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North Africa Research Group

# *WORKSHOP 3*
# JURASSIC CARBONATES

A. Duval-Arnould ; N. Al-Sinawi;  S. Schroeder ; C. Hollis

*THEME 1*

# JURASSIC STRATIGRAPHY COMPARISONS

EAB and TARFAYA BASIN, CHA, CANADA AND PORTUGAL

# PERSPECTIVE OF ANALYSIS

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## Jurassic Stratigraphy

1) Essaouira-Agadir Basin Stratigraphy

2) Comparison with the **Central High Atlas**

3) Comparison with basins of the **Atlantic Margin**


PORCUPINE
FUNDY
SCOTIAN
LUSITANIAN
ALENTEJO
CENTRAL HIGH ATLAS
ESSAOUIRA-AGADIR
TARFAYA

# ESSAOUIRA – AGADIR BASIN

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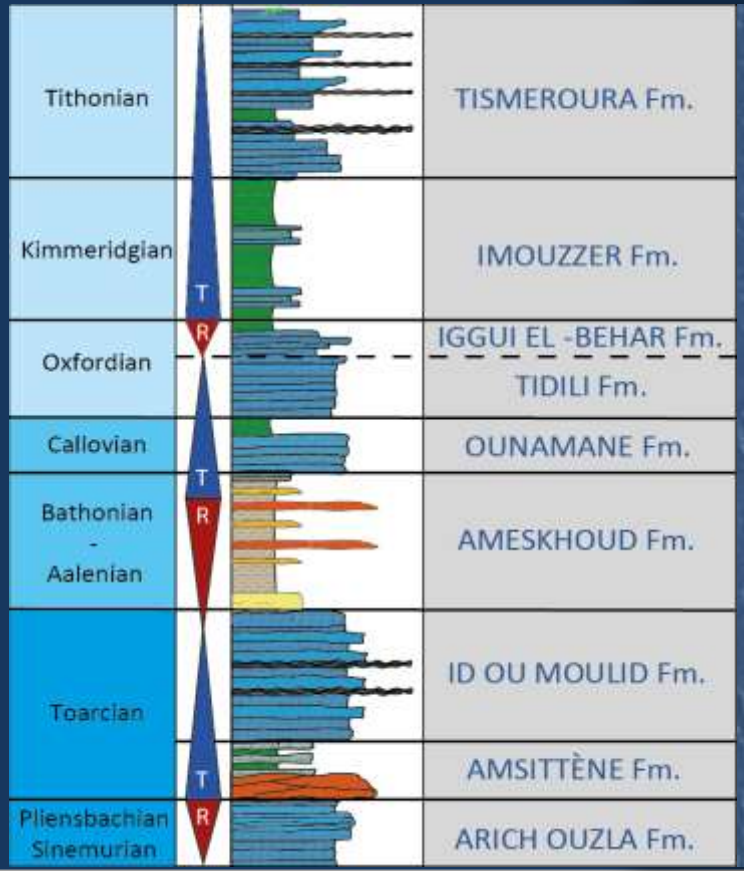


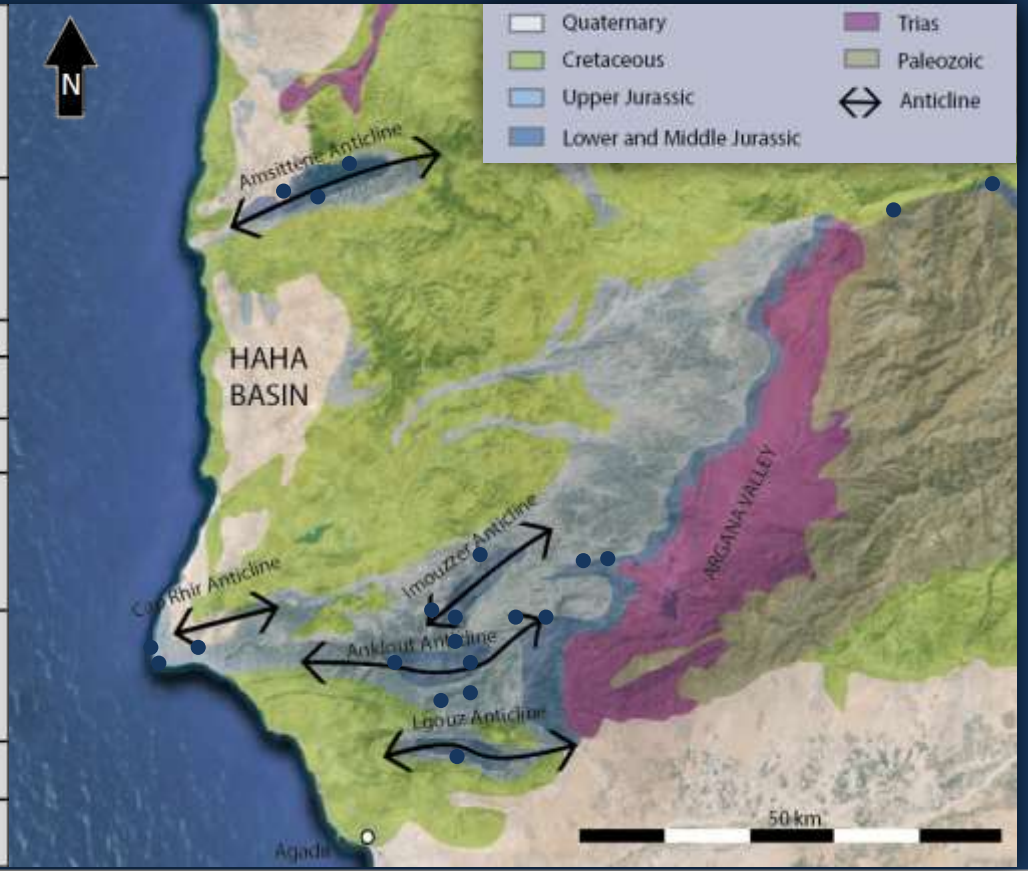

# LIAS - DOGGER *EAB*

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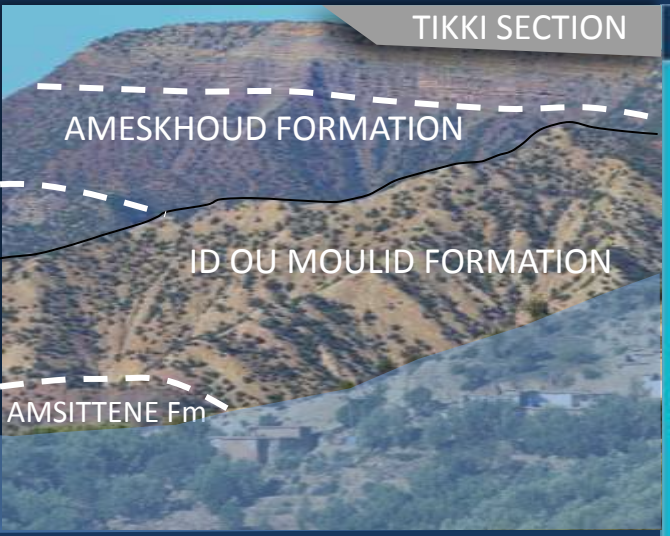
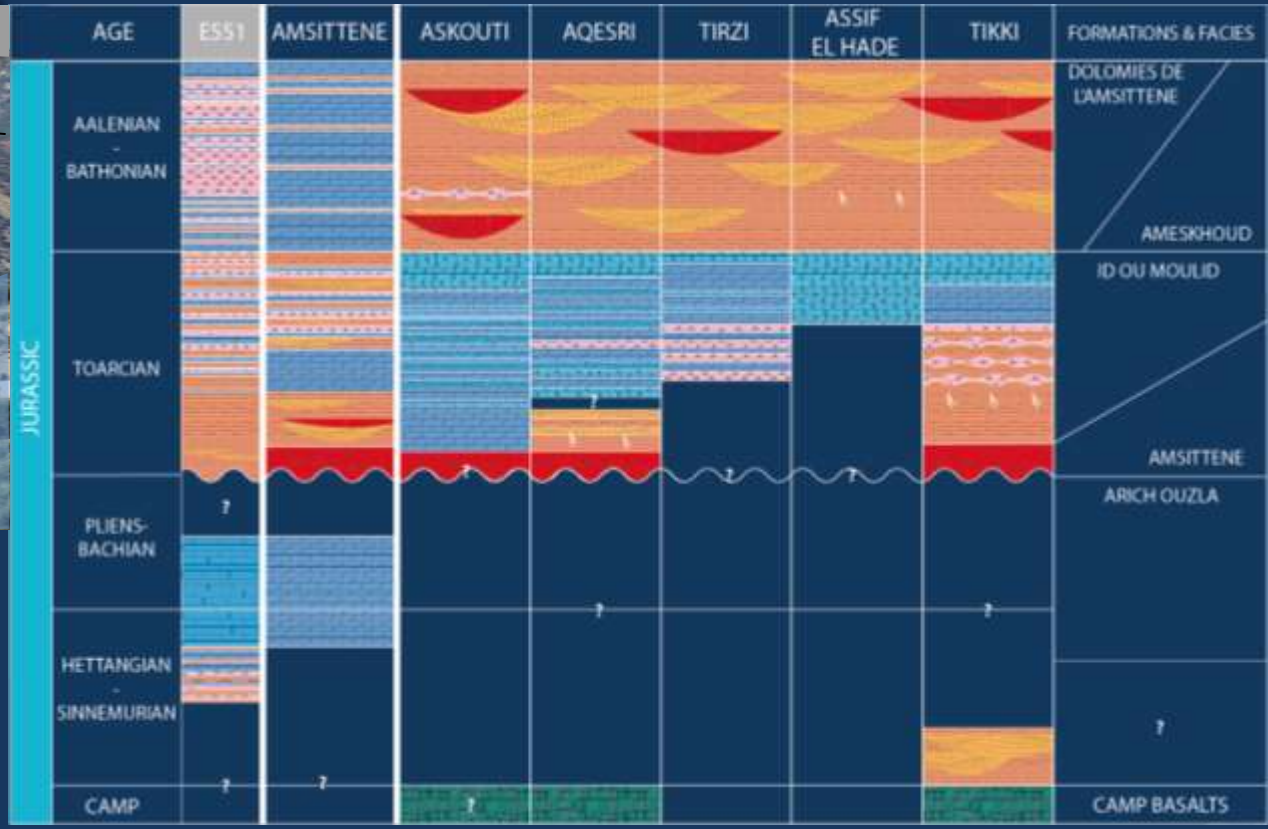


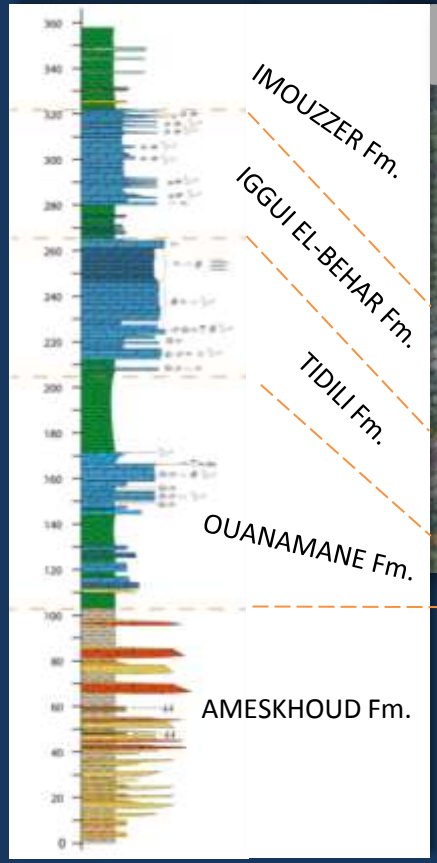

**Toarcian**: establishment of a carbonate platform across the basin

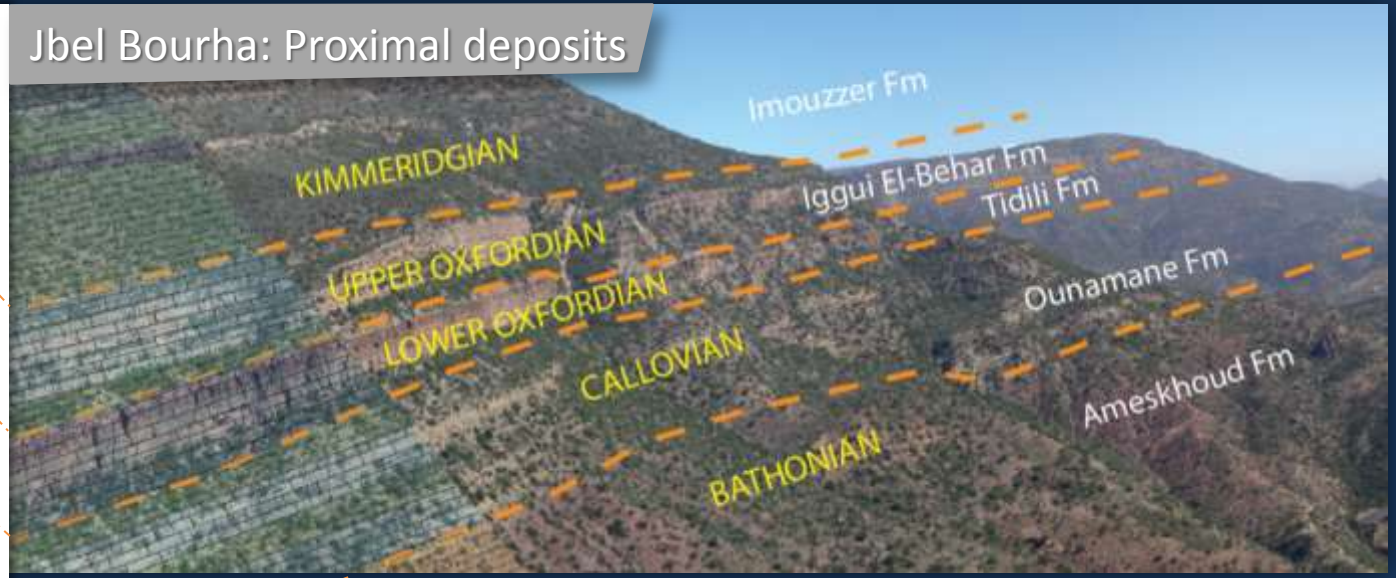
**Dogger**: regression to fluvial deposits



