

# **The Sarir (Nubian) Sandstone Sequence in Sirt Basin and its Correlatives: Interplay of Rift Tectonics and Eustasy\***

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## **Abstract**

The Upper Jurassic-Lower Cretaceous, early syn-rift Sarir (Nubian) sequence in Sirt Basin, Libya, has evolved as a consequence of the interplay between global eustasy and regional tectonics. These conditions led to the establishment of a tripartite subdivision of the sequence in most parts of the basin. Members of this subdivision exhibit thickness variation and lateral facies changes (that often acquire different local names) attributed to the prevailing syn-depositional, structurally controlled basinal palaeotopography. These common depositional themes and controls may change in time and space, due to overprinting by local basement tectonics during rifting.

At the basin's central troughs, where maximum subsidence was attained, the Sarir (Nubian) Sandstone sequence is dominated by marine deposits referred to as the Cocolith Formation. In the proximity of basement highs, the tripartite sequence is dominated by coarse braided and meandering stream fluvial facies that form major hydrocarbon reservoirs. The Middle Sandstone Member of this division, however, exhibits mixed depositional attributes as it passes laterally into mainly lacustrine shale facies in the adjacent marginal rift troughs.

Following the initial development of the Sirt rift system, during the Barremian-Berriasian time, the basin center was invaded by the Tethyan marine waters; whereas, the marginal areas of the basin were dominated by continental sedimentation. During the Aptian eustatic sea-level rise, overflow of marine water through fault controlled inlets influenced conditions in the marginal troughs by changing the base level, leading to sedimentation of the Middle Shale Member.

In wells, the signature of the Aptian eustatic event in the Middle Sandstone Member often went unnoticed due to local erosion and overprinting by tectono-depositional regressive events. Extensive sedimentological study of cores from the Sarir and other key oil fields revealed evidence of the Aptian transgression. The following Albian events were marked by regional reactivation of basement structures leading to regressive fluvial sedimentation of the Upper Sandstone Member throughout the Sirt Basin and beyond.

In consequence of these shared tectonic and eustatic events and influences, the tripartite division of the Sarir (Nubian) sequence is the common theme not only in Sirt basin but also extends to the Al Jifara, Al Kufrah and Dakhla basins. However, due to its tectonic isolation, the sequence in Murzuq Basin is fluvially dominated and, so far, stratigraphically undifferentiated.

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**AAPG**

Middle East Region



# **THE SARIR SANDSTONE SEQUENCE IN SIRT BASIN AND ITS CORRELATIVES: *INTERPLAY OF RIFT TECTONICS AND EUSTASY***

**Ahmed S. El-Hawat**

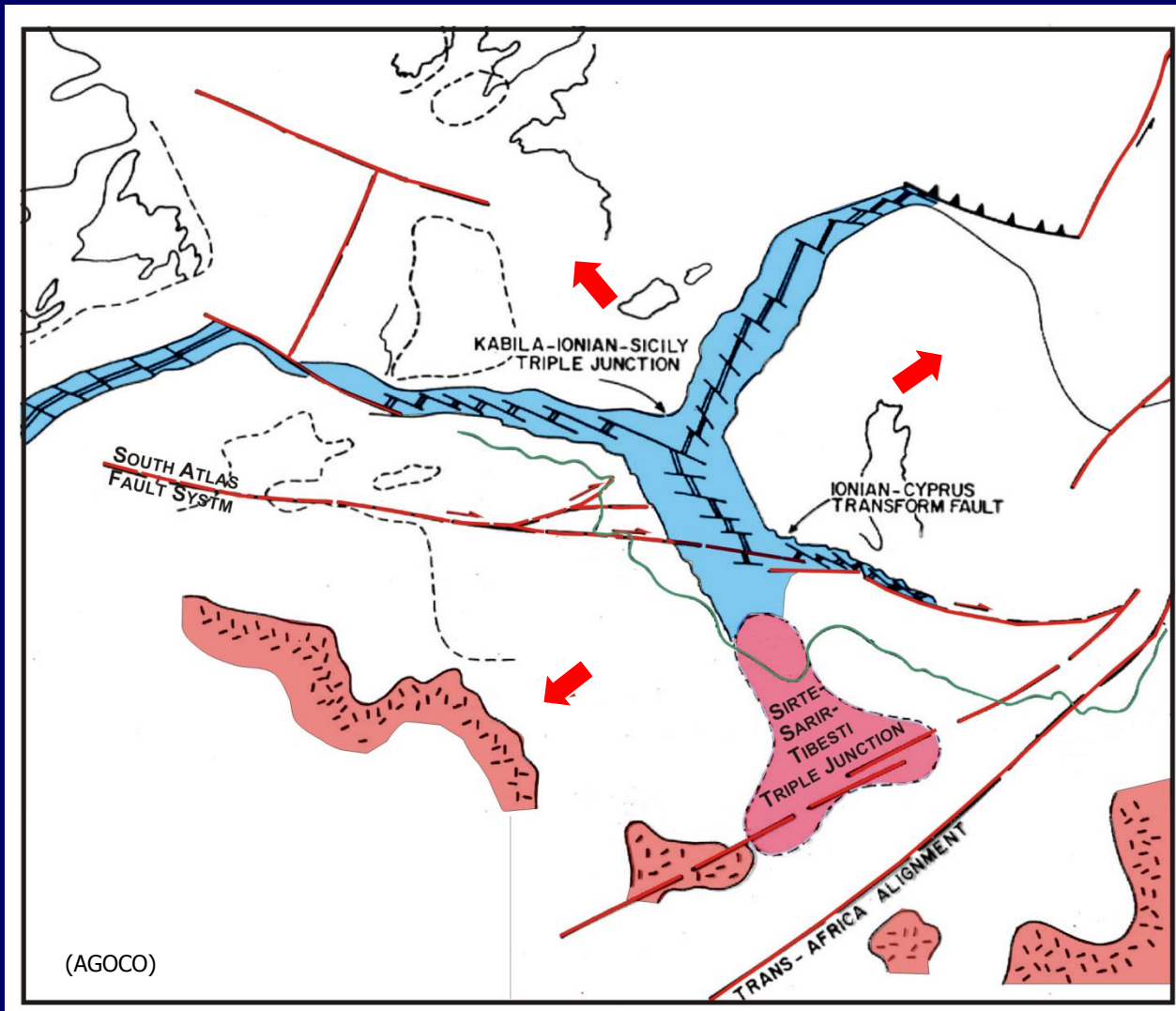
Professor Emeritus & Consultant  
University of Benghazi, Libya

## TALK POINTS

- Tectonics and sedimentation of the Early Syn-Rift Sarir Sandstone, a major reservoir (4.5billion boe) in the Sirt rift complex, Central Libya.
- Correlation of type-sections in the rift arms based on recognition of eustatic and tectonic stratigraphic signatures.
- Extending facies and events correlation to surface analogues exposed in the Western Desert of Egypt and Western Libyan basins.
- Tying stratigraphic signatures in North Africa to regional and global events.

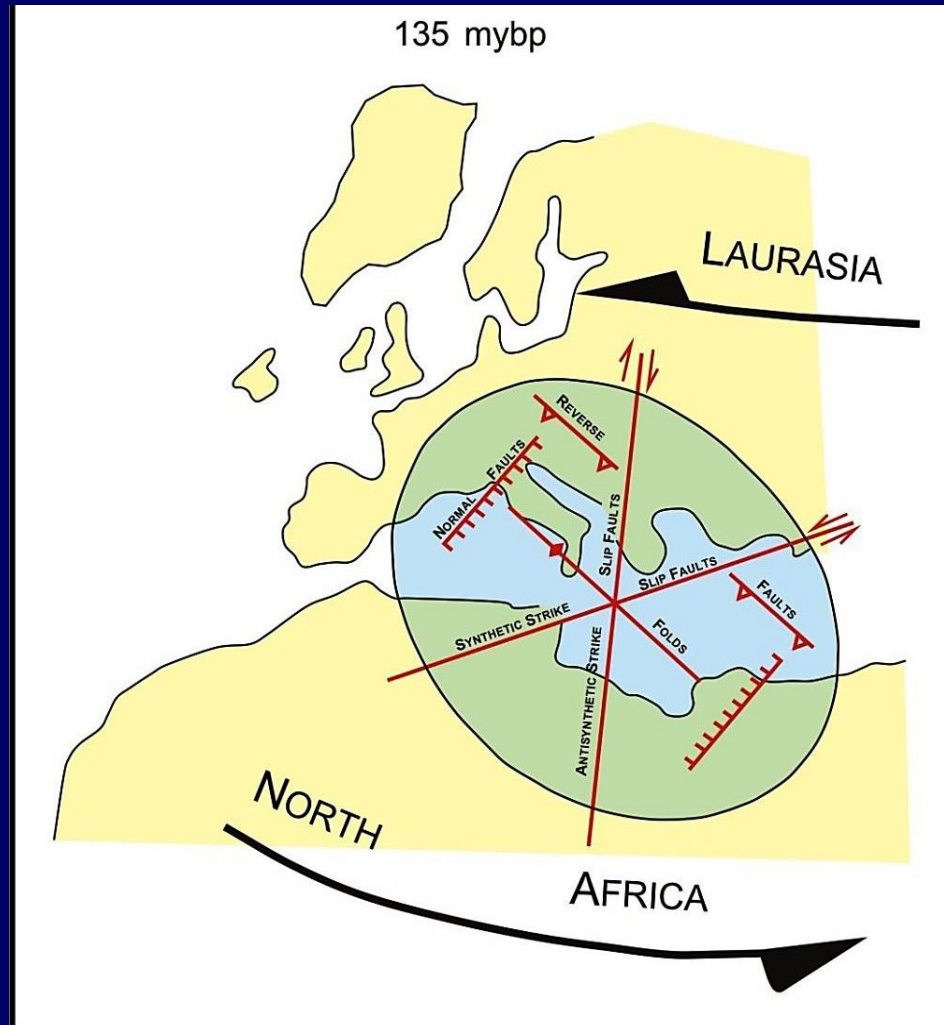
# Middle Jurassic Palaeogeographic Map of the Central Mediterranean

Break-up of Pangea and Thermal Uplift of Sirt-Tibesti Arch Due to Hotspot Activity



# Upper Jurassic – Lower Cretaceous Transcurrent Motion Between Africa & Laurasia During Mid-Atlantic Opening

African cratonic uplift & siliciclastic shedding into the North African basins  
Thermal subsidence & collapse of the Sirt-Tibesti Arch

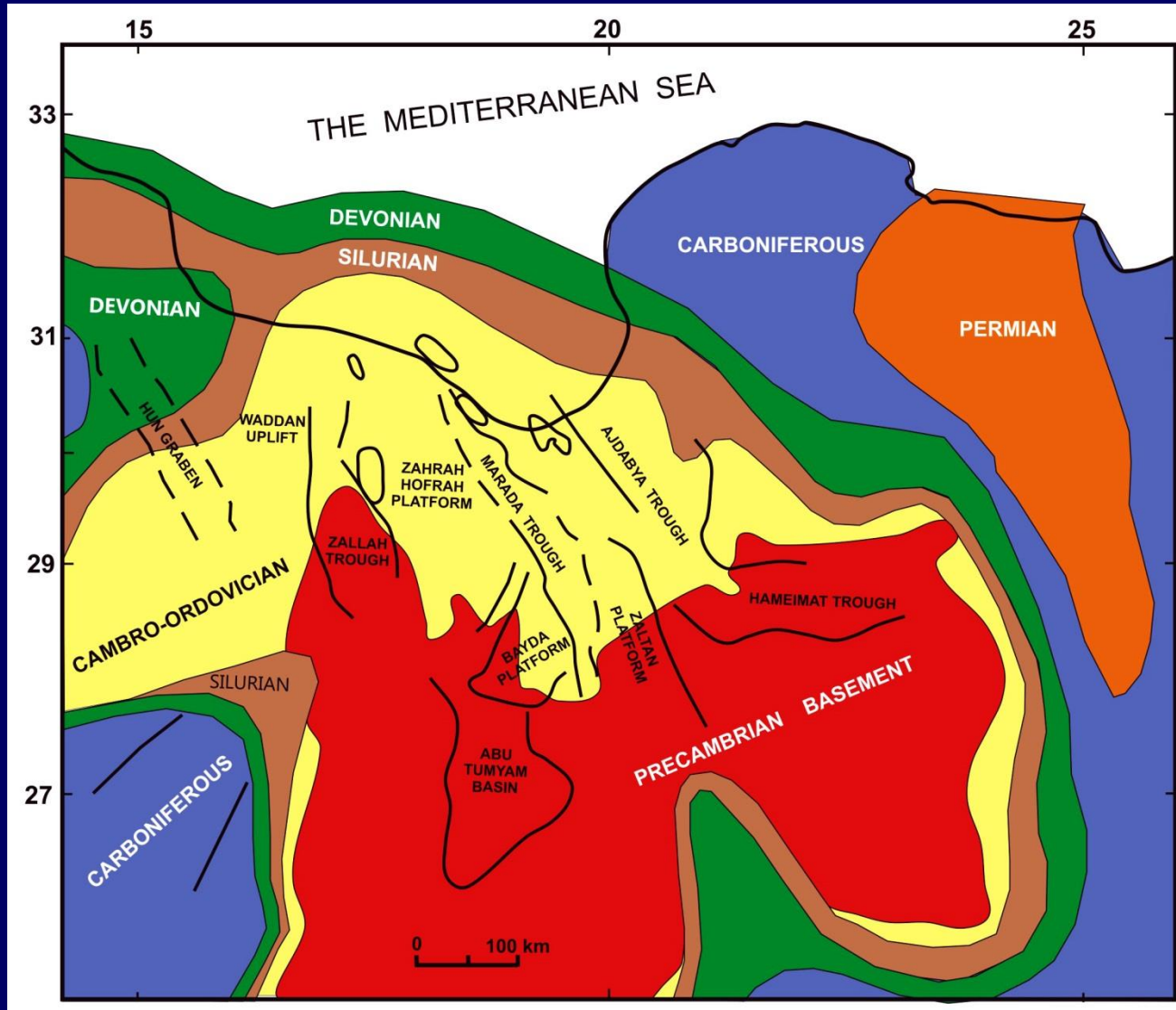


(Modified from Smith, 1971)



# Pre-Sarir Sub-Crop Map of Sirt Rift Complex

Showing the Basement & the Palaeozoic strata in relation to subsequent Sirt structures

