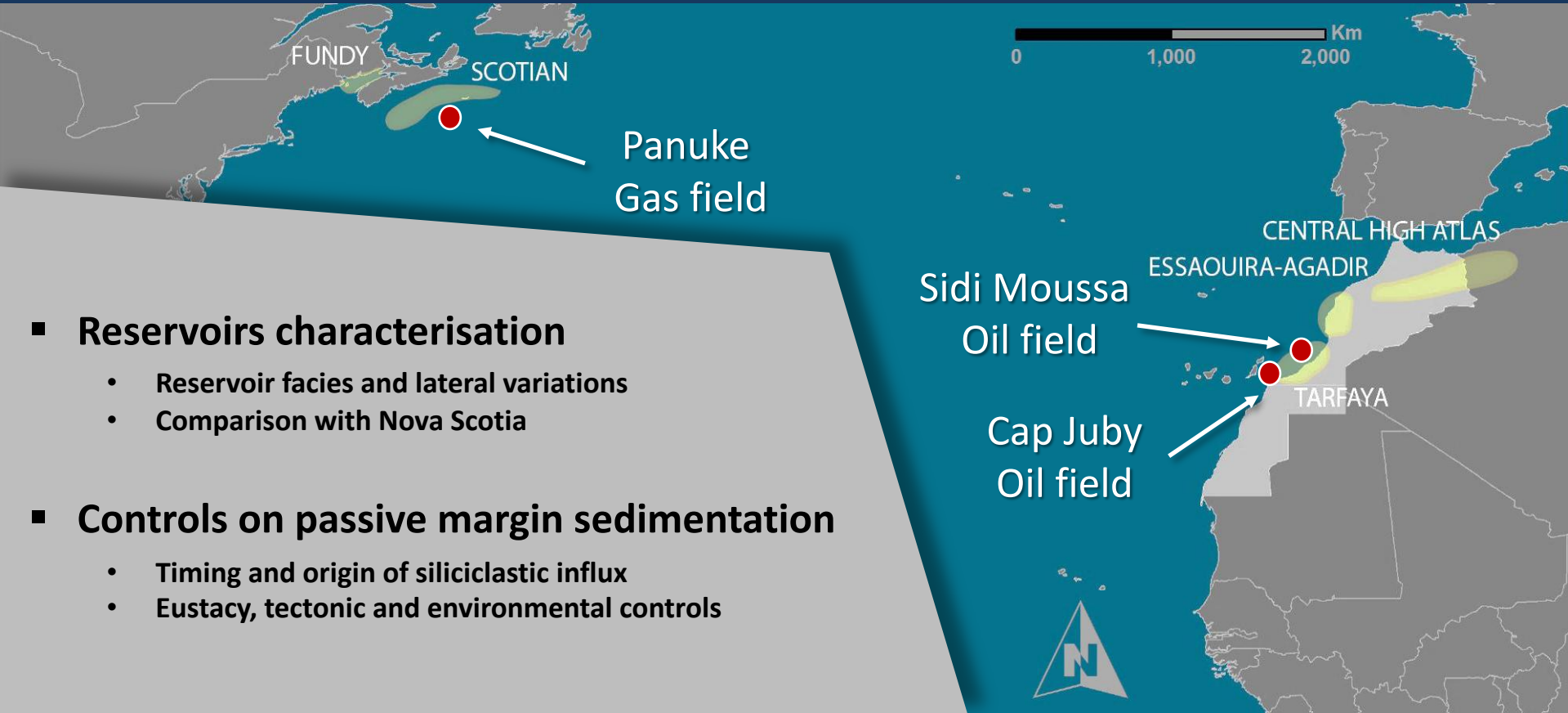




The interplay of carbonate platforms and siliciclastic influx during the Jurassic along the Moroccan Atlantic Margin



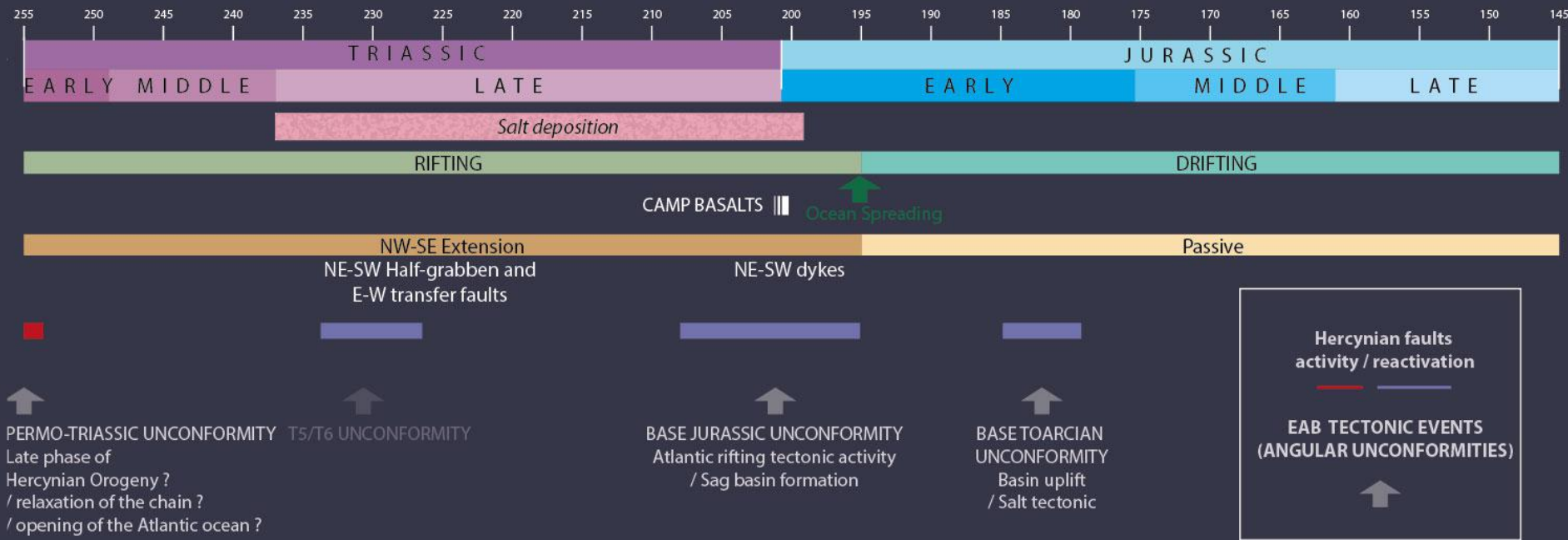
■ Reservoirs characterisation

- Reservoir facies and lateral variations
- Comparison with Nova Scotia

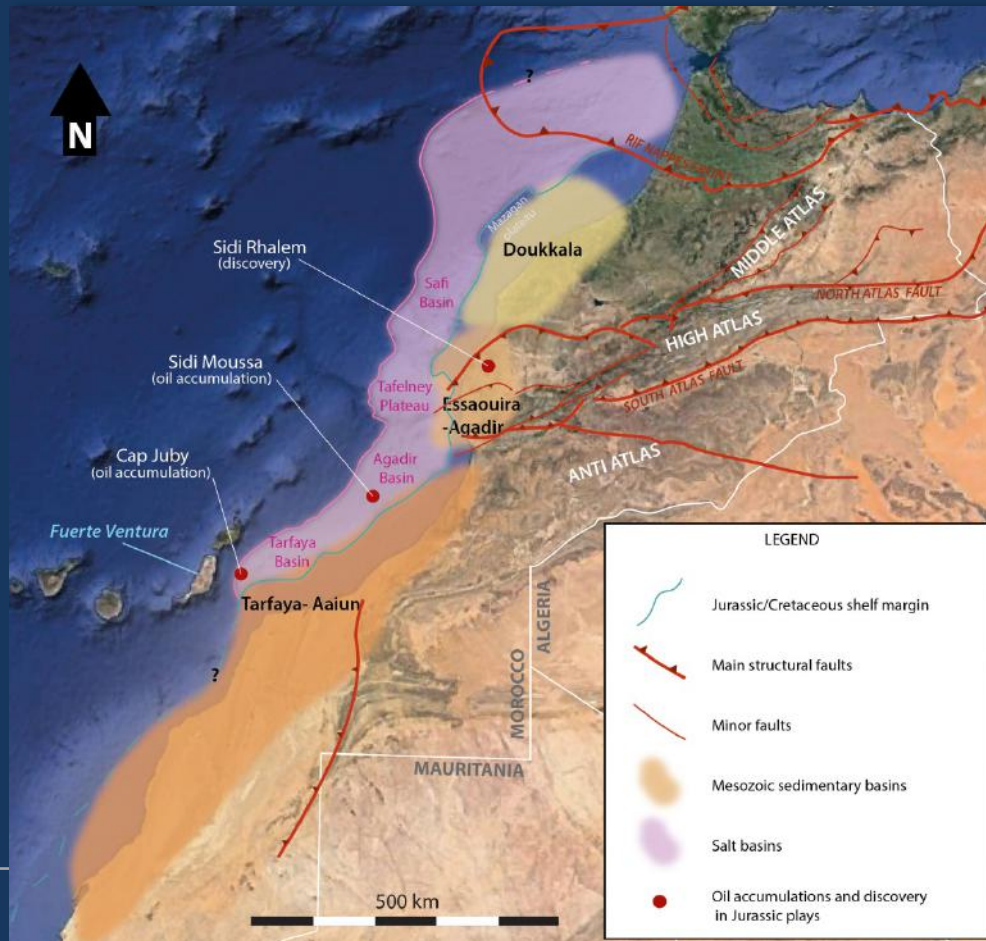
■ Controls on passive margin sedimentation

- Timing and origin of siliciclastic influx
- Eustacy, tectonic and environmental controls

TRIASSIC - JURASSIC TECTONIC EVOLUTION



Early Jurassic → Rift to drift transition : establishment of a carbonate platform along the Moroccan Atlantic Margin

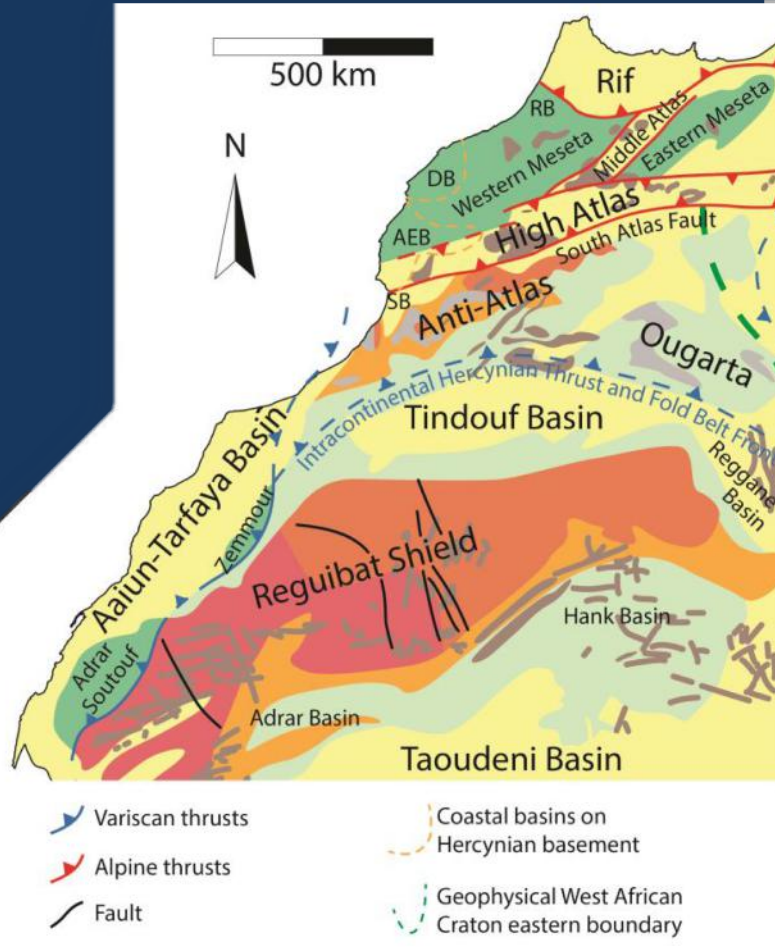


Moroccan Atlantic basins:

- DOUKKALA BASIN
- ESSAOUIRA-AGADIR BASIN
- TARFAYA-AAIUN BASIN

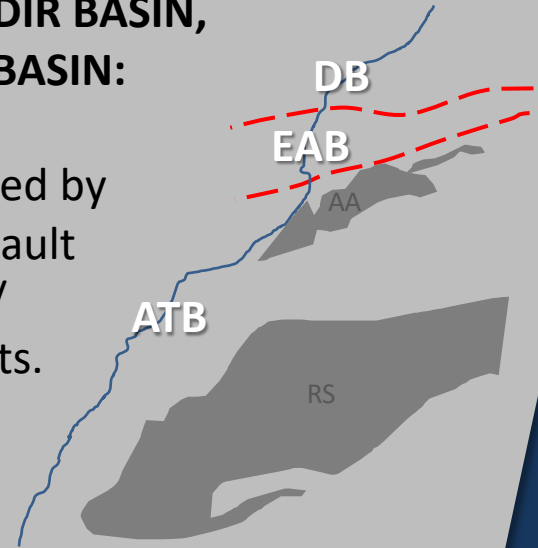
Triassic salt province offshore and partially onshore