# CALLOVIAN - OXFORDIAN *EAB*



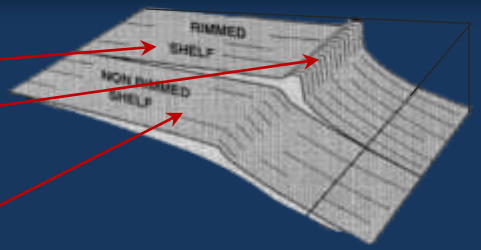



Iggui-El Behar Fm: **LAGOON**

Tidili Fm: **CORAL REEFS**

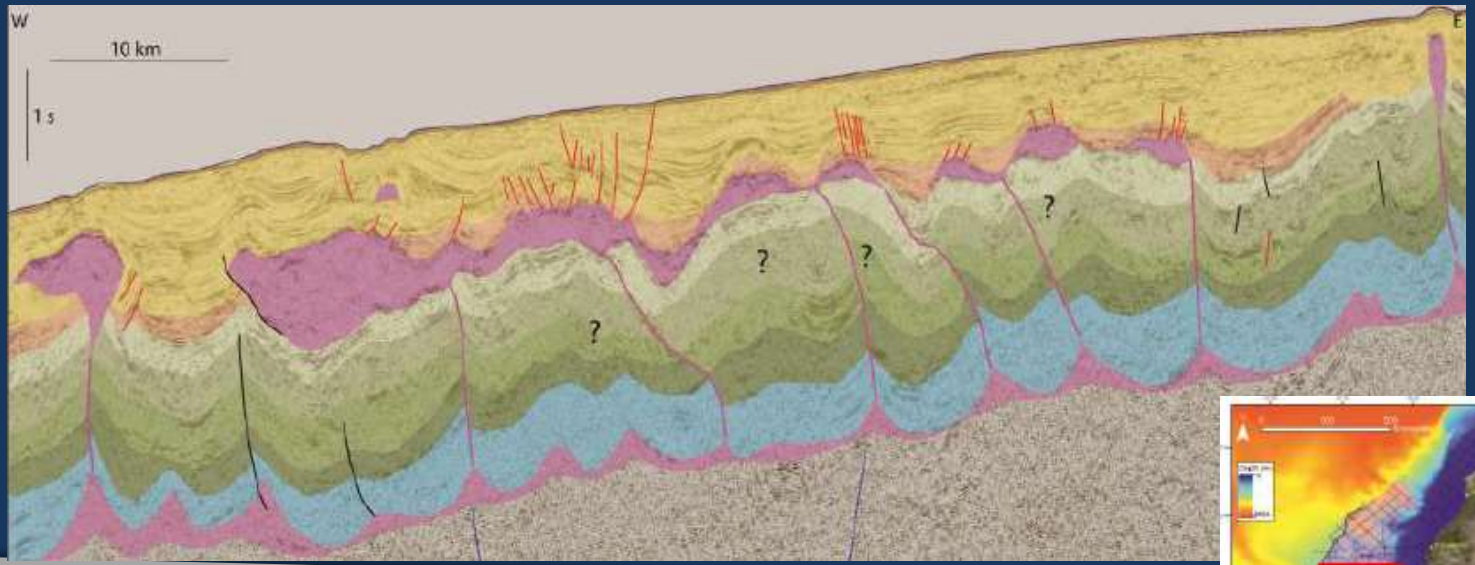
Ouanamane Fm: **OPEN PLATFORM**

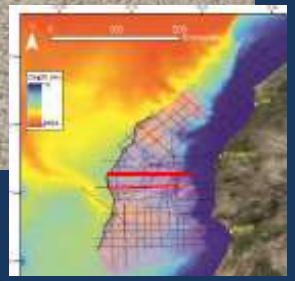



*Modified after Pomar, 2001*

# EAB OFFSHORE





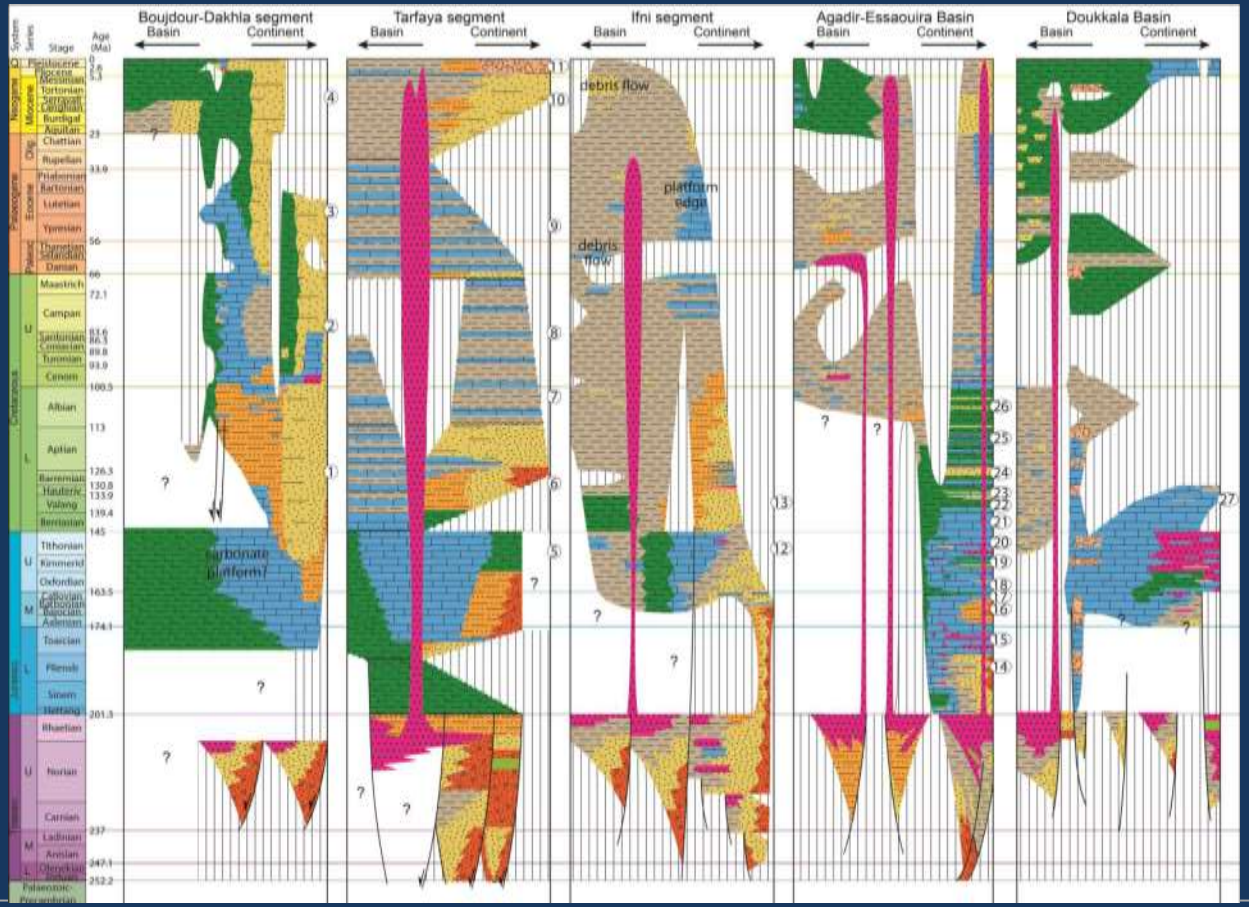



→ Mini Basins driven by diapir shortening
→ Reactive diapirism?: Early – Middle Jurassic
→ Passive diapirism (turtle structures) – Late Jurassic to Cenomanian
→ Allochthonous salt tongs (propagate South and Seaward)


