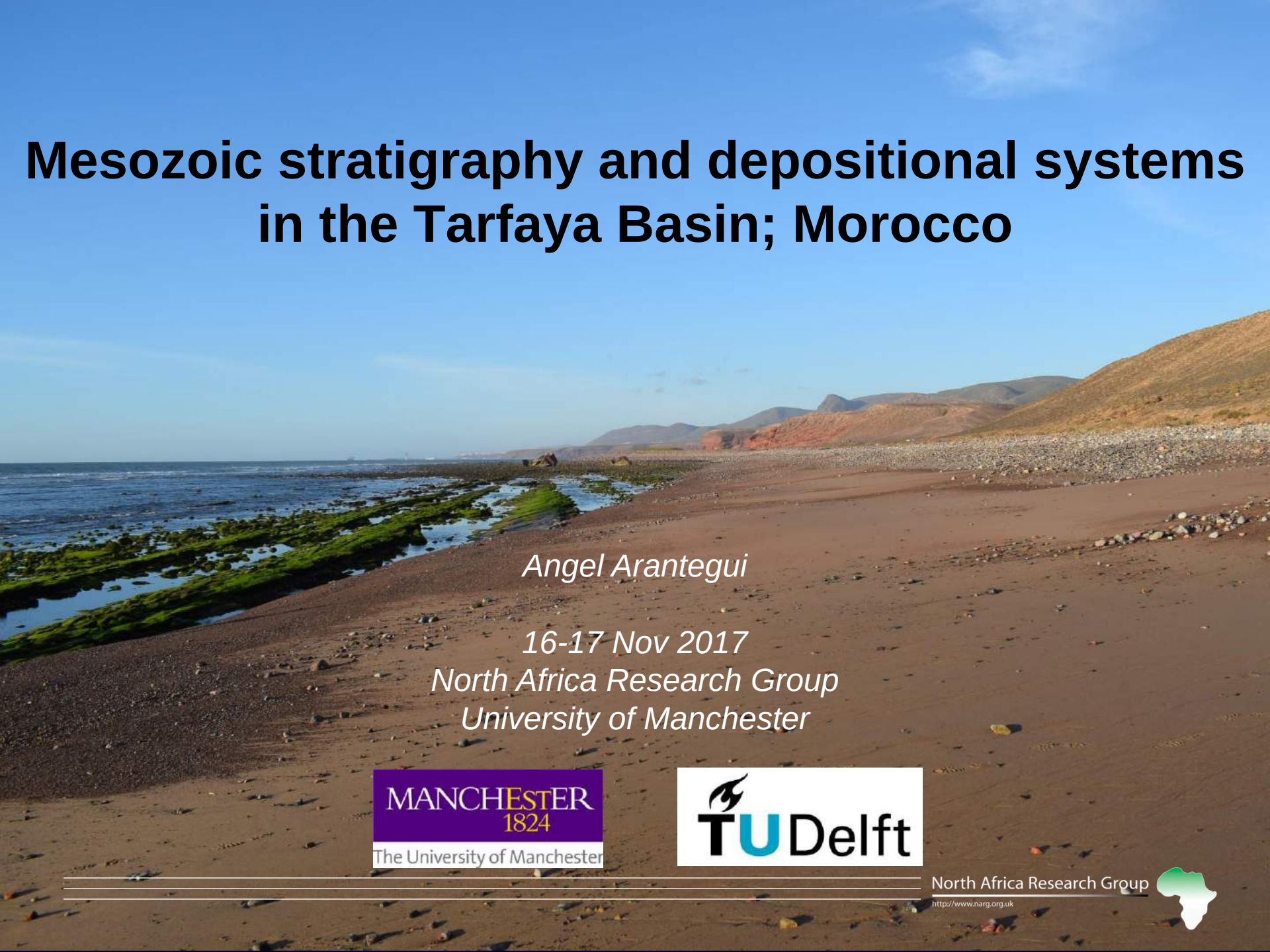
Mesozoic stratigraphy and depositional systems in the Tarfaya Basin; Morocco



Angel Arantegui

16-17 Nov 2017
North Africa Research Group
University of Manchester

MANCHESTER 1824
The University of Manchester

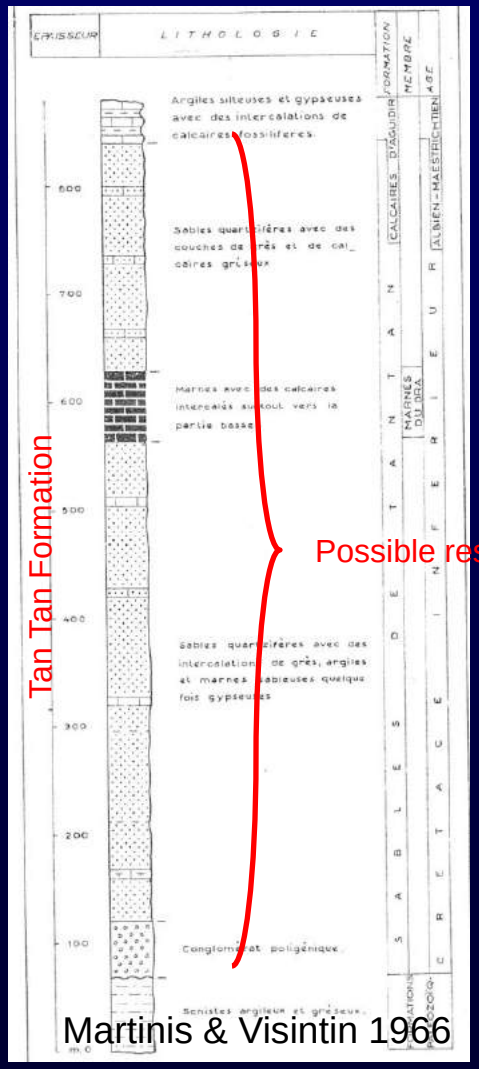
TU Delft

North Africa Research Group
http://www.narg.org.uk

INTRODUCTION

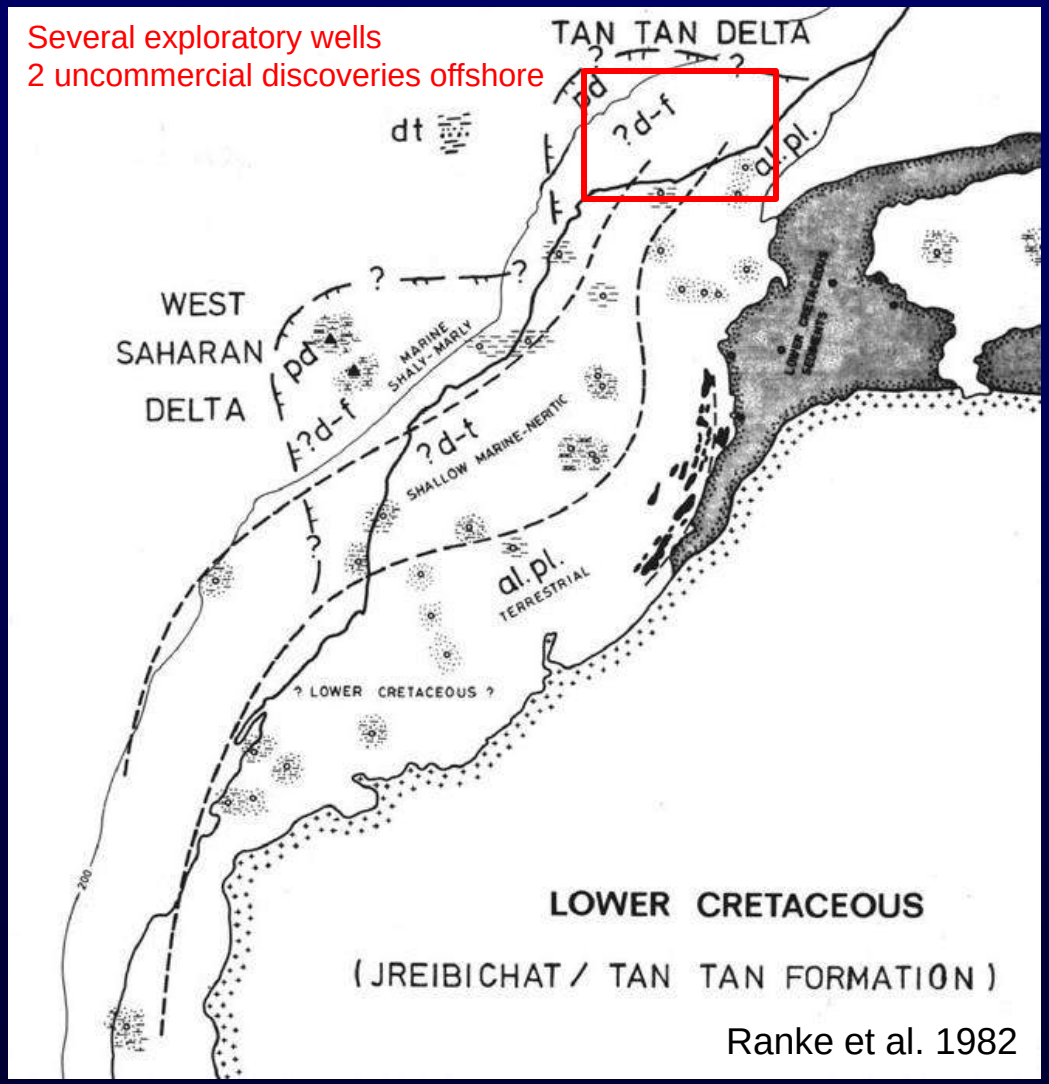
RATIONALE

- First geological maps in the 1940's
- 50-60's exploration and drilling of the first wells
- 1966 → Tan Tan Fm.



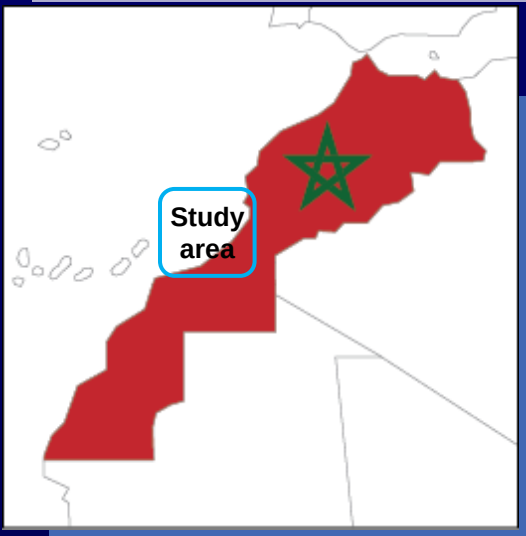
Martinis & Visintin 1966

Several exploratory wells
2 uncommercial discoveries offshore



Ranke et al. 1982

RATIONALE



- Sand present in the basin
- Working petroleum system (Jur carbonates)
- Reservoirs offshore?
- Still an underexplored basin

E Cretaceous

Deep basin

Present day shelf

Continent

Reservoir (Sand)