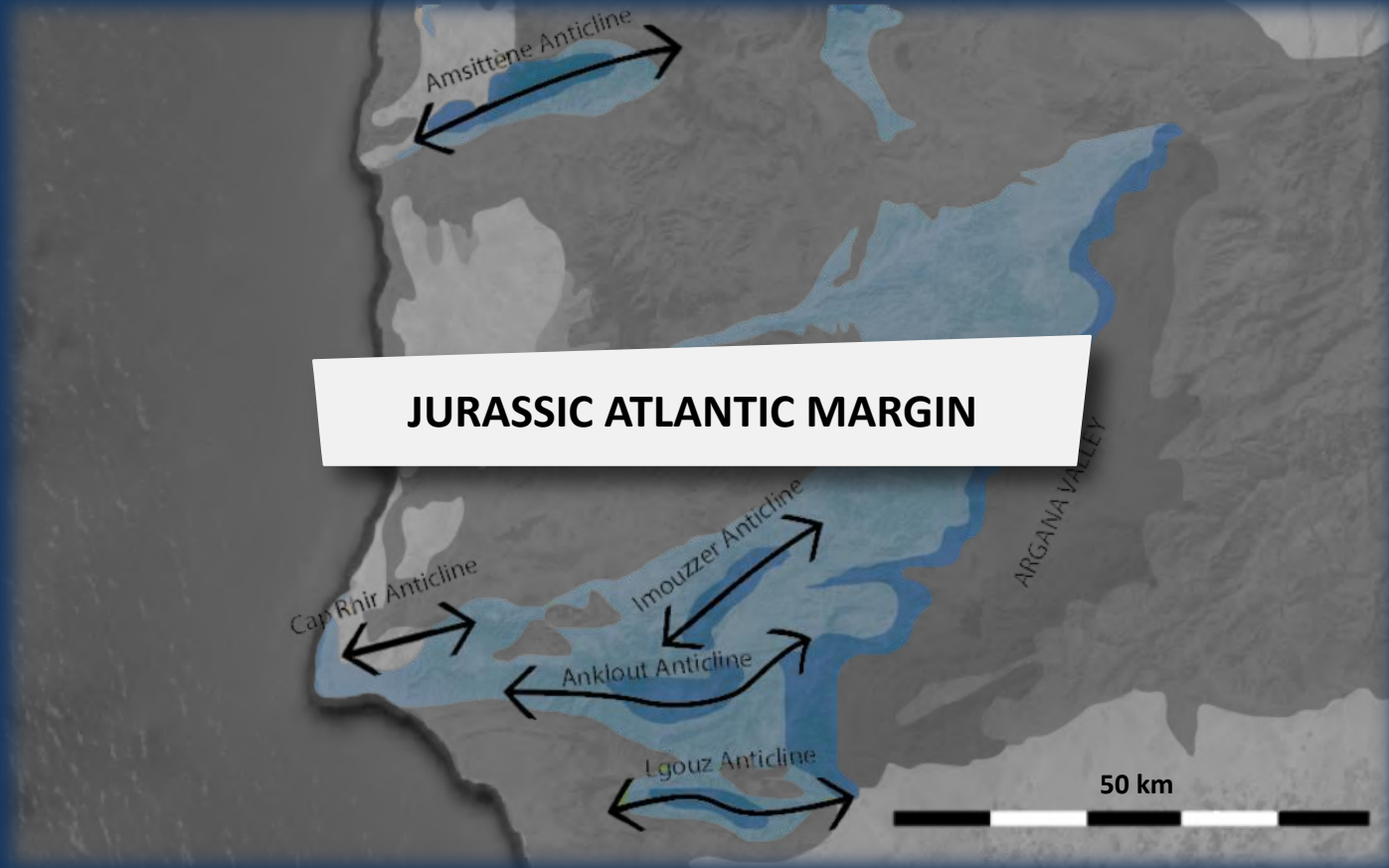
Tectonic influence of the Atlantic rifting AND the Atlas Rifting



DOUKKALA BASIN, ESSAOUIRA-AGADIR BASIN, AAIUN-TARFAYA BASIN:

- Basins separated by the South Atlas Fault and North Atlas / North Jebilet faults.
- Rift Basins, on the Atlantic Margin of Morocco

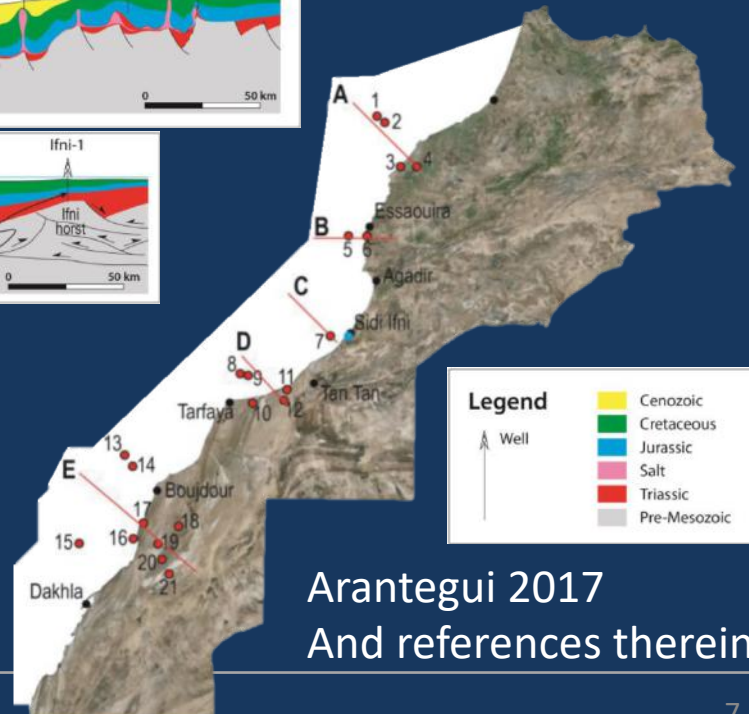
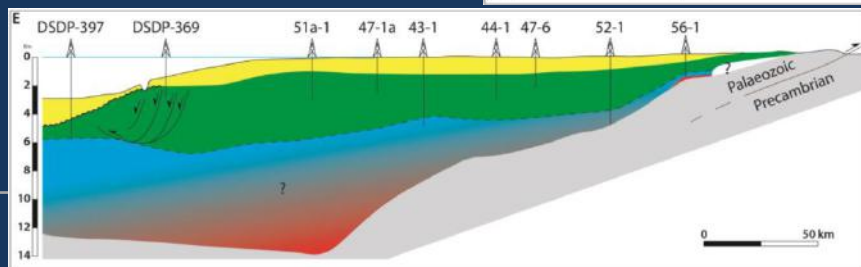
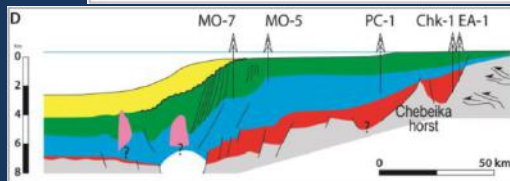
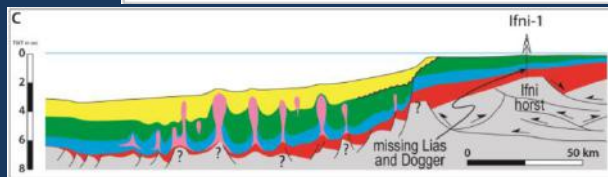
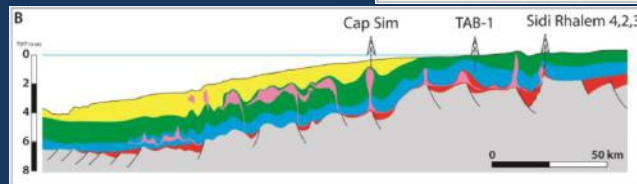
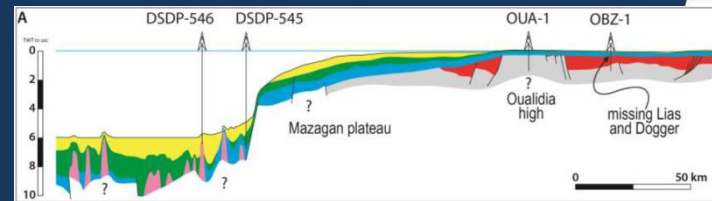




MARGIN ARCHITECTURE



- Jurassic early post-rift succession
- Variations of salt tectonic geometries along the margin
- Less to no salt diapirism in the Aaiun-Tarfaya Basin
- Jurassic mini-basins formation elsewhere

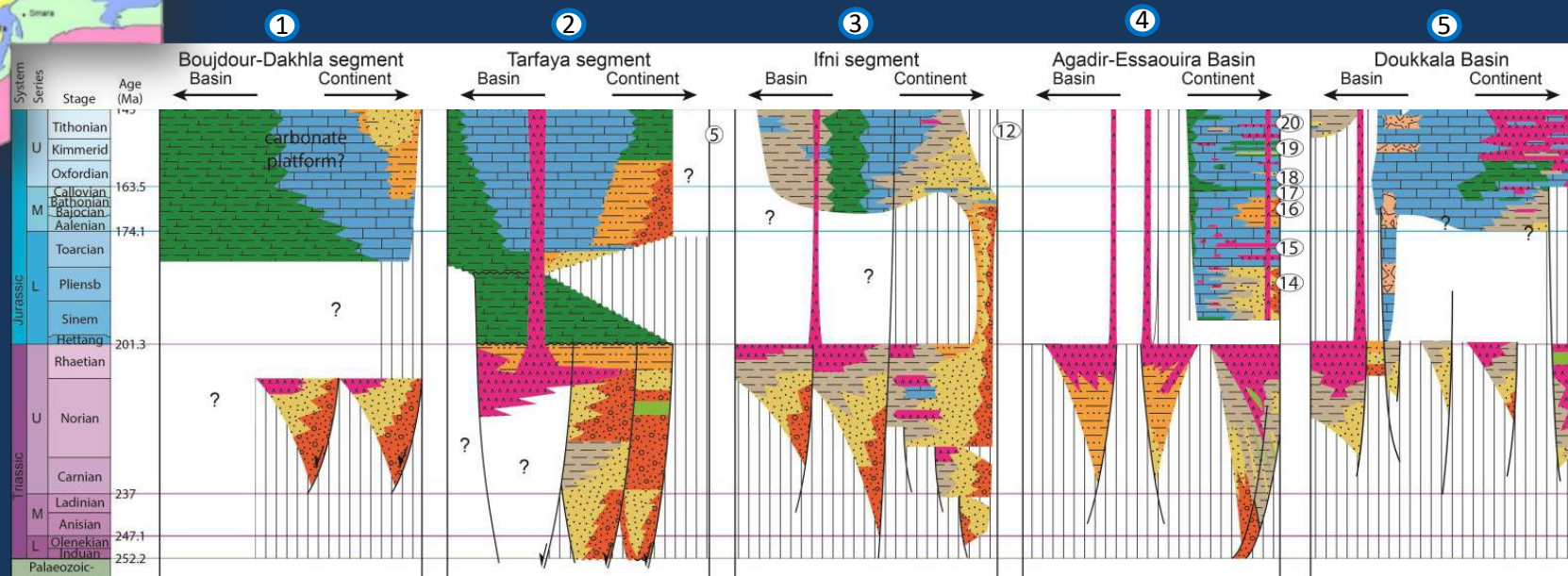


Arantegui 2017
And references therein



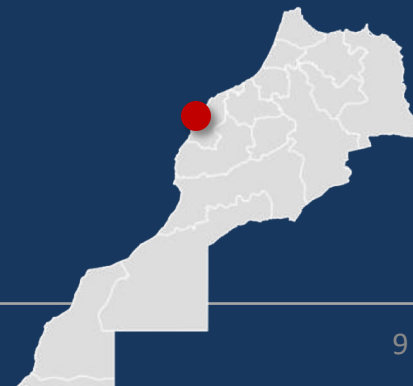
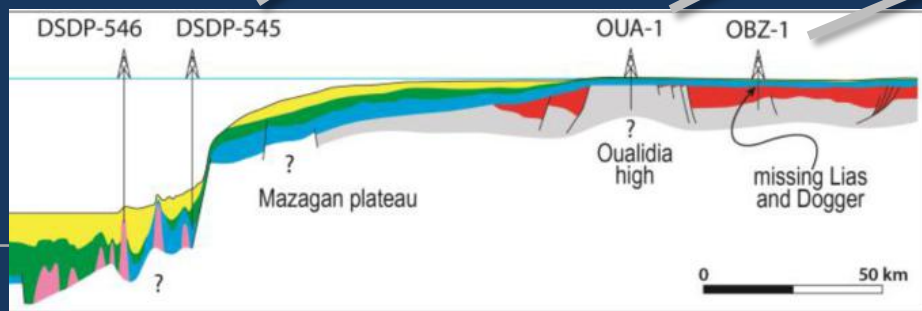
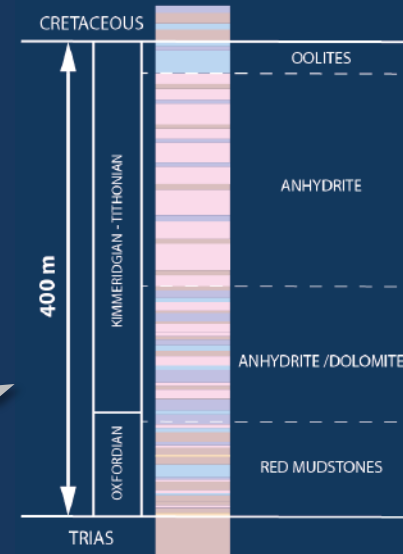
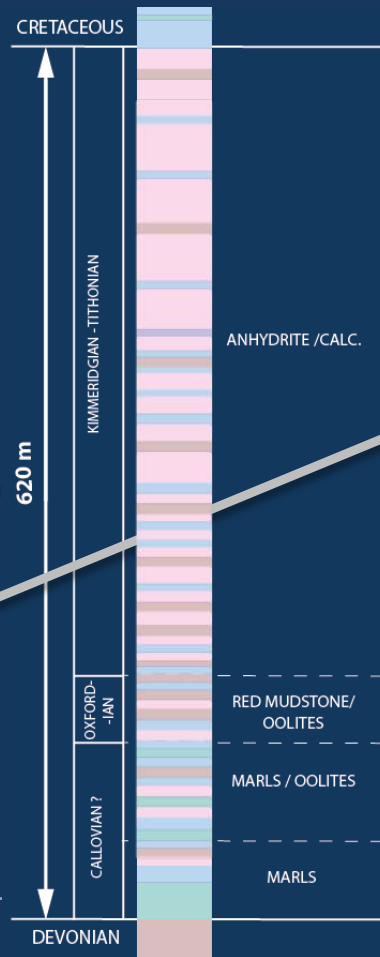
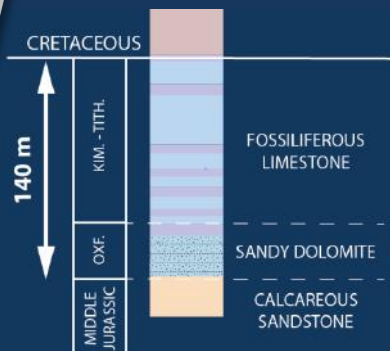
- Lower Jurassic poorly preserved
- Lower and Middle Jurassic siliciclastics
- Upper Jurassic Carbonates and siliciclastics

