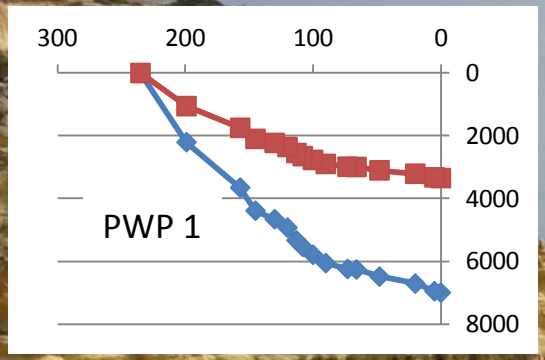


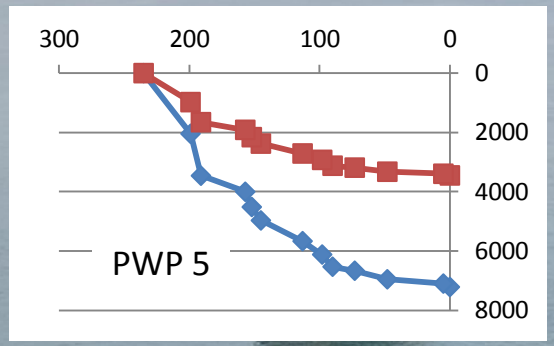
b) BACKSTRIPPING
Pseudo-wells
Peniche Basin