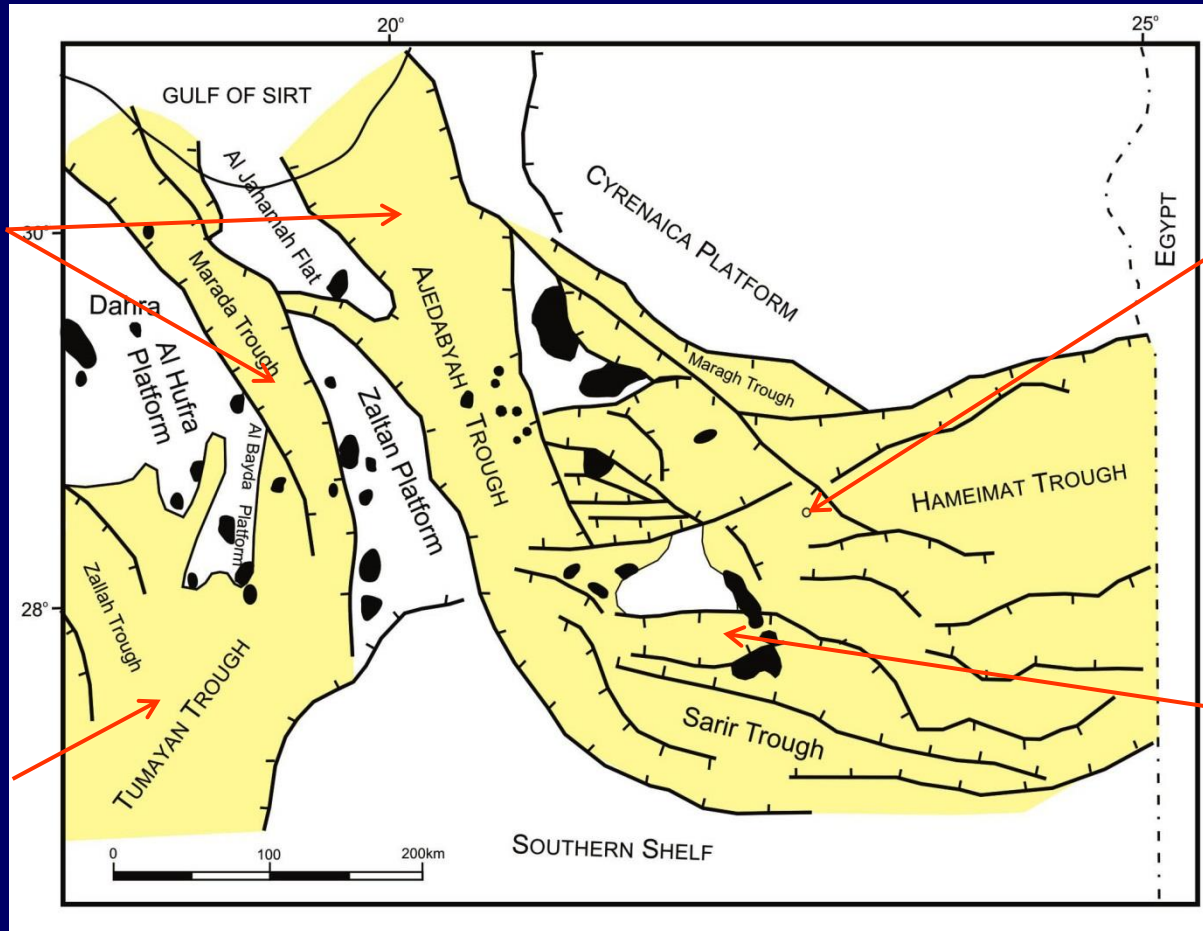




# Tectonic Map Of The Sirt Rift Complex

## Sirt-Tibesti Arch Collapse Forming Triple Arms of the Rift

**NW-SE Arm**  
**Central Rift**



**E-W Arm**  
**Marginal Rift**

**Junction**  
**of EW&NESW**  
**trending arms**

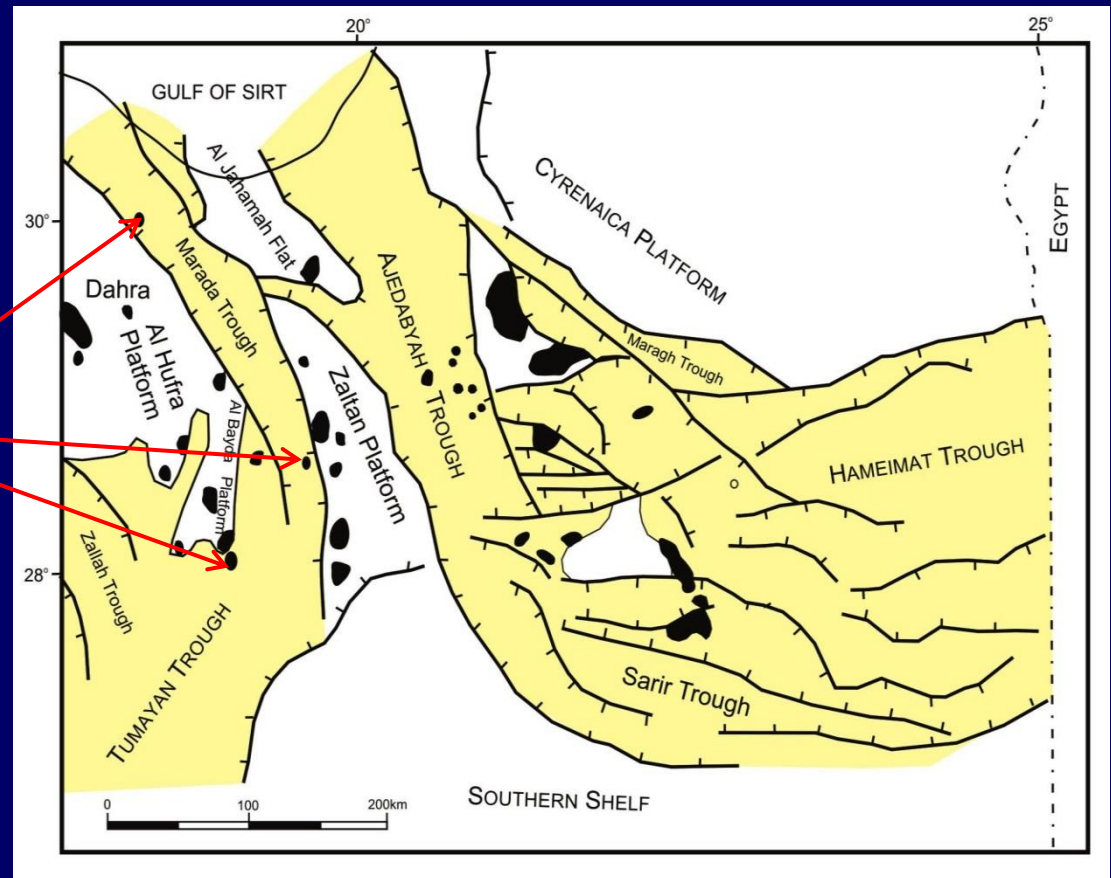
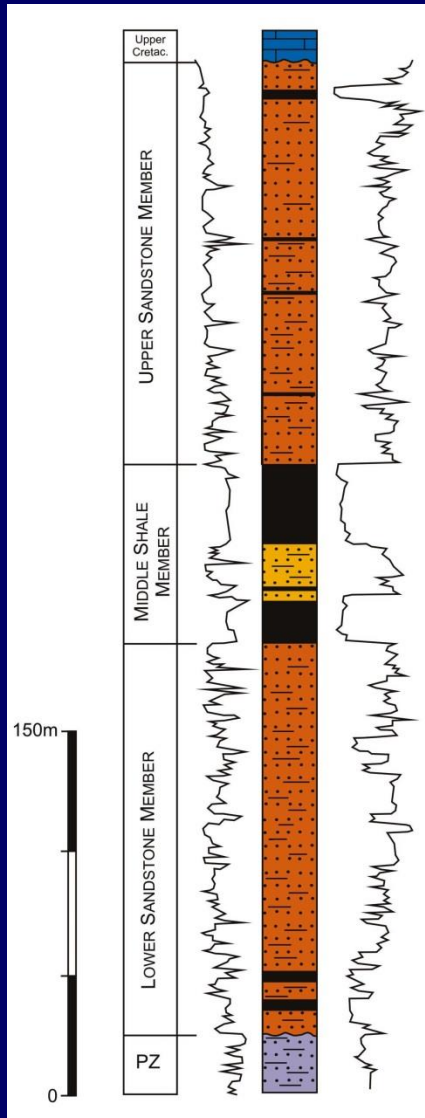
**Bold Basement**  
**&**  
**Inlets**

**NE-SW Arm**  
**Aborted Rift**

The early synrift Sarir Ss. reservoir was studied in wells representing three main tectonostratigraphic localities

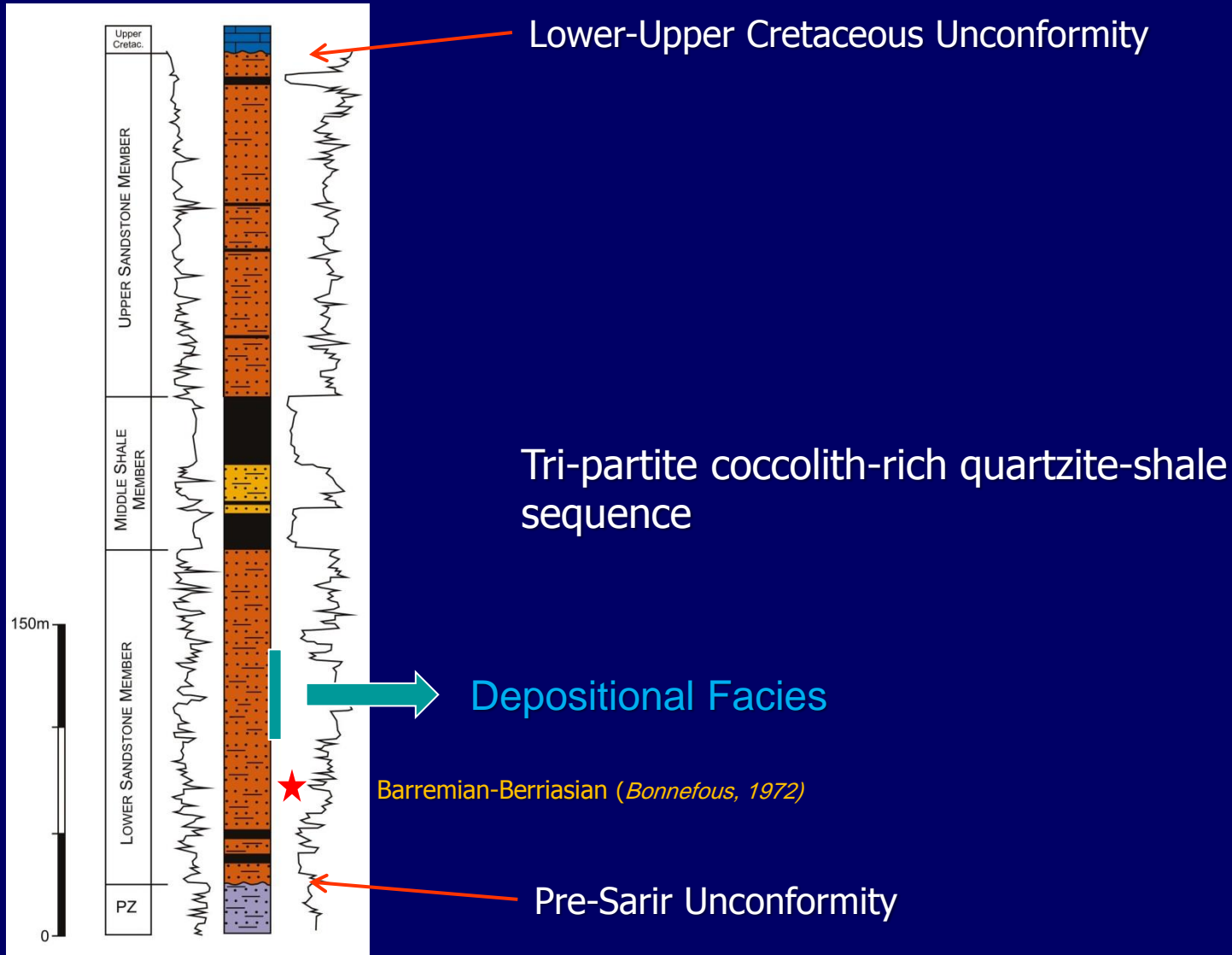
# The Sarir Sandstone Correlative in the NW-SE Arm Central Rift

## Marada Tectonostratigraphic Type-Section (*Coccolith Fm.*)



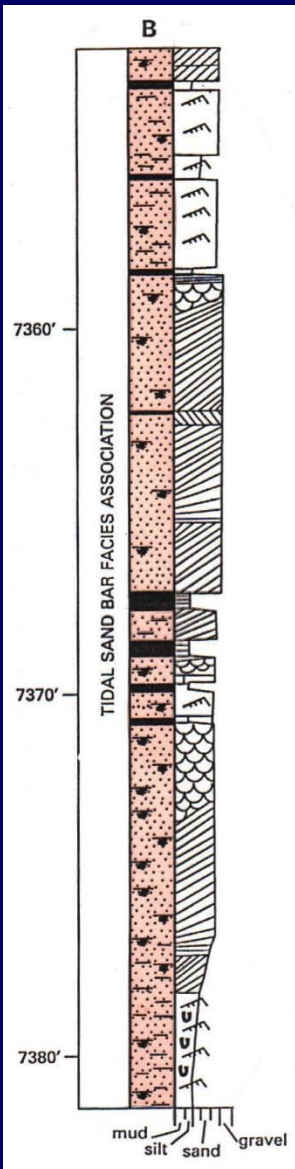
# The Sarir Sandstone Correlative in the NW-SE Arm Central Rift

Marada Tectonostratigraphic Type-Section (*Coccolith Fm.*)