PORCUPINE
FUNDY
SCOTIAN
LUSITANIAN
ALENTEJO
CENTRAL HIGH ATLAS
ESSAOUIRA-AGADIR
TARFAYA

# TARFAYA BASIN

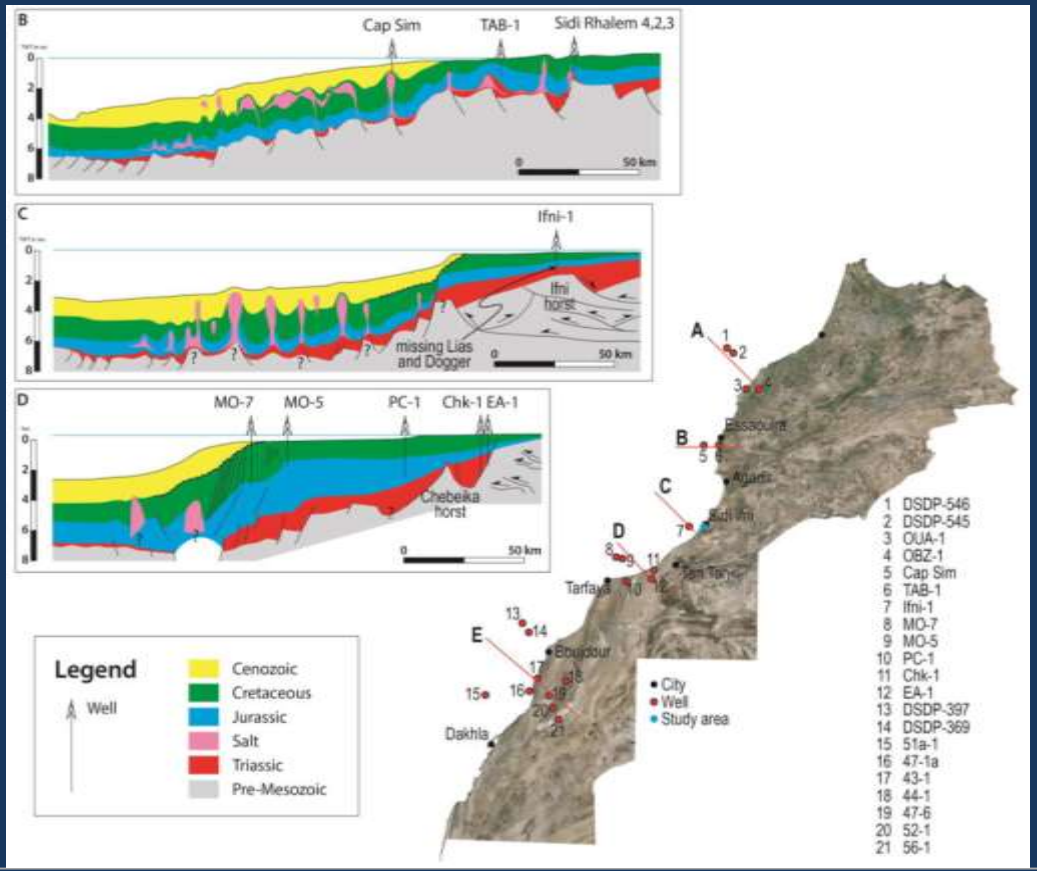





Arantegui, 2018

# TARFAYA BASIN





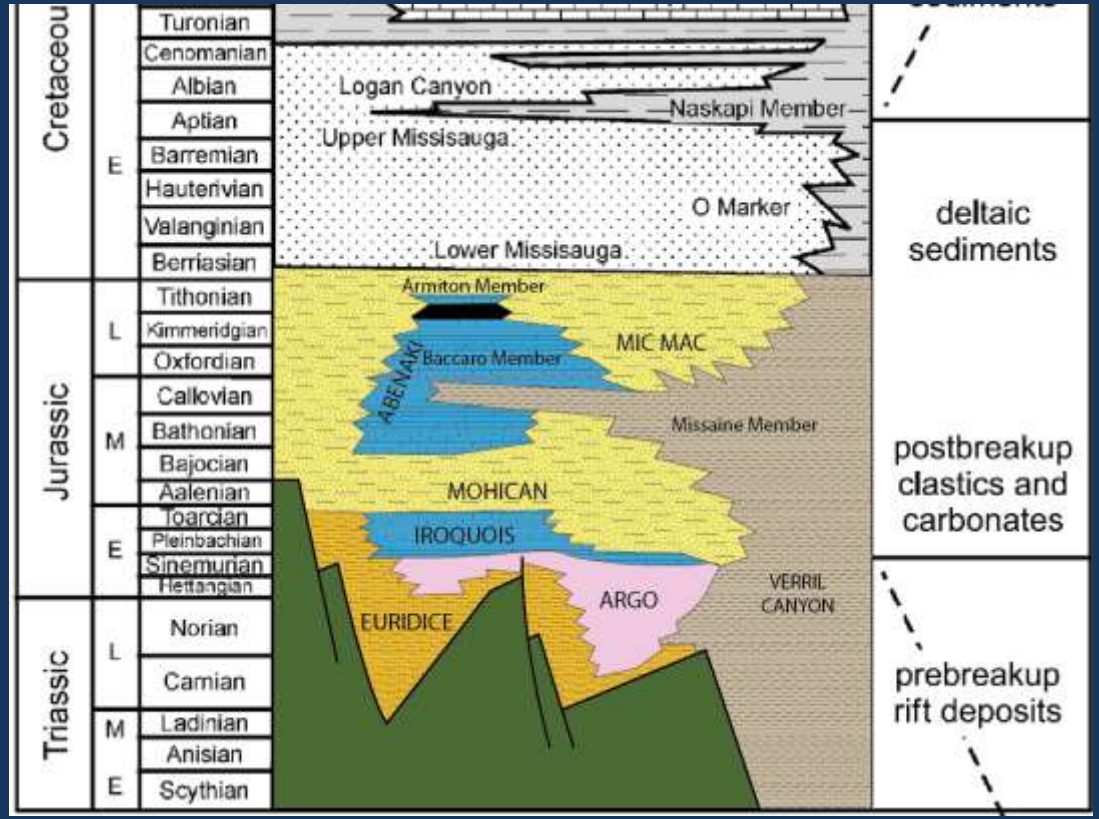

→ Less diapiric influence
→ Different diapirasm style
→ Dogger marine deposits
→ Jurassic thinning dramatically towards the coast

Arantegui, 2018


PORCUPINE
FUNDY
SCOTIAN
LUSITANIAN
ALENTEJO
CENTRAL HIGH ATLAS
ESSAOUIRA-AGADIR
TARFAYA

# SCOTIAN BASIN STRATIGRAPHY





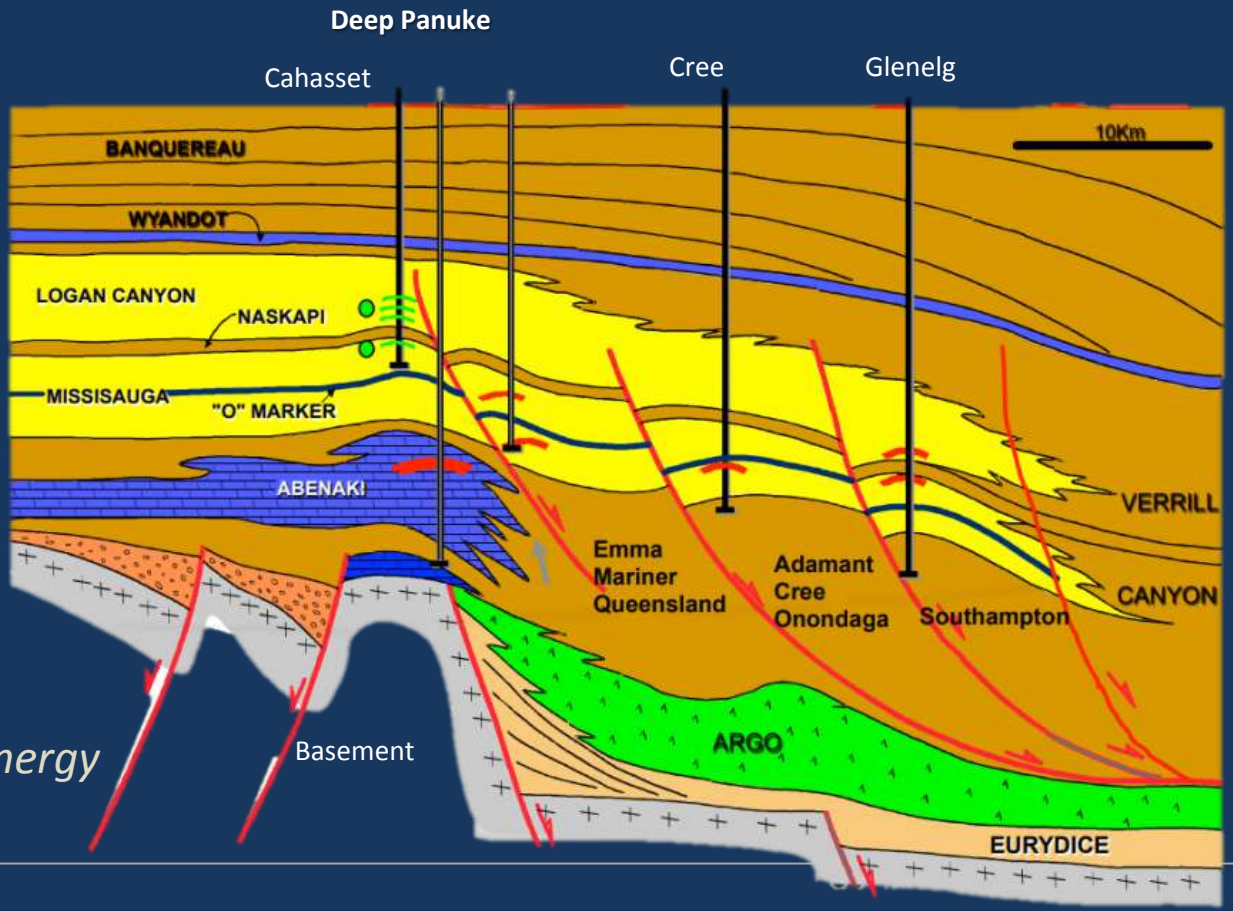

## Comparison EAB

- → Evaporite Formation
- → *Upper Lias* - Carbonates
- → *Dogger* - Clastics
- → *Upper Jurassic* - Marine carbonates
- → Upper Callovian transgression

Modified after Weissenberger et al, 2006

# SCOTIAN BASIN






*From Nova Scotia Departement of Energy (2011)*


PORCUPINE
FUNDY
SCOTIAN
LUSITANIAN
ALENTEJO
CENTRAL HIGH ATLAS
ESSAOUIRA-AGADIR
TARFAYA

# CENTRAL HIGH ATLAS

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BAJOCIAN

AALENIAN

TOARCIAN

PLIENSBACHIAN

Malaval, 2016

**MIXED SYSTEM**
Siliciclastic shelf
+ oolites and coral reefs

**CARBONATE SYSTEM**
Bioconstructed platform
*Lithiotis & corals*

BATHONIAN

BAJOCIAN

AALENIAN

TOARCIAN

**CONTINENTAL SYSTEM**

**MIXED SYSTEM**
Carbonate - Shale

***Mid ramp***

***Outer ramp***

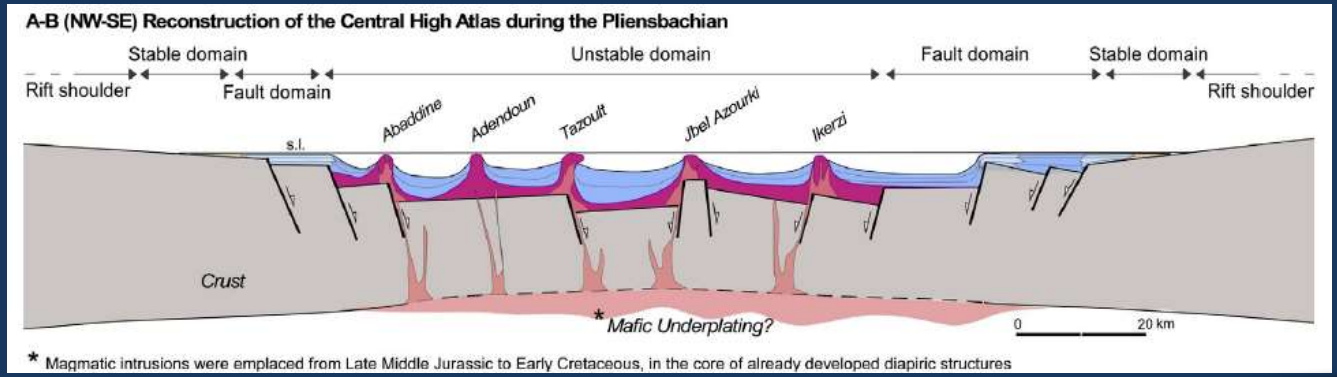
**CARBONATE SYSTEM**
*Oolite shoals*
*Coral reefs*

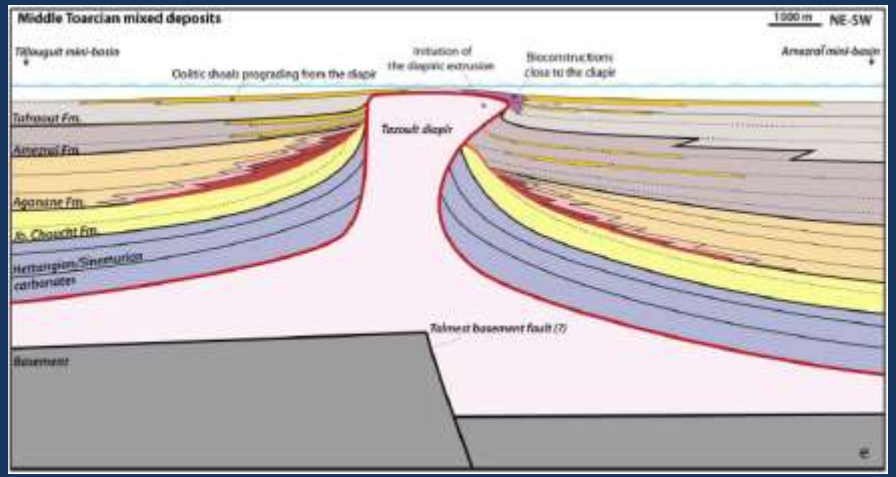
Joussiaume, 2016

# COMPARISON CENTRAL HIGH ATLAS



Verges et al., 2017



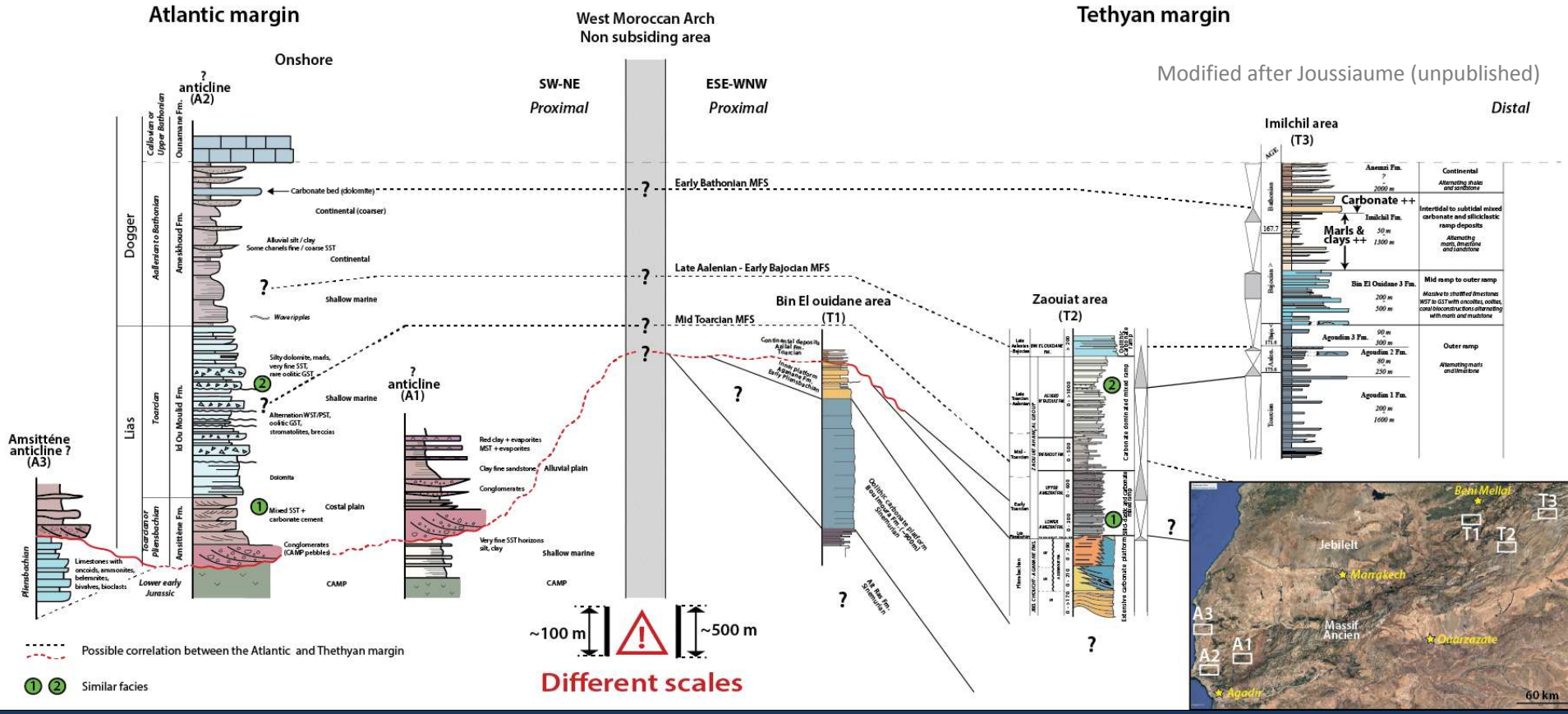




- → Sedimentation in Mini-Basins
- → Strong diapiric influence
- → Dogger marine deposits
- → Upper Bathonian/Callovian continental