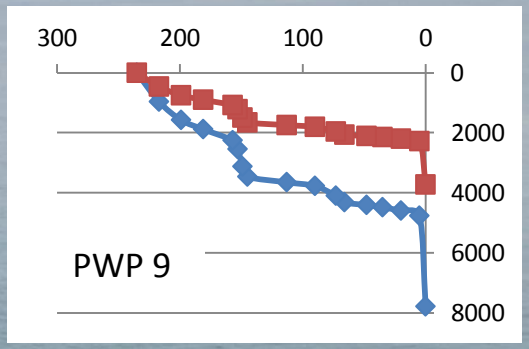
Pena dos Reis & Pimentel, 2013

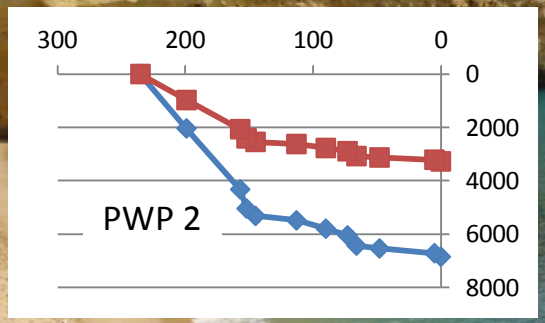


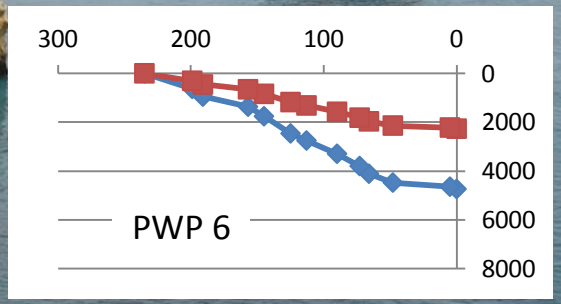


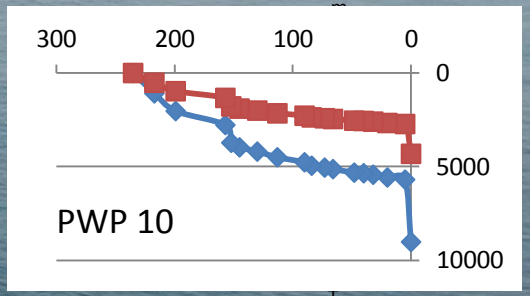


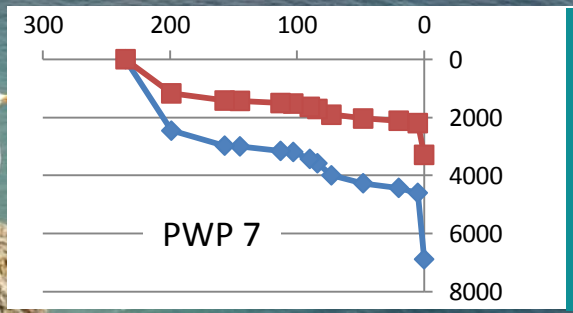


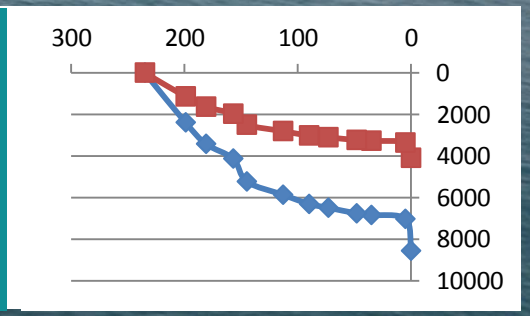






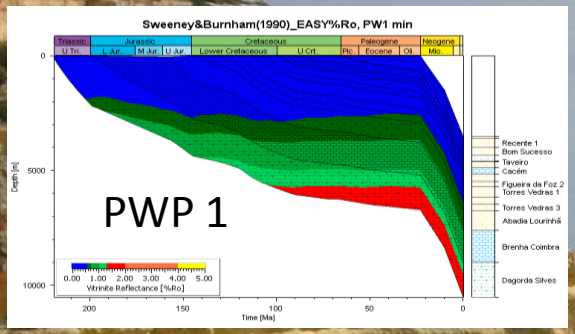


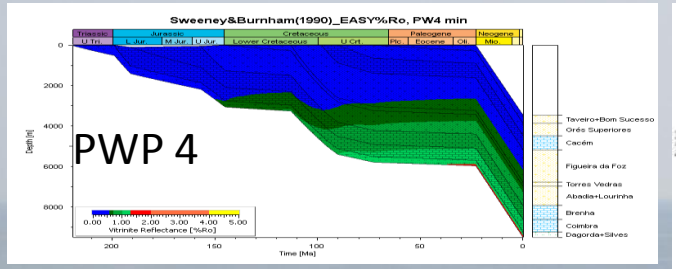


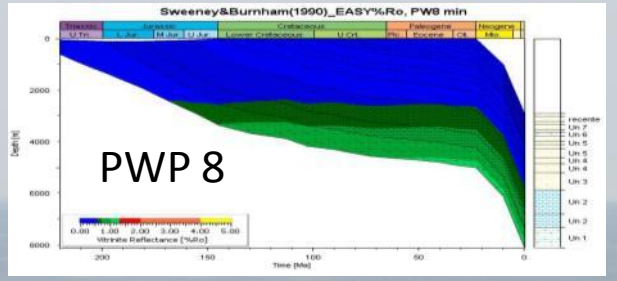


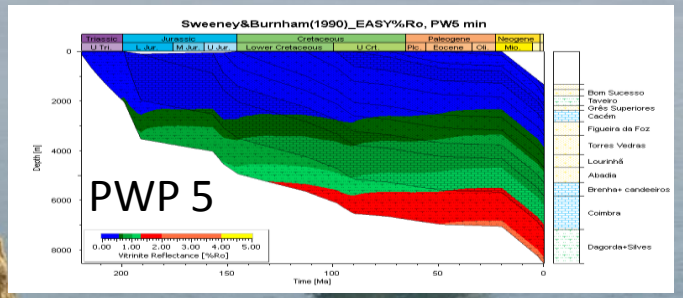
c) PETROMOD
Pseudo-Wells
Peniche Basin

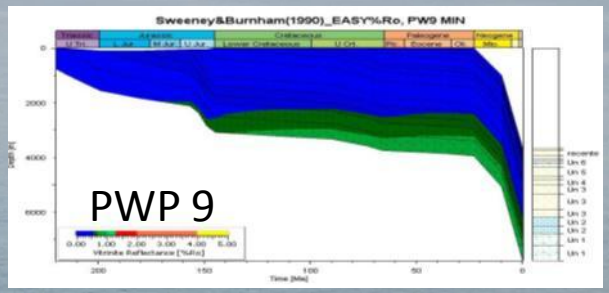
Pena dos Reis & Pimentel, 2013

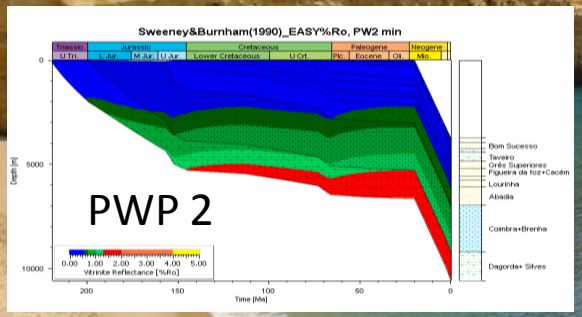


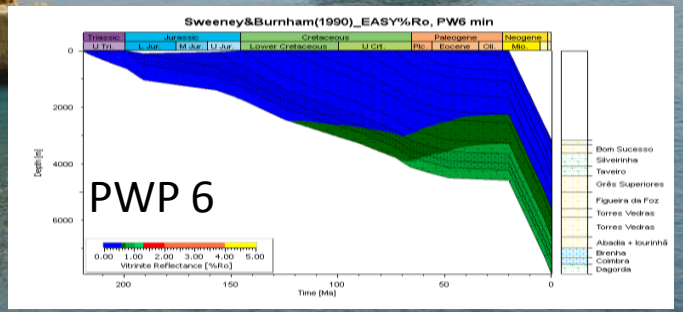


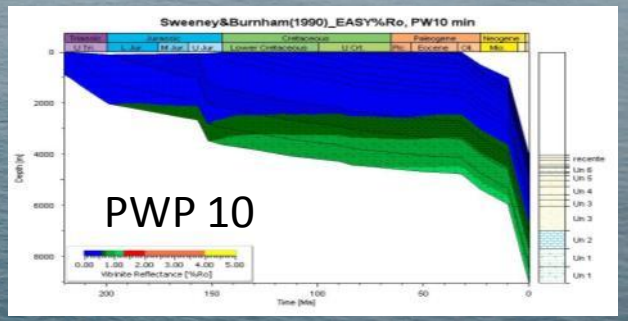


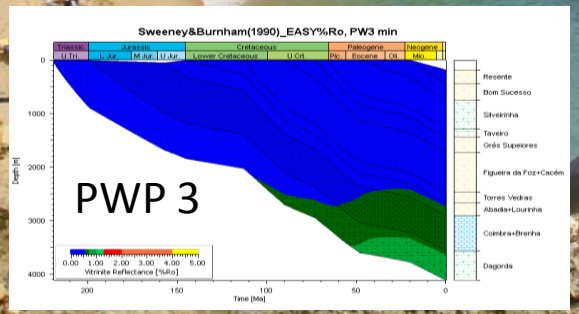


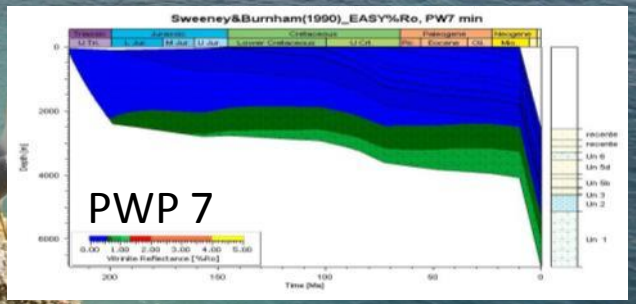