# 1. Shale – Sand Facies

Bioturbated, lenticular, wavy & flaser ripple bedding

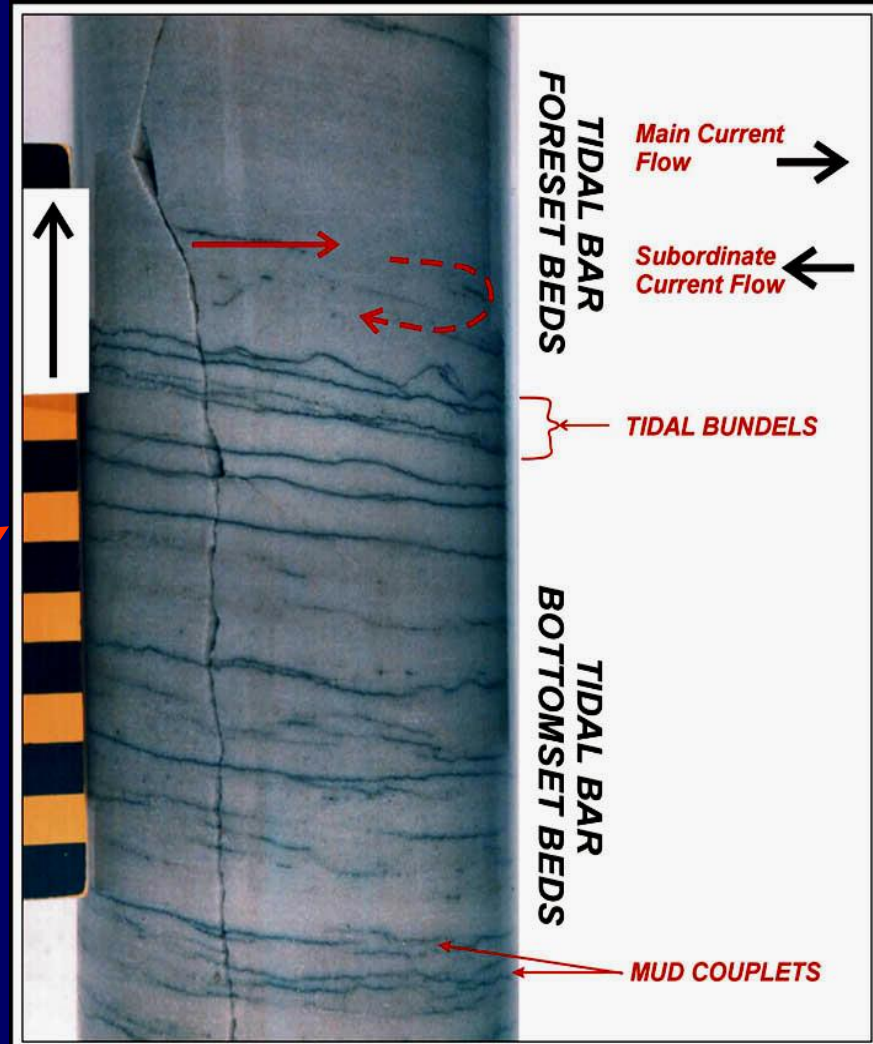
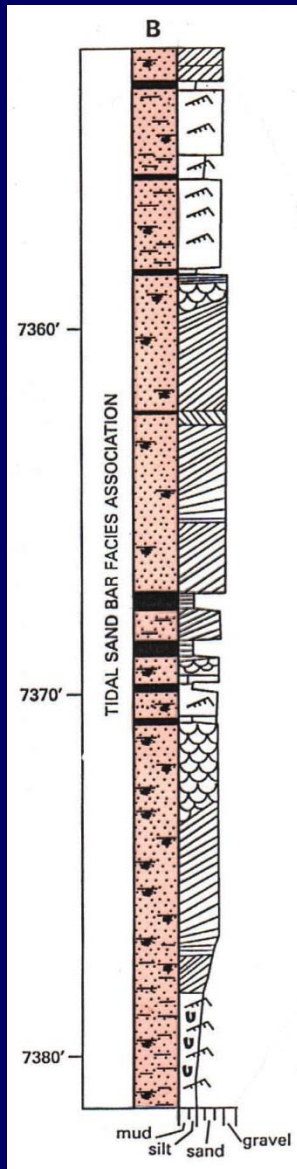




## 2. Sand - Shale Facies

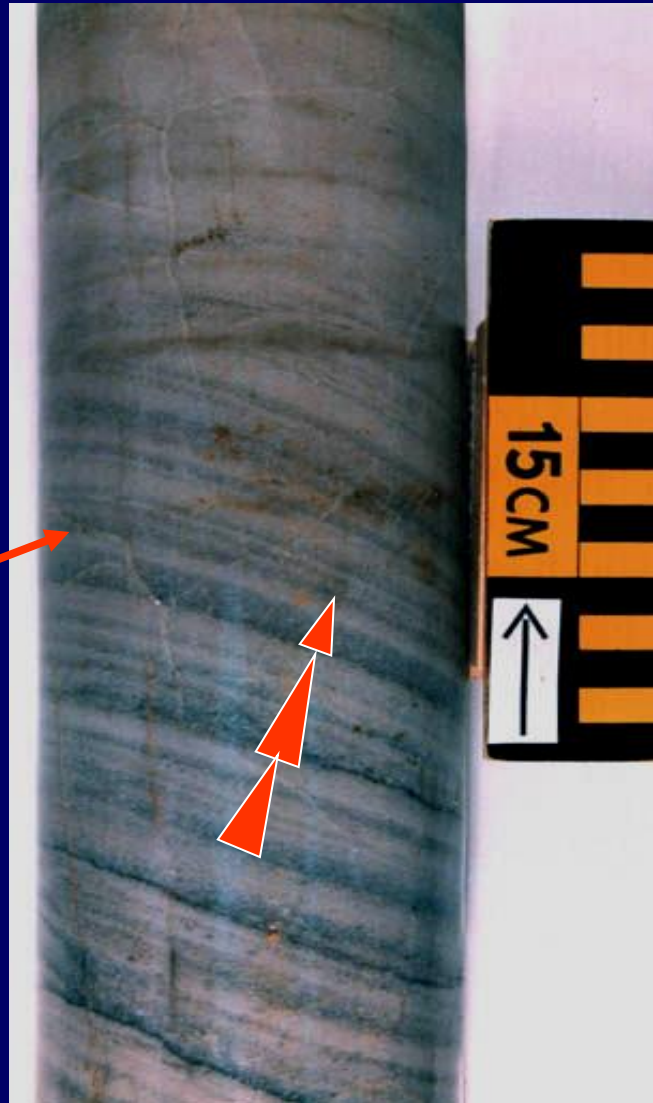
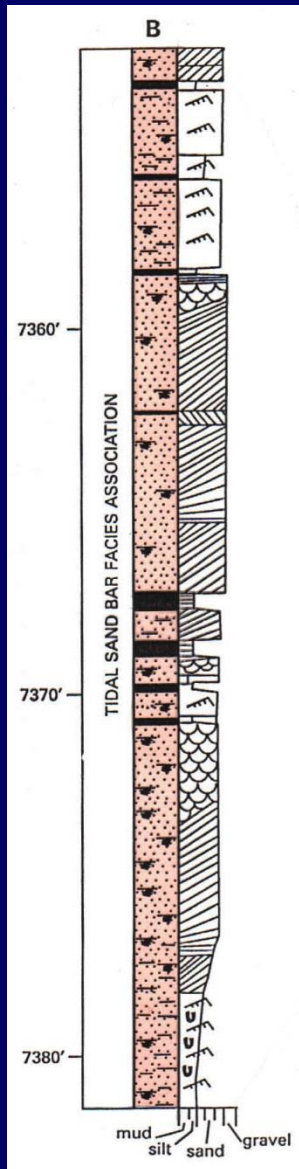
Bottom set – foreset core

Showing mud couplets & tidal bundles



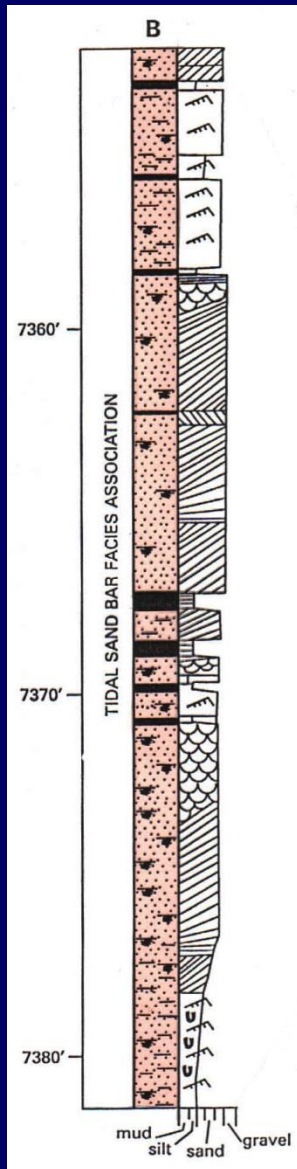
### 3. Sand Facies

Planar cross bedding, graded bedded foresets



## 4. Plane Bedded Sand Facies

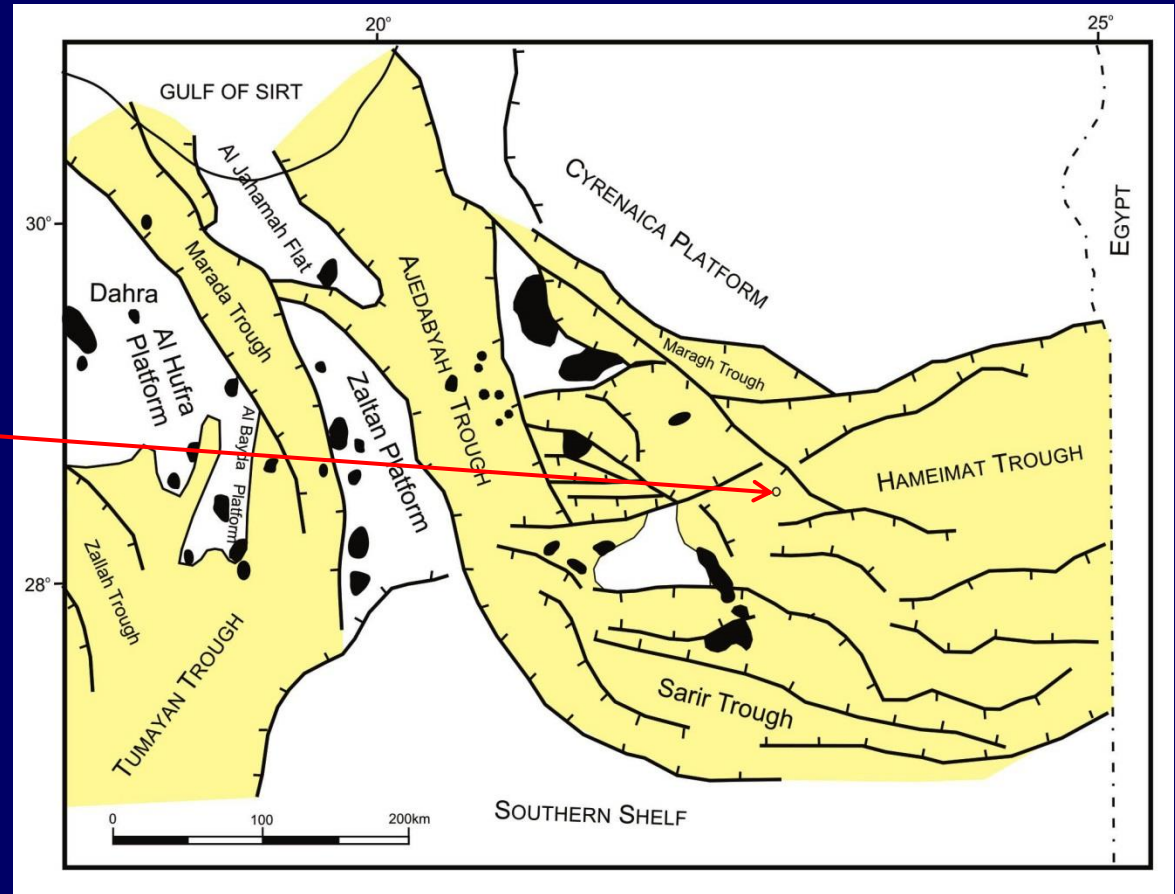
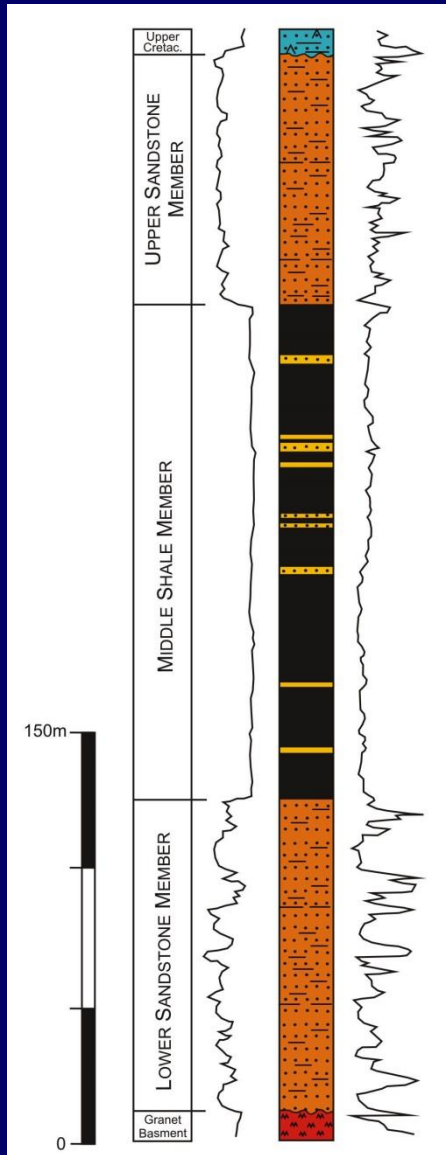
Skolithos burrows