ONHYM



DOUKKALA BASIN

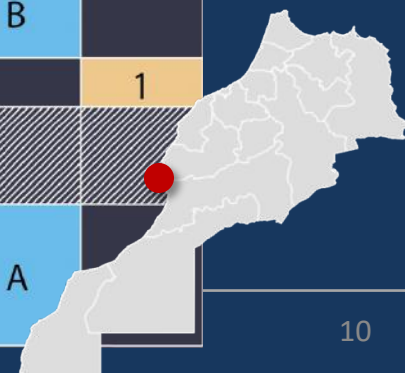
- Lower and Middle Jurassic missing
- Oxfordian sandy offshore
- Upper Jurassic anhydrite onshore / fossiliferous limestone offshore



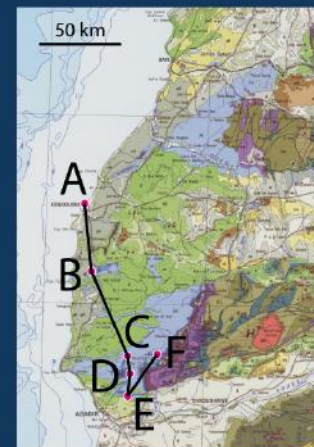
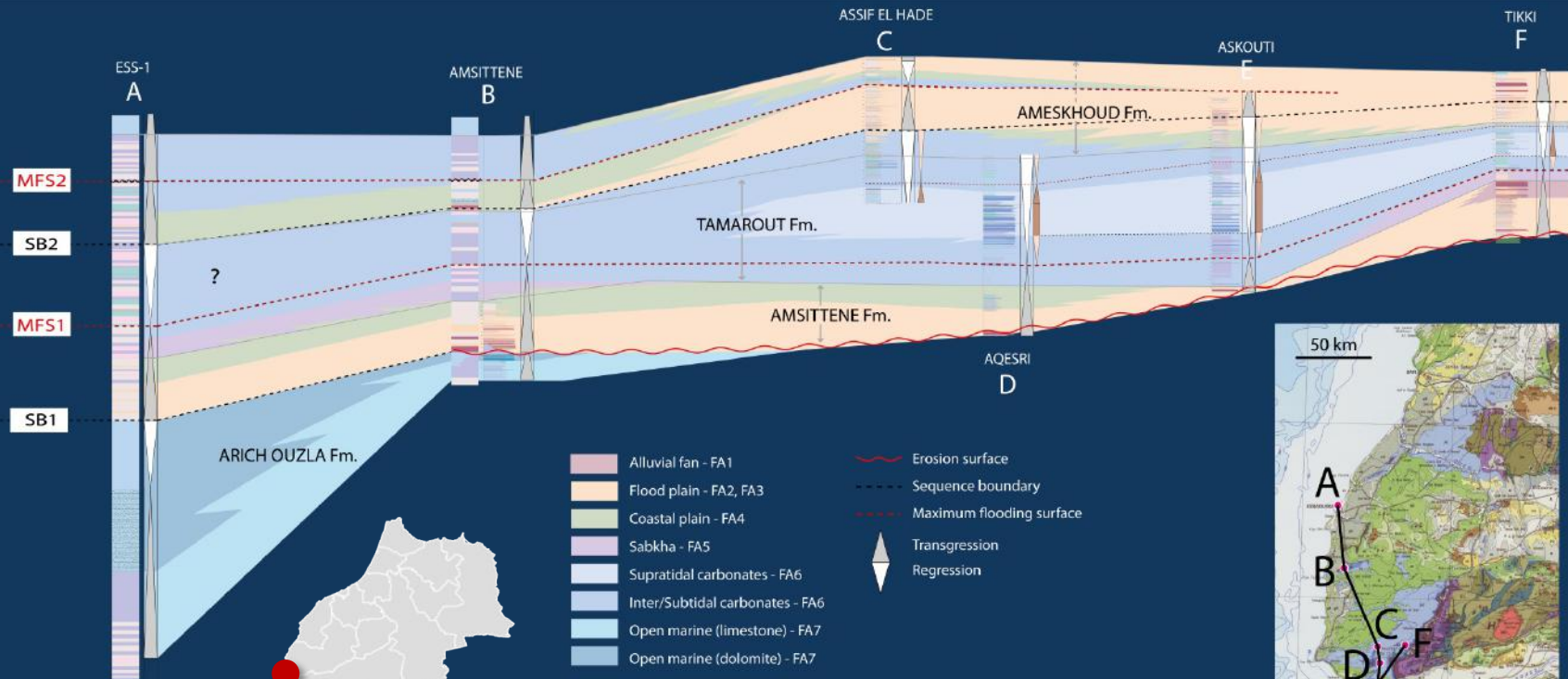
ESSAOUIRA-AGADIR BASIN STRATIGRAPHY



| Ages | | Simplified Section | Formations Name | T/R | Environments | Dominant Facies | Carbonates | Siliciclastics |
|--------|---------------|---------------------|--------------------------|---|--|--------------------|------------|----------------|
| UPPER | TITHONIAN | | TISMEROURA FORMATION | | Internal ramp (up to 300 m) | Dolomite | E | |
| | KIMMERIDGIAN | | IMOZZER FORMATION | | Lagoon / Emerged proximal (up to 150 m) | Red marls | | 3 |
| | OXFORDIAN | | IGGUI EL-BEHAR FORMATION | | Sabkha Shallow marine (up to 120 m) | MST - PST | D' | |
| | | | LALLA OUJJA FORMATION | | Coral build-ups Outer ramp (up to 60 m) | BST - Dolomite | D | |
| MIDDLE | CALLOVIAN | | OUNAMANE FORMATION | | Inner ramp carbonates (up to 170 m) | Marls PST - RST | C | |
| | BATHONIAN | | AMESKHOUD FORMATION | | Alluvial plain (up to 300 m) | Clay - Silt - SST | | 2 |
| | BAJOCIAN | | | | Intertidal siliciclastic | | | |
| | AALENIAN | | | | | | | |
| | TOARCIAN | | TAMAROUT FORMATION | | Supratidal Subtidal Intertidal (up to 400 m) | GST - Dolomite | B | |
| | | AMSITTÈNE FORMATION | | Alluvial fan Coastal plain (up to 50 m) | Conglomerates | | 1 | |
| LOWER | PLIENSBACHIAN | | | | | | | |
| | SINEMURIAN | | ARICH OUZLA FORMATION | | Open ramp (outer) Open ramp (middle) (up to 150 m) | GST - Dolomite | A | |



EAB LOWER- /MIDDLE JURASSIC



AAIUN-TARFAYA STRATIGRAPHY



2200 m

TRIAS

L. J.

MIDDLE JURASSIC

OXF.

KIMMERIDGIAN - TITHONIAN

Limestone and dolomite

Red siltstone

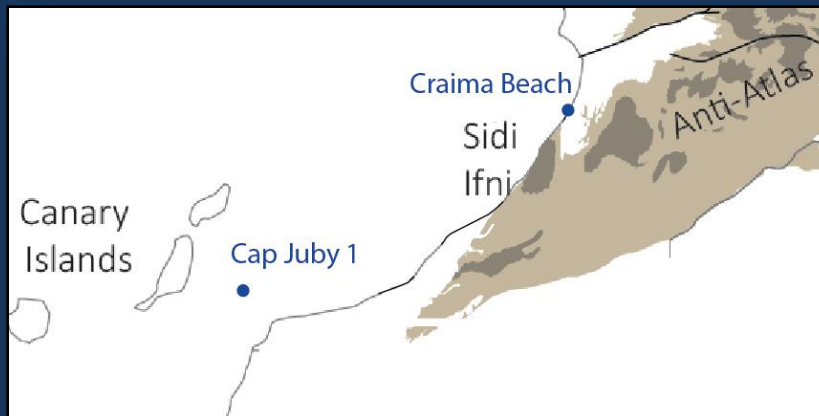
Red siltstone

Limestone and dolomite

Limestone

Limestone and dolomite

Cap Juby



- Offshore dominated by carbonates
- Lower and Middle Jurassic Siliciclastic influx
- Mixed system during Bathonian

450 m

TRIAS / LOWER JURASSIC /
MIDDLE JURASSIC ?

BATHONIAN

Craima

LAGOONAL

laminated muds,
calcareous sandstones and
bioclastic, peloid- and
ooid-bearing limestones.