No reservoir

Amber-01

Rak-01

Foum Draa-01

Sidi Moussa-01

Ifni-01

Tan Tan-01

Haut Mer-01

MO-6

MO-4

MO-7

MO-1

MO-3

MO-5

Fuerteventura

Cap-Juby-01

Tarfaya-01

Oued Draa

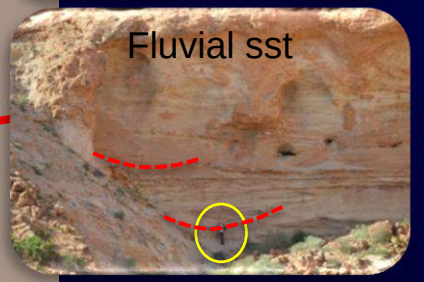
Oued Chebeika

Chebeika

Puerto Cansado

El Amra

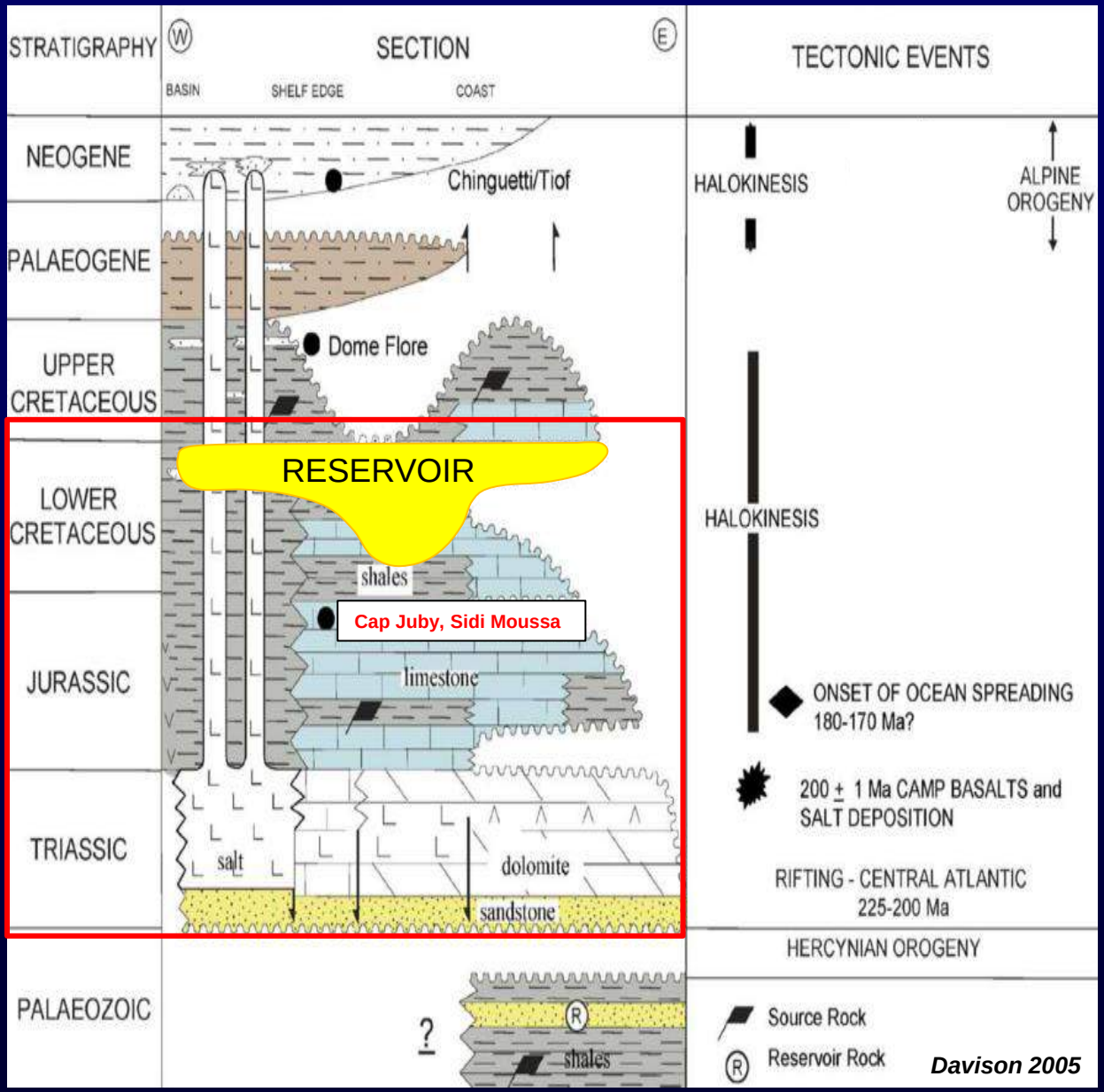
0 15 30 60 90 120 Km

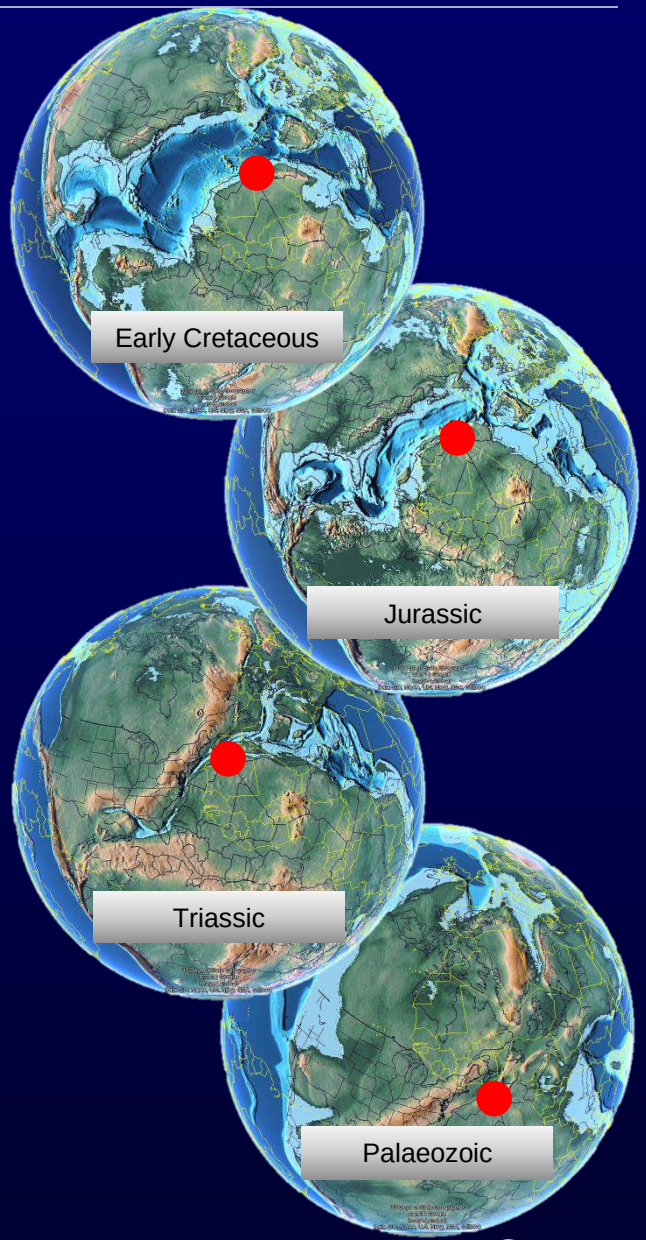


AIMS

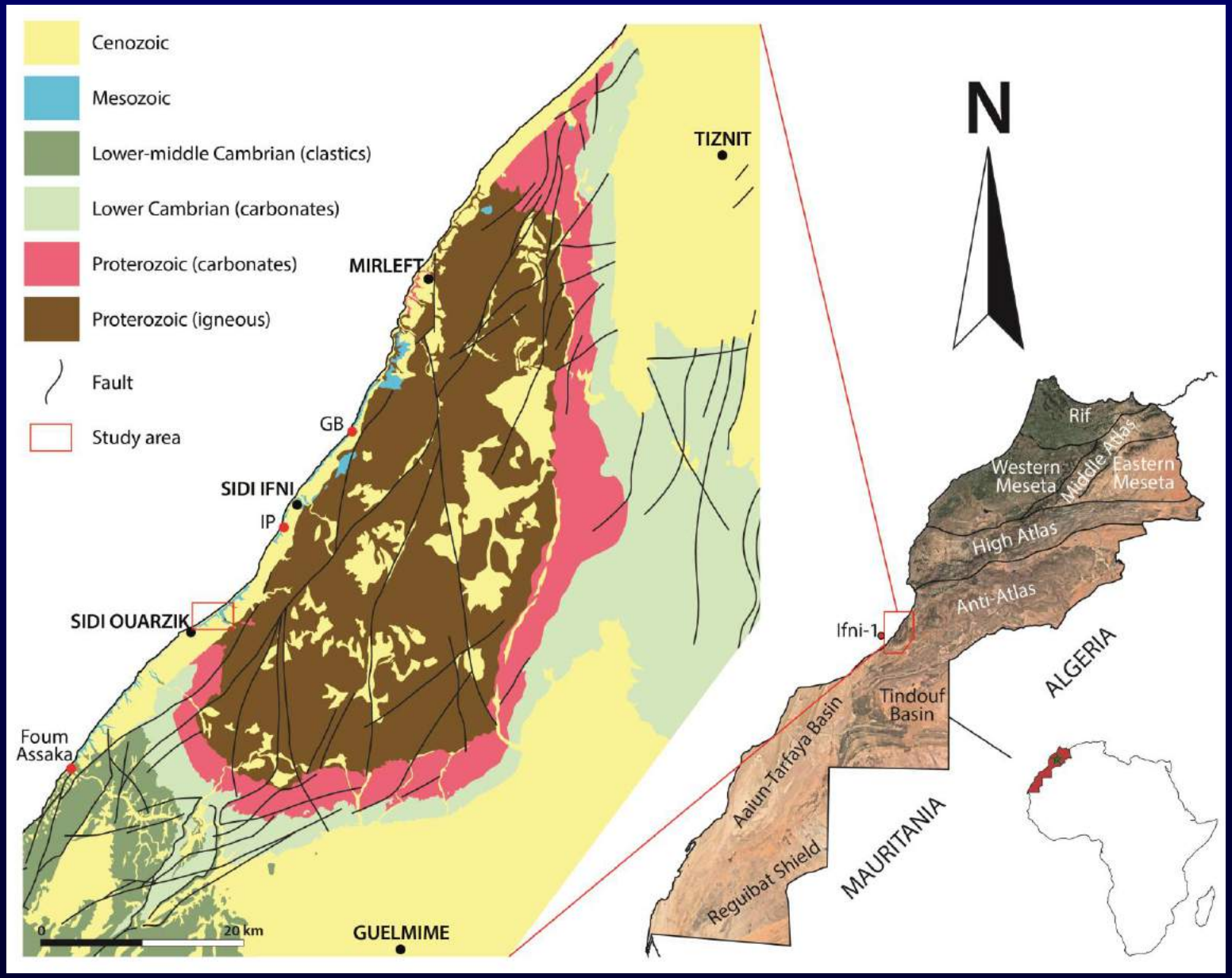
- To revise the lower Cretaceous succession (and Jurassic)
  - Lithostratigraphy
  - Biostratigraphy
  - Vertical and lateral facies distribution
- Palaeogeographic maps for selected times
- Depositional model to aid in reservoir prediction offshore