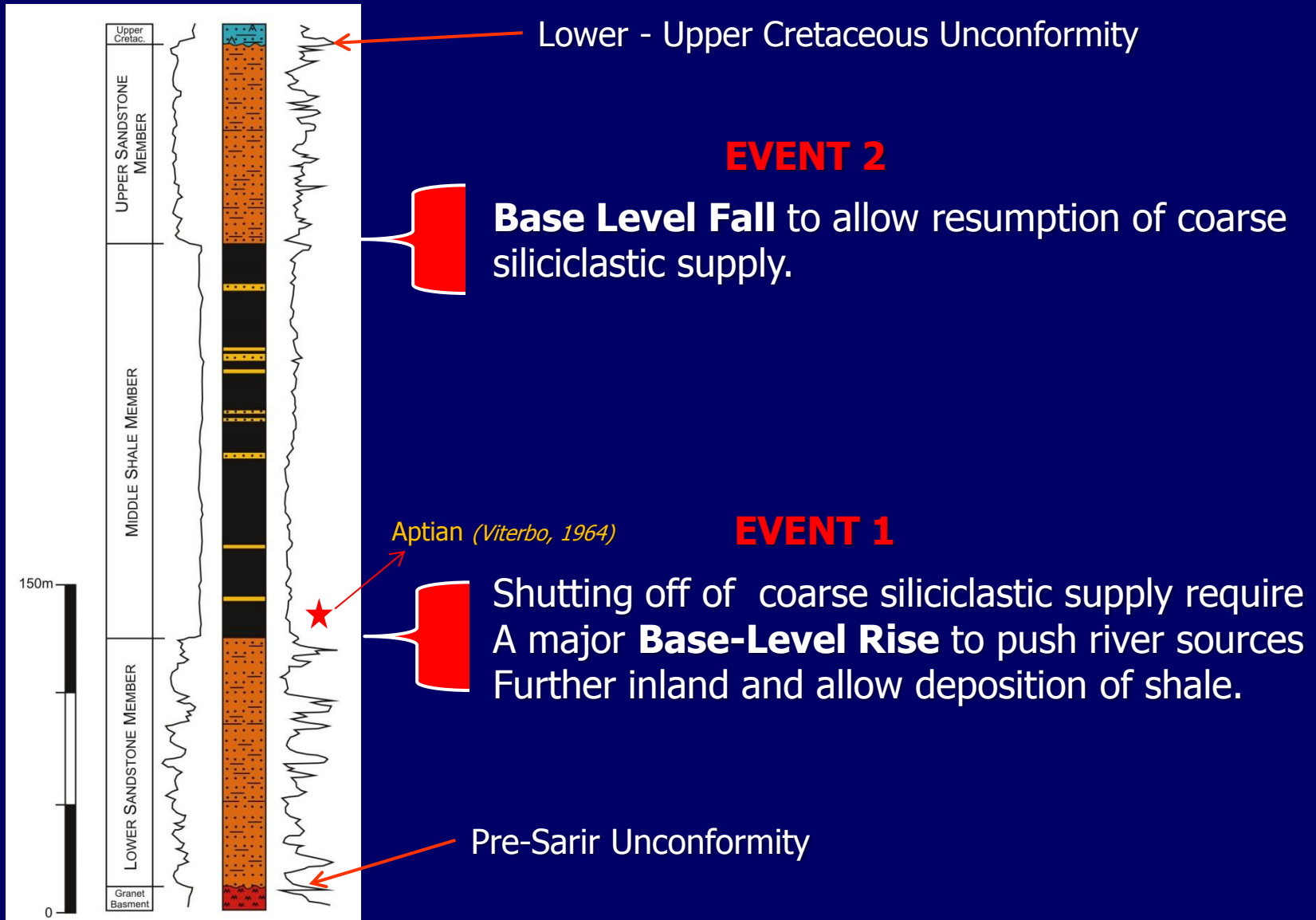
# The Sarir Sandstone type-section in the E-W arm

## Central Hameimat Trough



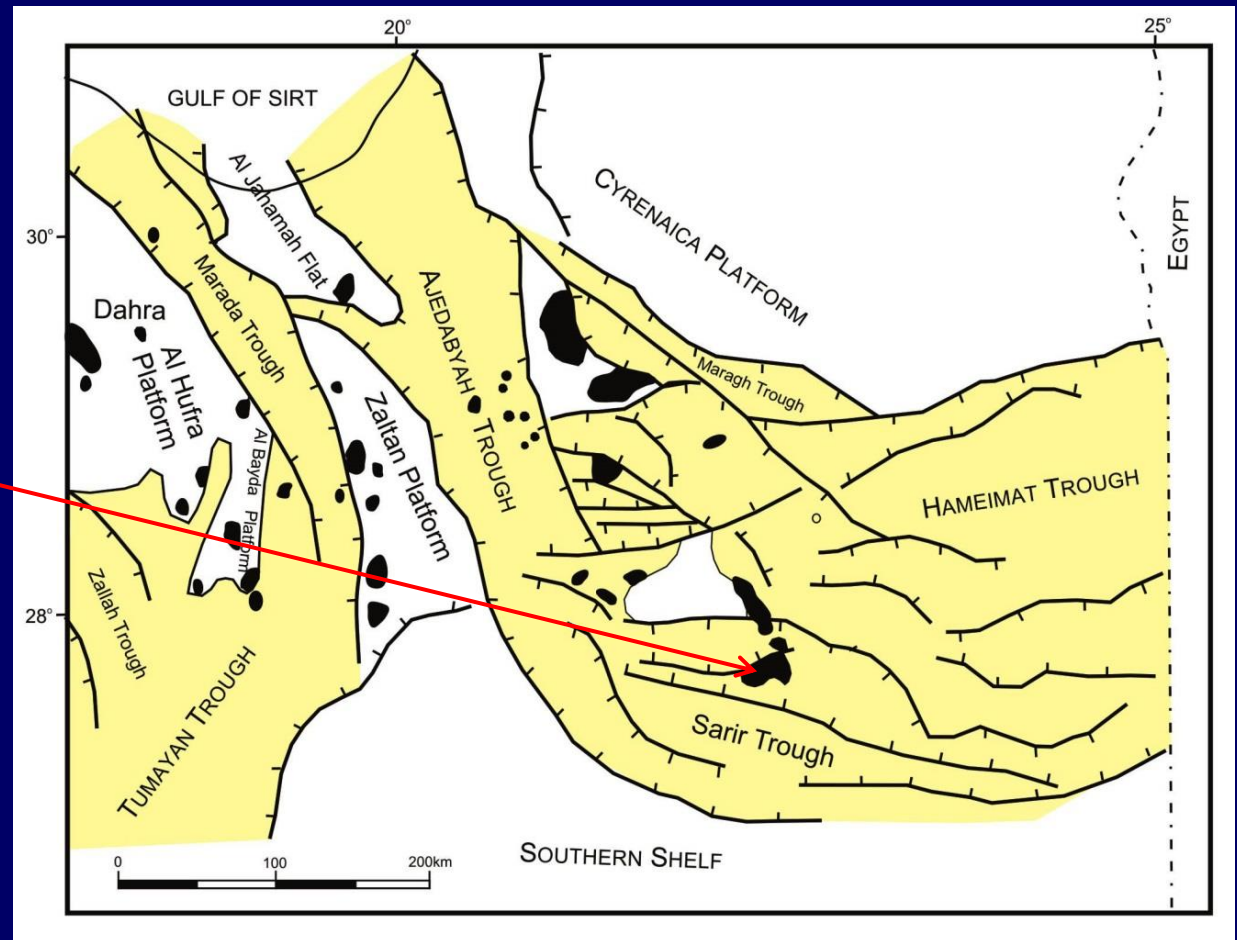
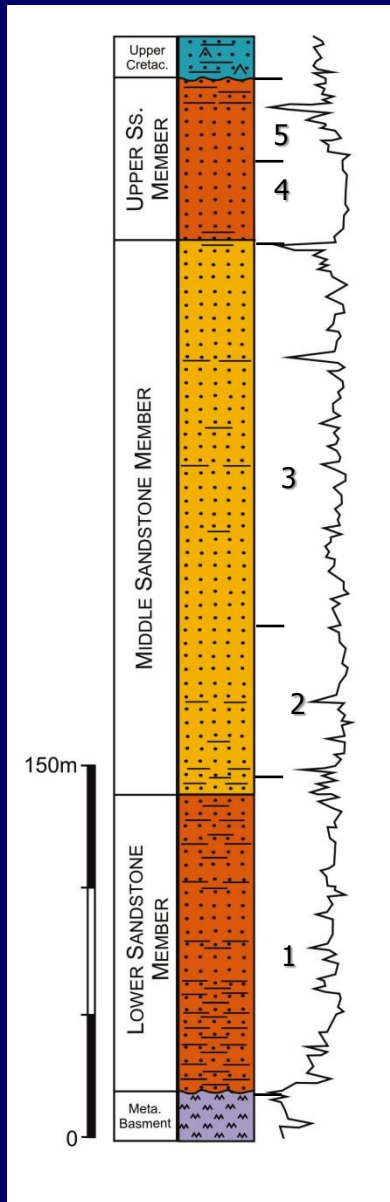
# The Sarir Sandstone type-section in the E-W arm

## Central Hameimat Trough



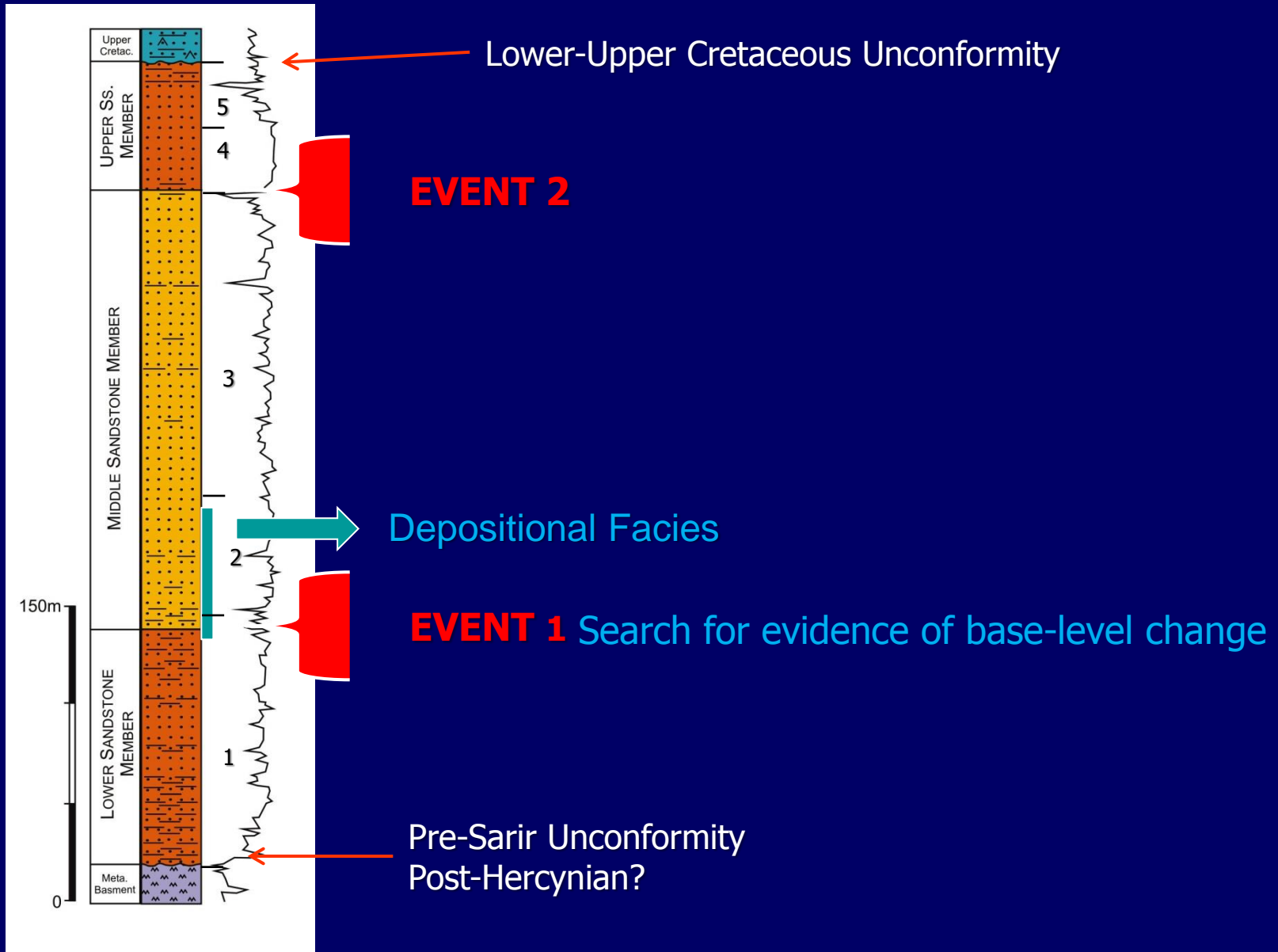
# The Sarir Sandstone reservoir type-section at the Junction

## Cyclicity of the Middle Sandstone Member: Rift tectonics overprinting Aptian eustasy

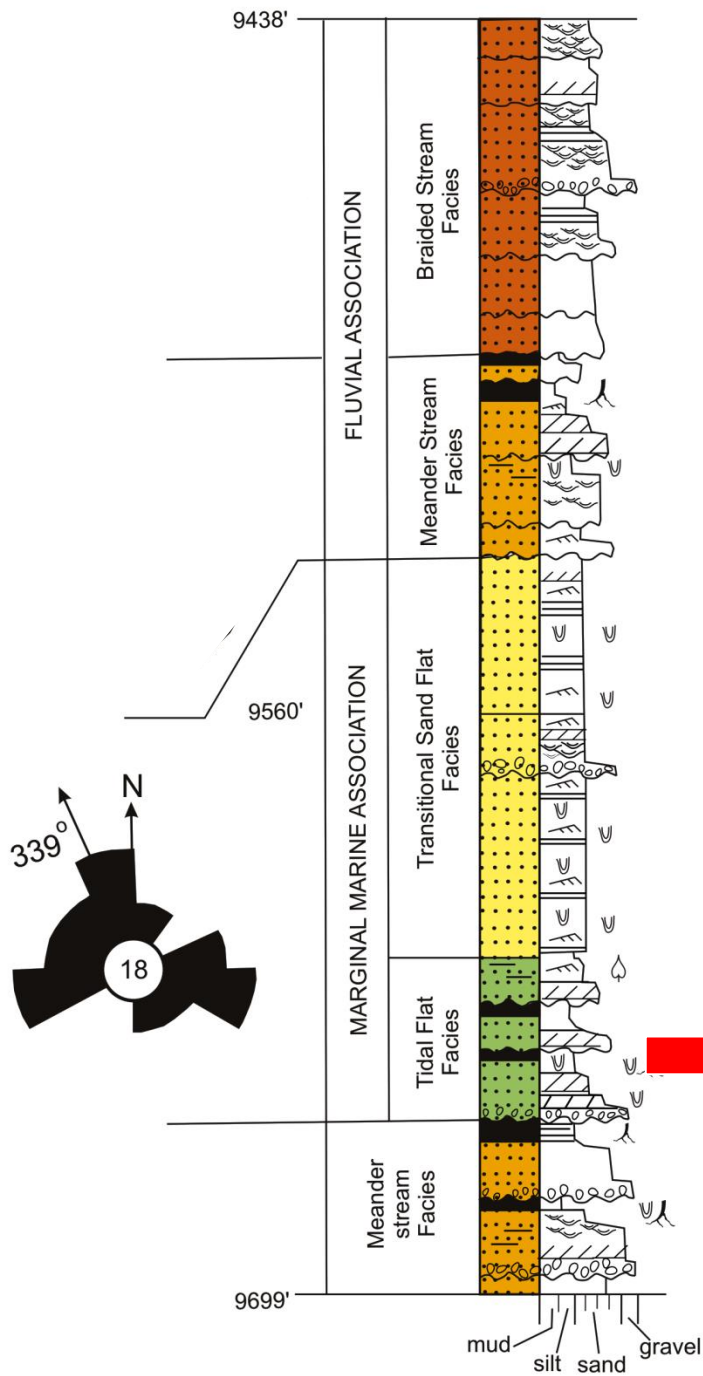


# The Sarir Sandstone reservoir type-section at the Junction

Cyclicity of the Middle Sandstone Member: Rift tectonics overprinting Aptian eustasy