Joussiaume, 2016

# LIAS COMPARISON CHA





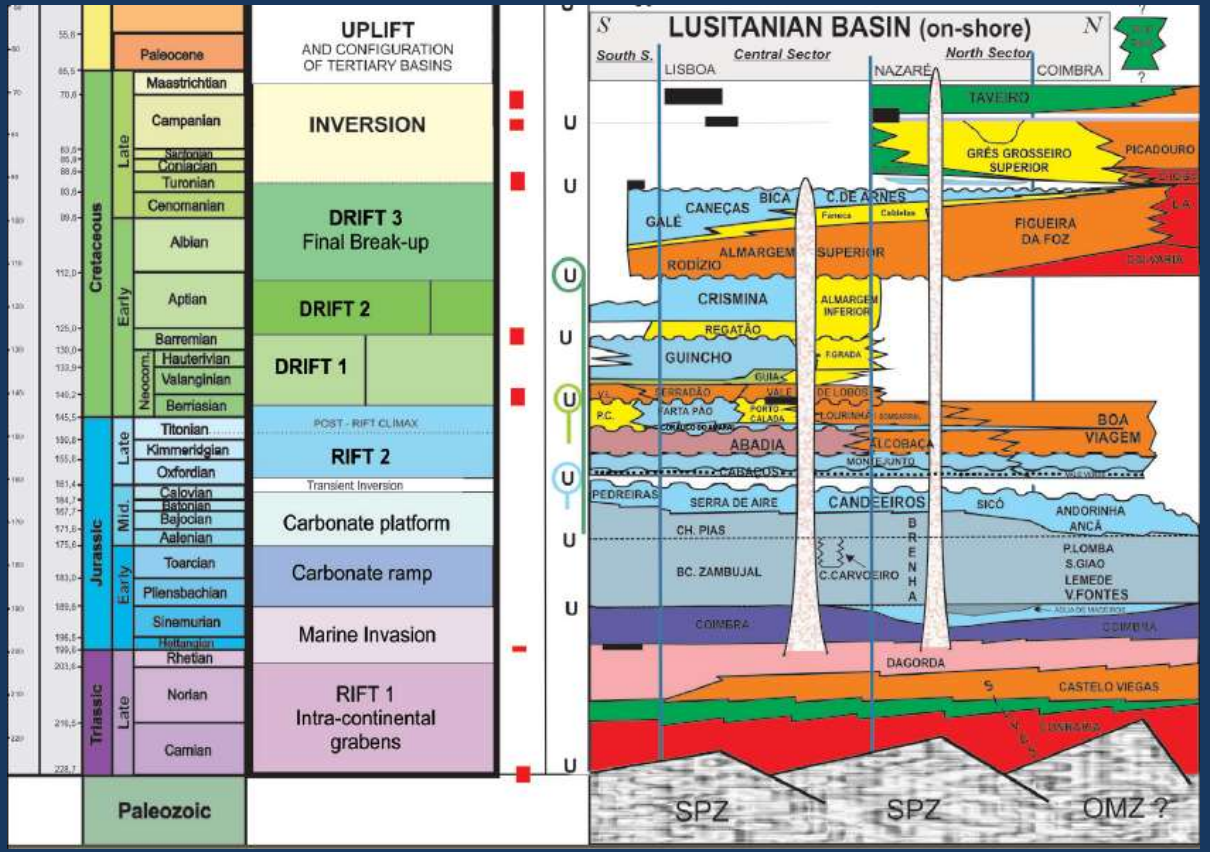

PORCUPINE
FUNDY
SCOTIAN
LUSITANIAN
ALENTEJO
CENTRAL HIGH ATLAS
ESSAOUIRA-AGADIR
TARFAYA

# LUSITANIAN / ALENTEJO BASINS



Salt diapirs
→ Fracturation
→ Porosity ↗

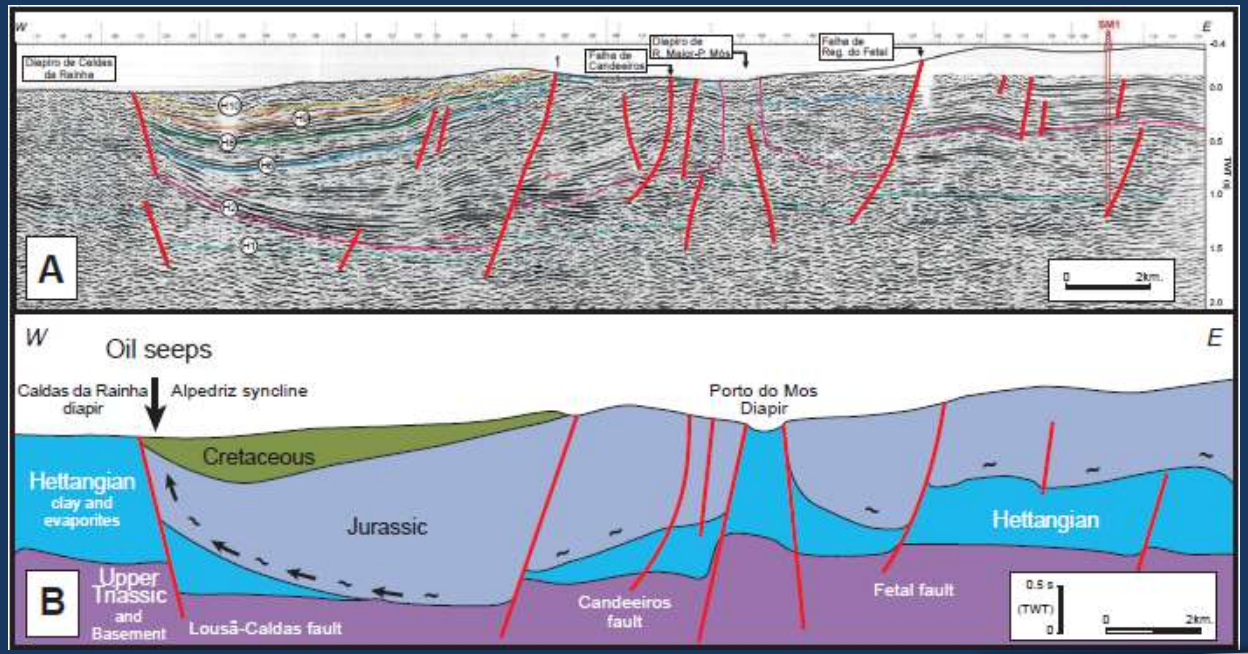
2 rift phases




After Pimentel & Pena dos Reis, 2016

# LUSITANIAN / ALENTEJO BASINS






After Pimentel & Pena dos Reis, 2016

→ Later diapiric influence
→ Dogger marine deposits
→ Siliciclastics from Kimmeridgian

# DISCUSSION



TARFAYA BASIN OFFSHORE:

→ Less diapirism

→ Marine Carbonates Dogger

**Essaouira-Agadir Basin**

SCOTIAN BASIN:

→ Very similar to EAB onshore

**Dogger clastics origin?**

CENTRAL HIGH ATLAS:

→ Dogger marine (CHA) /continental (EAB)

→ Toarcian erosion in western part

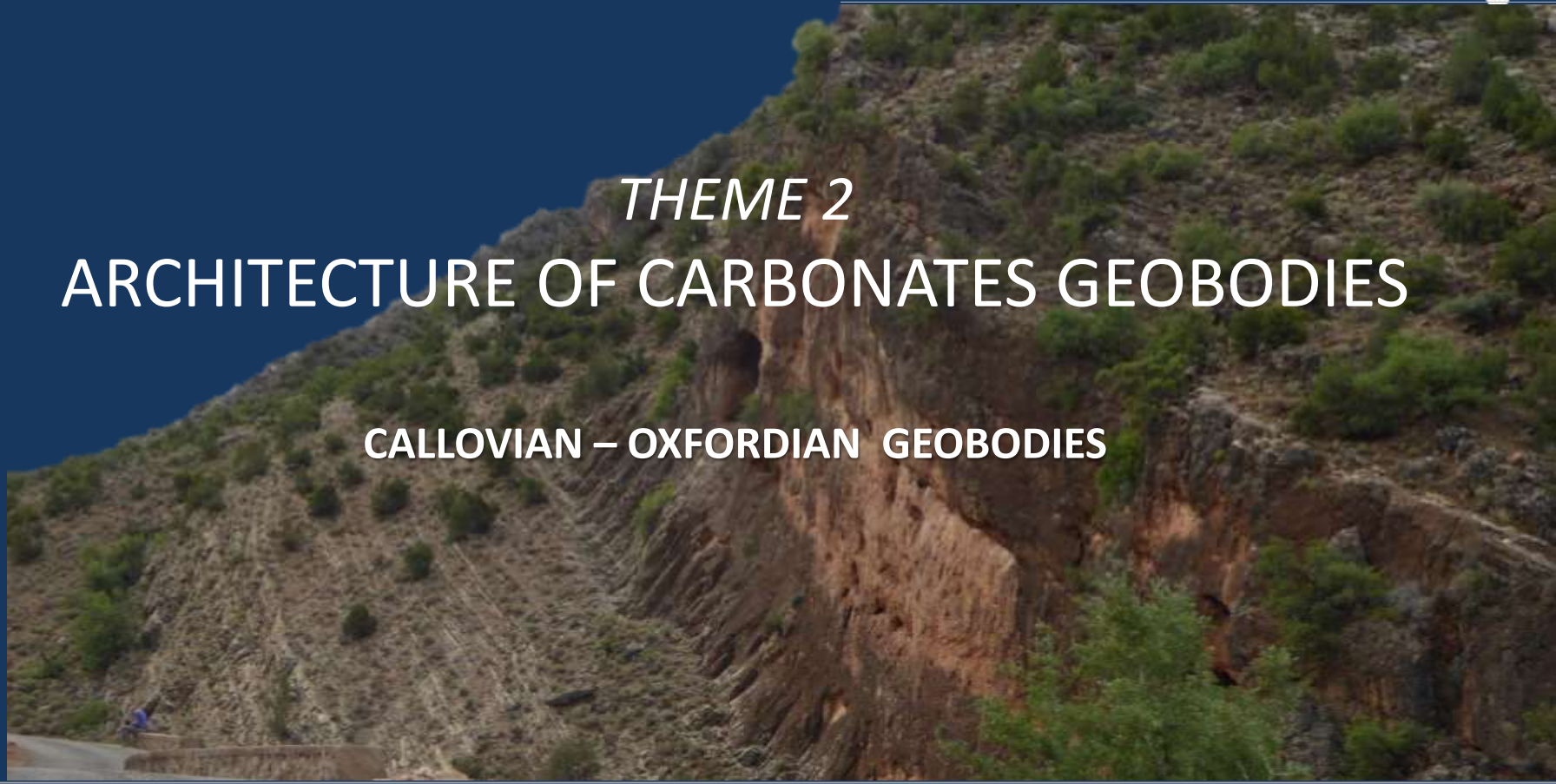
**Toarcian erosion: Exhumation WMA?**

LUSITANIAN BASIN:

→ Two rift phases: different sedimentation (carbonates all Jurassic)