STRATIGRAPHY





RESULTS - IFNI



Ifni inlier - Precambrian

Continental

Peritidal

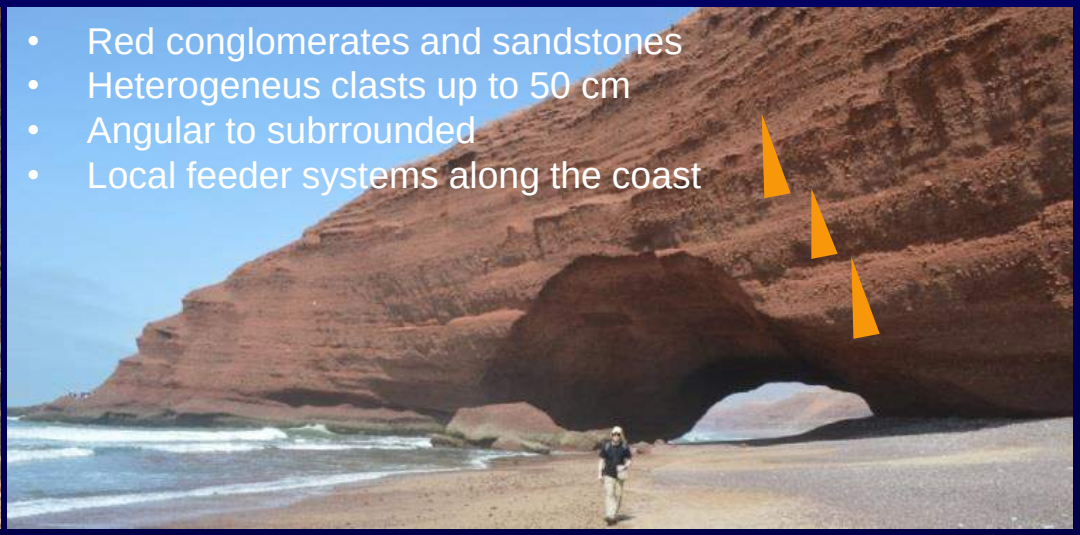
Shallow marine

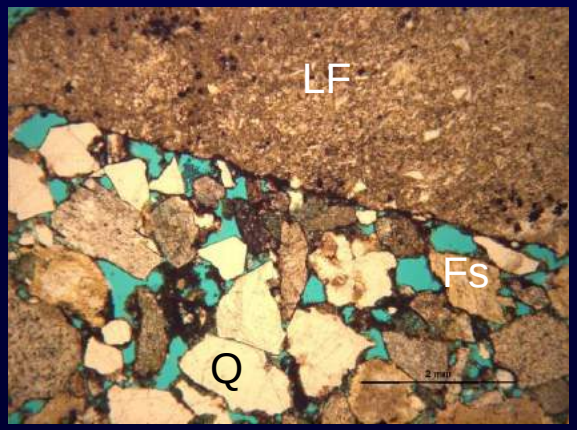
Previously Tan Tan Fm.
Three new lithostratigraphic units (Fm.)
Continental red conglomerates and sands
Peritidal mixed clastics and carbonates
Shallow marine mixed carbonates and clastics

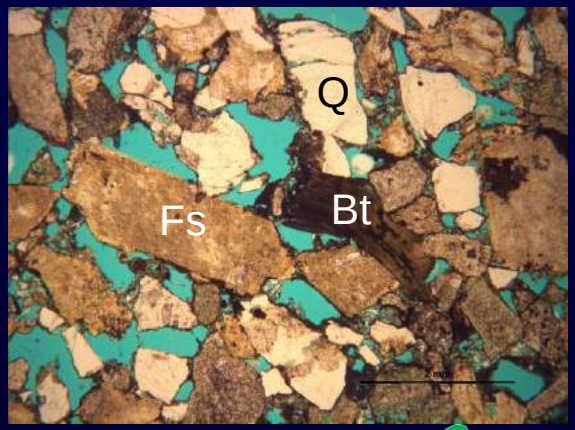
200 m

Alluvial Fans – Guezira Beach Fm.

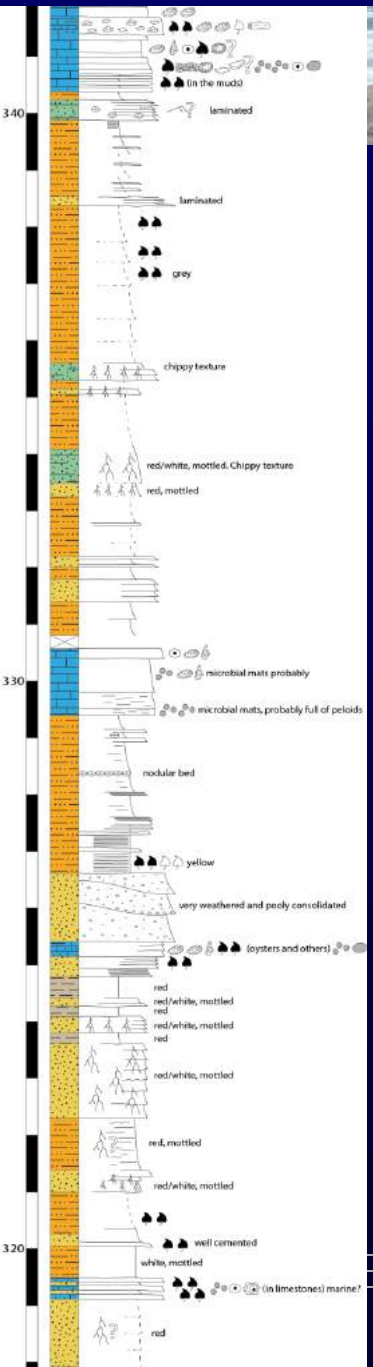
- Red conglomerates and sandstones
- Heterogeneus clasts up to 50 cm
- Angular to subrrounded
- Local feeder systems along the coast







Tidal flats – Oued Craima Fm.

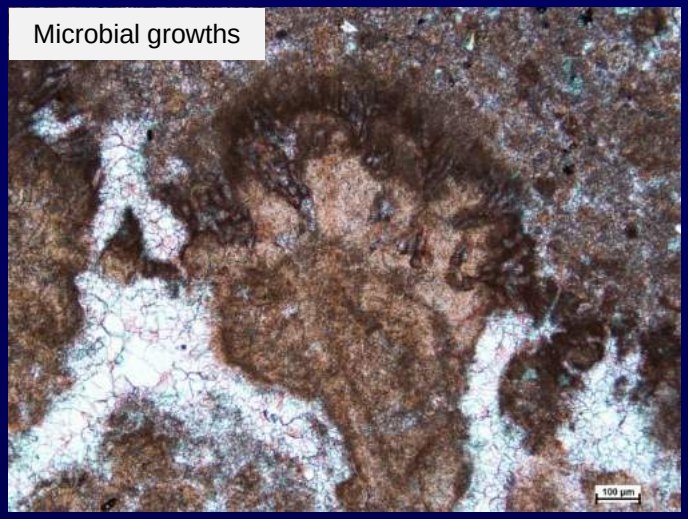


- Laminated siltstones and sandstones
- Ripple cross lamination
- Frequent palaeosols
- Microbial/algal carbonate interbeds
- Fossil-rich carbonate beds

AGE

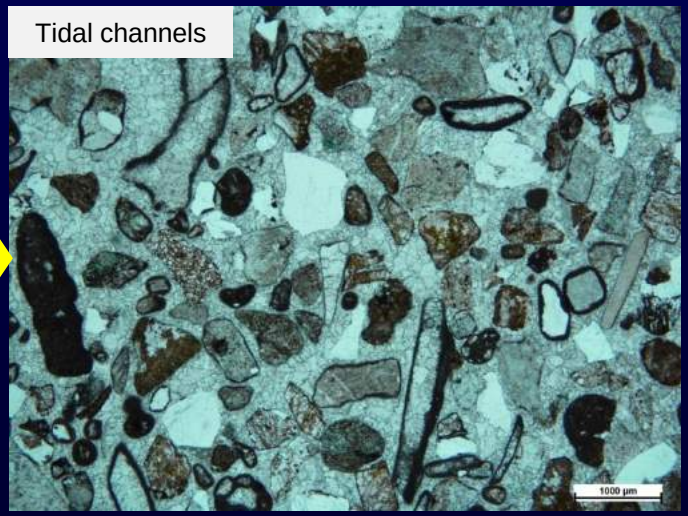
- Benthic foraminifers → Middle Jurassic
- Bivalves + gastropods → Bathonian

Microbial growths

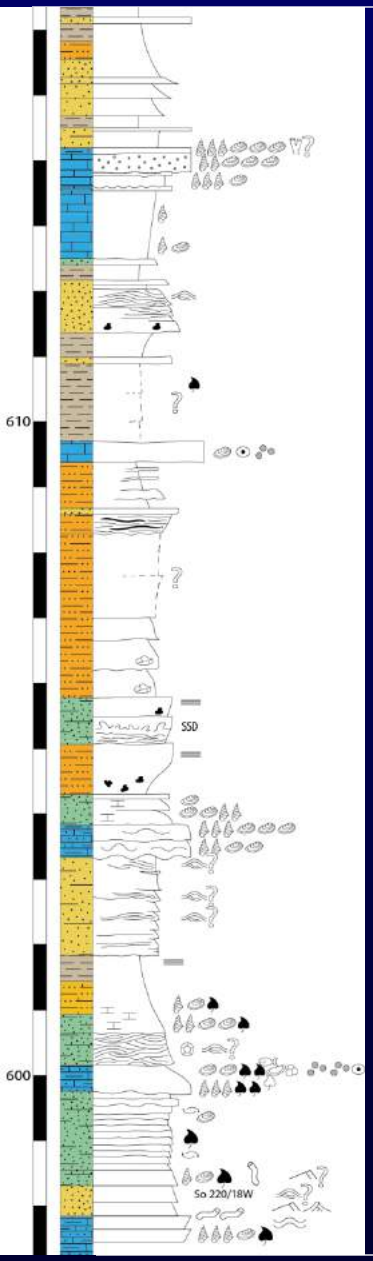


Tidal channels

Tidal channels



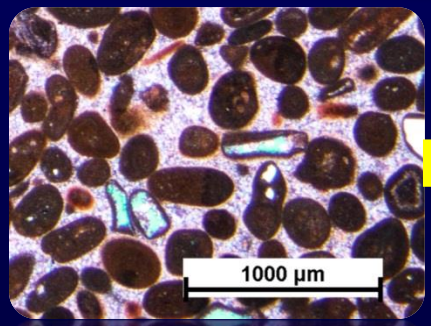
Shallow marine – Craima Beach Fm.

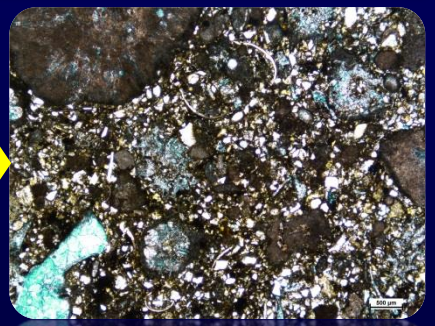


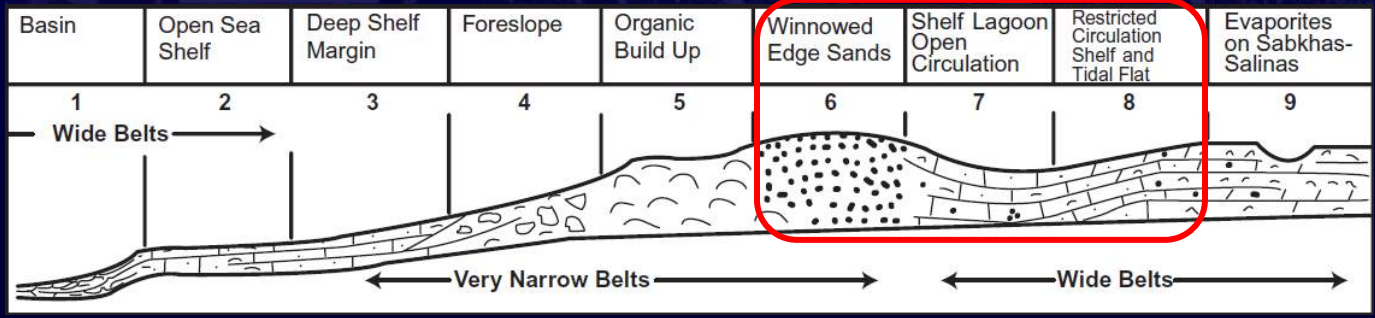
- Mixed siliciclastic-carbonate system
- Shallowing-upward cycles
- Lagoon to shoal carbonates
- Restricted muds
- Shoreface bioclastic-rich sandstones (top)

Bathonian

clastic input







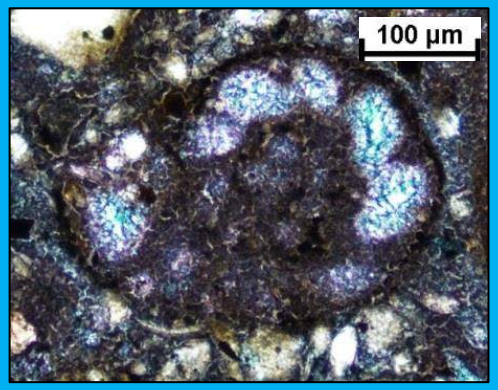
Middle to Late Jurassic

Benthic foraminifers:

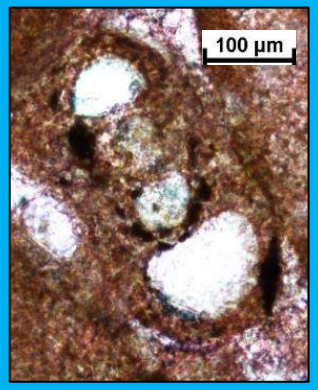
- **Nautiloculina sp.**
- **Nautiloculina oolithica**
- **Nautiloculina circularis**
- **Bosniella croatica**
- **“Globuligerina“**

Green algae (Dasyclads):

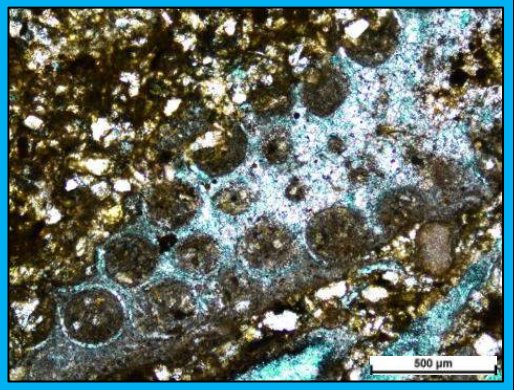
- **Holosporella siamensis**



Bosniella croatica

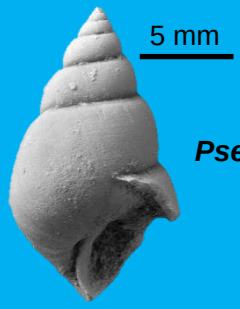


Nautiloculina oolitica

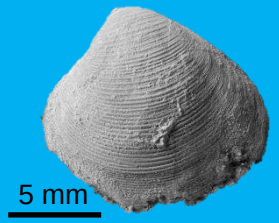


Holosporella siamensis

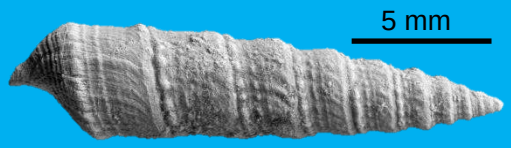
Bathonian



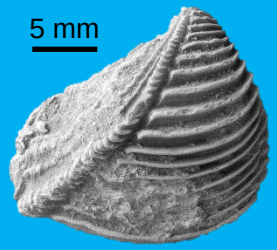
***Pseudomelania* (*Oonia*) *variata* (Lycett, 1863)**