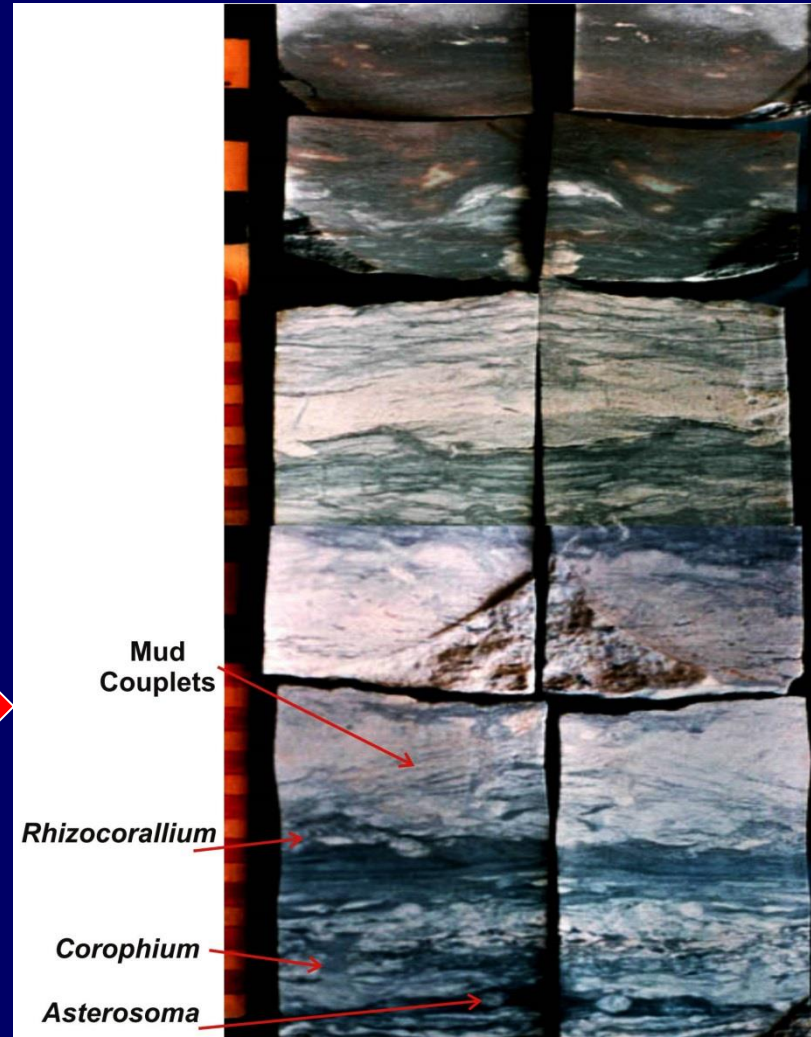


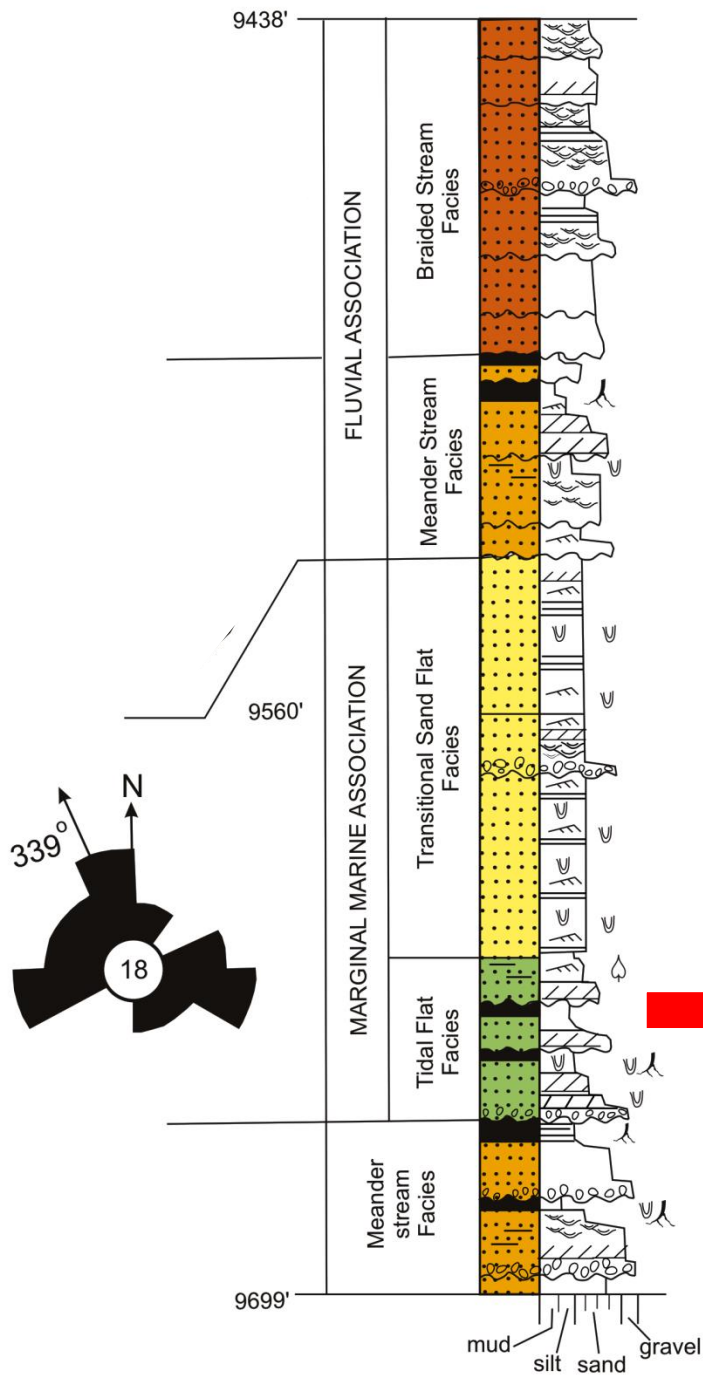


## Sedimentological Log of a Core at the Lower - Middle Sandstone Members Boundary

Palaeocurrents rose diagram is based on depth calibrate to core FMS imaging data

*Tidal Flat Facies-1*

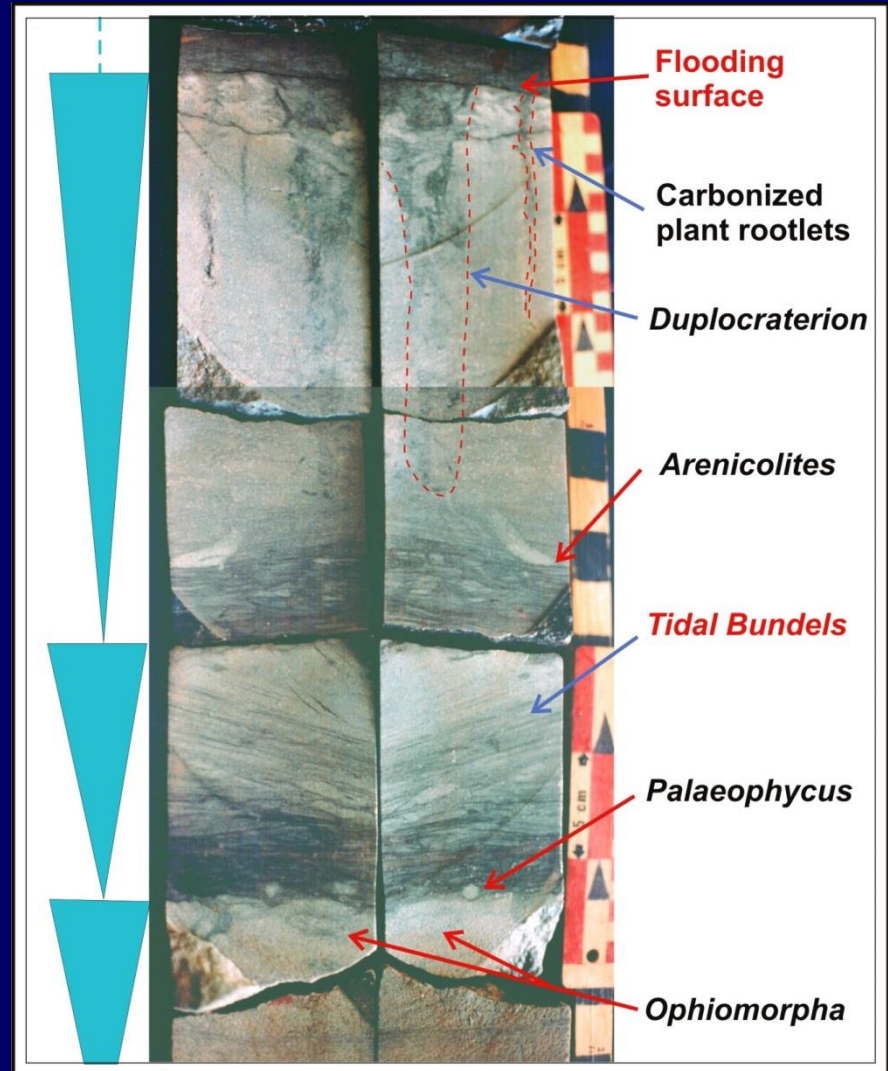




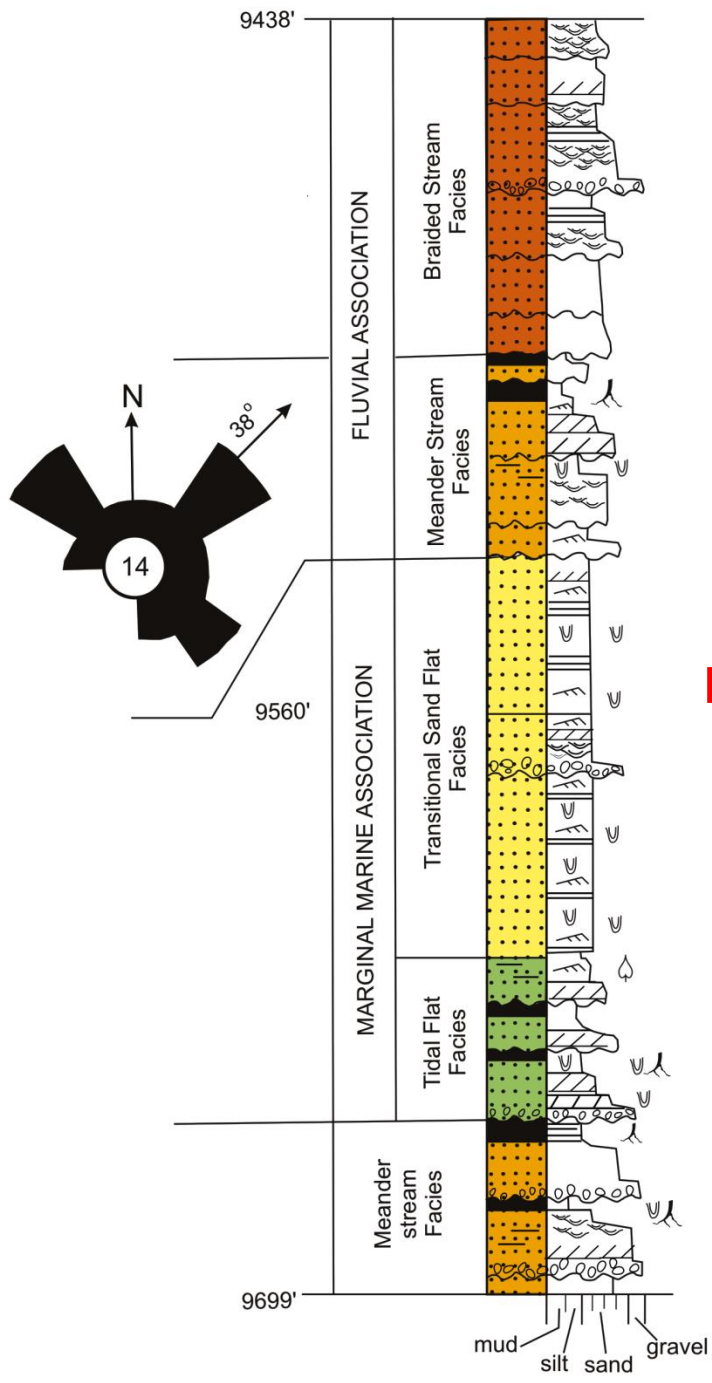
## Sedimentological Log of a Core at the Lower - Middle Sandstone Members Boundary