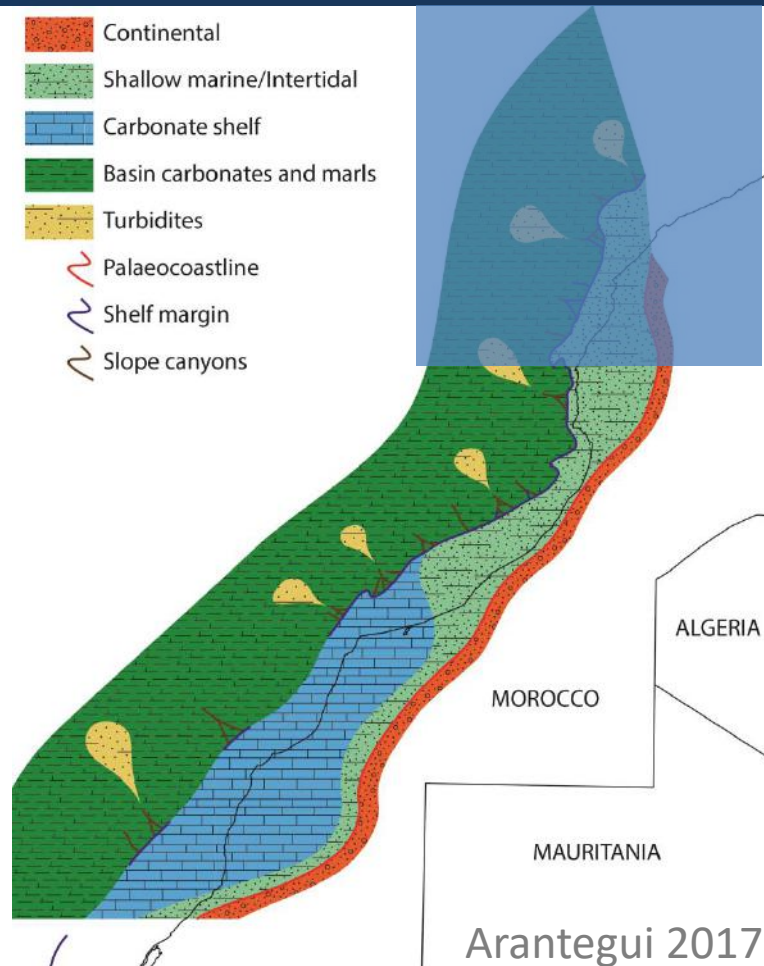
PERITIDAL

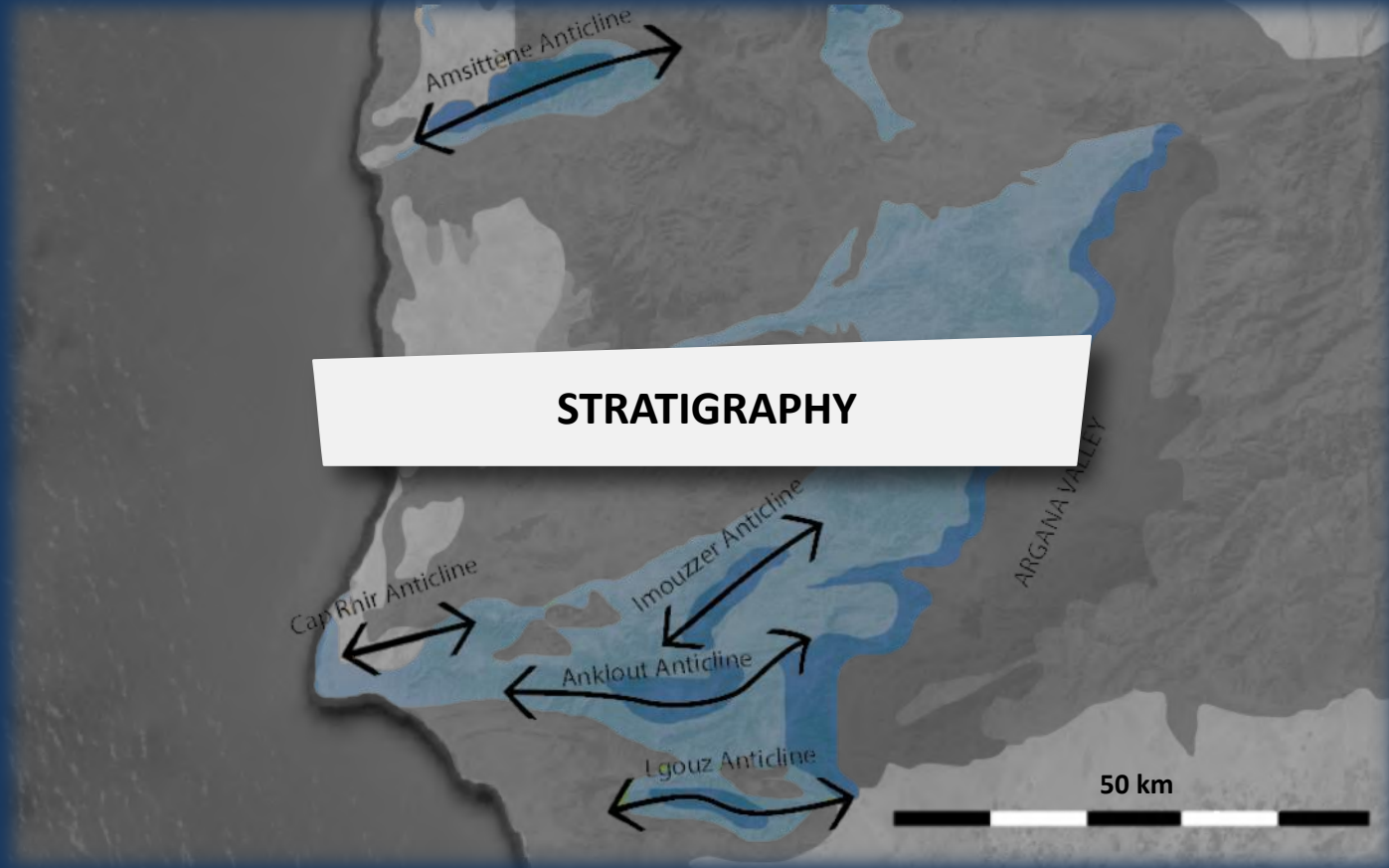
Red and grey mudstone
fine-grained sandstones,
grey oncoidal packstones,
algal laminitesALLUVIAL FANS
Conglomerates

BATHONIAN MARGIN

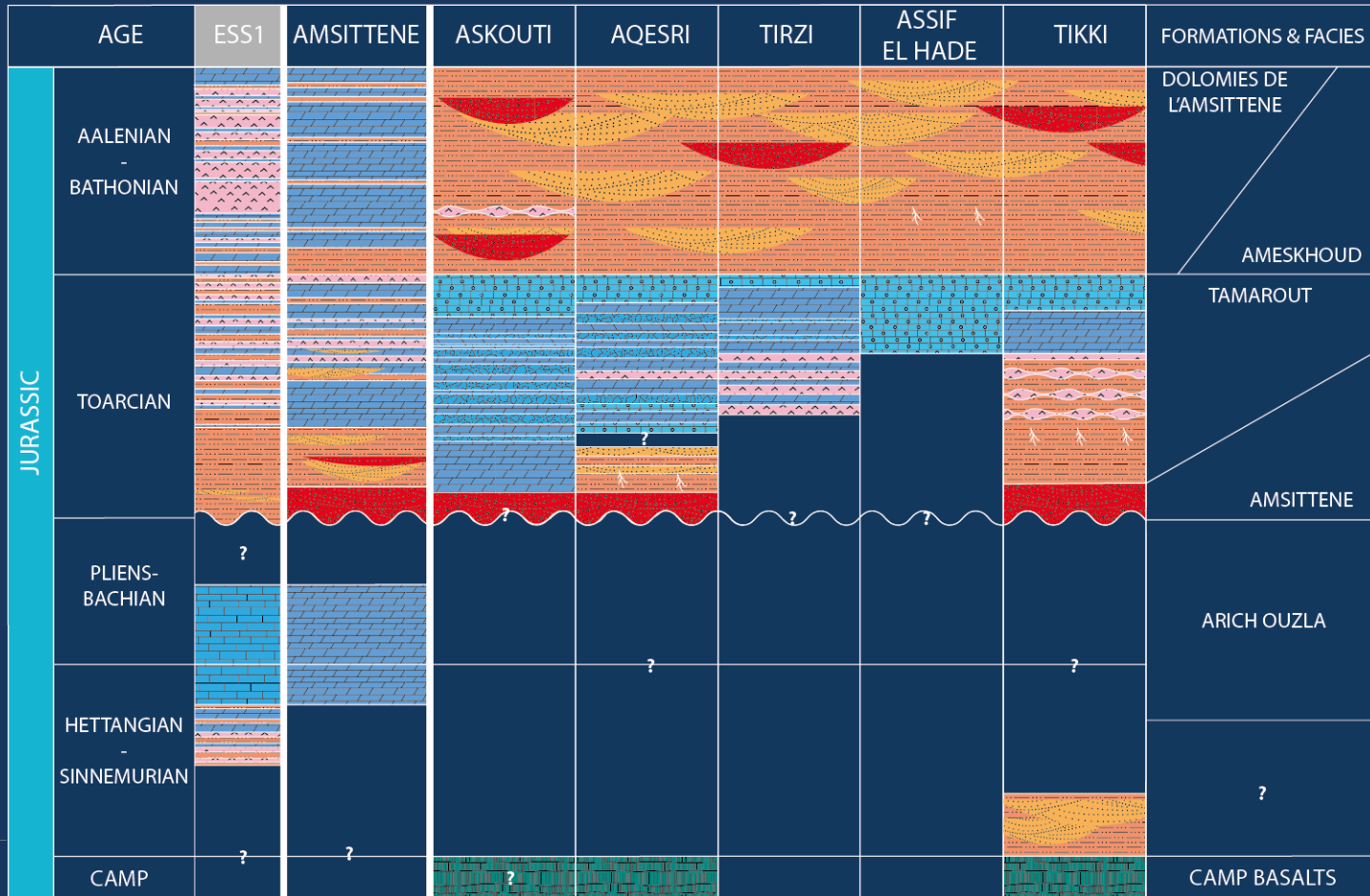


- Carbonate platform in the South
- Shallow marine and terrestrial towards the North
- In accordance with APT data that suggest a siliciclastic provenance from the central Anti Atlas and not the Reguibat Schield

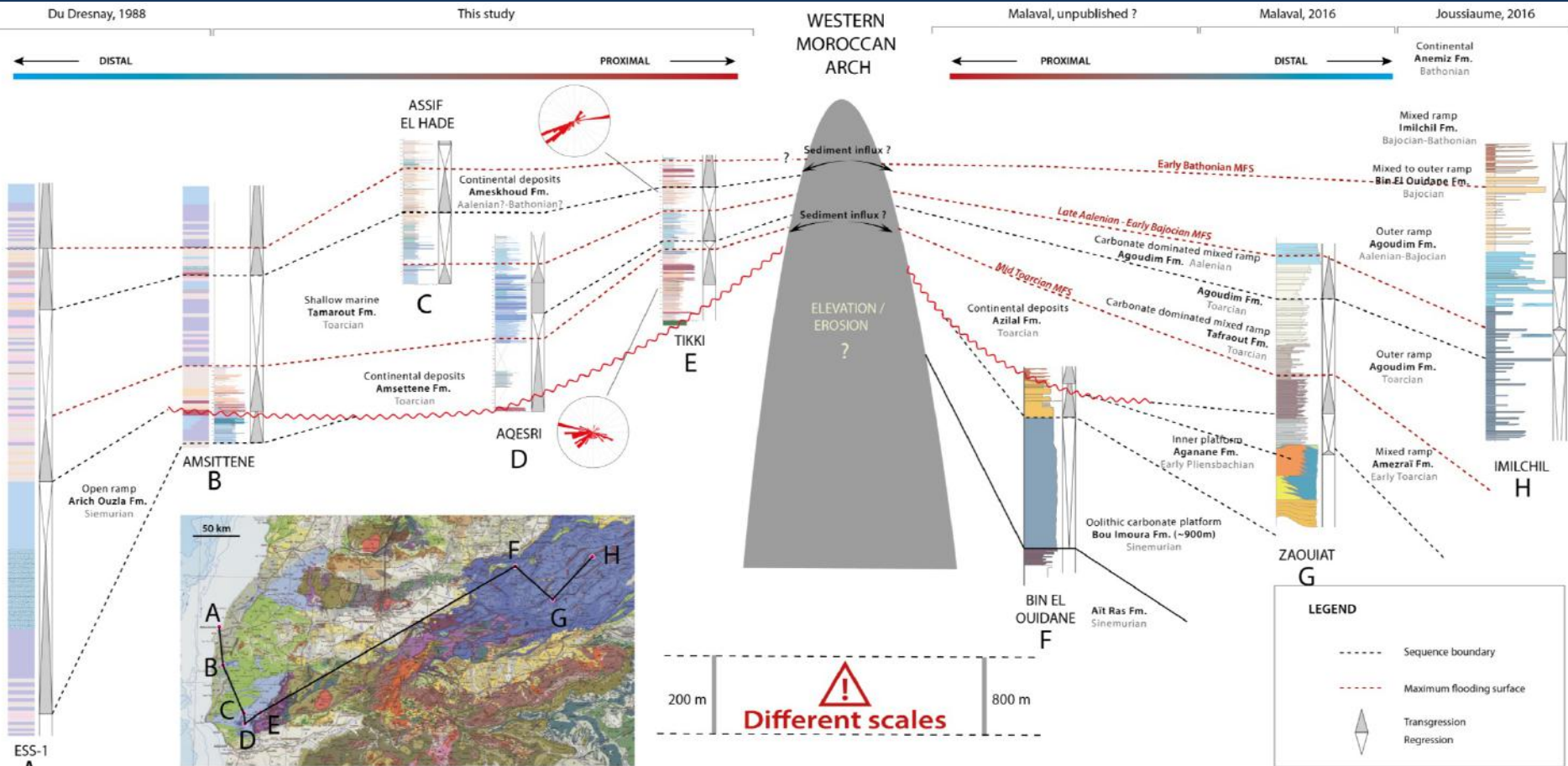




LOWER AND MIDDLE JURASSIC



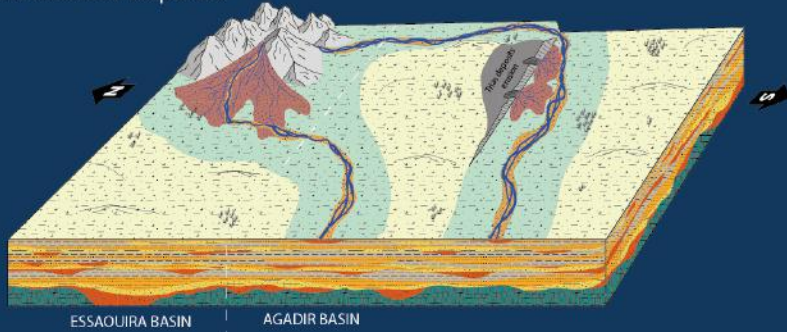
COMPARISON CENTRAL HIGH ATLAS



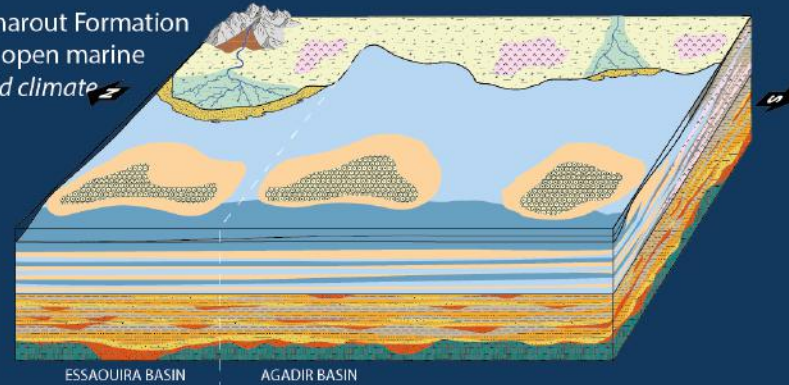
DEPOSITIONAL ENVIRONMENTS



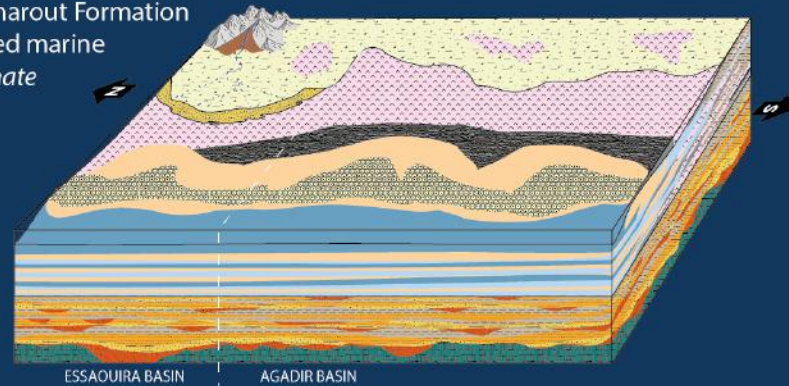
A - Amsittene Formation
Continental deposits