***Eocallista antiopa* (d'Orbigny, 1850)**

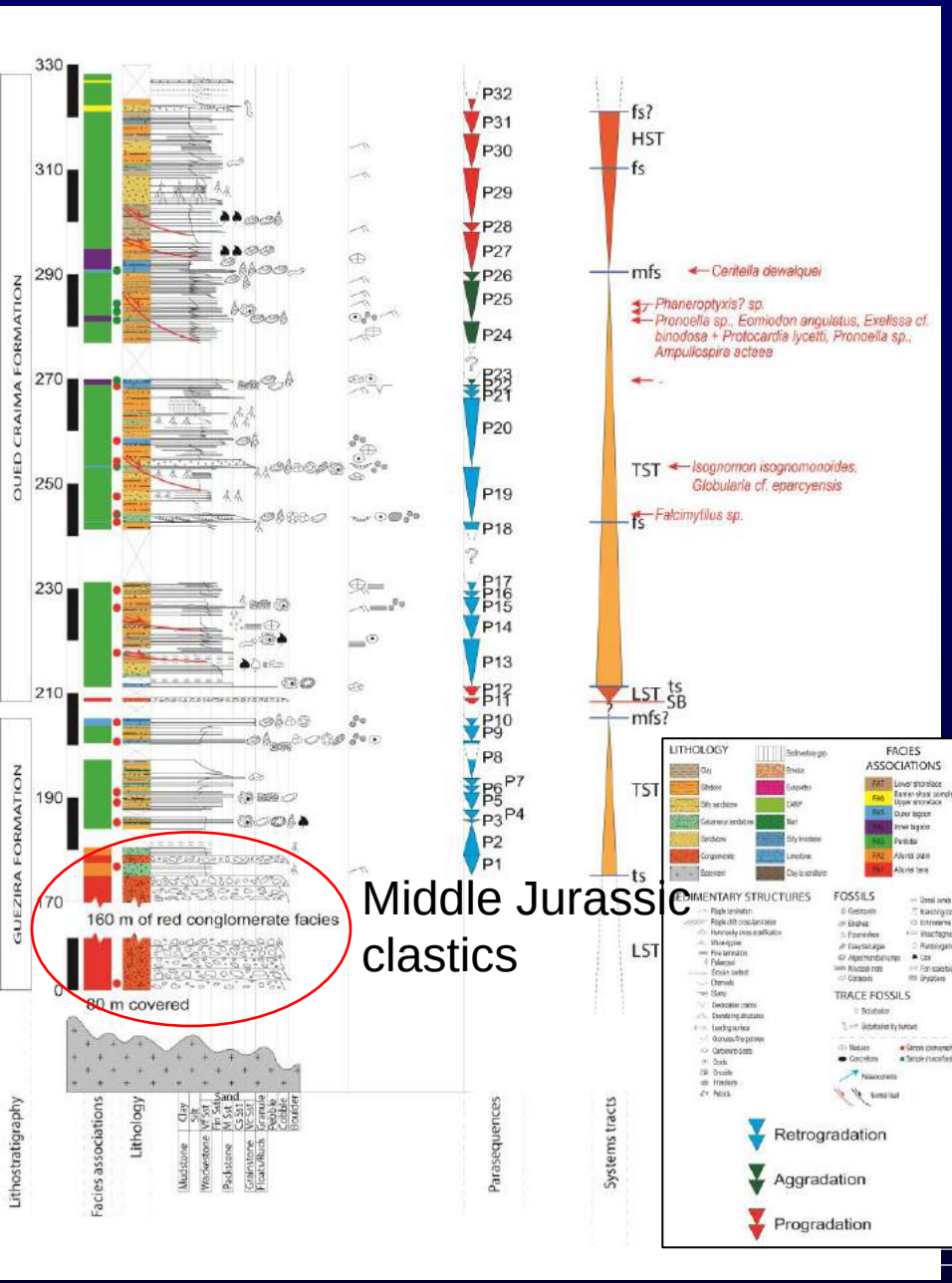


***Ceritella dewalquei* (Piette, 1857)**

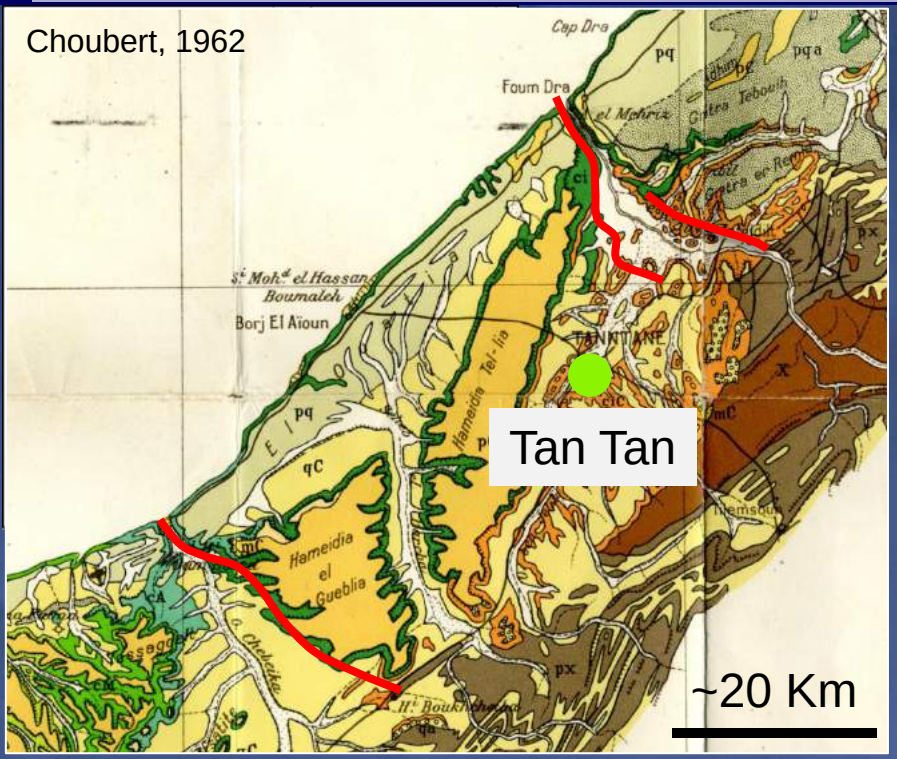


***Trigonia pullus* J. de C. Sowerby, 1826**

CRAIMA - DATING



RESULTS – TAN TAN



Sidi Ifni

Guelmim

Oued Draa

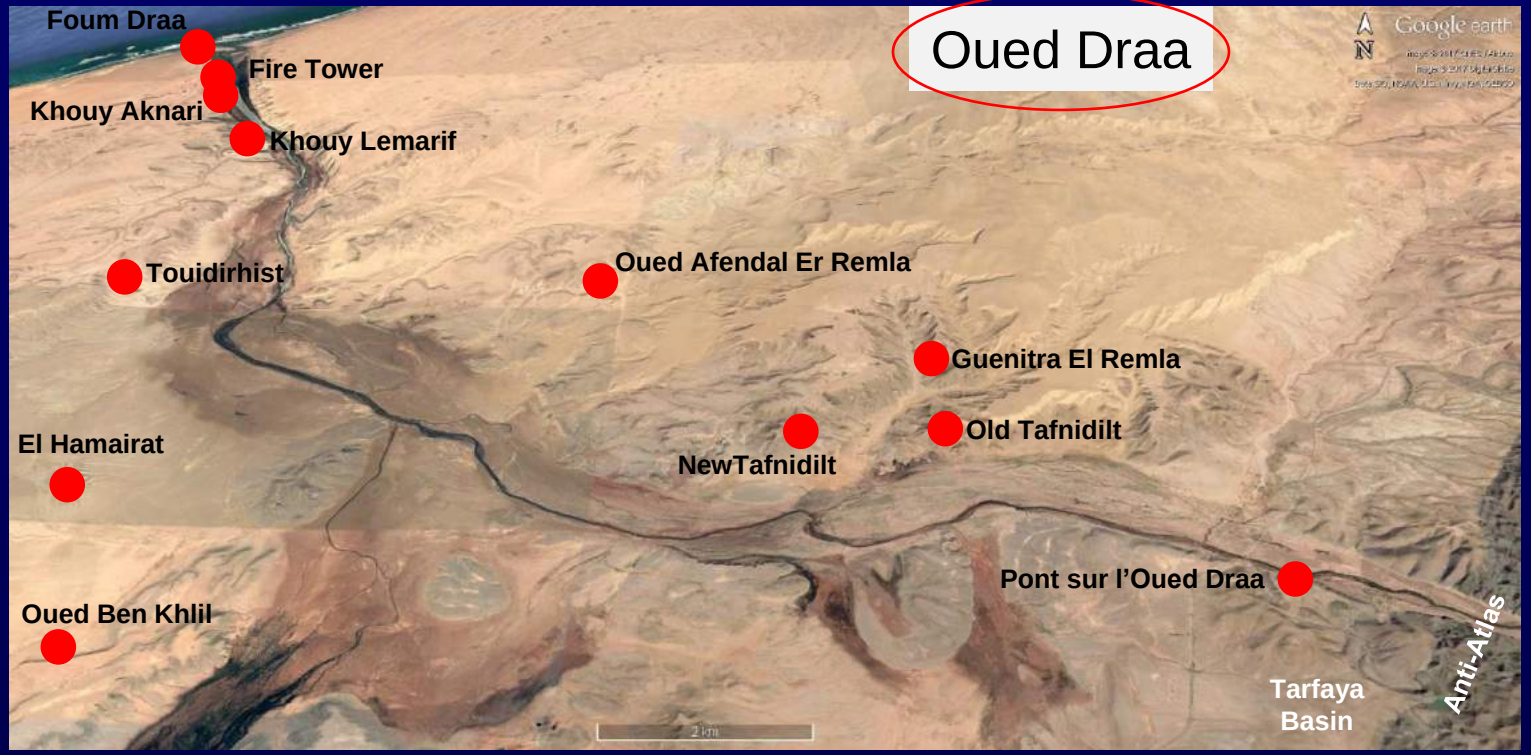
Tan Tan

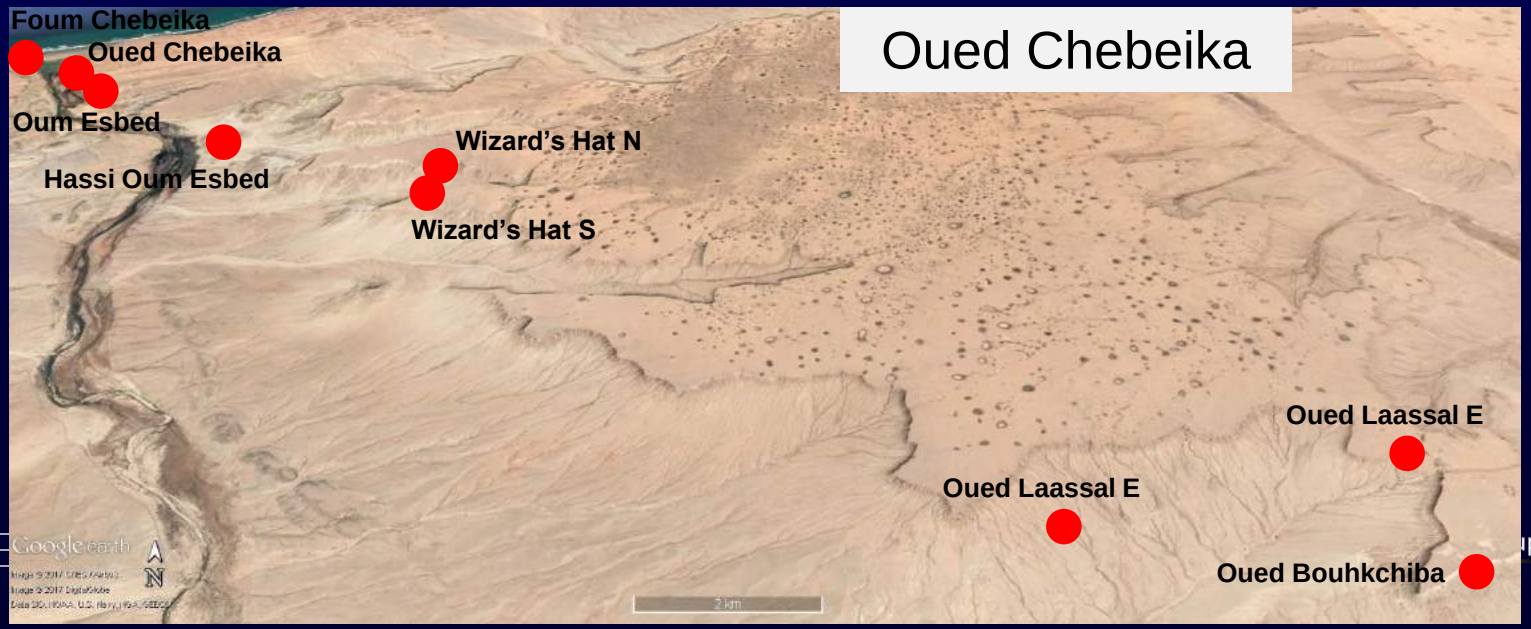
Tarfaya Basin

Oued Chebeika

N

50 km


Oued Draa
Foum Draa
Fire Tower
Khouy Aknari
Khouy Lemarif
Touidirhist
Oued Afendal Er Remla
Guenitra El Remla
Old Tafnidilt
NewTafnidilt
El Hamairat
Pont sur l'Oued Draa
Oued Ben Khlil
Tarfaya Basin
Anti-Atlas


Oued Chebeika
Foum Chebeika
Oued Chebeika
Oum Esbed
Hassi Oum Esbed
Wizard's Hat N
Wizard's Hat S
Oued Laassal E
Oued Laassal E
Oued Bouhkchiba

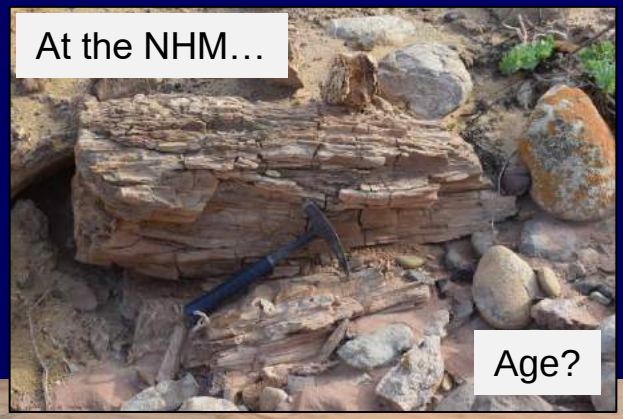
Pont Sur l'Oued Draa

Anti-Atlas

Tarfaya Basin

- Red polymictic conglomerates
- ~ 50 m thick
- Clasts from Anti-Atlas
- No sedimentary structures

Pont Sur l'Oued Draa



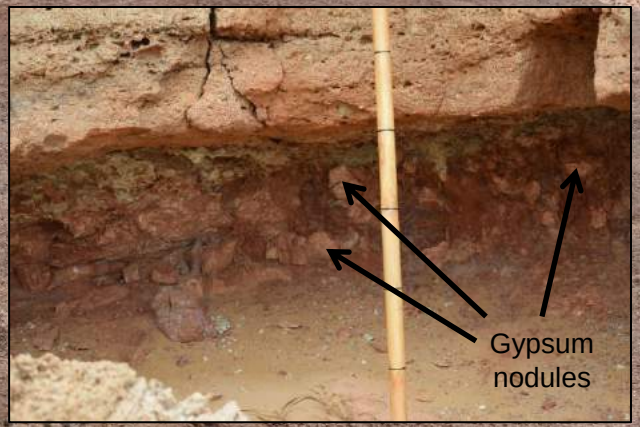
conglomerates

Oued Draa

- Oued Draa active at this time

Channel fills and flood plain

- Coarse-very coarse-gr sandstones (+ pebbles)
- Crossbedding
- Palaeosols on silts-sandstones



Oued Ben Khlil

Tidal flats

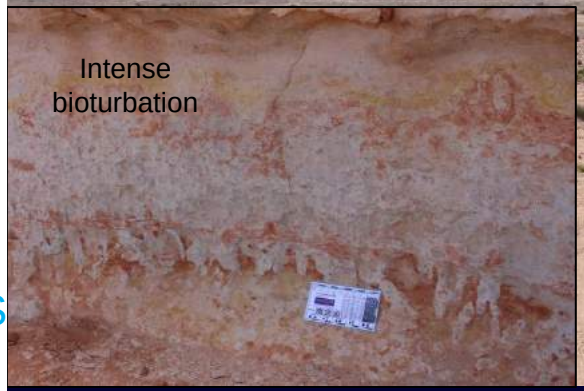
- Development of thick palaeosols
- Intensely bioturbated fine-grained sandstones
- Occasional tidal channels/creeks
- Possible eolian dunes?

FS

FS

FS

FS



Outcrop: New Tafnidilt

Khouy Aknari

Shoreface

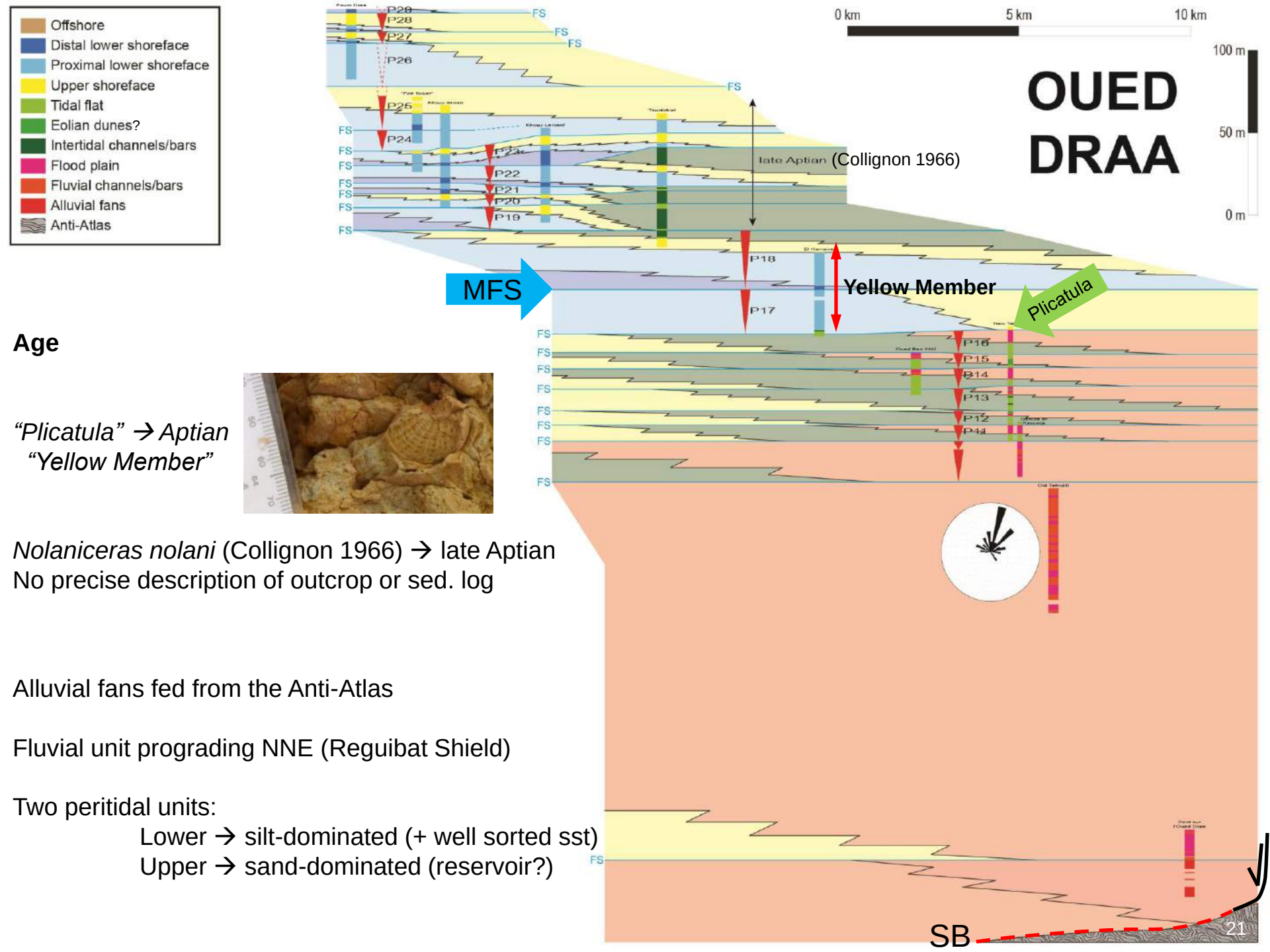
- Marine facies systematically yellow in the field
- Sand to silt (occasional limestones and clays)
- Crossbedding, wave and current ripples, HCS, pebble/shell lags, etc.
- Locally, intense bioturbation


Shell lags


Wave ripples


Bioturbation


HCS



Age

"Plicatula" → Aptian
"Yellow Member"