Palaeocurrents rose diagram is based on depth calibrate to core FMS imaging data

*Tidal Flat Facies-2*



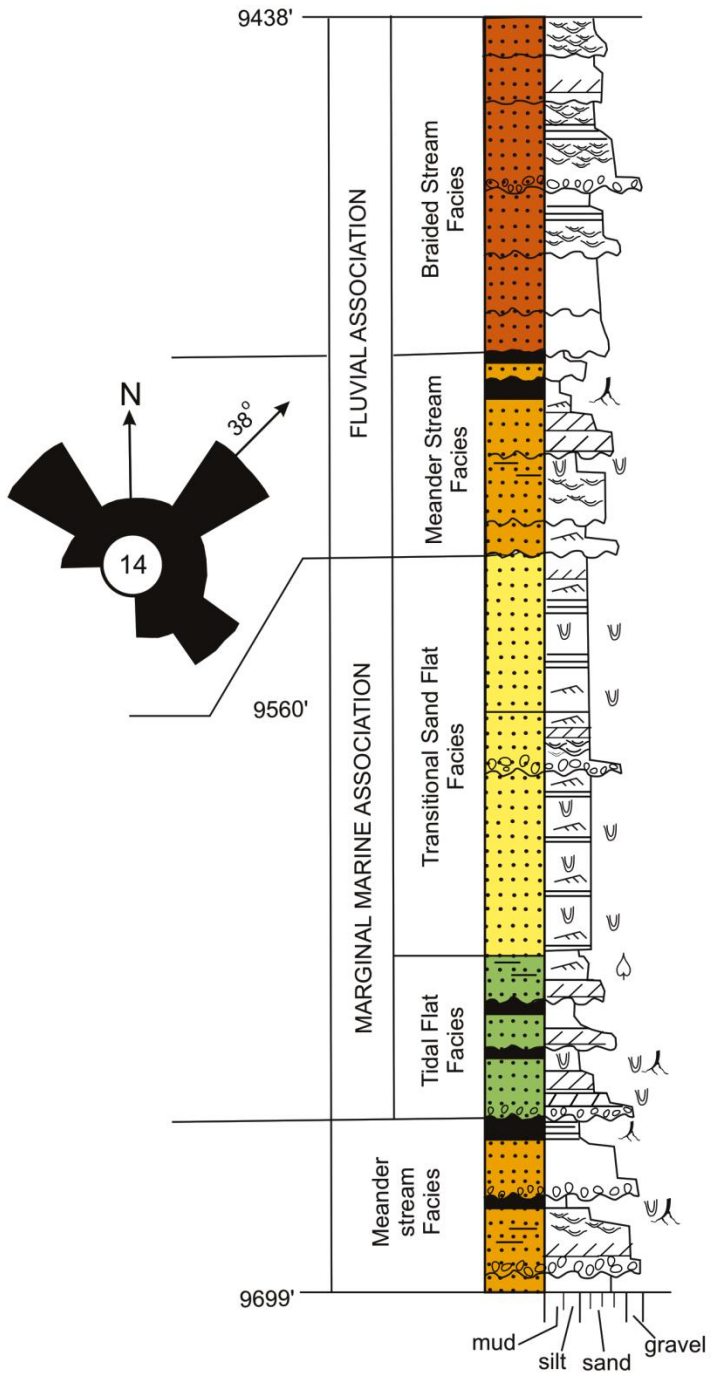




## *Transitional Sand Flat Facies*

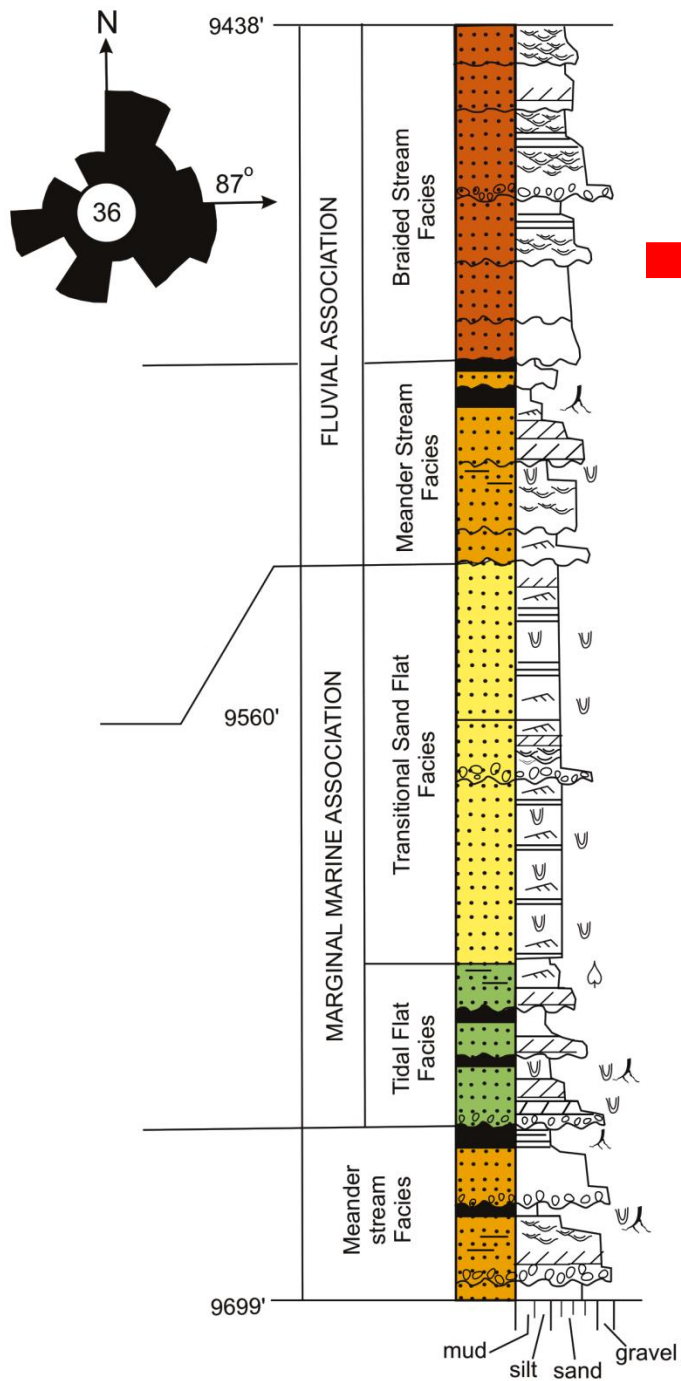




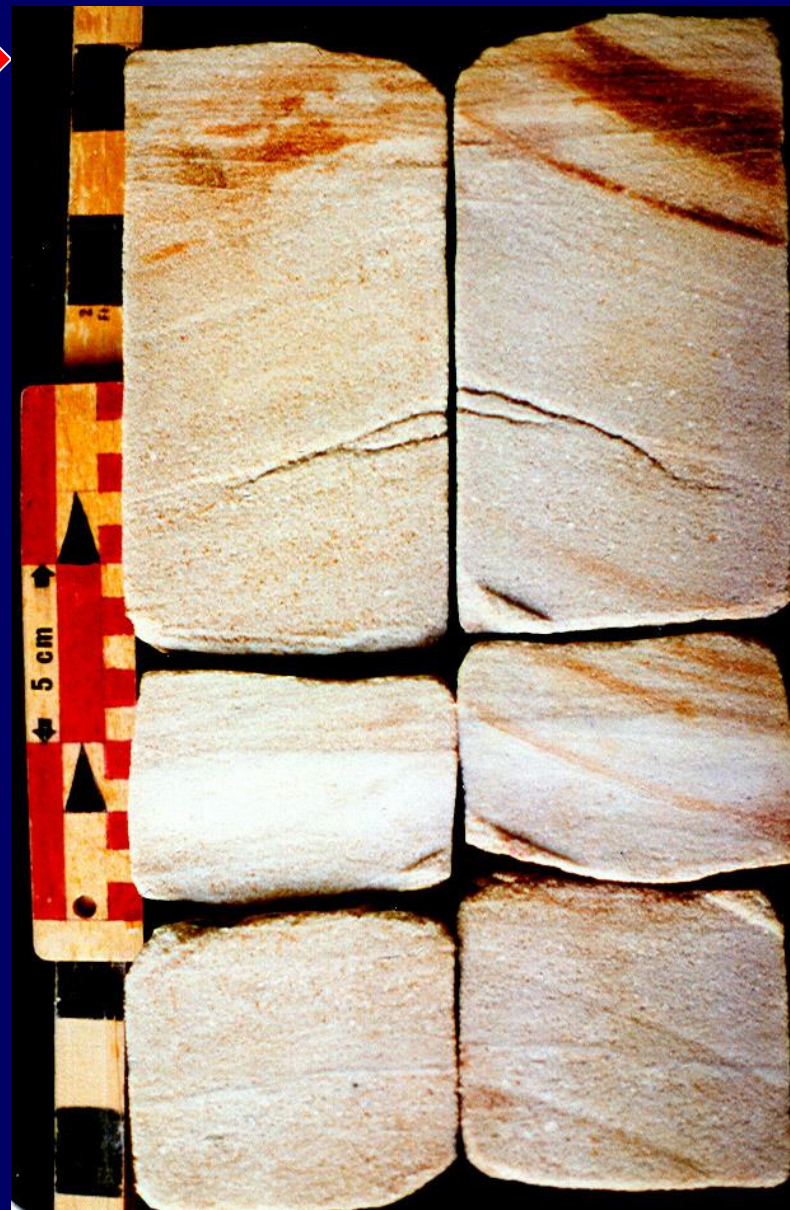


## *Meander Stream Facies*





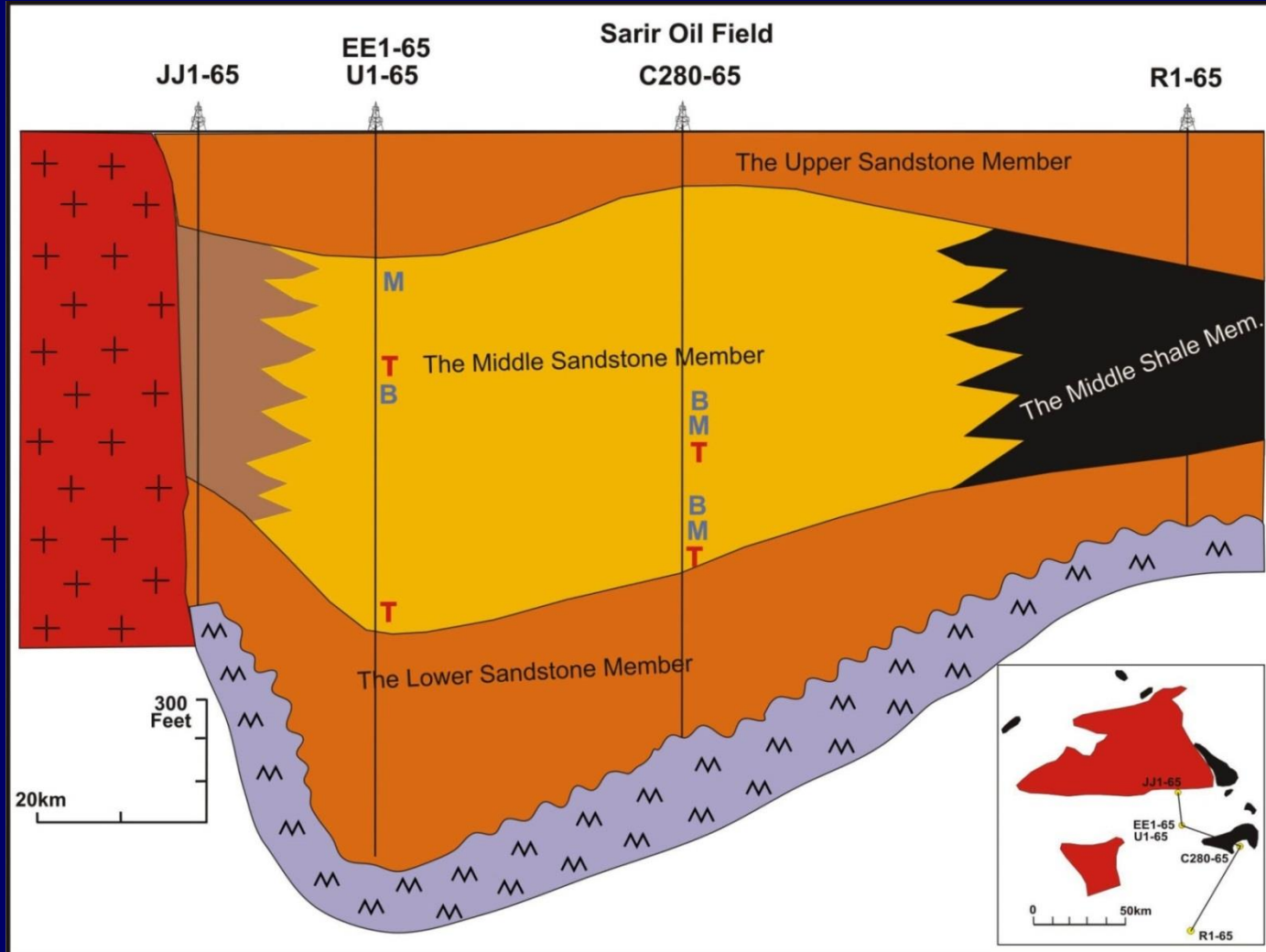
## *Braided Stream Facies*



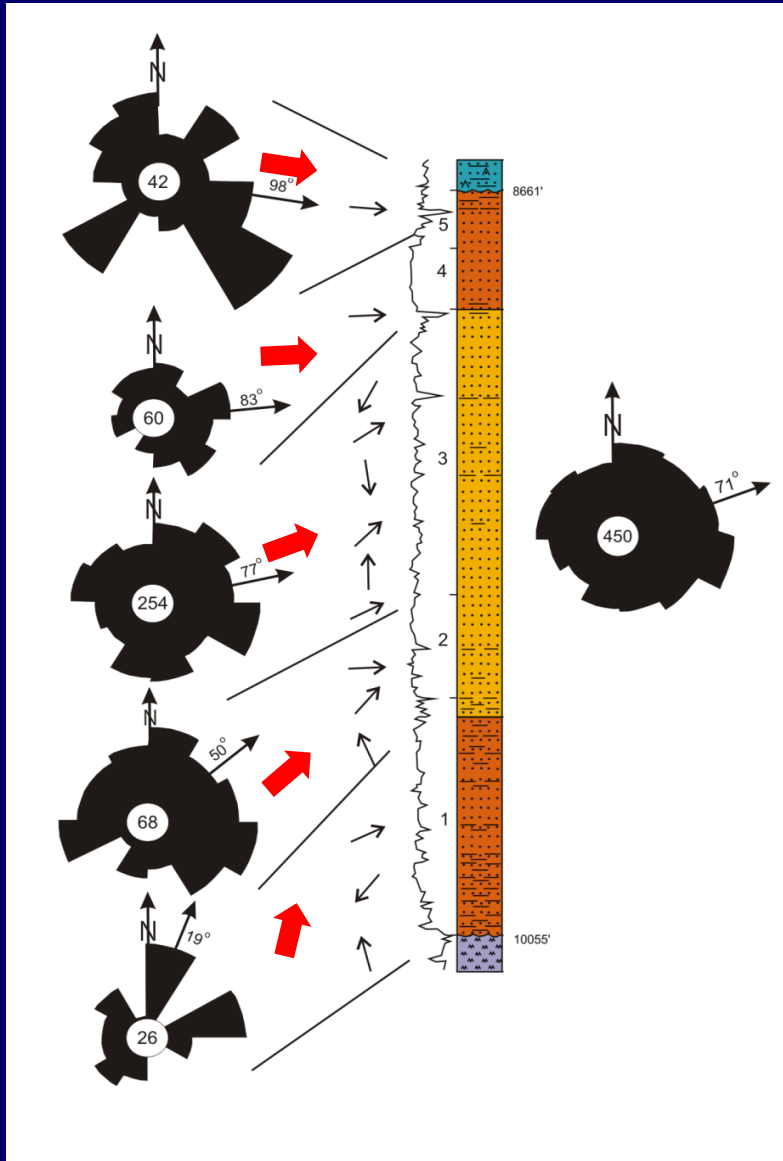


# N-S strat. x-section across the Sarir Inlet showing lateral facies change & cyclicity in the Middle Sandstone

Sedimentological core analysis of the Middle Sandstone cycles suggest tectonic overprint of the Aptian eustasy in proximity of basement highs (sediment source)