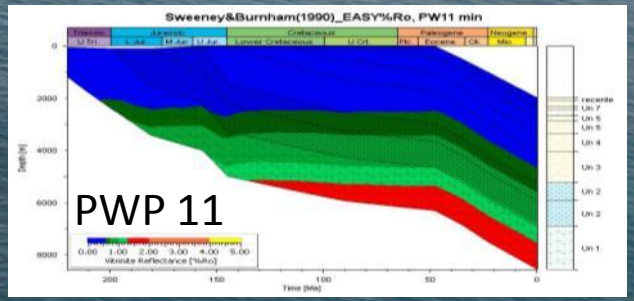












3. MATURATION

a) Timings

Pena dos Reis & Pimentel, 2013

LUSITANIAN BASIN (Onshore)

PENICHE BASIN (Offshore)

	Jinf	Jmed	Jsup	Csup	Pg	M	PQ
Bacia Lusitânica							
14A - 1							
Vm-1							
SM-1							
Cp-1							
Fx-1							
20B-1							
Sb-1							

	Jinf	Jmed	M	PQ
Bacia Peniche				
PWP 1				
PWP 2				
PWP 3				
PWP 4				
PWP 5				
PWP 6				
PWP 7				
PWP 8				
PWP 9				
PWP10				
PWP 11				
PWP 12				
PWP 13				
S 1				
S 2				

EXACT TIMINGS FOR EACH WELL HAVE BEEN REMOVED FROM THE ORIGINAL PRESENTATION

LOWER SOURCE-ROCK Into Oil-Window

UPPER SOURCE-ROCK Into Oil-Window

LOWER SOURCE-ROCK Into GAS-Window

TWO SLIDES HAVE BEEN REMOVED FROM THE ORIGINAL PRESENTATION

i) REGIONAL MATURATION EVOLUTION MAPS, FROM LATE JURASSIC TO RECENT;