→ Later diapirism influencing porosity

**Fractures related Porosity ?**



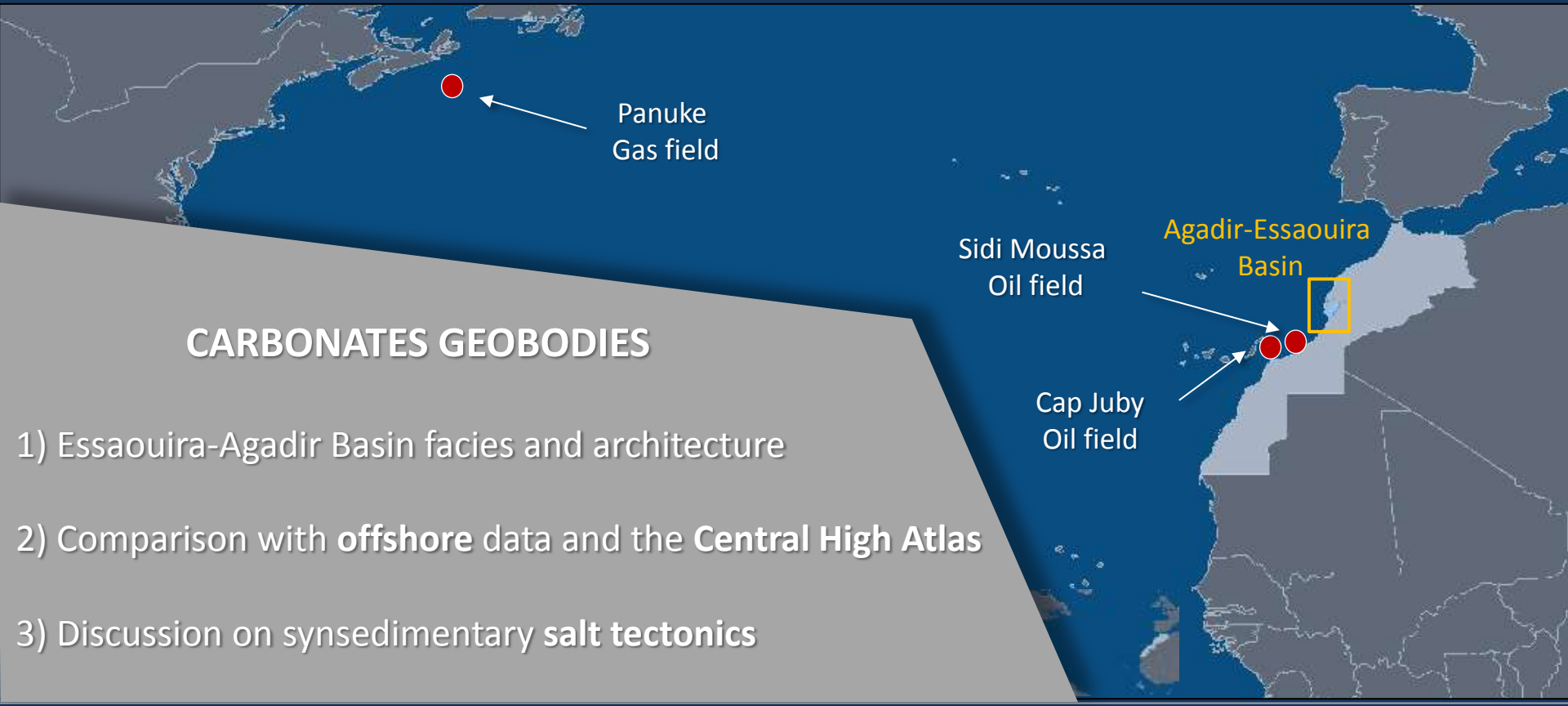
*THEME 2*

# ARCHITECTURE OF CARBONATES GEOBODIES

**CALLOVIAN – OXFORDIAN GEOBODIES**

# PERSPECTIVE OF ANALYSIS






## CARBONATES GEOBODIES

1) Essaouira-Agadir Basin facies and architecture

2) Comparison with **offshore** data and the **Central High Atlas**

3) Discussion on synsedimentary **salt tectonics**

# MIDDLE-LATE JURASSIC BASINS

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ORPHAN Basin

FUNDY Basin

SCOTIAN Basin

AQUITAINE Basin

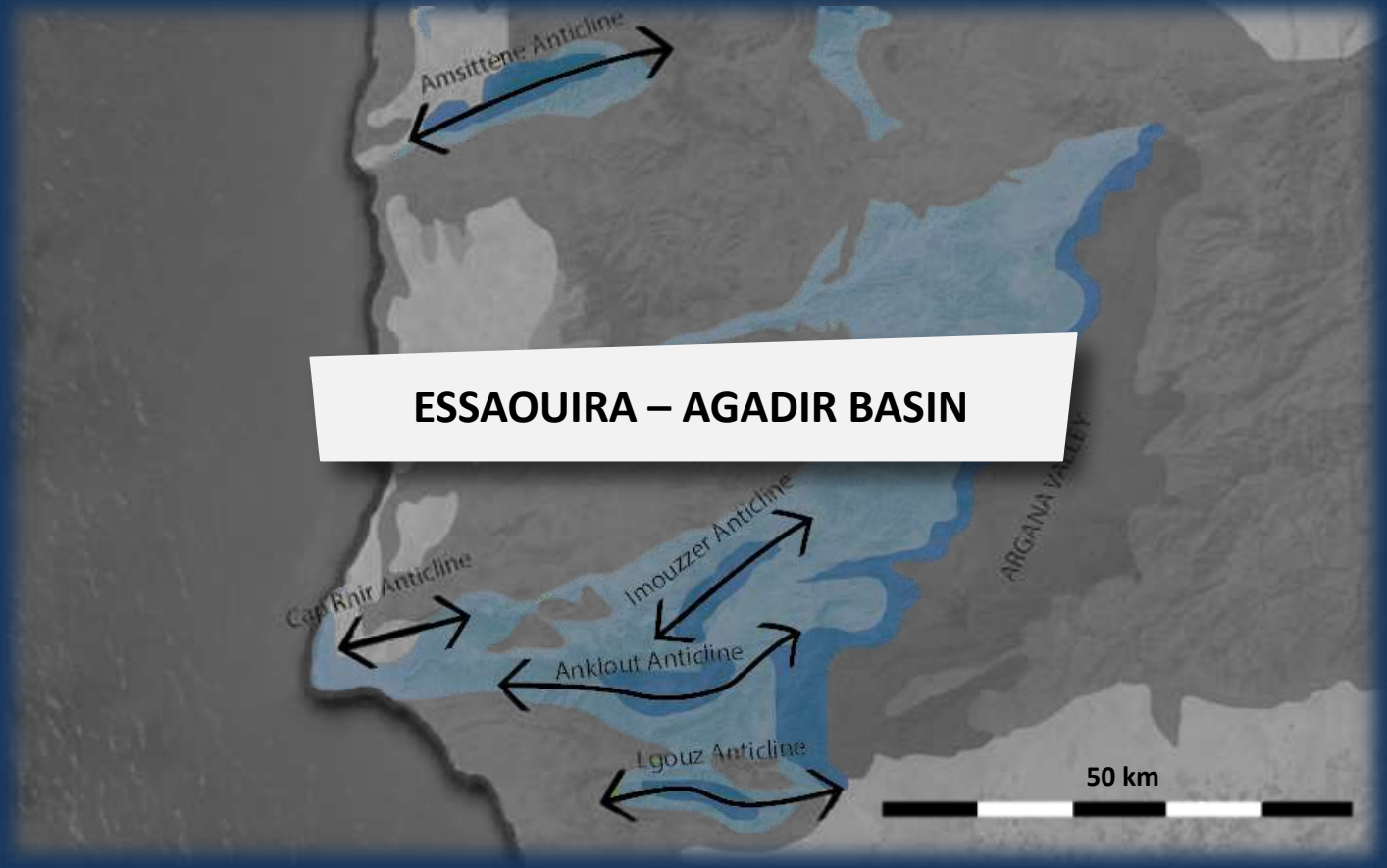
LUSITANIAN Basin

HIGH ATLAS Basin

E-AGADIR Basin

TARFAYA Basin

*Modified after Scotese PALEOMAP Project, 2013*


Amsittène Anticline
ESSAOUIRA – AGADIR BASIN
Imouzzer Anticline
Cap Rhir Anticline
Anklout Anticline
Lgouz Anticline
50 km

# TIDILI FORMATION

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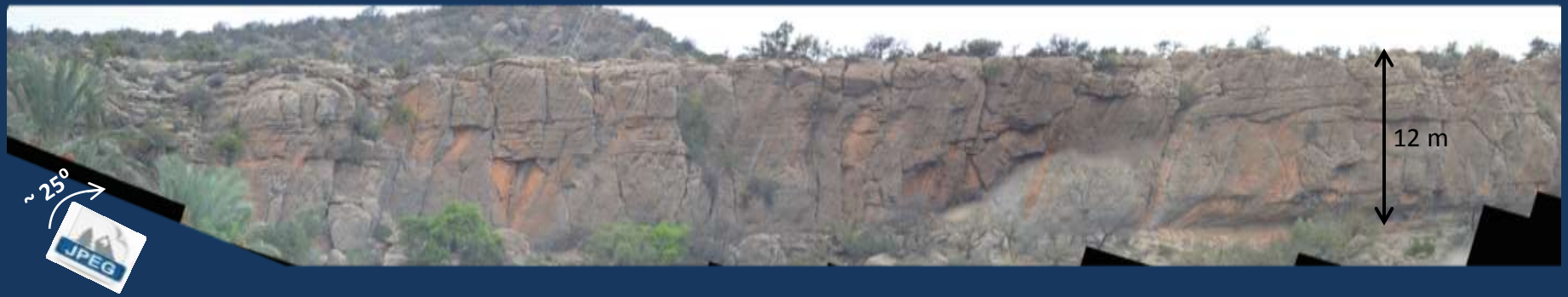
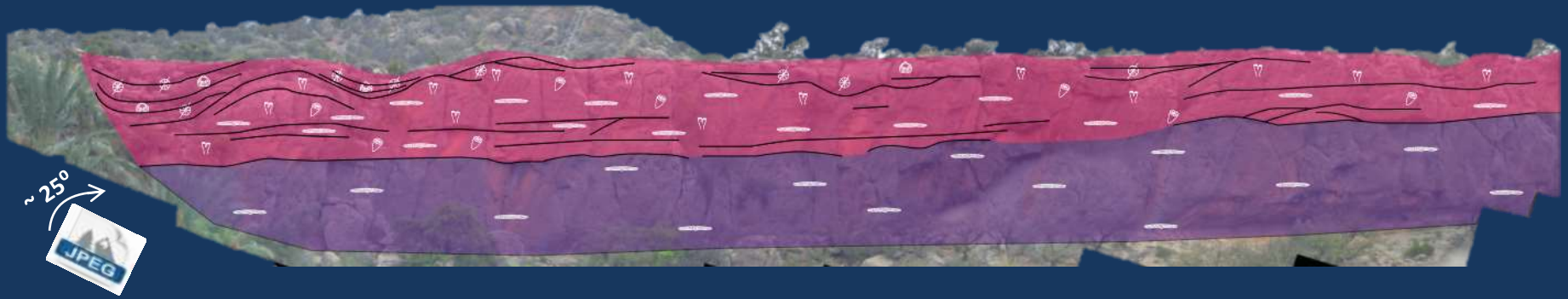