B1 - Tamarout Formation
Shallow open marine
Semi-arid climate



B2 - Tamarout Formation
Restricted marine
Arid climate

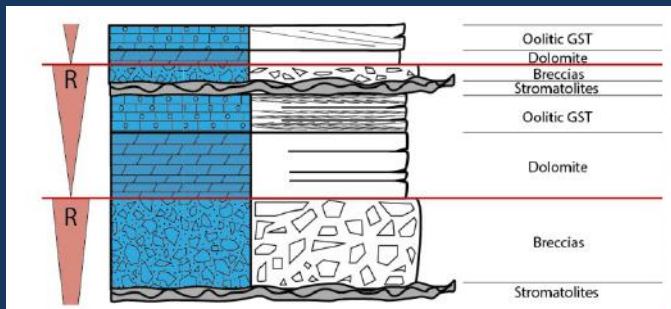


LOWER JURASSIC



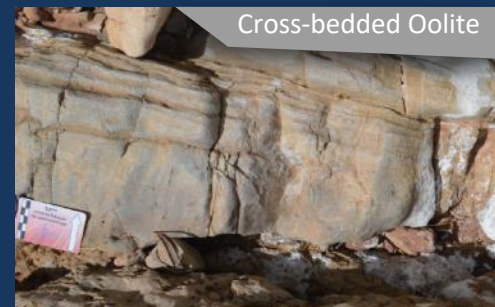
UNIT 2

Intertidal to
Supratidal cycles

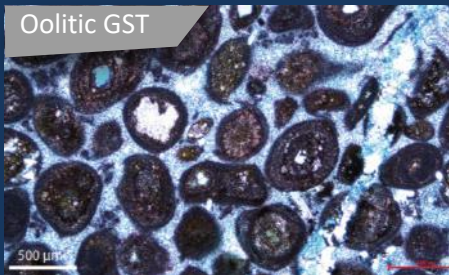


UNIT 3

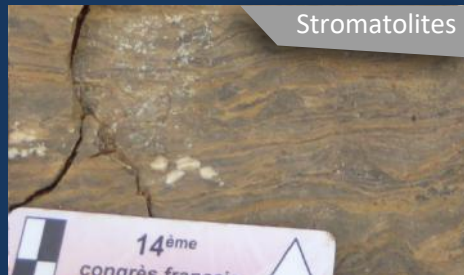
Subtidal deposits
Oolitic GST



Oolitic GST



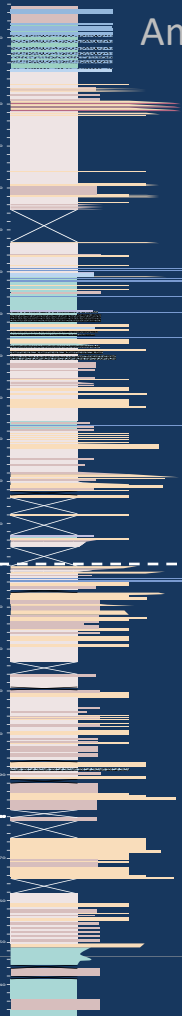
Stromatolites



*Apparition of dark,
Kerogenic horizons,
presence of wood
fragments*



→ Best potential reservoir unit



Red mudstones



Roots traces



Dolomite horizons



Red sandstones



Wave ripples

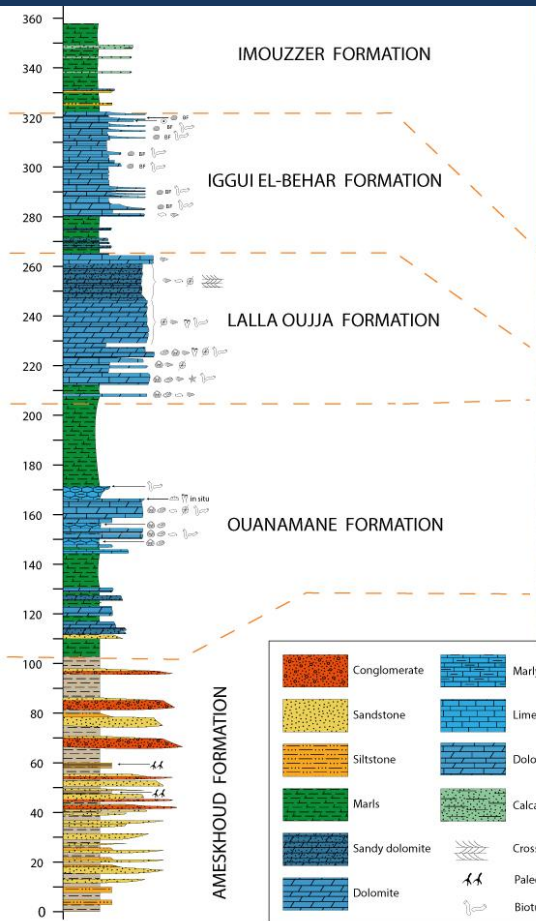


Tidal channels

TERRESTRIAL

MARINE

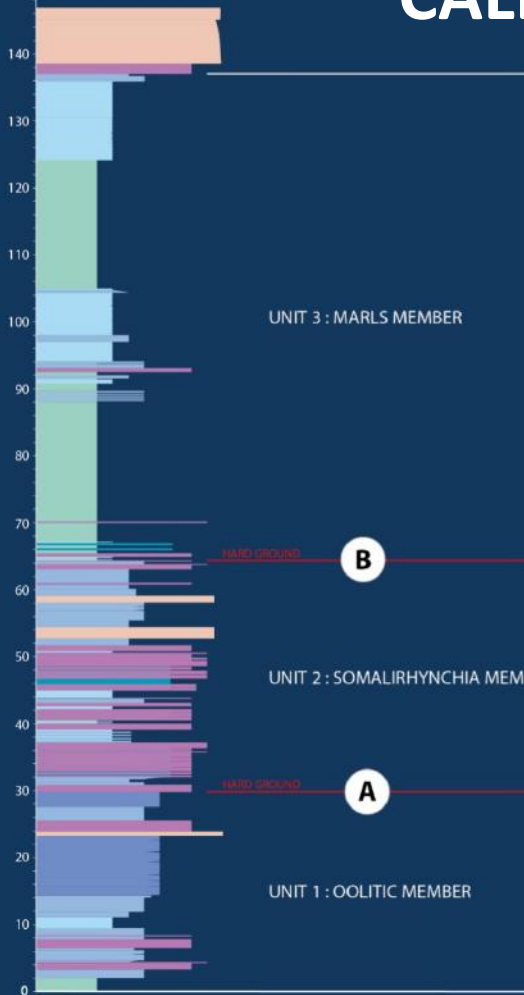
MIDDLE JURASSIC



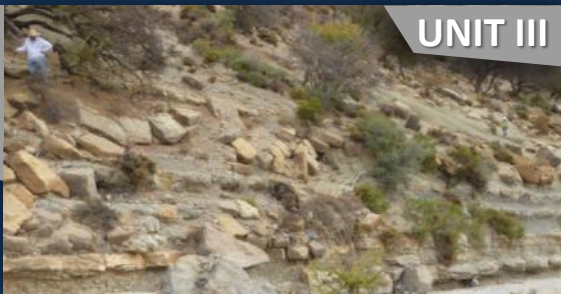
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| | | | | | | | | | |
|--|-----------------------------|--|-------------------------|--|-----------------------|--|--------------|--|-----------------------------|
| | Dolomitic limestones | | Marly limestones | | Sandy dolomite | | Marls | | Calcareous siltstone |
|--|-----------------------------|--|-------------------------|--|-----------------------|--|--------------|--|-----------------------------|

CALLOVIAN TRANSGRESSION



transgression



UNIT III



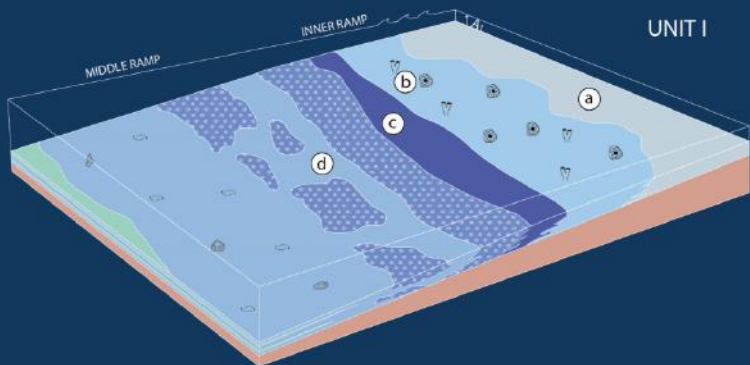
UNIT II



UNIT I

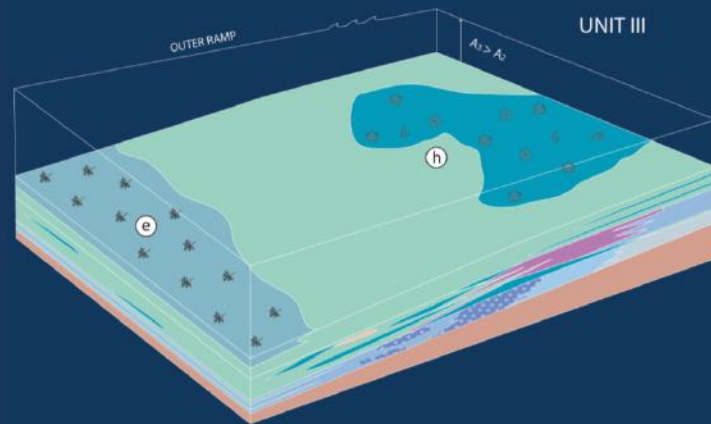


DEPOSITIONAL ENVIRONMENTS

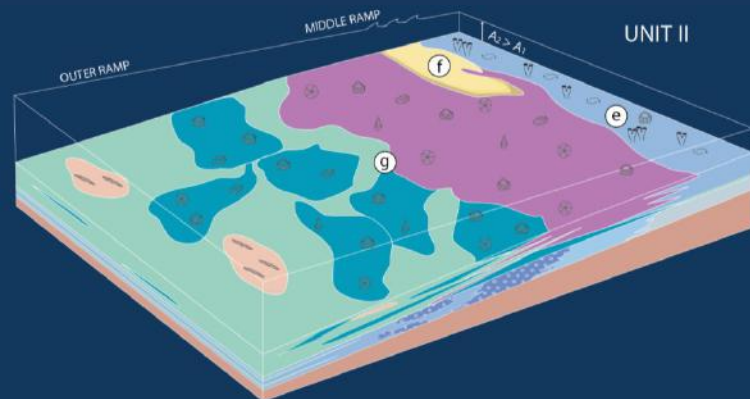


UNIT I







-  Silty/sandy limestone
-  WST/PST and oncoidal FST with patch-reefs
-  Coralline RST and Oolitic /Bioclastic GST
-  Oolitic and Bioclastic GST
-  Bioclastic WST/PST locally FST






UNIT III



UNIT II

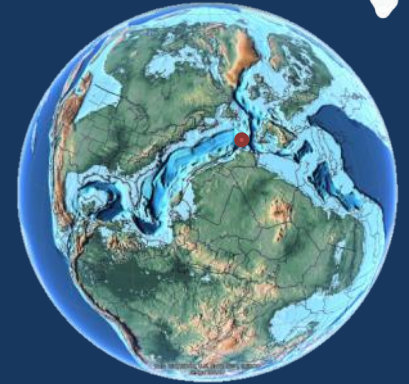
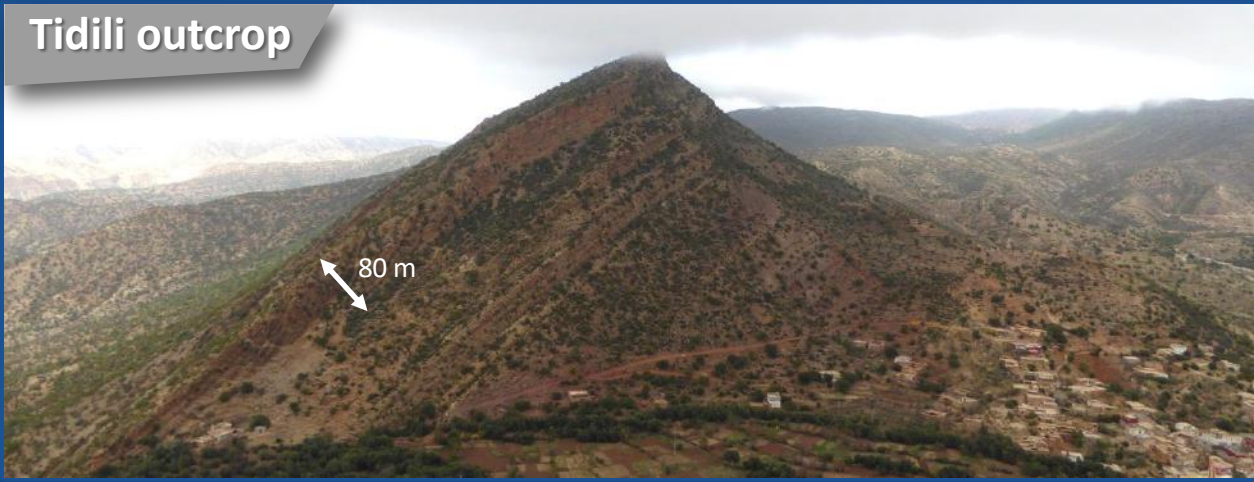
-  Bioclastic WST/PST with patch-reefs
-  Carbonate sandstone and sandy carbonates
-  Brachiopod-rich FST and RST
-  Brachiopod-rich marly FST and RST
-  Marls
-  Platy-coral Boundstones