# Early Synrift Sediments Dispersal & Tectonic Adjustment

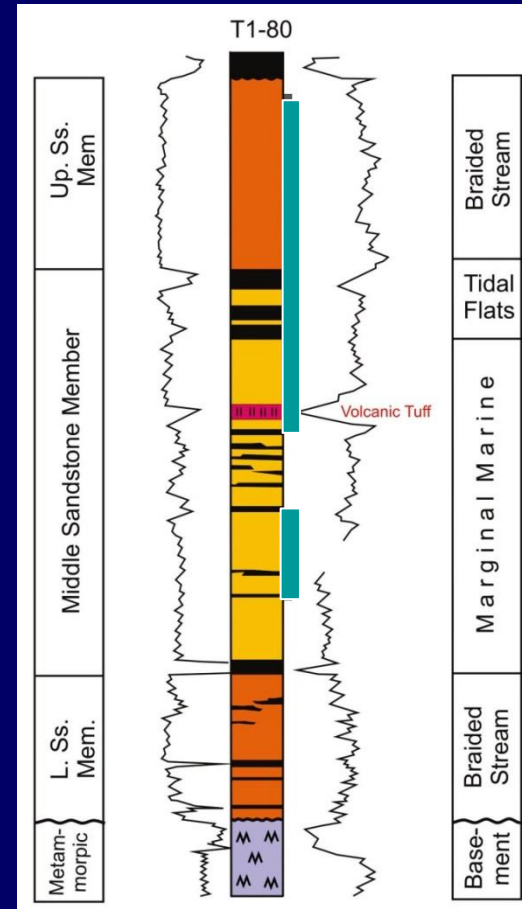
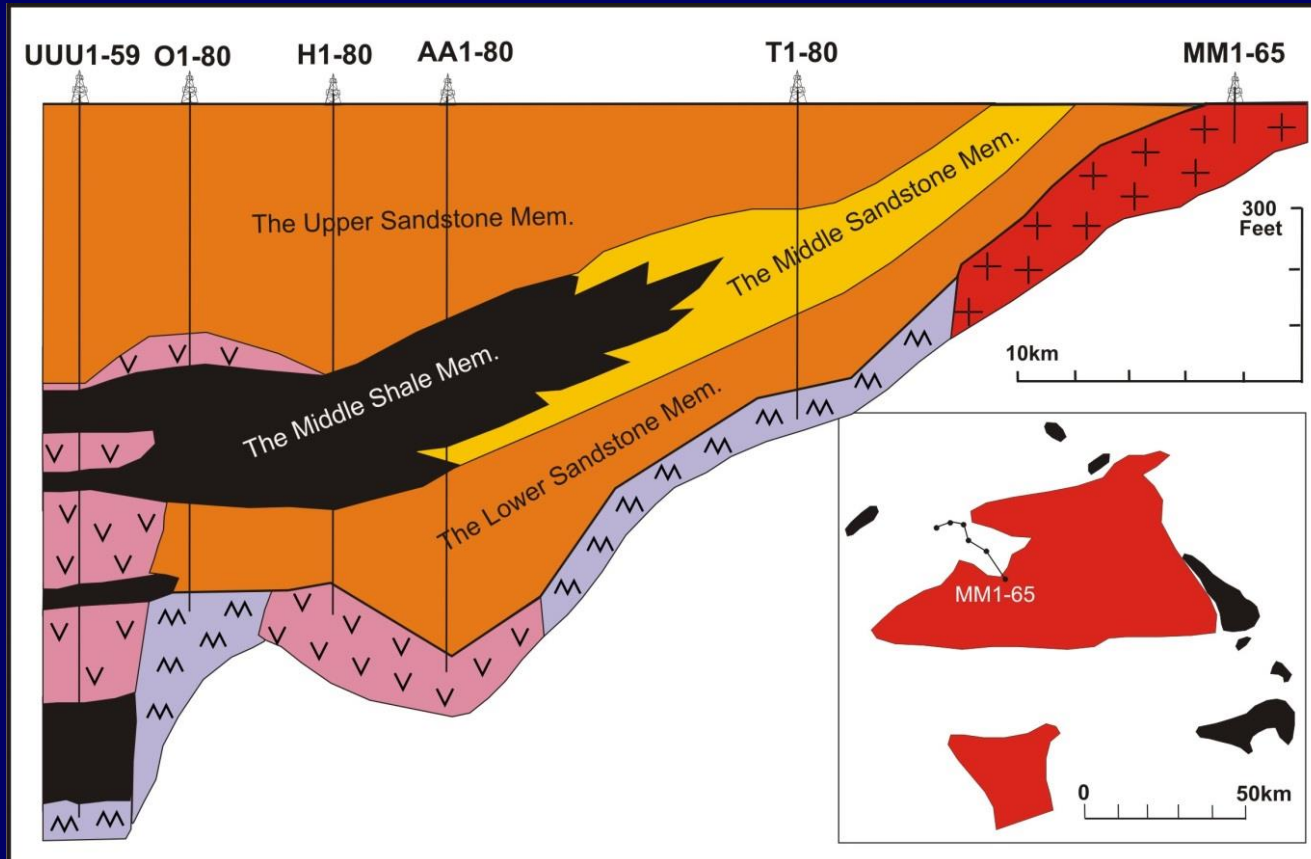


Rose diagrams based on depth calibrated FMS imaging data of the Sarir Sandstone cross-bedding inclination azimuth

**Vector means shows clockwise 79° rotation at the Sarir Oil Field.**

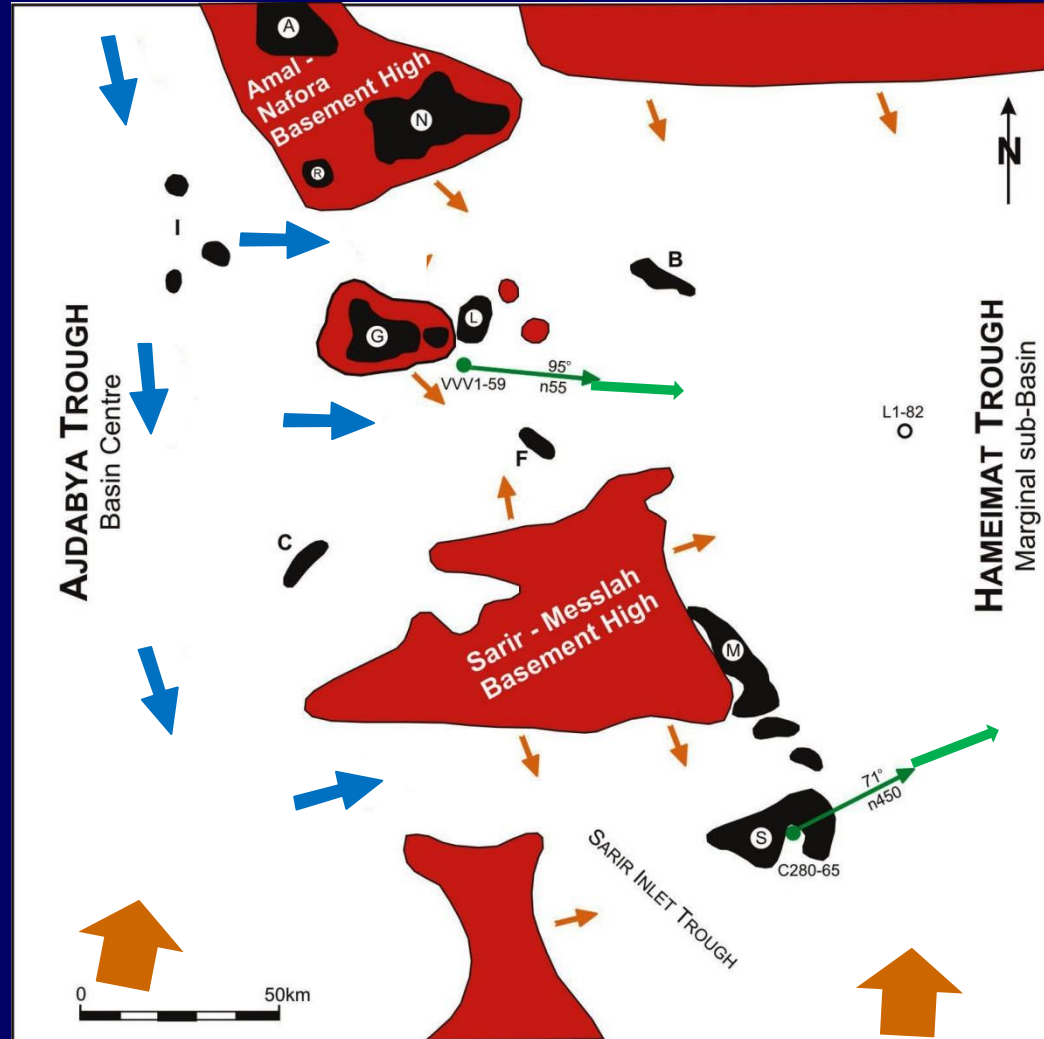
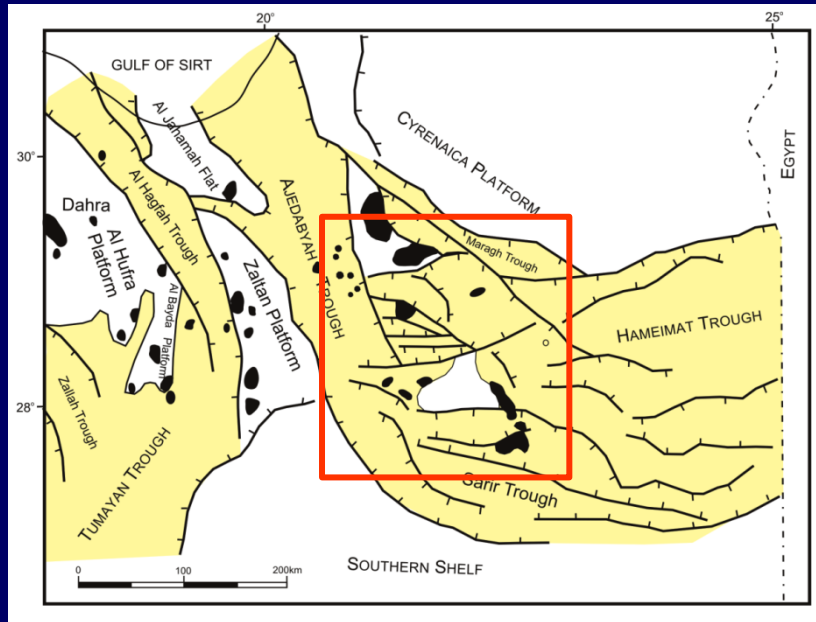
# Stratigraphic cross section from the bold basement towards Ajdabiya Trough

The Middle Sandstone Member is dominated by marginal marine facies



# Sediments Dispersal Map of The Sarir Sandstone

Deposition in inlets cutting across Gialo – Sarir bold basement high



Siliciclastic source from Tibesti Mountains



Local basement source

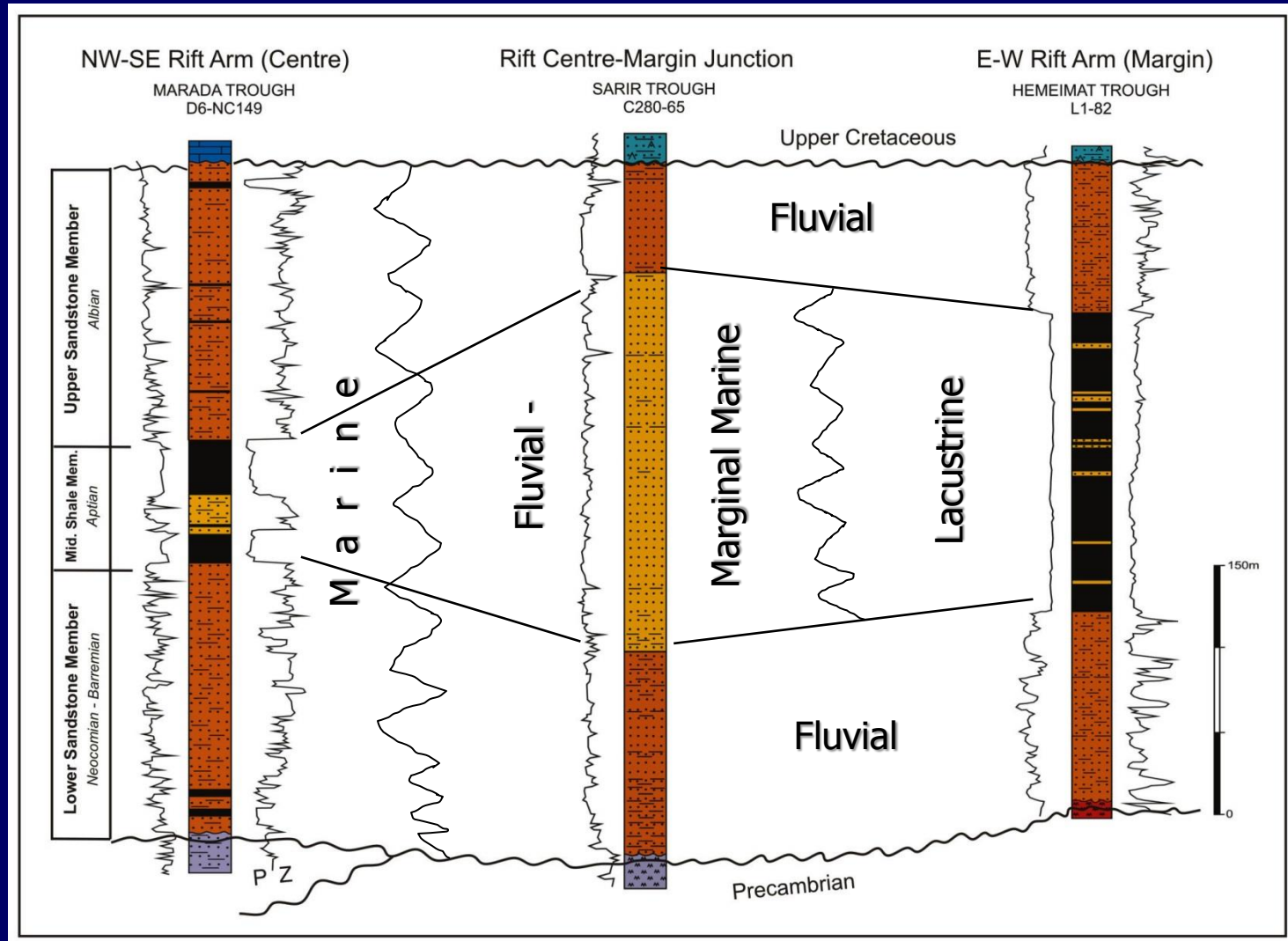


FMS & dip meter vector mean measurements at The Sarir and Gialo oil fields respectively