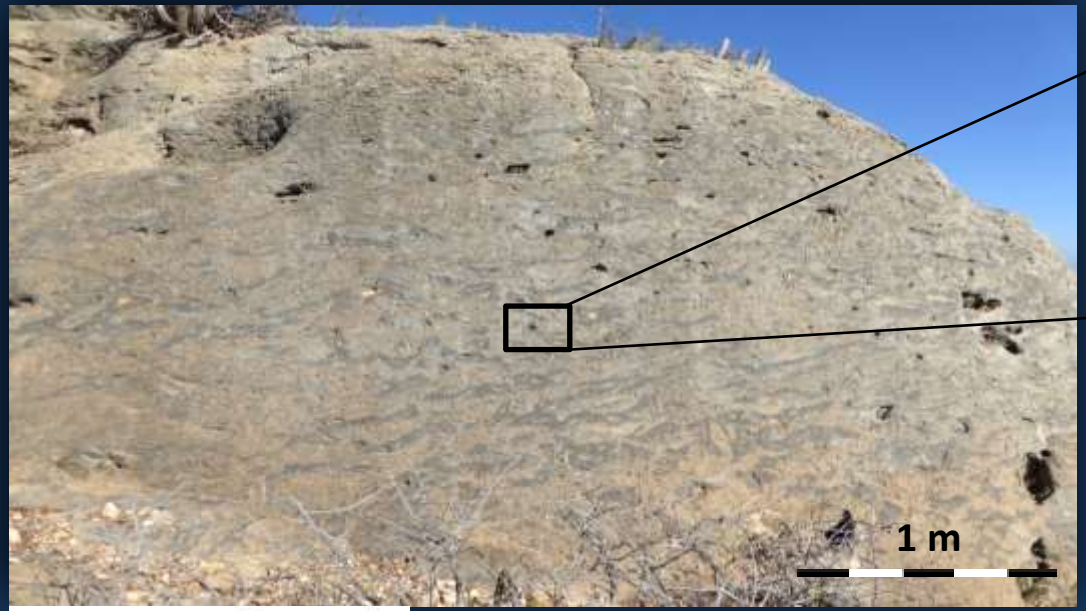
# TIDILI FORMATION

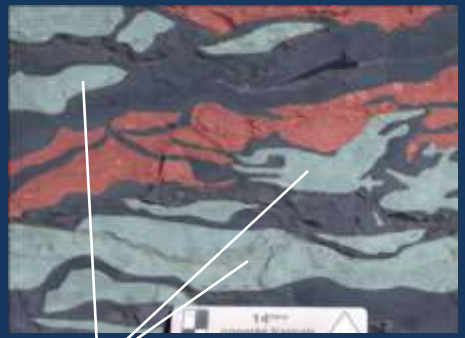
North Africa Research Group



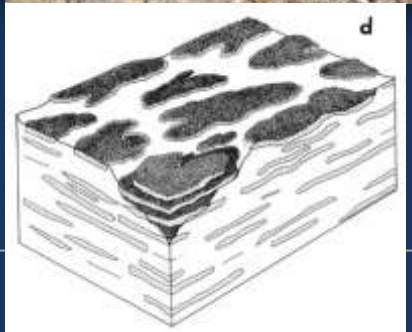
# DIMORPHAREA DOMINATION





*Dimorpharaea*




Associated with a marly matrix or a bioclastic WST/PST matrix, locally encrusted

*Insalaco, 1998*

# TIDILI FORMATION

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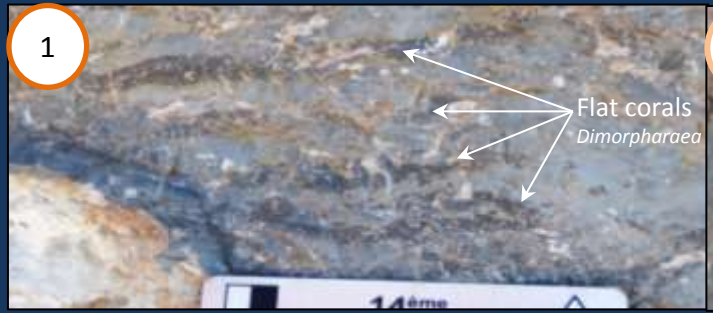
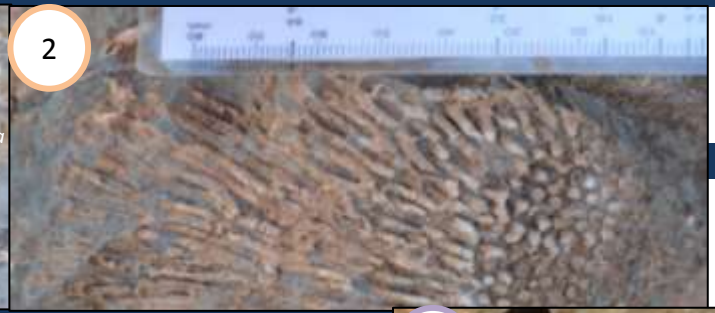
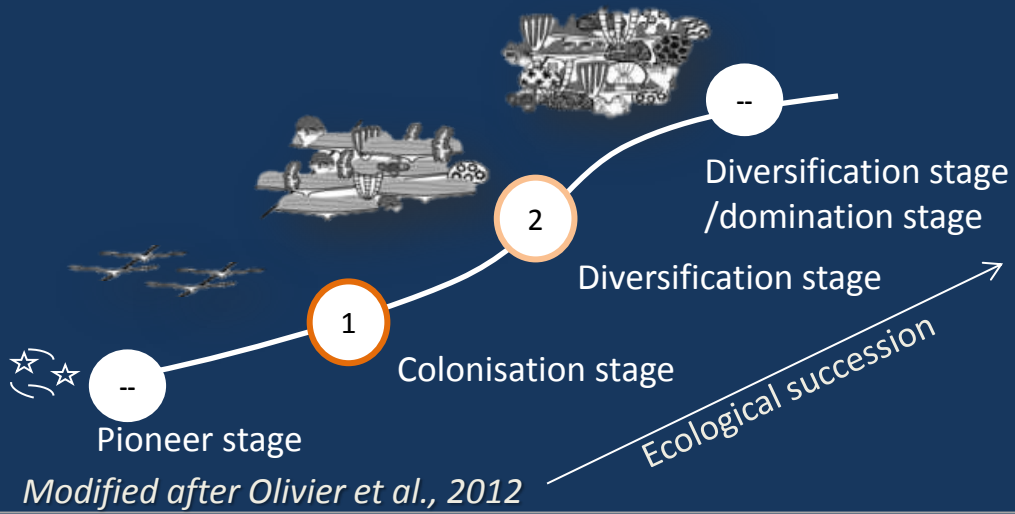



**Dolomitic Bst**
corals (platy, branching), serpulids, brachiopods…

**Dolomitic F/Rst (W/Pst)**
coral fragments, crinoids, shells…

## OXFORDIAN REEF ECOLOGICAL SUCCESSION




*Modified after Olivier et al., 2012*



**Dolomitic fine P/Gst :** shelly fragments, brachiopods, gastropods …

# TIDILI FORMATION

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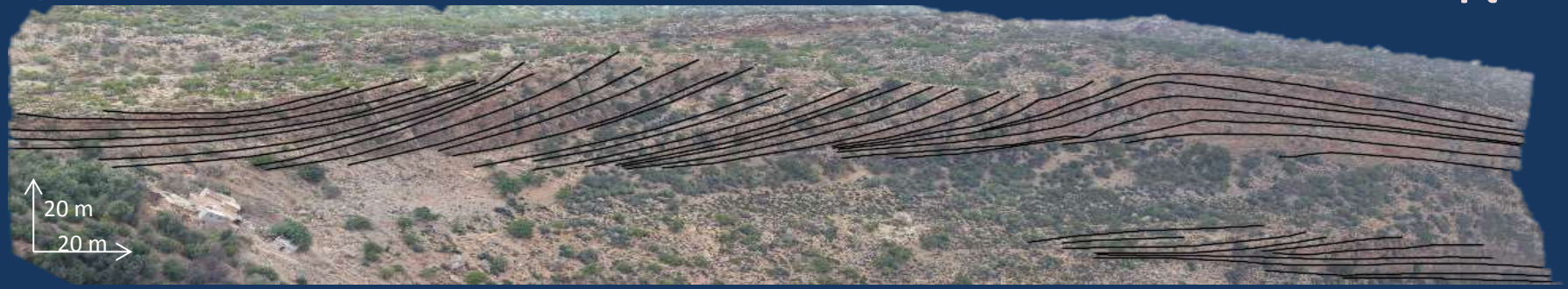
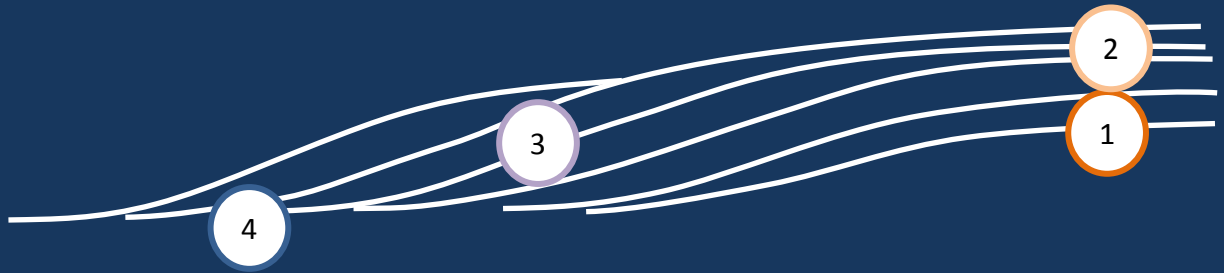




Large clinoforms offlapping the reef structure

**REEF EDGE / CLINOFORMS**




# TIDILI FORMATION

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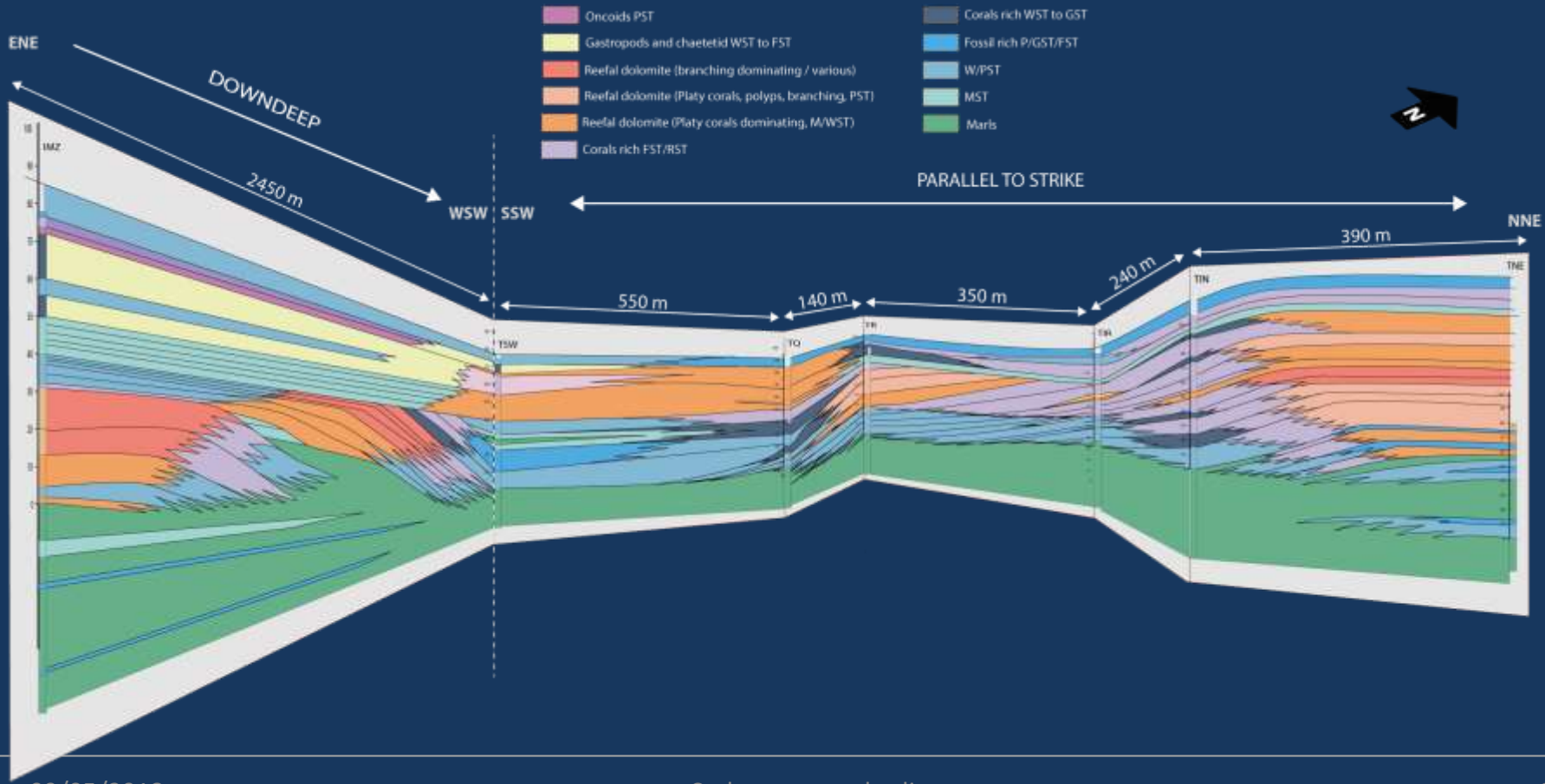
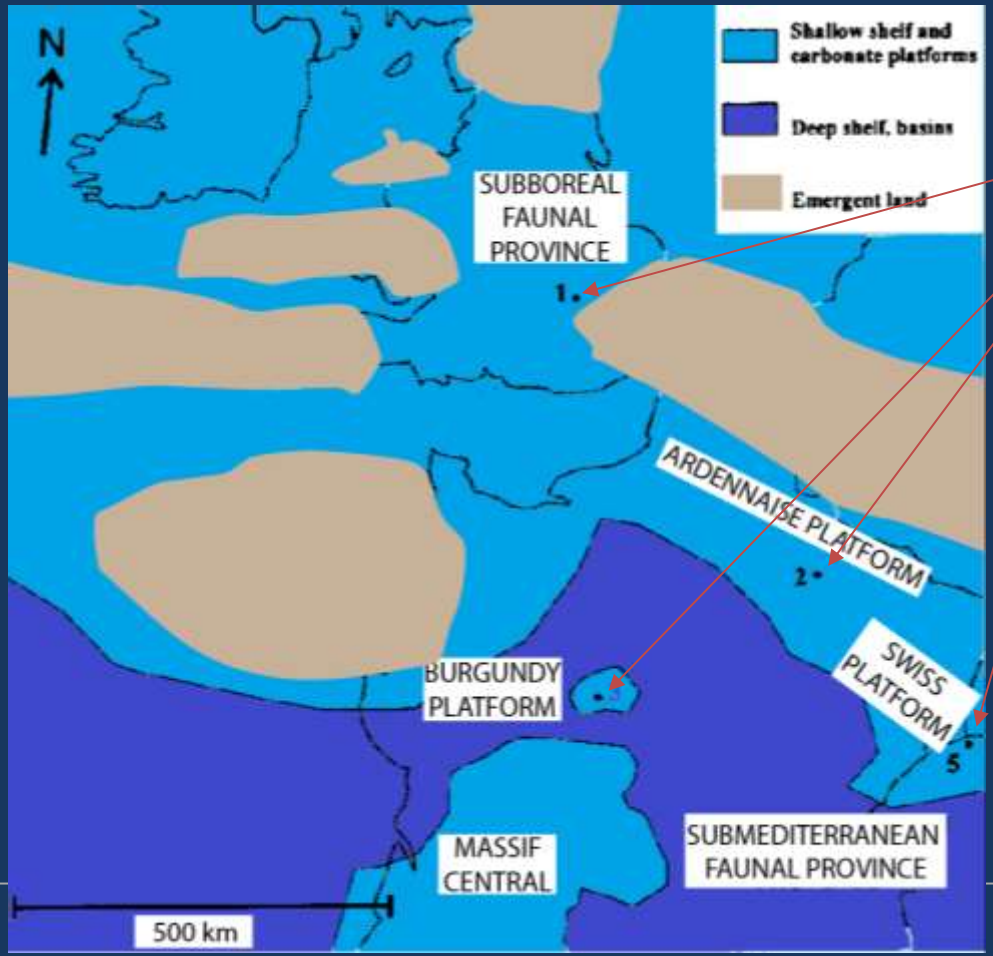