-  Chondrites trace-fossil
-  Gastropods
-  Echinoderms
-  Corals
-  Oncoids
-  Bivalves
-  Brachiopods
-  Bioclasts

-  Brachiopod-rich marly FST and RST
-  Marls
-  Marly MST

OXFORDIAN BIOSTROMES

Tidili outcrop



Oxfordian-Kimmeridgian
Palaeomap
From Scotese, 2011

Evolution of coral
associations

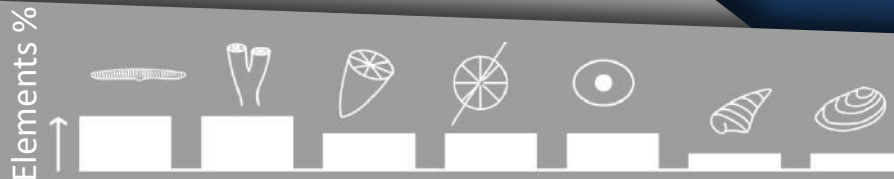


Prograding
Clinoforms

Rimmed platform:

- Coral reefs
- MST / PST / BST
- Diachronism
- Shallowing upward

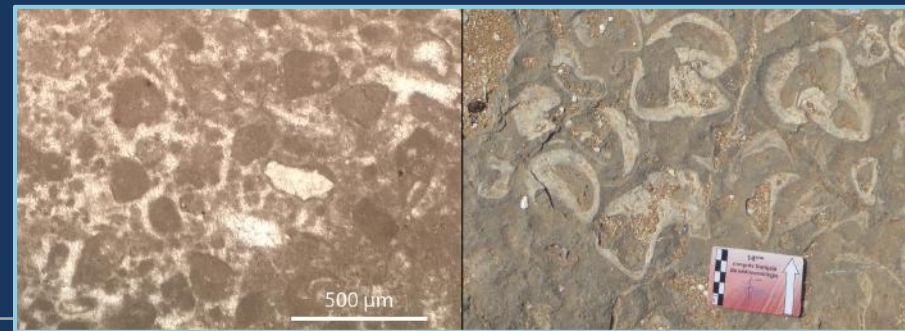
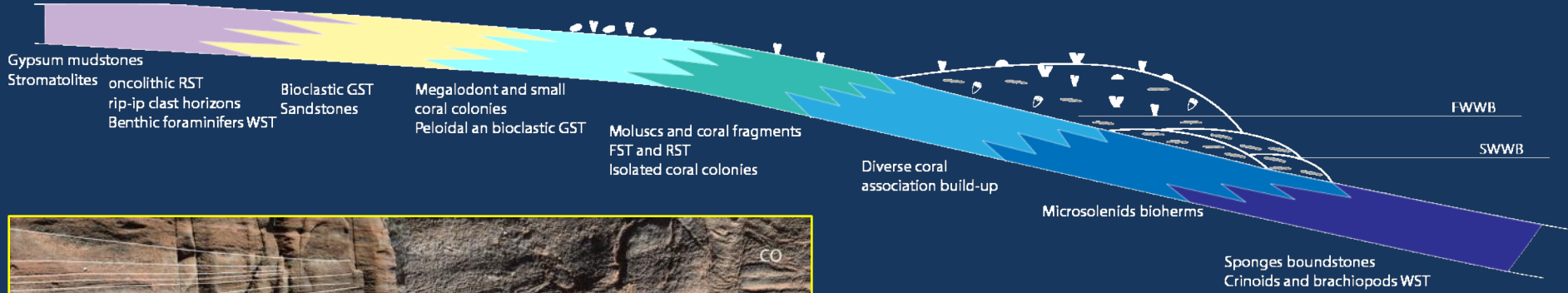
BST/FST
Elements



DEPOSITIONAL ENVIRONMENT

SUPRATIDAL INTERTIDAL SUBTIDAL

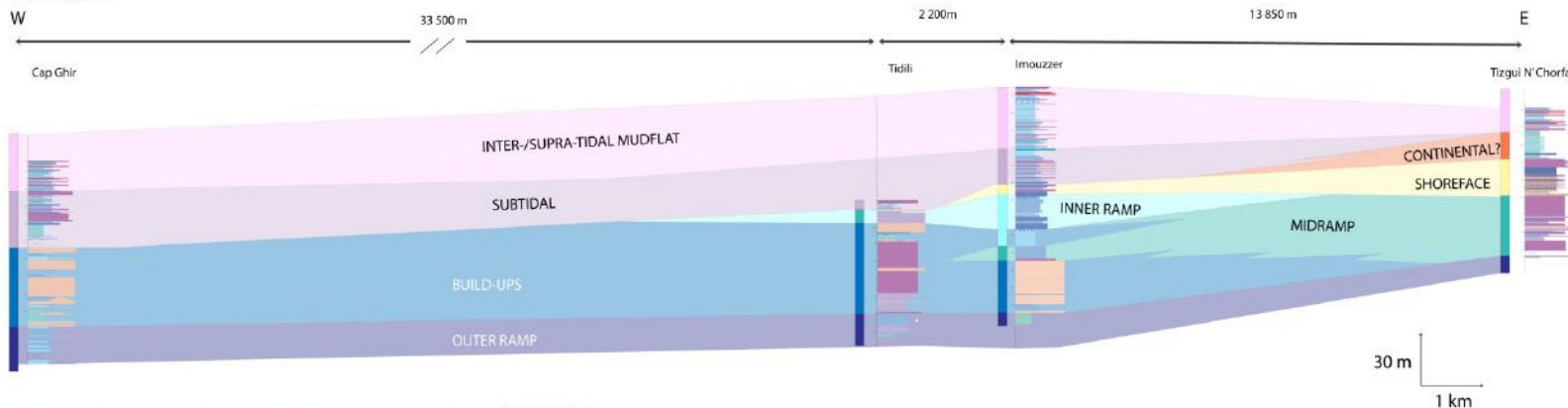
MUDFLAT UPPER SHOREFACE INNER RAMP MIDDLE RAMP OUTER RAMP



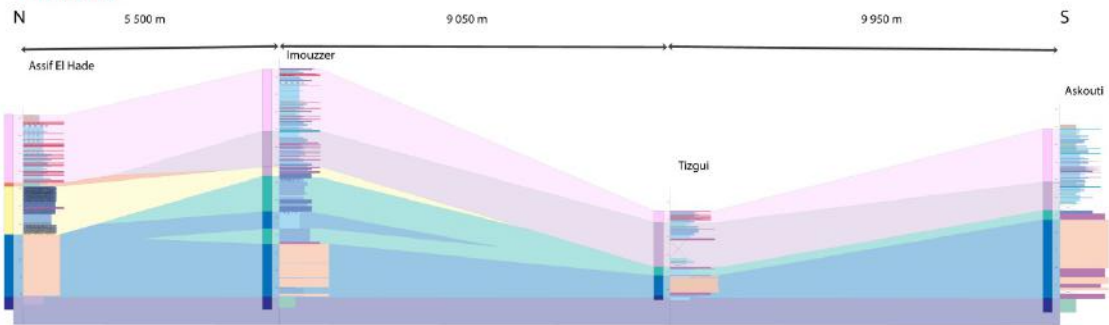
CALLOVIAN - OXFORDIAN

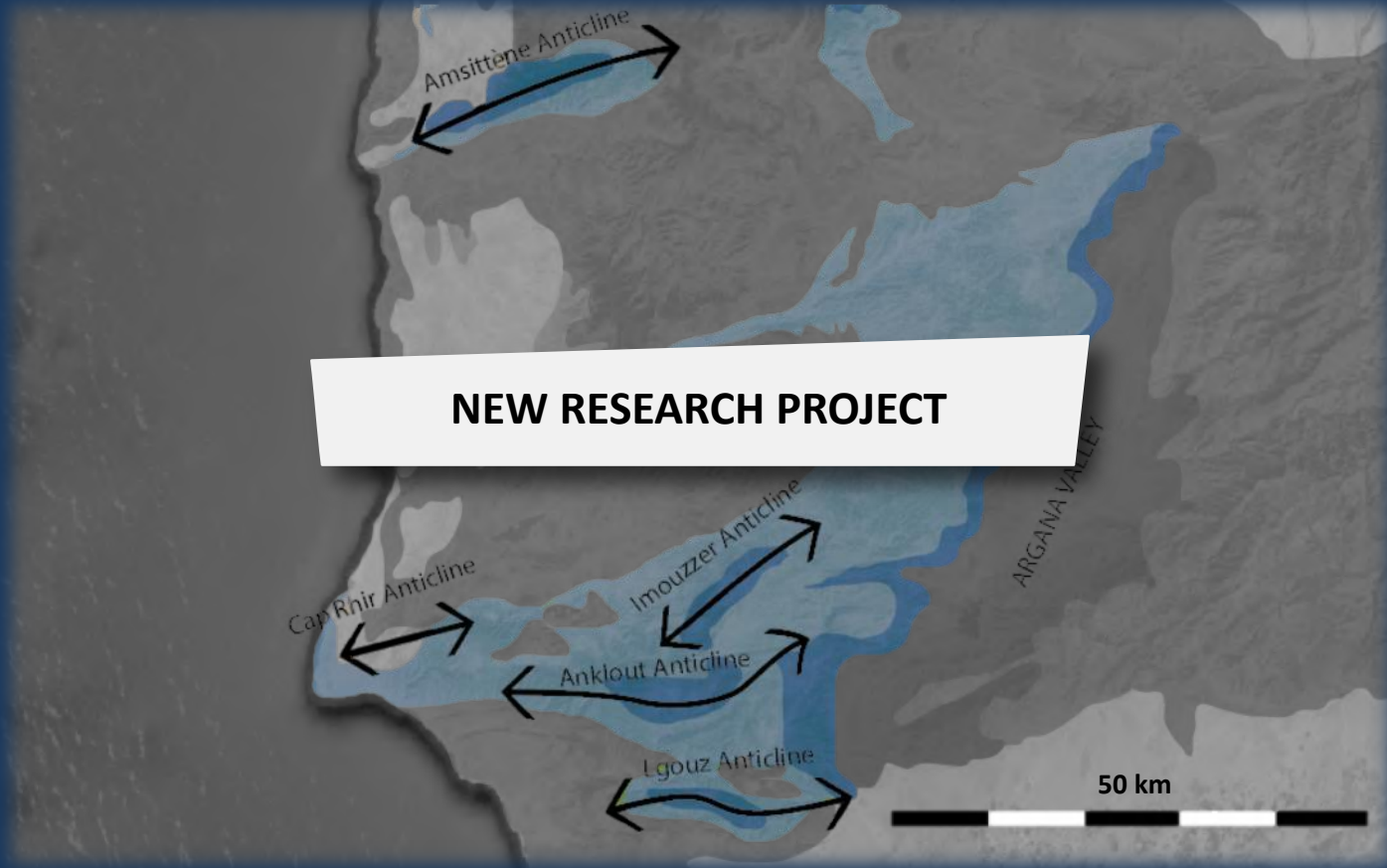


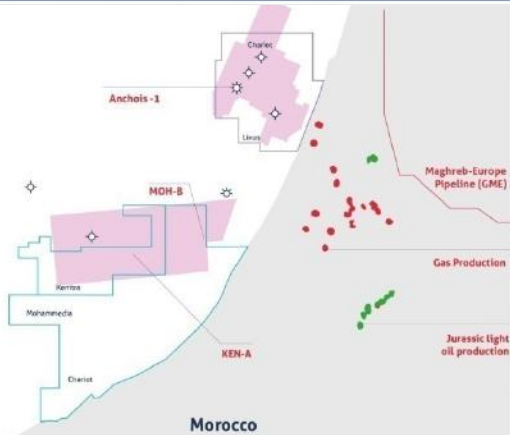
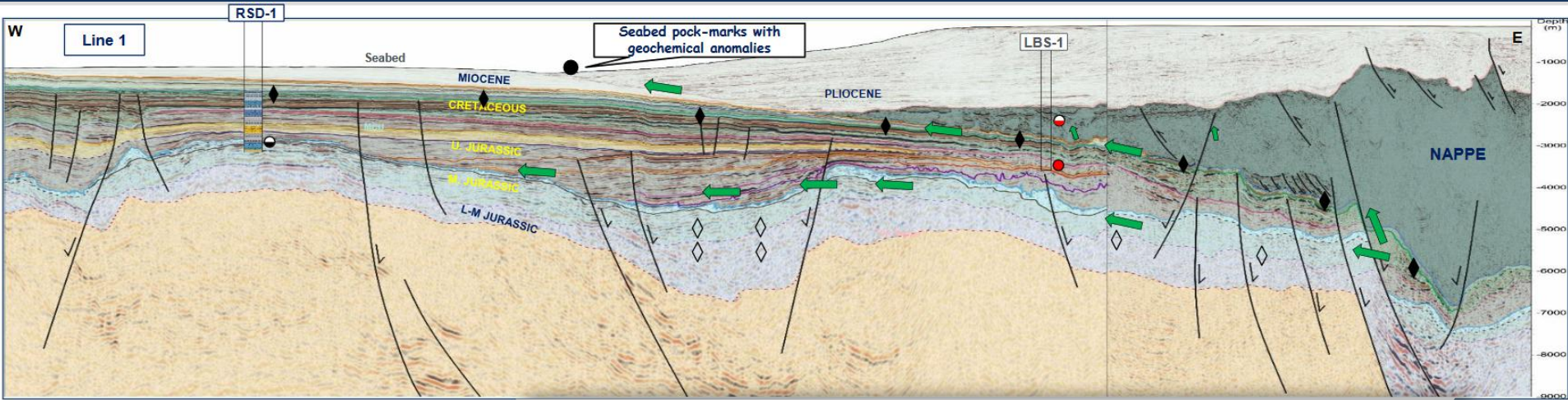
Transect A:



Transect B:



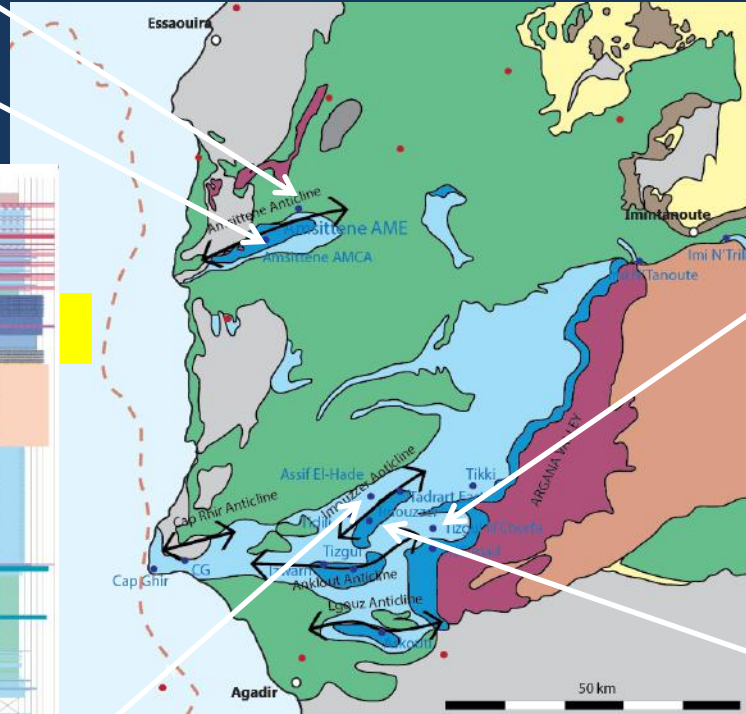




CHARIOT OIL & GAS

- Upper Jurassic clastic reservoirs
- Up to 20-30% porosity
- Cretaceous potential source rock

SILICICLASTIC INFLUX



AMSITTENE NE

TIZGUI N'CHORFA



AMSITTENE S

ASSIF EL HADE

IMOUZZER



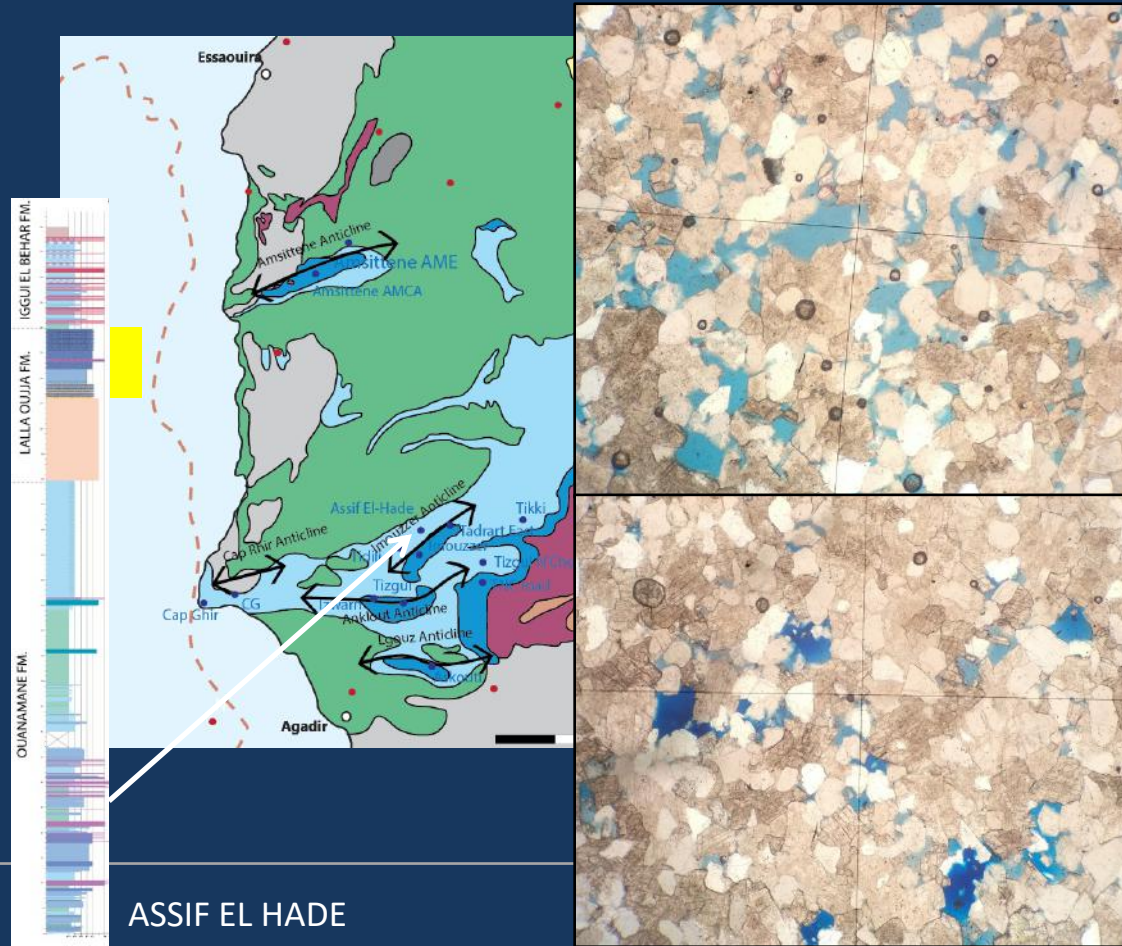
SILICICLASTIC INFLUX



Dolomitic sandstones
Rounded Qz grains

Qz content: 60-70%
Fine to medium grains

Porosity: 7-20%

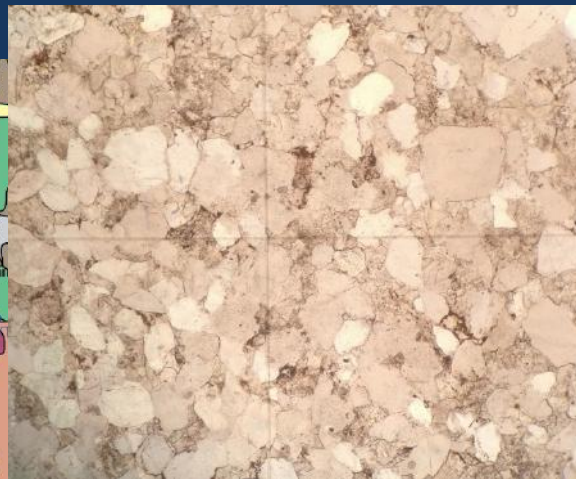
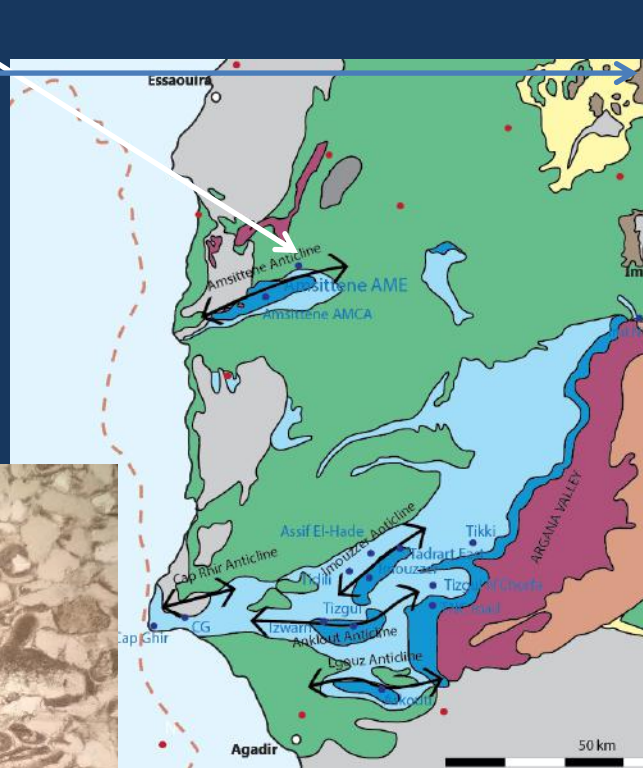