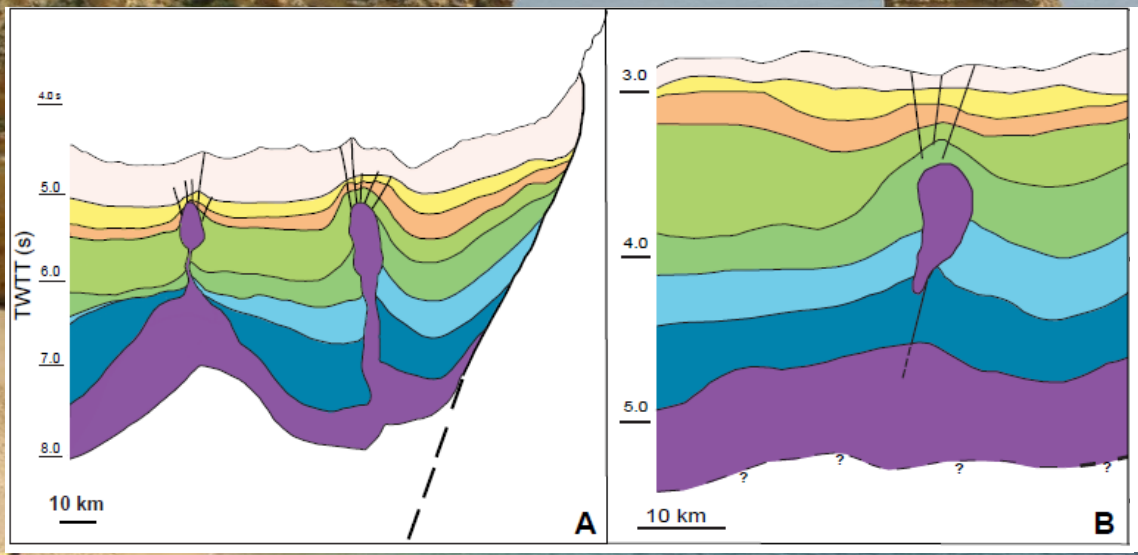
ii) OVERLAPPED RESERVOIRS vs. MATURATION MAPS

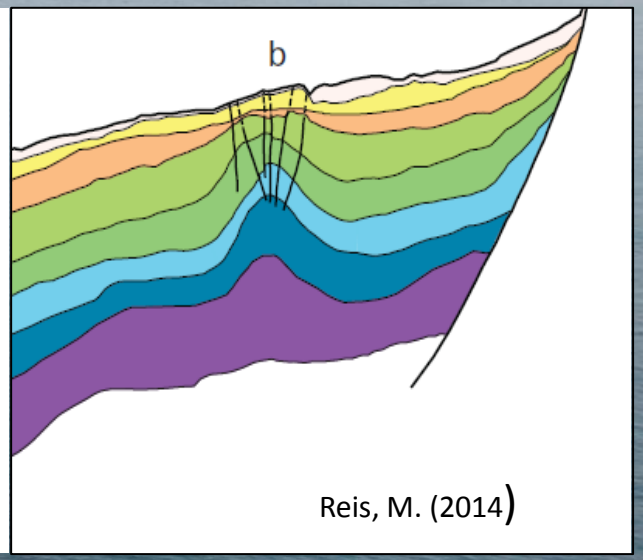
4. TRAPS & SEALS

Several thick reservoirs, including late Cretaceous and Tertiary siliciclastics, may have accumulated oil, migrated along faults and diapiric structures, related with Mesozoic extension and also with alpine compression.

These reservoirs are well sealed by clayey units, expected to thicken distally towards the outer basins.

Alpine inversion structures may have promoted good trap geometries, but also seriously affected seal-integrity, specially in the southern offshore areas (Estremadura Spur).





Reis, M. (2014)

CONCLUSIONS

- **Thermal modeling along the West Iberian Margin shows that maturation has been attained by both major Jurassic source-rocks:**
- **– Pliensbaquian marine marls and Oxfordian lagoonal marls.**
- **Subsidence and overburden has varied with time and space, originating different "kitchens".**
- **Maturation of both potential source-rocks has been begun in Late Jurassic but occurred mostly during Cretaceous times.**
- **In the onshore Lusitanian basin, maturation occurred earlier (Late Jurassic to Early Cretaceous) and concentrated in depocentric sub-basins.**
- **In the offshore Peniche Basin maturation occurred later (mostly Early to Late Cretaceous) and has been more widespread.**
- **Looking at the distribution of the main identified reservoirs, and correlating it with the maturation maps, it can be suggested that:**

  i) the Upper Jurassic petroleum system is possibly restricted to the onshore sub-basins;

  ii) the Lower Jurassic SR – Cretaceous Reservoir petroleum system is expected to be more widespread, particularly offshore.
- **All these interpretations are still to be validated by a wildcat well, constraining stratigraphic and thermal assumptions.**

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