# CENTRAL EUROPE






Upper Jurassic Microsolenoid Biostrom development

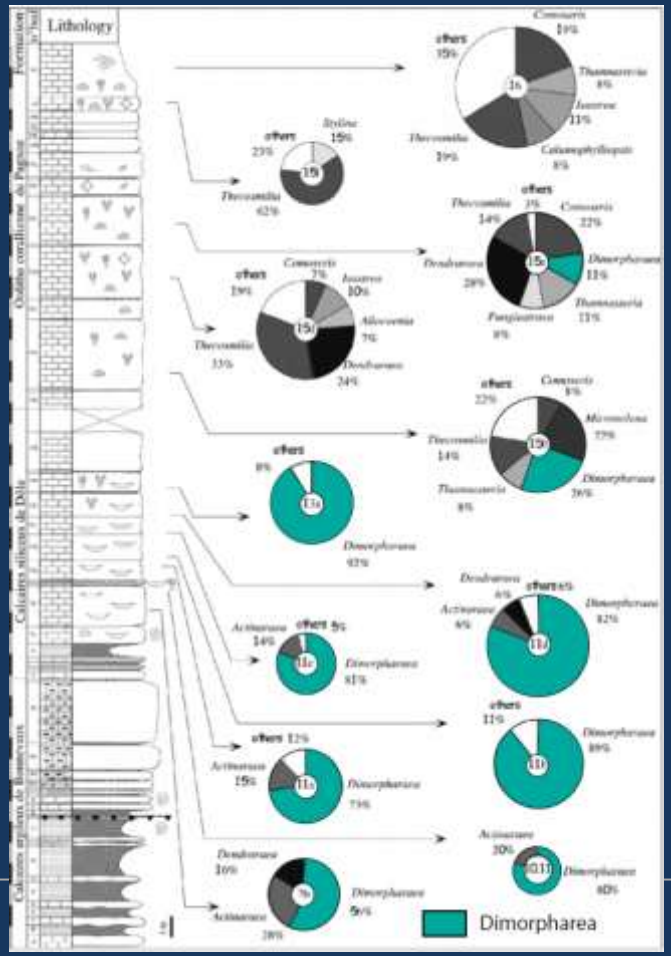
- → Microsolenoid Biostrom very common during Upper Jurassic
- → Low relief, laterally very extensive
- → Micritic matrix with unsorted bioclasts
- → Low generic diversity
- → Low light, background sedimentation rate, low energy

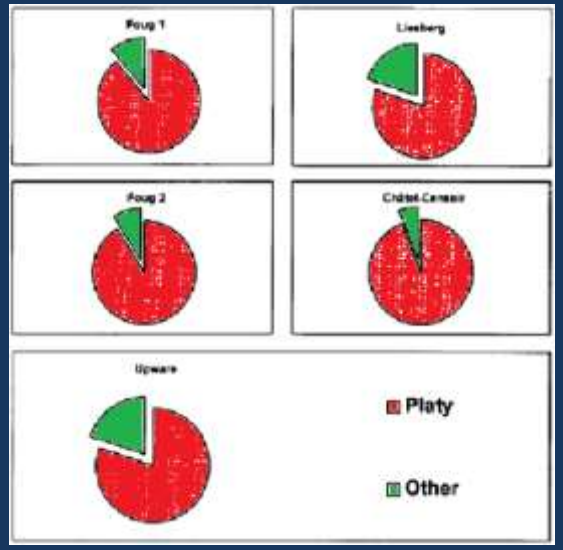
*Insalaco, 1996*

# CENTRAL EUROPE



JURAS-Oxfordian




*Insalaco, 1996*

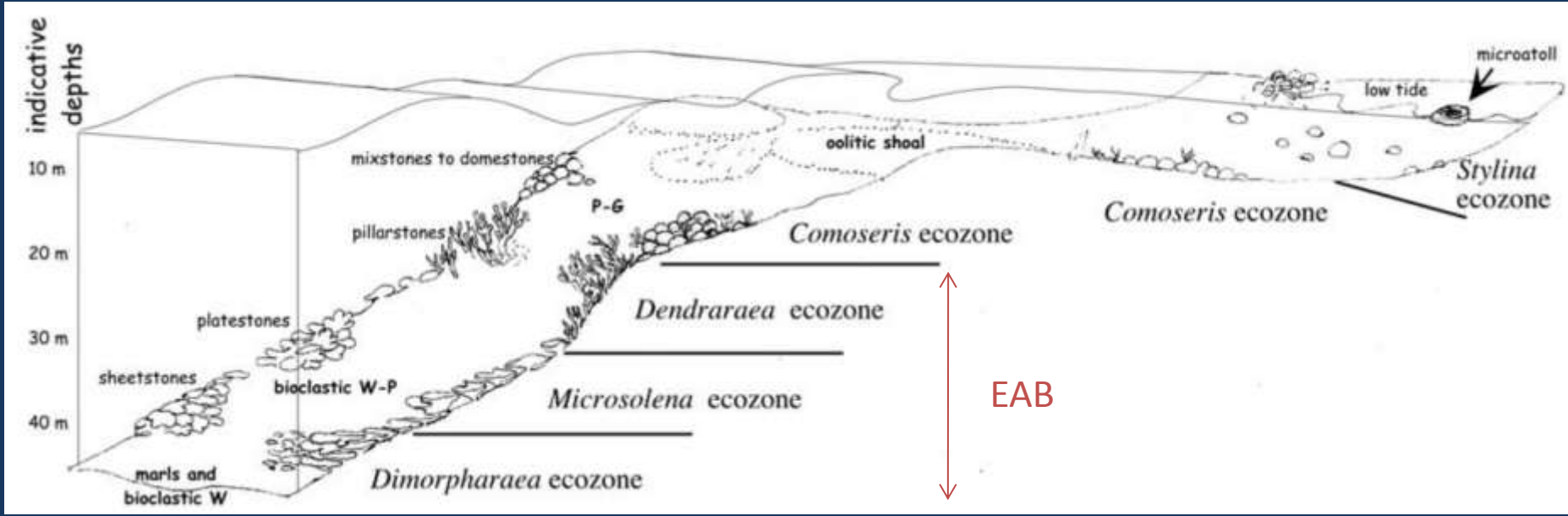
SWISS
FRANCE
ENGLAND

Purer limestones: *Microsolena dominates*
High siliciclastic component: Dimorpharea dominates
→ better sediment-dispelling capabilities

*Lathuiliere et al,. 2005*

# CENTRAL EUROPE






Bionomic zonation of the corallian platform of Bonnevaux-le-Prieur (Juras)

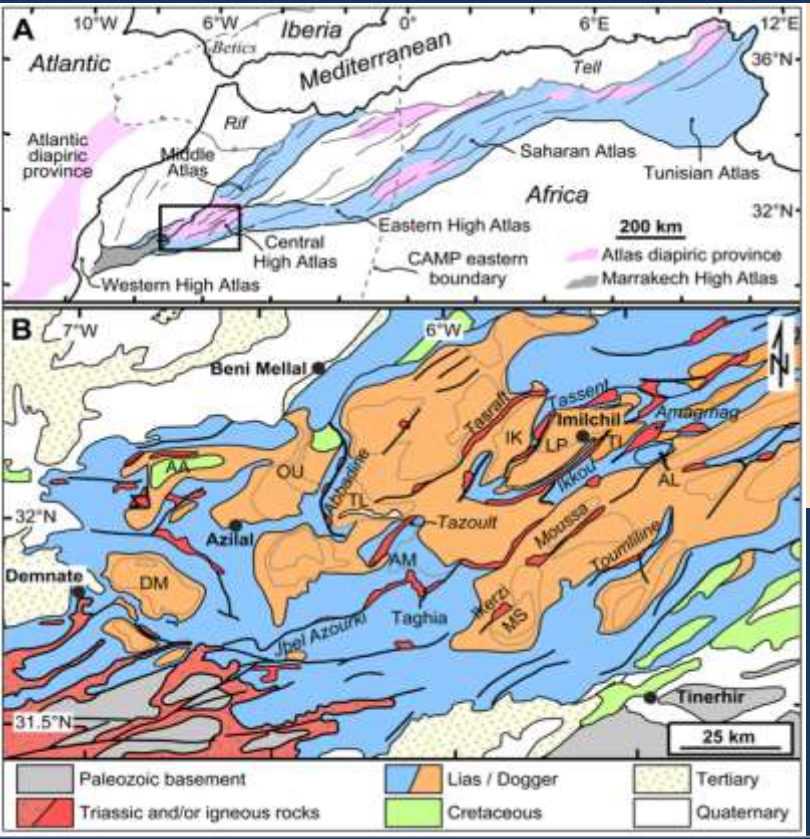
*Lathuiliere et al,. 2005*

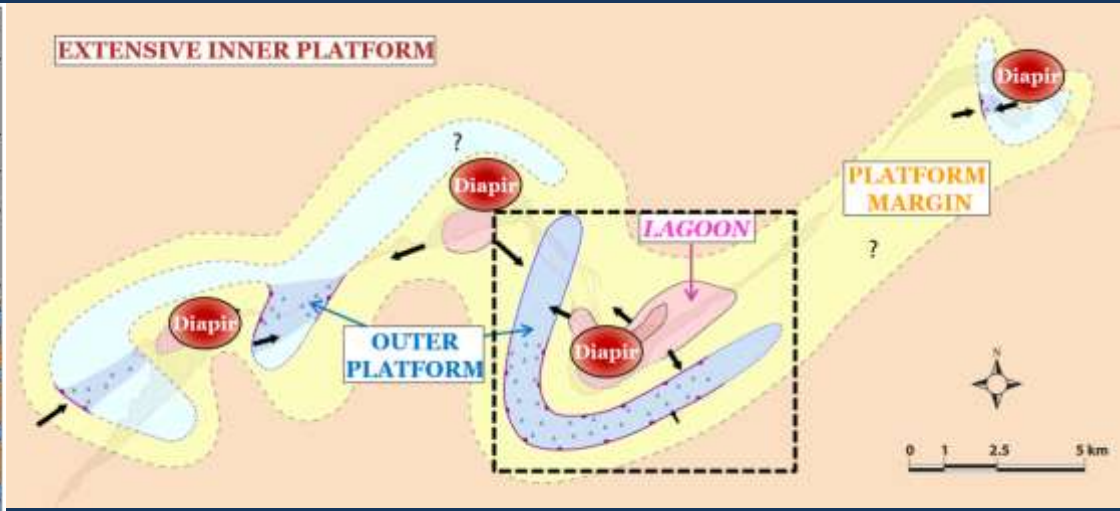
→ Patchy reefal frameworks

→ Relation with textures of juxtaposed sediments (WPG)

# CENTRAL HIGH ATLAS






→ Extensive diapirism
→ Salt withdrawal and diapirism influence
→ Carbonate platform and hemipellagic deposits
→ Rapid facies variation