ASSIF EL HADE



SILICICLASTIC INFLUX

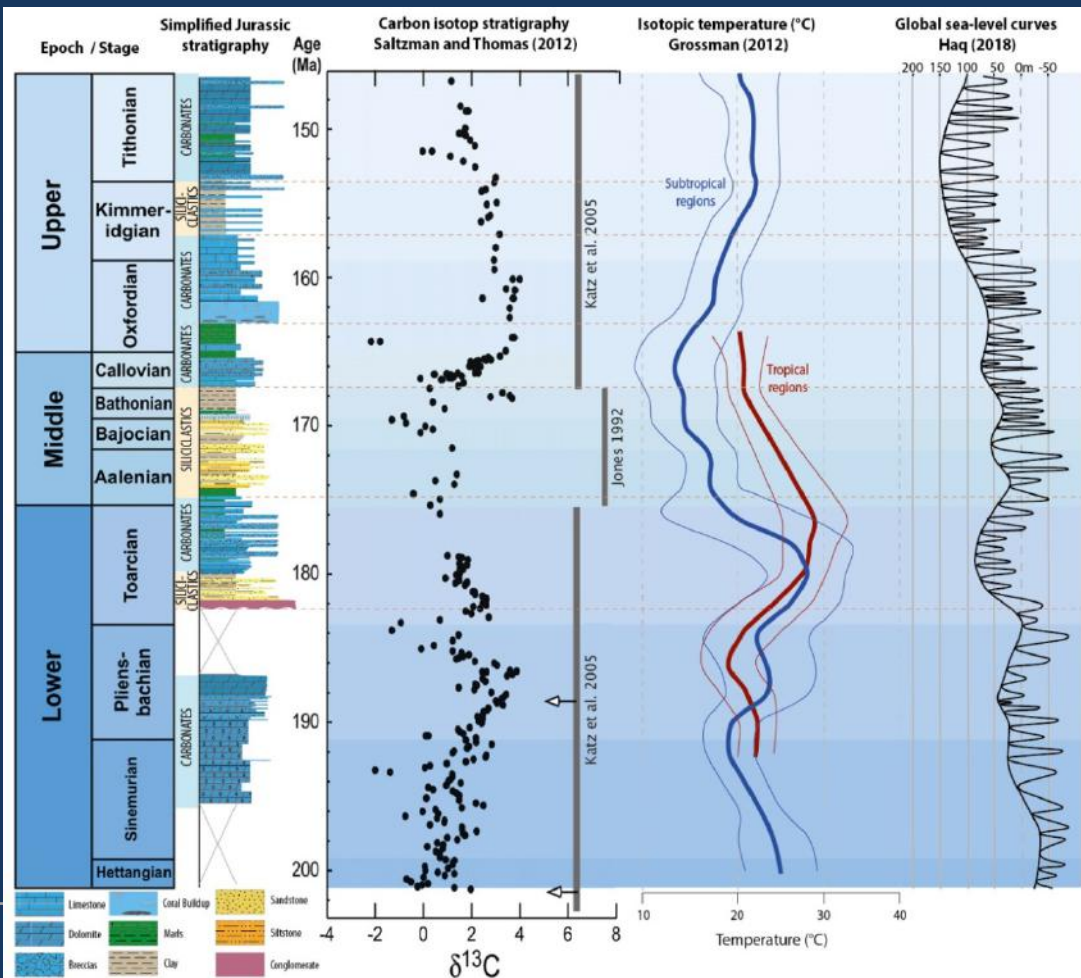
AMSITTENE NE



Sandstone
Carbonate cement
→ Very well rounded
→ Fine to coarse Qz

Sandstone and few bioclasts (10-15%)
Carbonate cement

ENVIRONMENTAL VARIATIONS



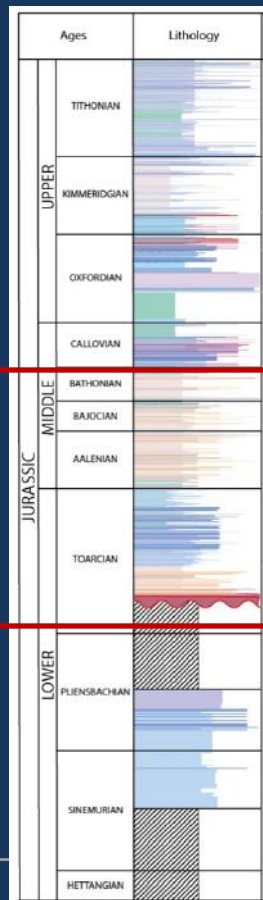
Carbon + Temperatures



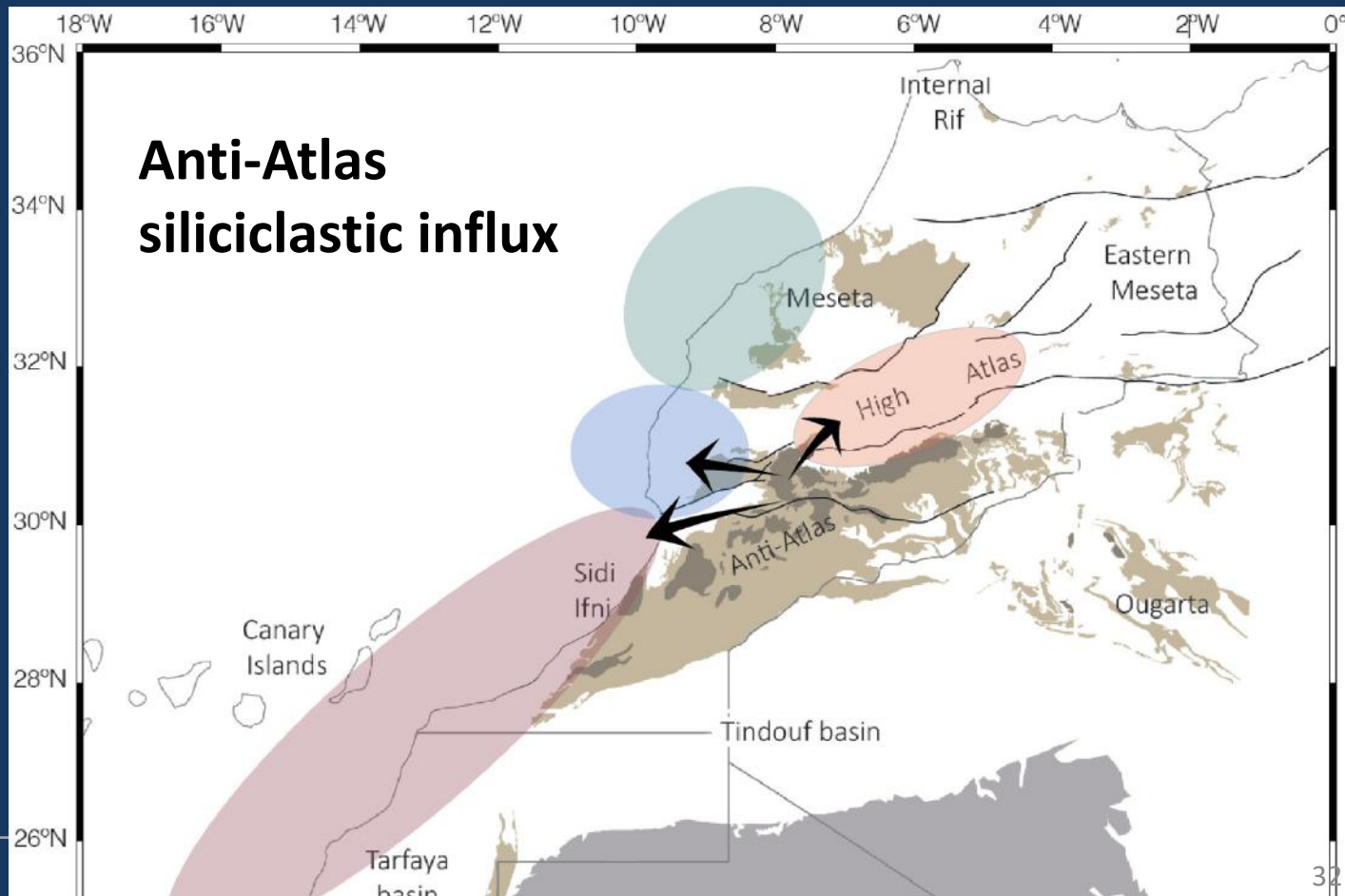
Temperatures + Carbon



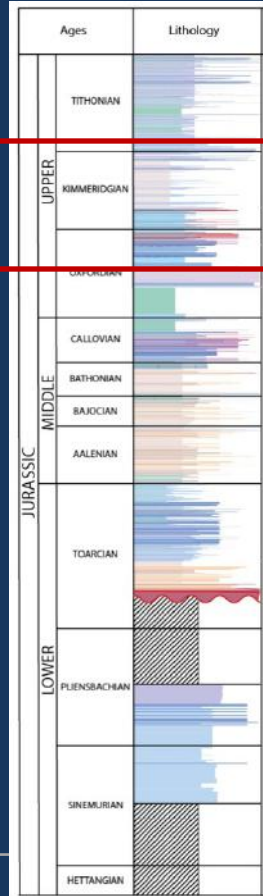
LOWER AND MIDDLE JURASSIC



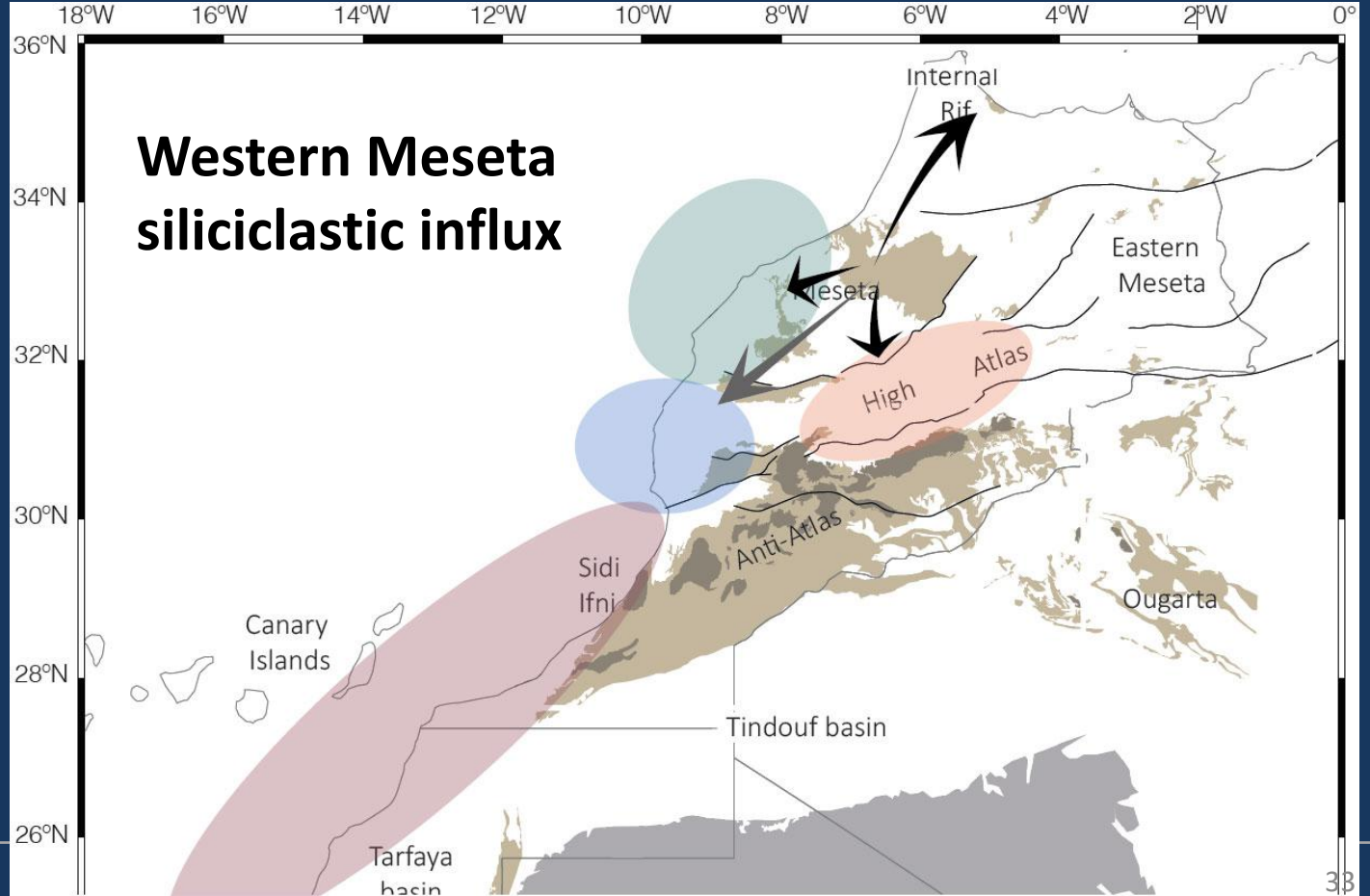
Siliciclastic influx



UPPER JURASSIC



Siliciclastic influx

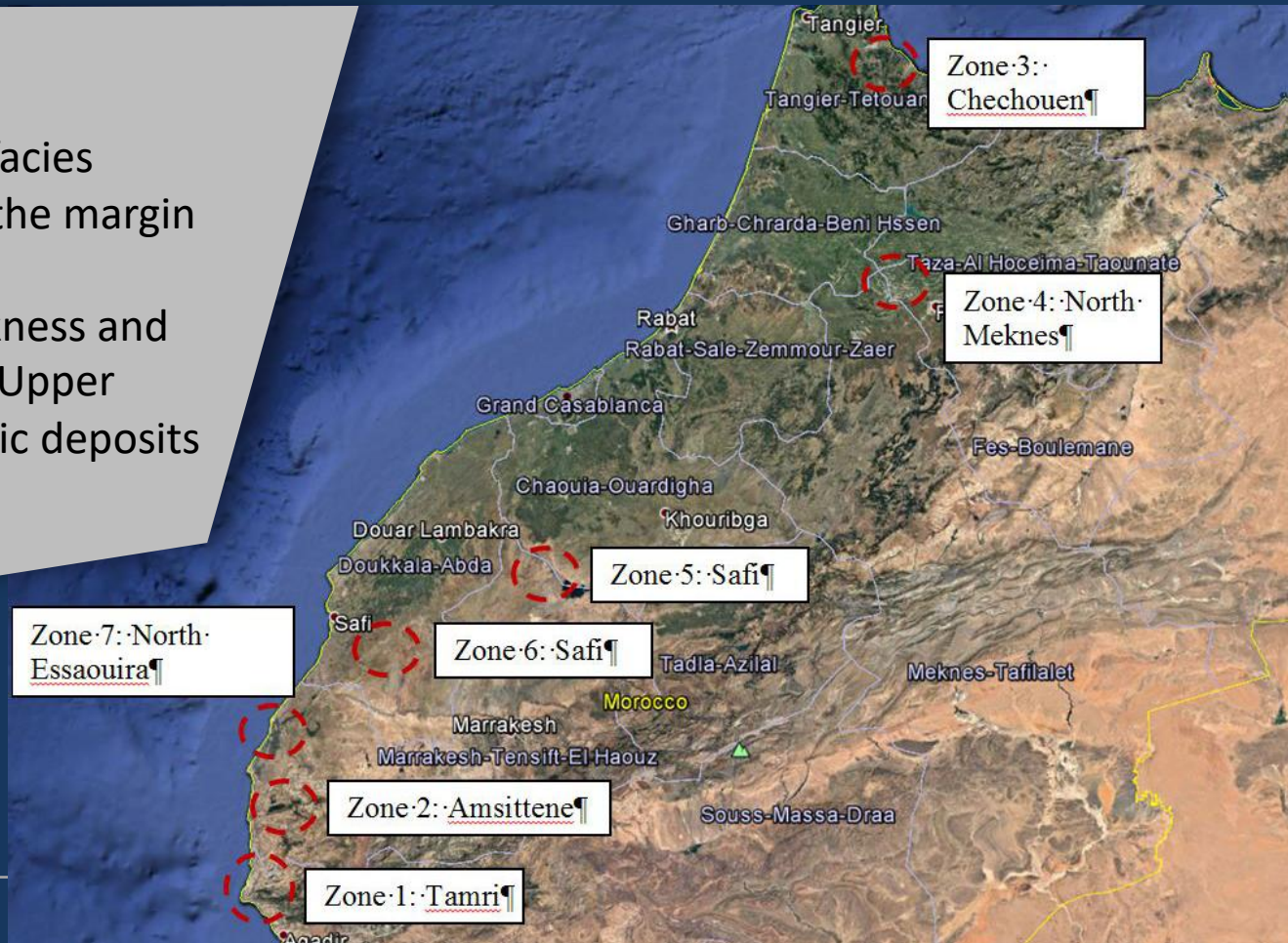


PLANNED FIELD WORK



GOALS:

- Document the facies variations along the margin
- Assess the thickness and extension of the Upper Jurassic siliciclastic deposits





- New focus on Upper Oxfordian Siliciclastics
- Potential for offshore reservoir
- Longer term focus on understanding the Atlantic Margin
- Constraint of the siliciclastic deposits extension
- Extend the study offshore
- Mixed systems understanding / Model
- Good analogue for the Sable Delta (Nova Scotia)

THANK TO OUR SPONSORS :



TOTAL

woodside

REPSOL

bp



equinor



Special thanks :