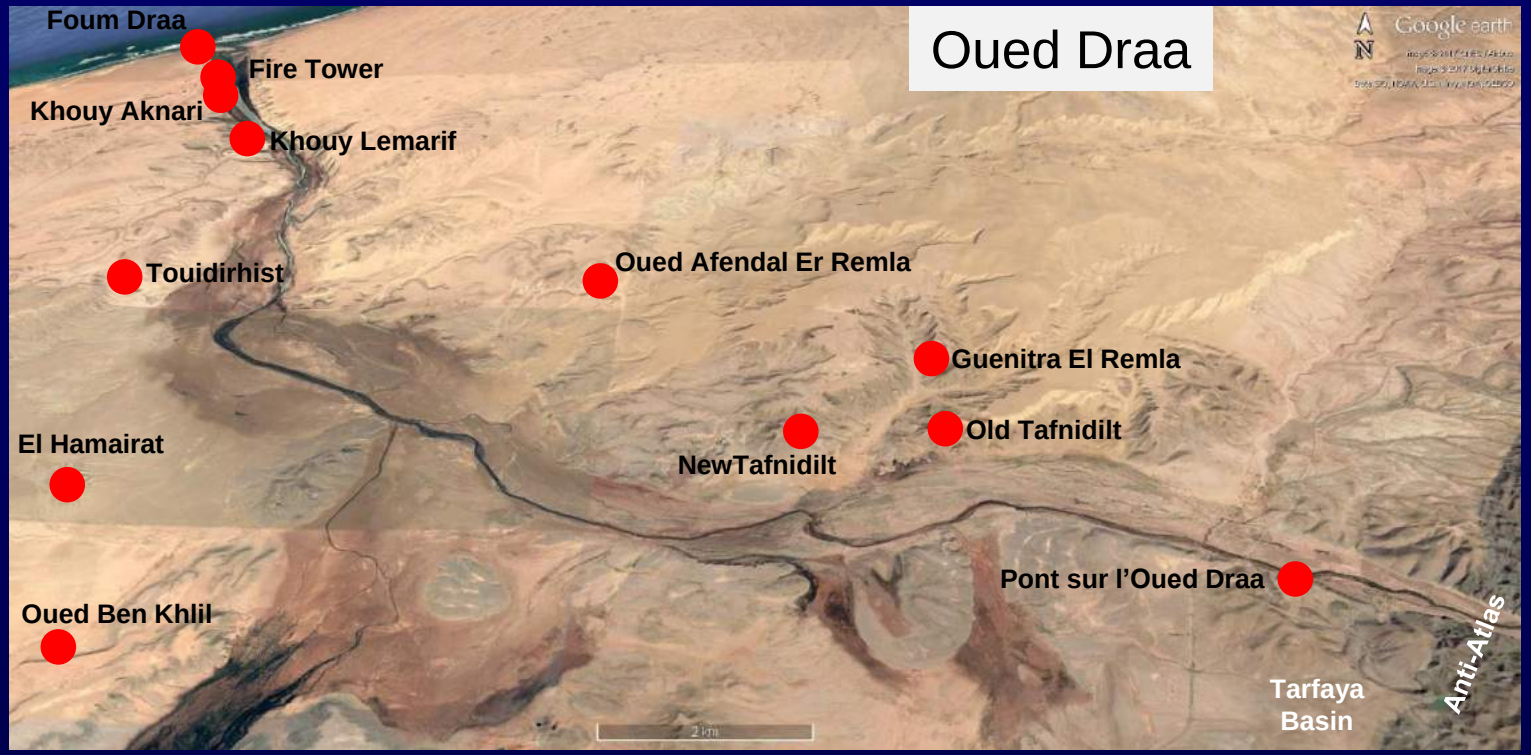
Nolaniceras nolani (Collignon 1966) → late Aptian
No precise description of outcrop or sed. log

Alluvial fans fed from the Anti-Atlas

Fluvial unit prograding NNE (Reguibat Shield)

Two peritidal units:

Lower → silt-dominated (+ well sorted sst)
Upper → sand-dominated (reservoir?)


Oued Draa
Foum Draa
Fire Tower
Khouy Aknari
Khouy Lemarif
Touidirhist
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Guenitra El Remla
Old Tafnidilt
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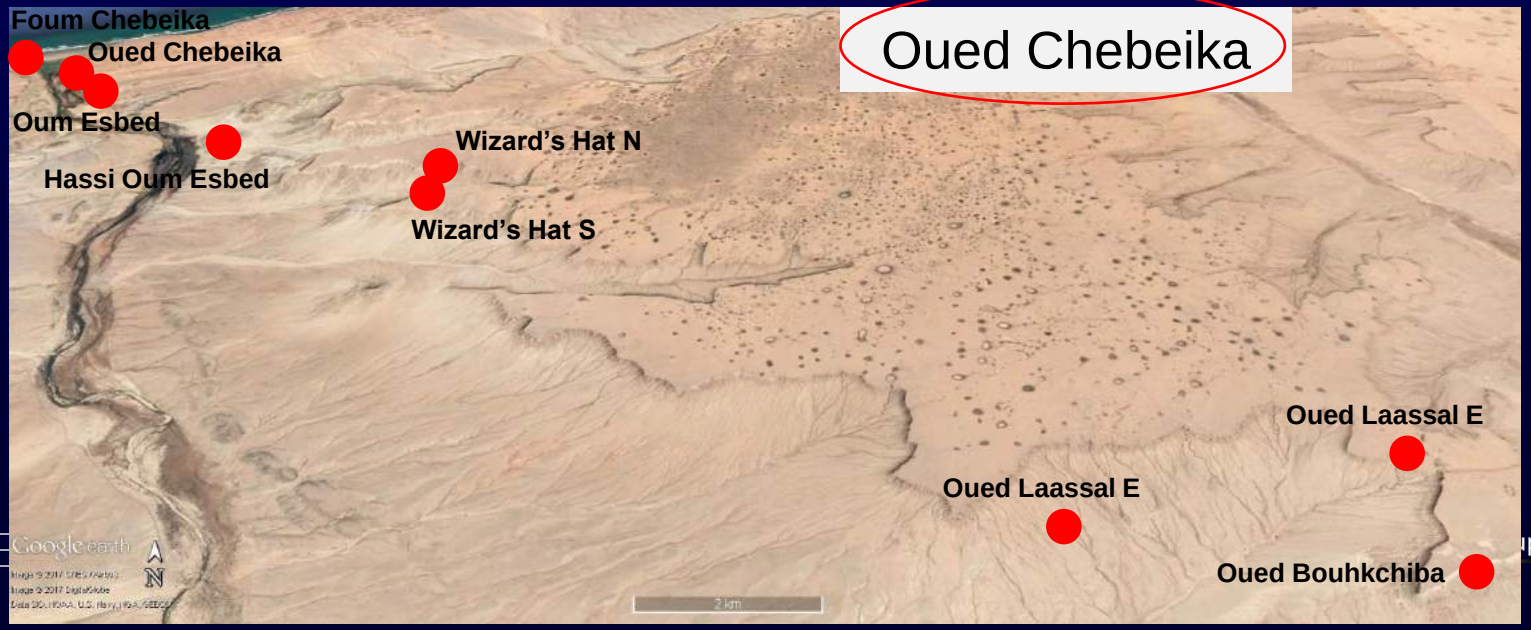
Oued Chebeika
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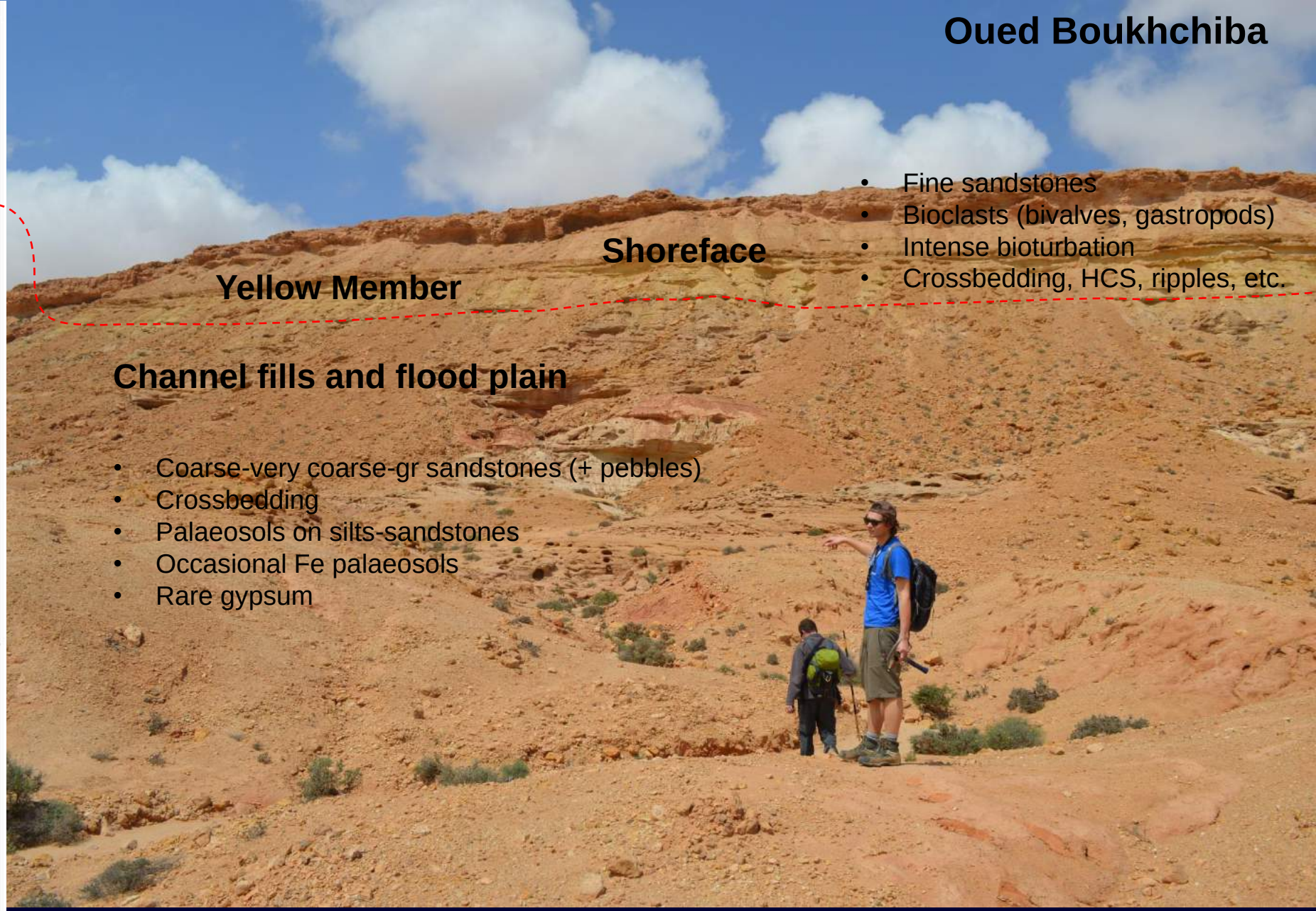
Oued Laassal E
Oued Bouhkchiba

Oued Boukhchiba



- Fine sandstones
- Bioclasts (bivalves, gastropods)
- Intense bioturbation
- Crossbedding, HCS, ripples, etc.