*Saura et al., 2014*

# CENTRAL HIGH ATLAS

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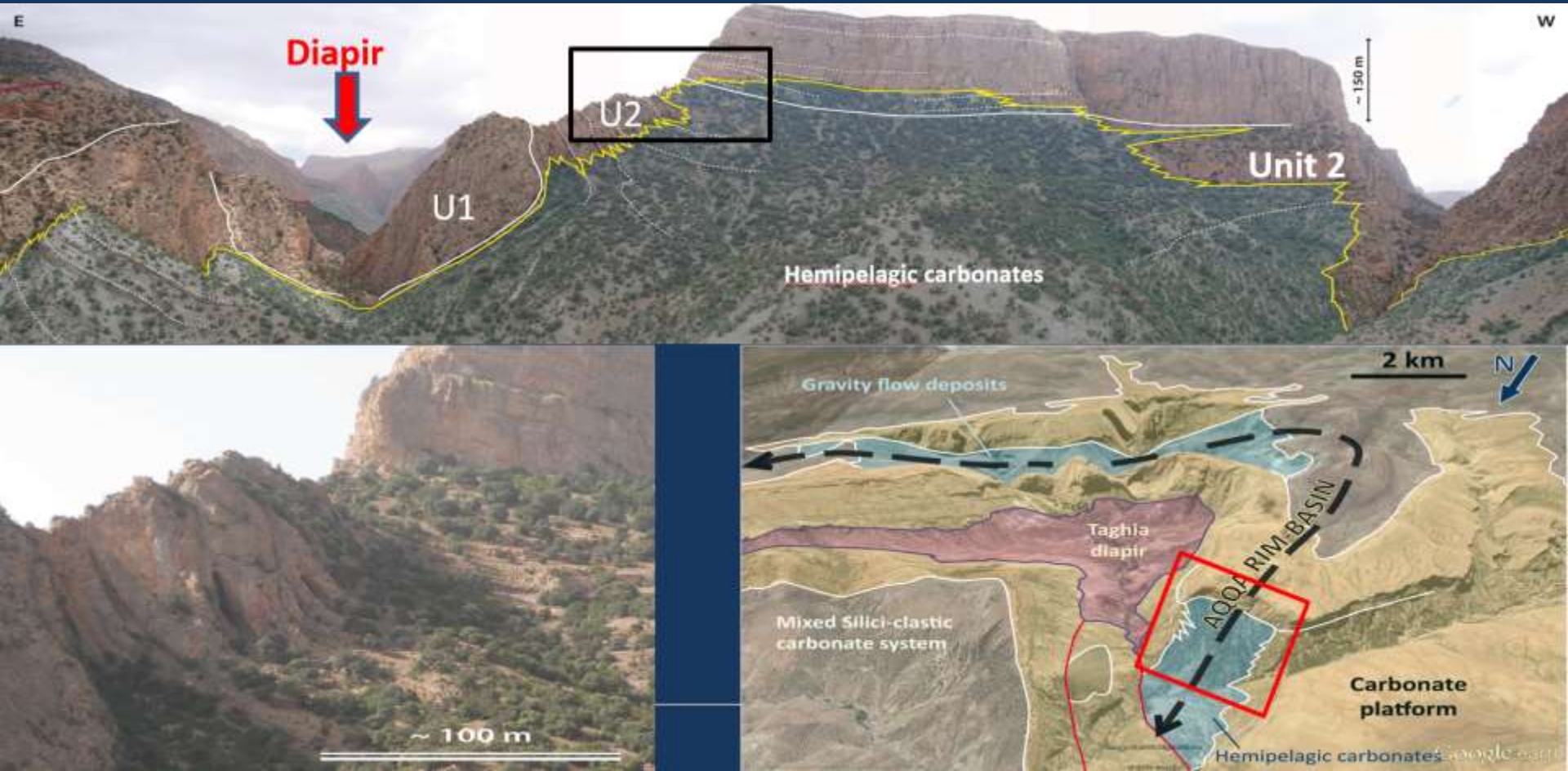


# DISCUSSIONS

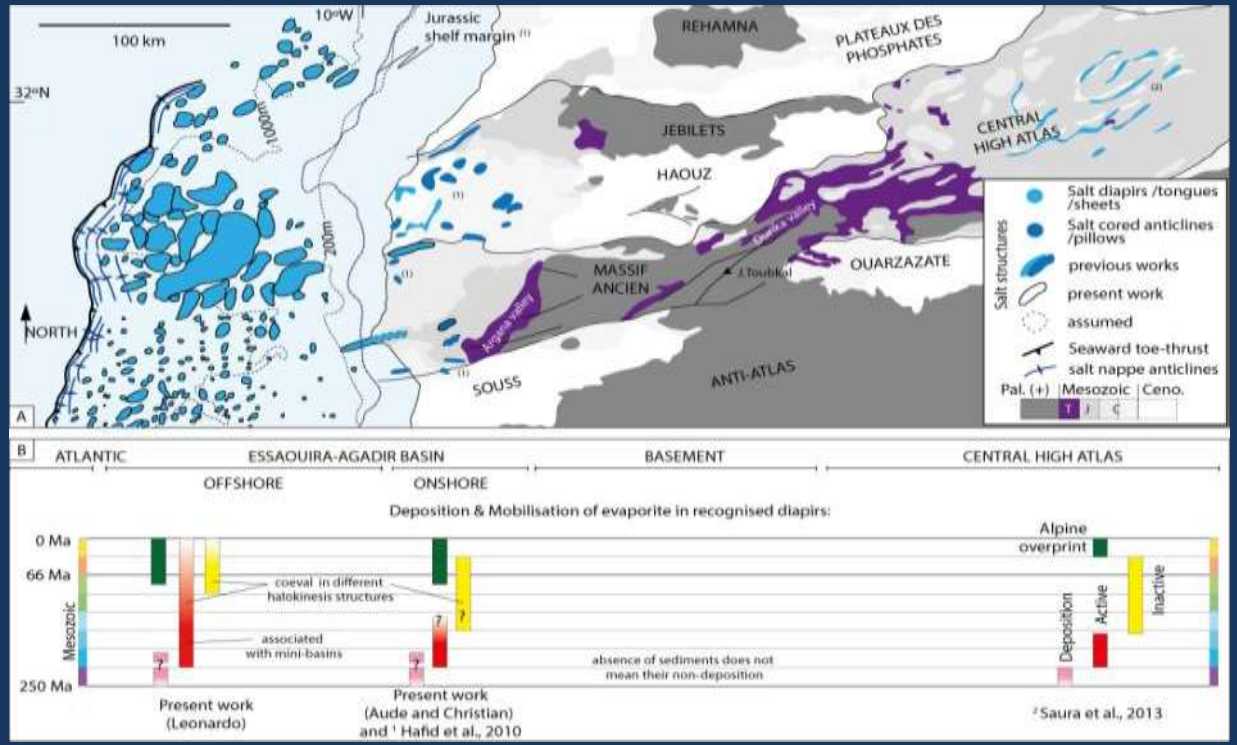
## Geometries linked to structural evolution

**Onshore salt anticlines:**

- Clastics distribution
- Reefs geometries (CHA)

**Offshore salt diapirs:**

- Mini basins
- Small scale platforms
- Strong facies control




*Work from R. Charton, unpublished*

# DISCUSSION



AGADIR-ESSAOUIRA BASIN ONSHORE:

→ No strong diapirism evidence (turtle back salt domes?)
→ Extensive biostromes with low coral diversity
→ Various buildups sizes and geometry, no reef

**For EAB Offshore**

Why different to Nova Scotia?
Clastic influence?

CENTRAL EUROPE:

→ Similar coral associations / facies
→ Dimorpharea high tolerance to higher background sedimentation rates

CENTRAL HIGH ATLAS:

→ Strong influence of diapirs on the architecture
→ Rapid facies variations on the edges of the diapirs

NOVA SCOTIA:

→ Abenaki Formation: thrombolite-stromatolite buildups and calcareous sponges

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Special thanks :

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المكتب الوطني للهيدروكاربورات و المعادن

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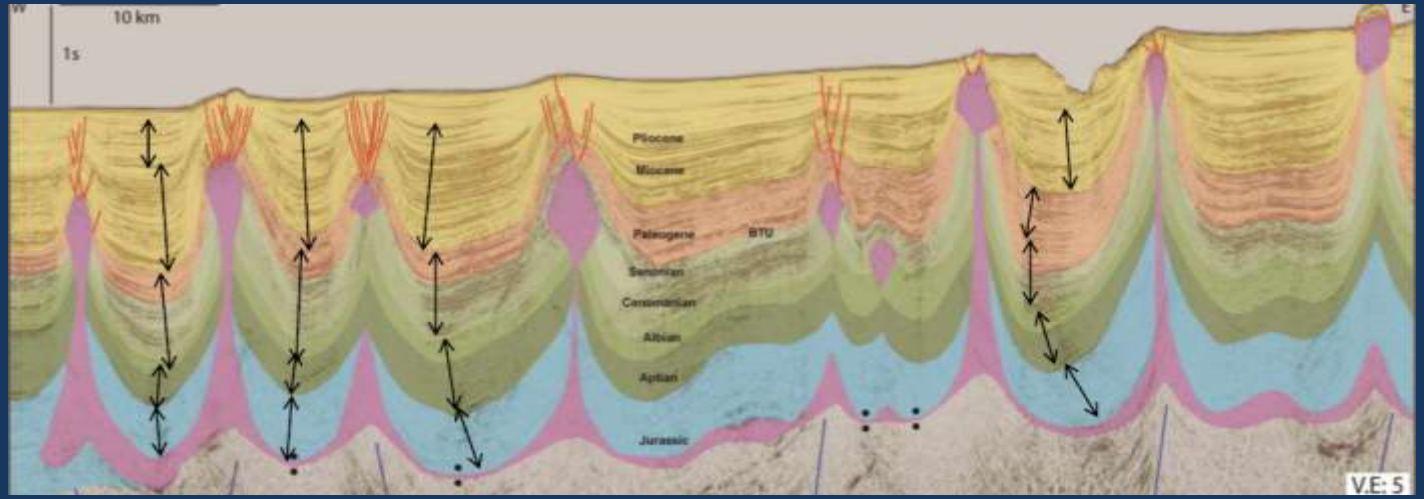
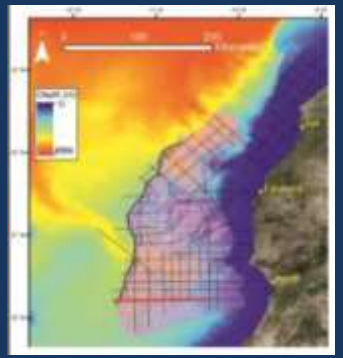
# IFNI OFFSHORE





- Squeezed and tea-drop diapirs (symmetric and up-right structures)
- Intense folding & thicknesses variations across minibasins
- Minibasins driven by **DIAPIR SHORTENING** – abrupt depocentre shift

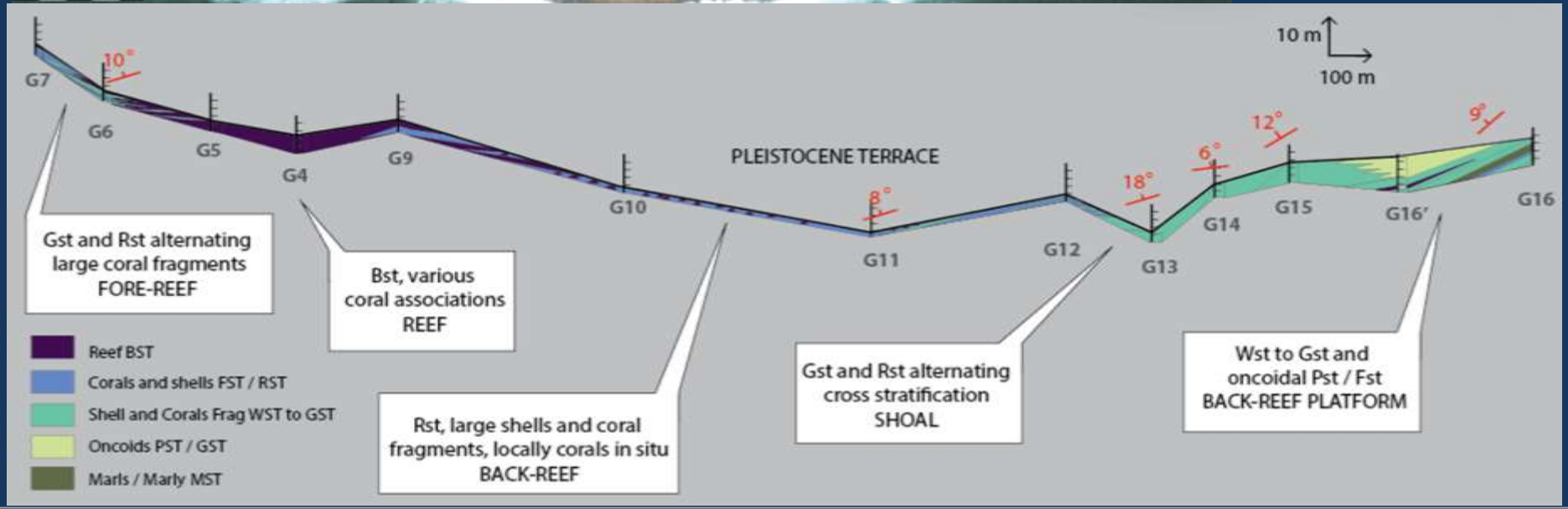
- Reactive diapirism?: Early – Middle Jurassic
- **Passive diapirism** (turtle structures) – Late Jurassic to Cenomanian
- Active diapirism - Late Cretaceous- recent

*Ongoing work Leonardo Muniz-Pichel*

# CAP GHIR - EAB




PLEISTOCENE TERRACE
500 m
N


10 m
100 m
G7
10°
G6
G5
G4
G9
G10
PLEISTOCENE TERRACE
8°
G11
G12
18°
G13
6°
G14
12°
G15
9°
G16'
G16
Gst and Rst alternating large coral fragments FORE-REEF
Bst, various coral associations REEF
Rst, large shells and coral fragments, locally corals in situ BACK-REEF
Gst and Rst alternating cross stratification SHOAL
Wst to Gst and oncoidal Pst / Fst BACK-REEF PLATFORM
Reef BST
Corals and shells FST / RST
Shell and Corals Frag WST to GST
Oncoids PST / GST
Marls / Marly MST