- Coarse-very coarse-gr sandstones (+ pebbles)
- Crossbedding
- Palaeosols on silts-sandstones
- Occasional Fe palaeosols
- Rare gypsum

Hassi Oum Esbed

Yellow Member

Shallow marine

- Fine sandstones and carbonates
- Abundant bioclasts (bivalves, gastropods, corals,…)
- Minor cephalopods (belemnites, ammonites, nautiloids)
- Marine bioturbation (thalassinoides)

White Member

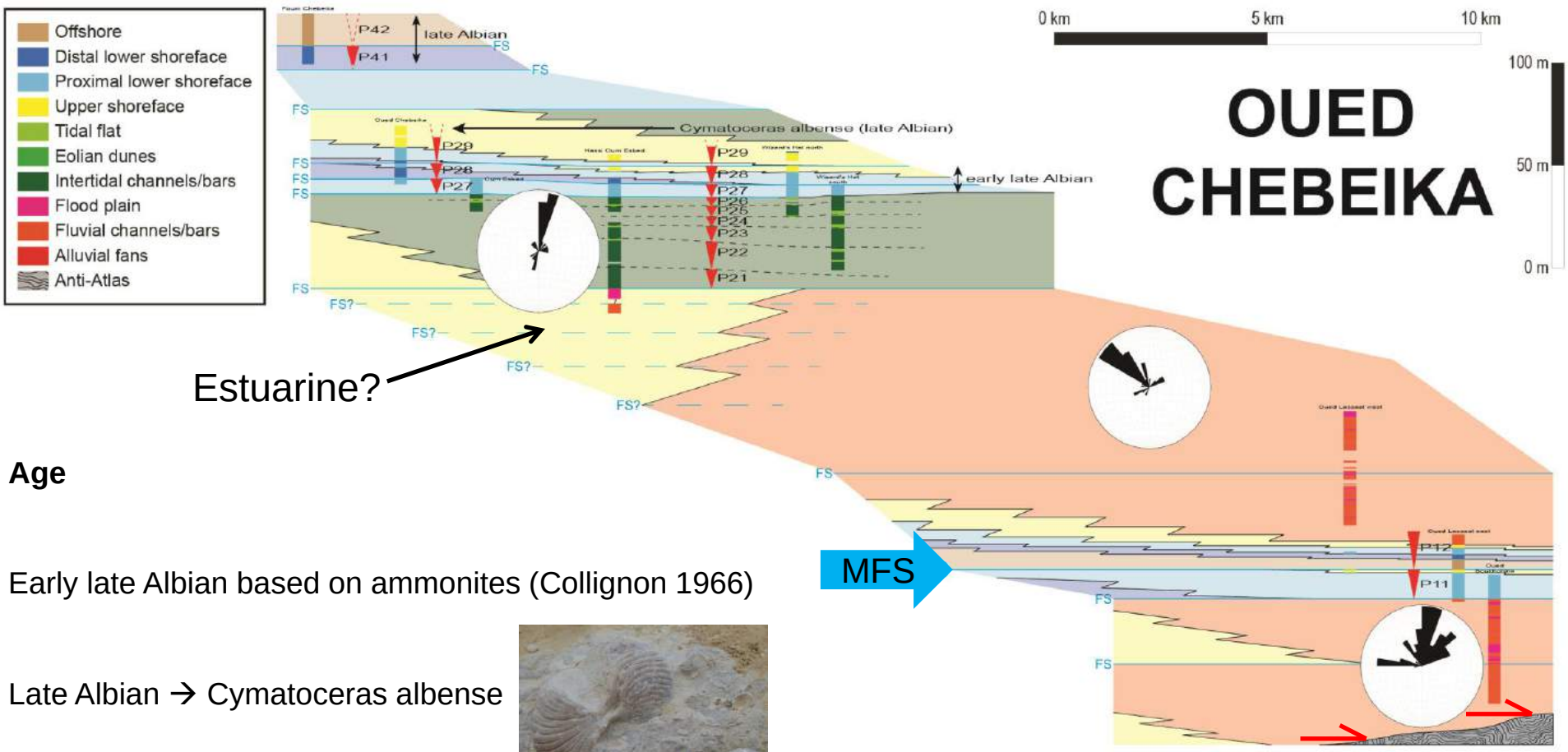
Estuarine

- Dominated by medium to coarse sandstones
- Crossbeds
- Palaeosols on siltstones
- Bioturbation (burrowing)
- Occasional mud drapes
- Bidirectional palaeocurrents

Red Member

Fluvial

- Coarse sandstones + granules
- Trough crossbeds
- Point bars
- Thick palaeosols on vf-gr sst
- Intense bioturbation



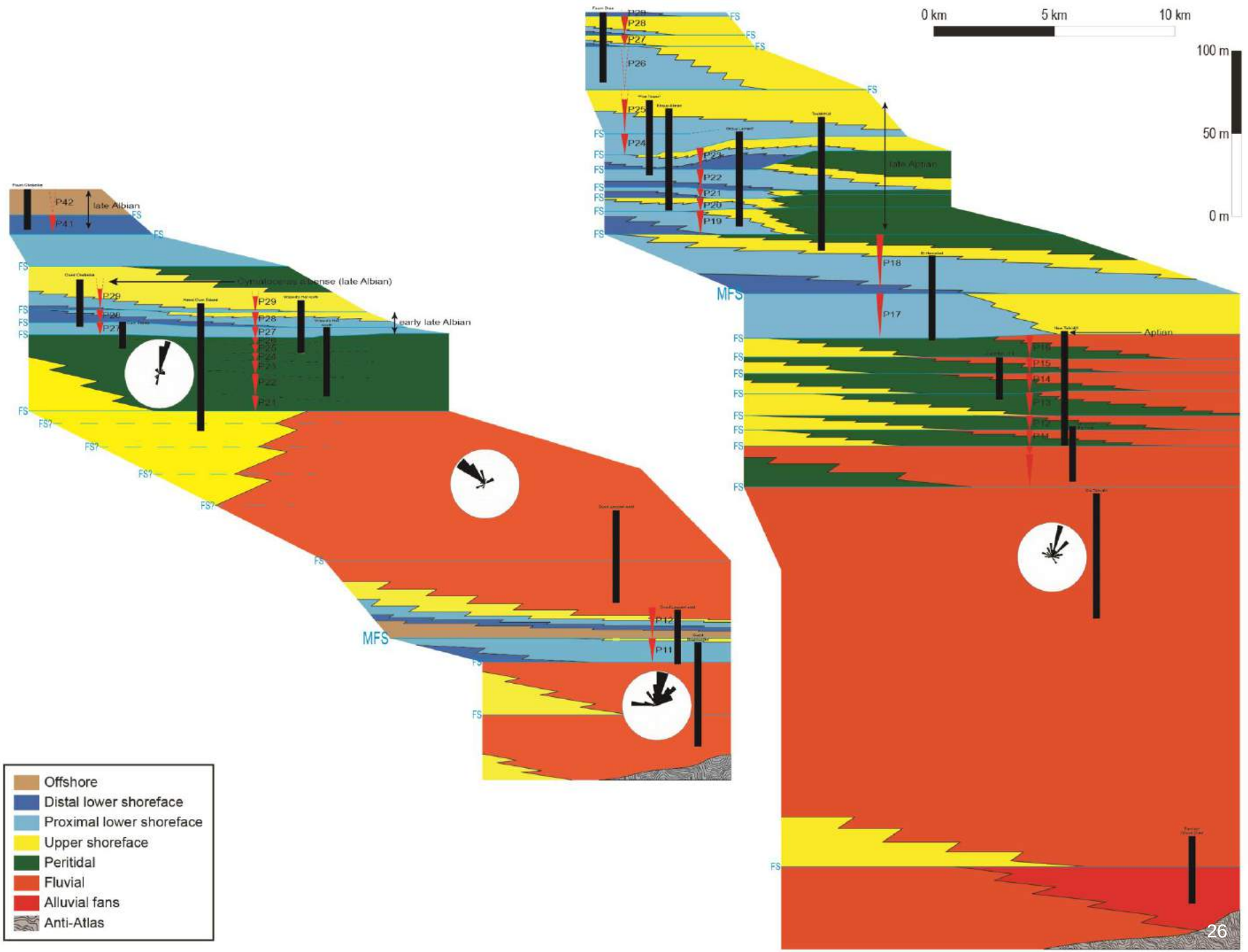
Age

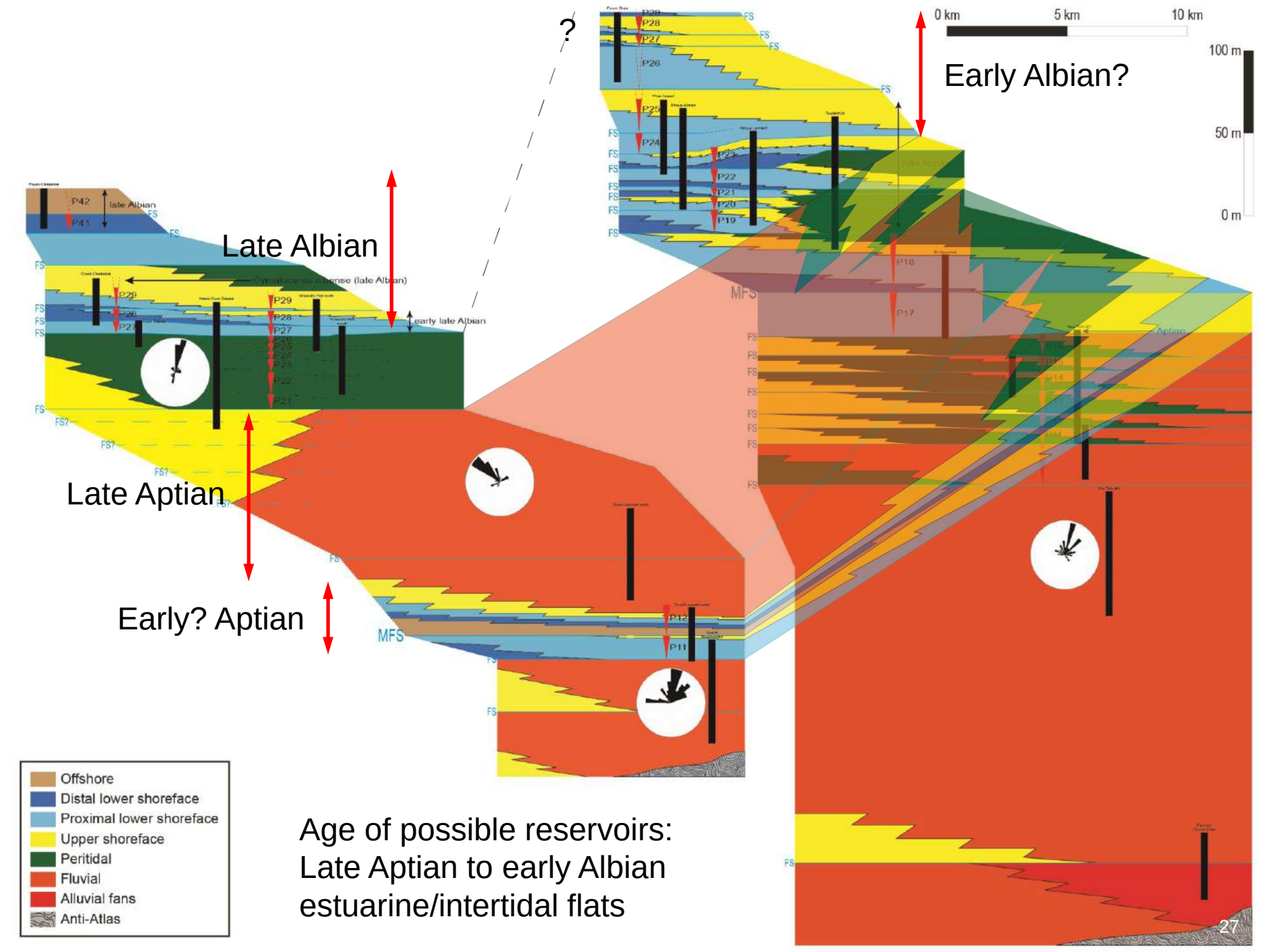
Early late Albian based on ammonites (Collignon 1966)

Late Albian → Cymatoceras albense

Latest Albian (to Cenomanian) from palynomorphs

Basal fluvial unit significantly shorter than Oued Draa. Lower part not exposed
Change in palaeocurrents. Autocyclic?
Sand-dominated estuarine facies (reservoir?). Up to 12 km of exposure along Oued Chebeika

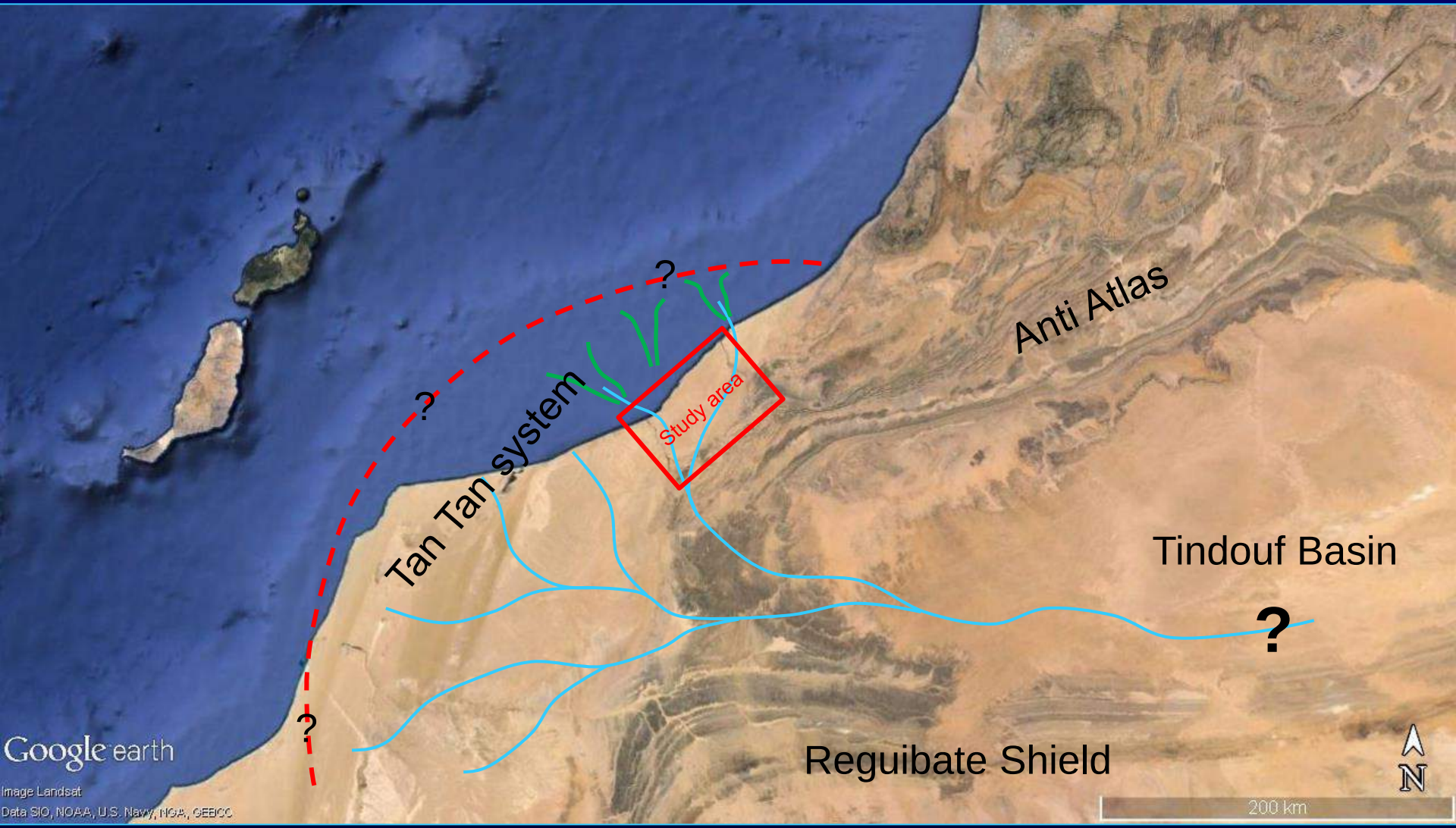

0 km
5 km
10 km
100 m
50 m
0 m
late Albian
early late Albian
Cymatoceras albense (late Albian)
late Aptian
Aptian
MFS
MFS
FS
FS?
P42
P41
P29
P28
P27
P26
P25
P24
P23
P22
P21
P20
P19
P18
P17
P16
P15
P14
P13
P12
P11
Offshore
Distal lower shoreface
Proximal lower shoreface
Upper shoreface
Peritidal
Fluvial
Alluvial fans
Anti-Atlas



Age of possible reservoirs:
Late Aptian to early Albian
estuarine/intertidal flats

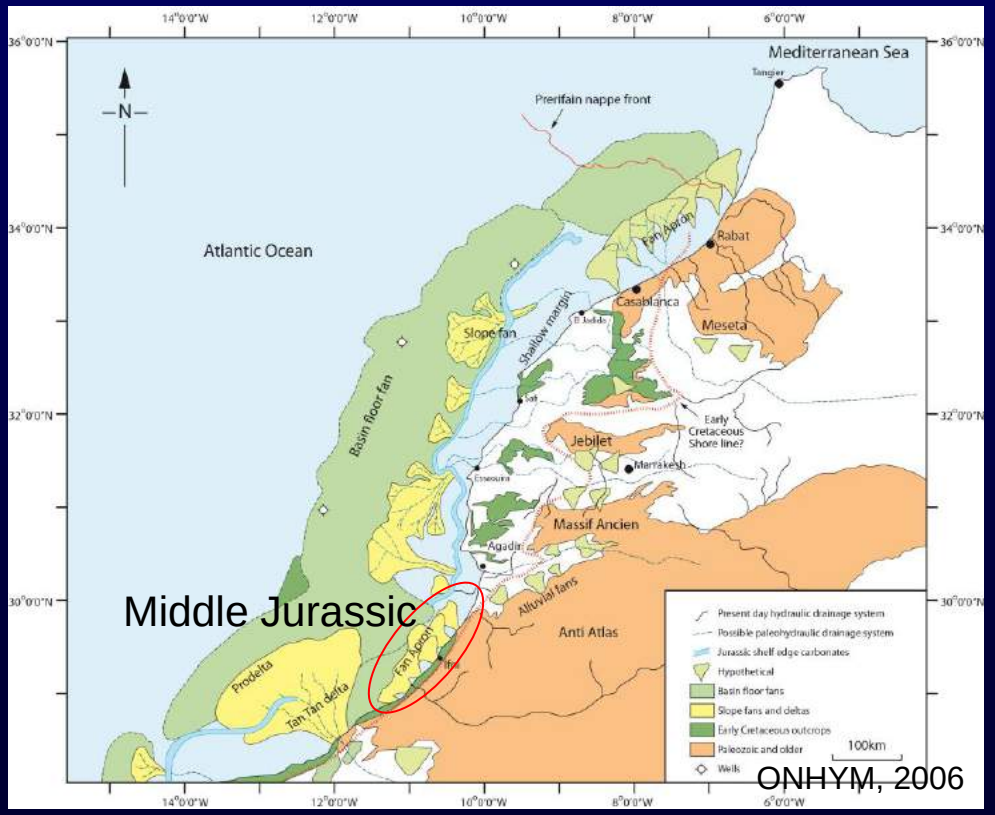
TAN TAN

E Cretaceous



CONCLUSIONS

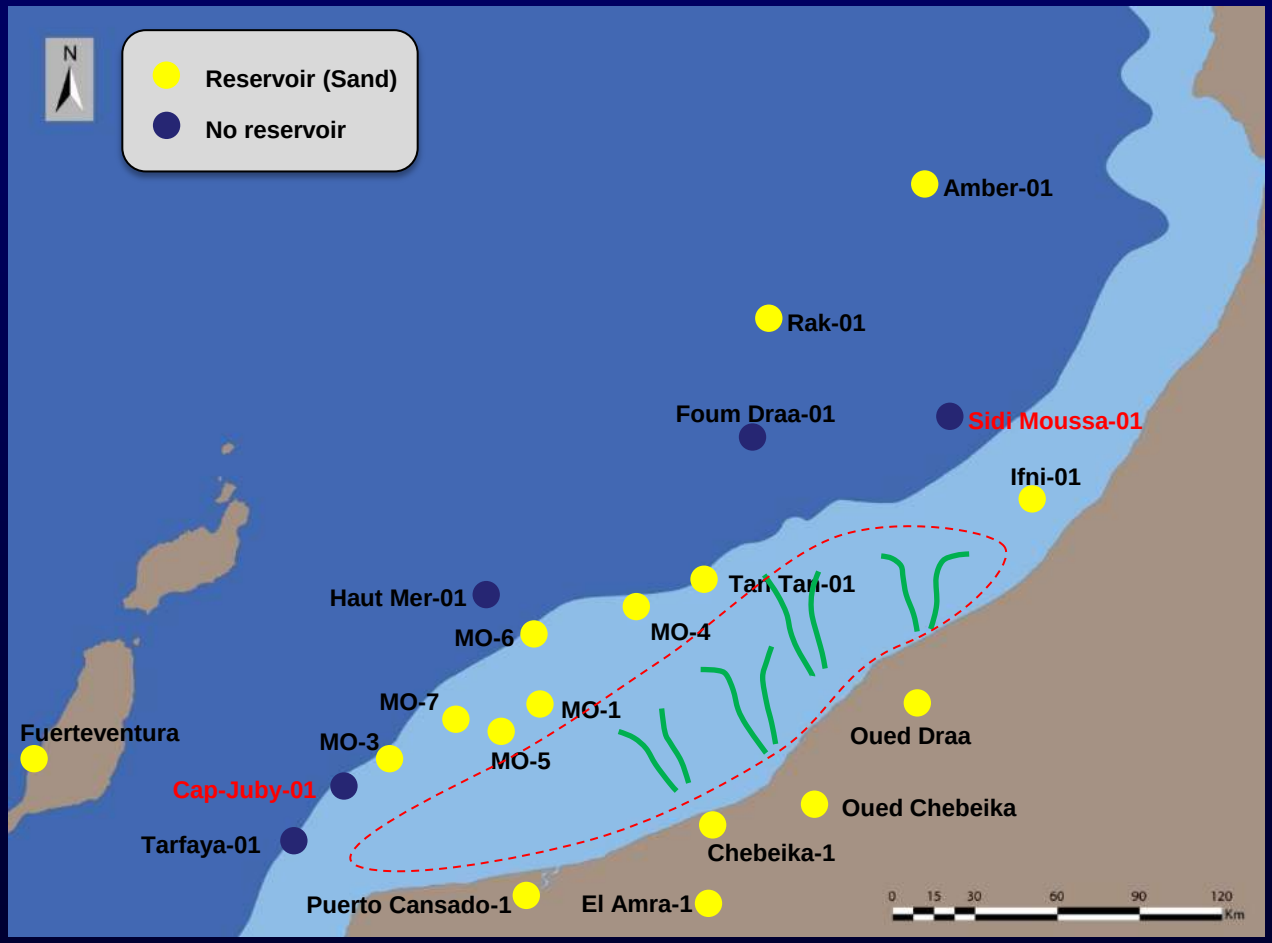
- Succession in Ifni has been revised and new age, lithostratigraphy and sequence stratigraphic model have been proposed. Early Cretaceous succession has been reassigned to Bathonian. The succession correlates with the global eustatic signal, showing overall transgression, but recording periods of coarse clastic delivery interpreted as response to post-rift Anti-Atlas exhumation pulses. Lowstands during the Bathonian are periods prone to deposition of reservoir facies on the shelf.



CONCLUSIONS

- Tan Tan formation has been relogged and expanded (transects along Oued Draa and Oued Chebeika). Lithostratigraphy and dating of part of the Tan Tan Fm. have been updated and improved allowing to date the first transgression as Aptian.

- The Tan Tan Fm. overall represents a retreating delta throughout the early Cretaceous sea-level rise. Thick peritidal, sand-dominated succession are recorded in outcrop. Possible estuarine-related reservoir facies at the present shelf during Aptian-Albian.



THANK YOU VERY MUCH

QUESTIONS?