Aptian marine influence along Ajdabya Trough

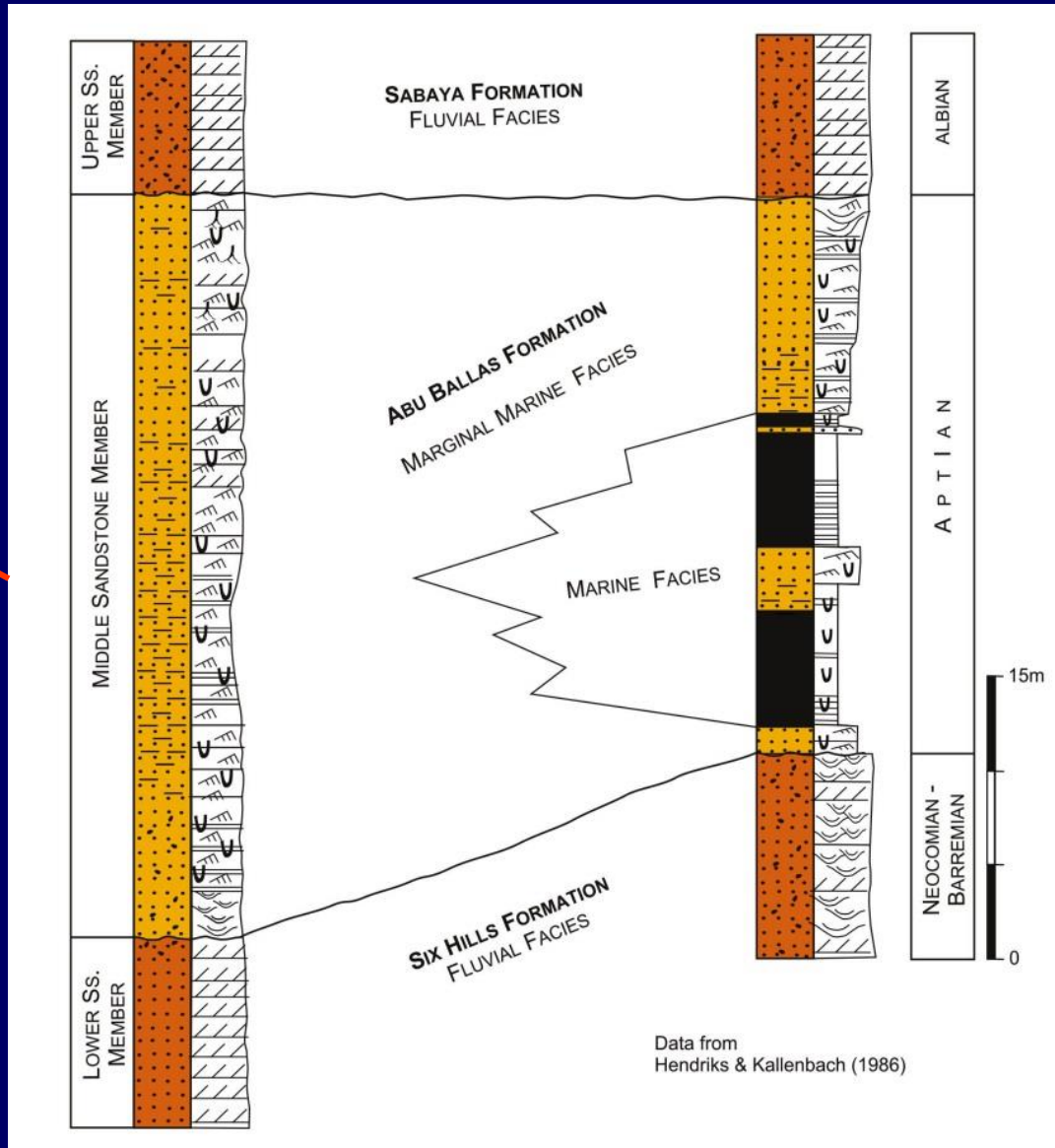
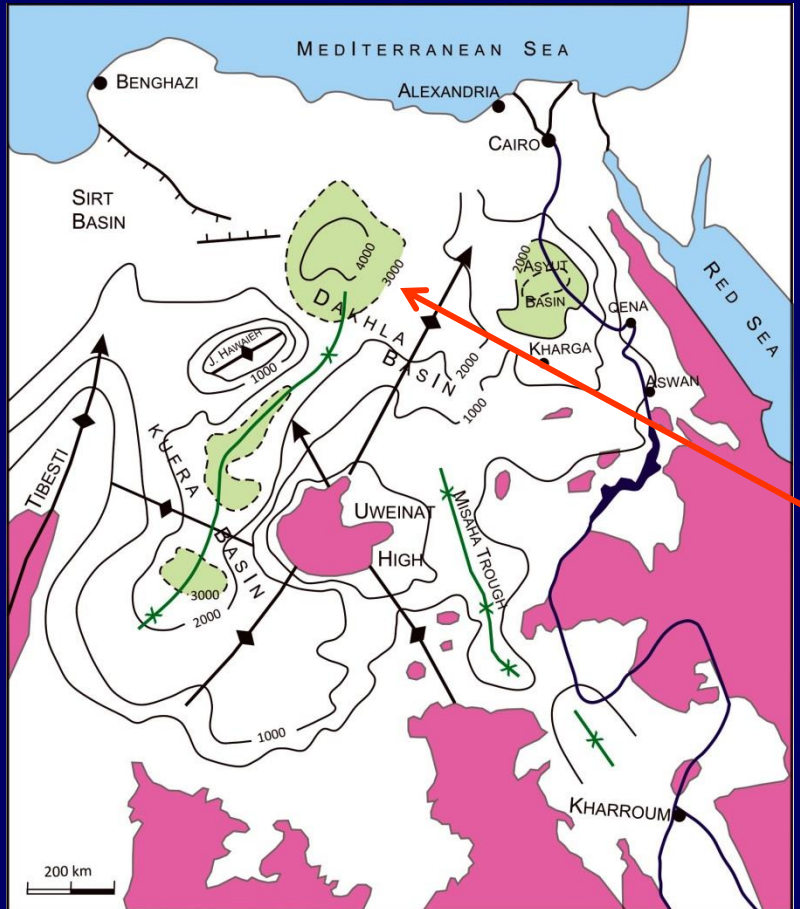
# Correlation of Facies and Event Signatures Across the Sirt Rift Complex





# The Sarir Sandstone Surface Analogue

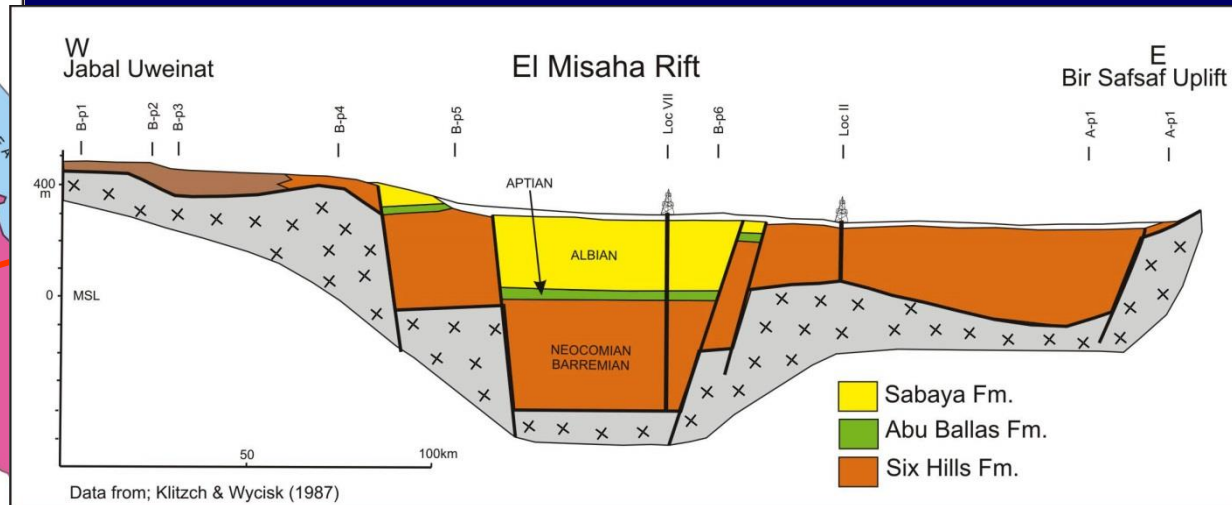
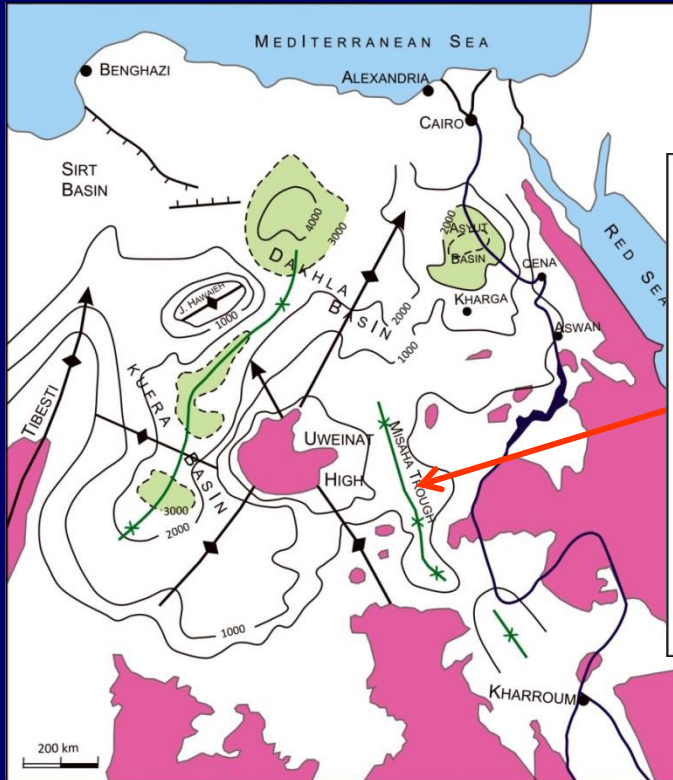
## The Dakhla Basin, The Western Desert of Egypt



# The Sarir Sandstone Analogue

## The Western Desert of Egypt & Northern Sudan

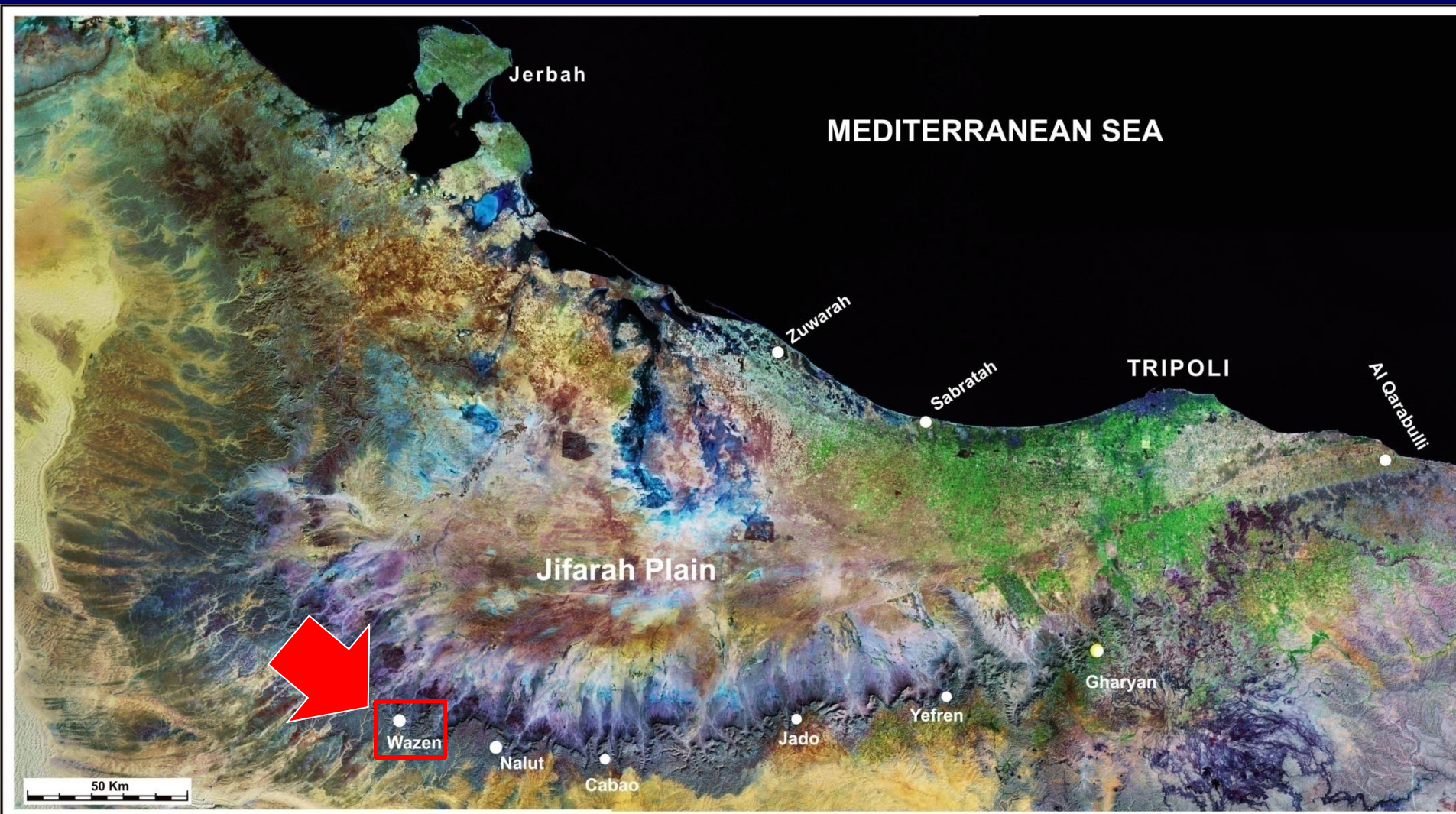
### Al Misaha Rift



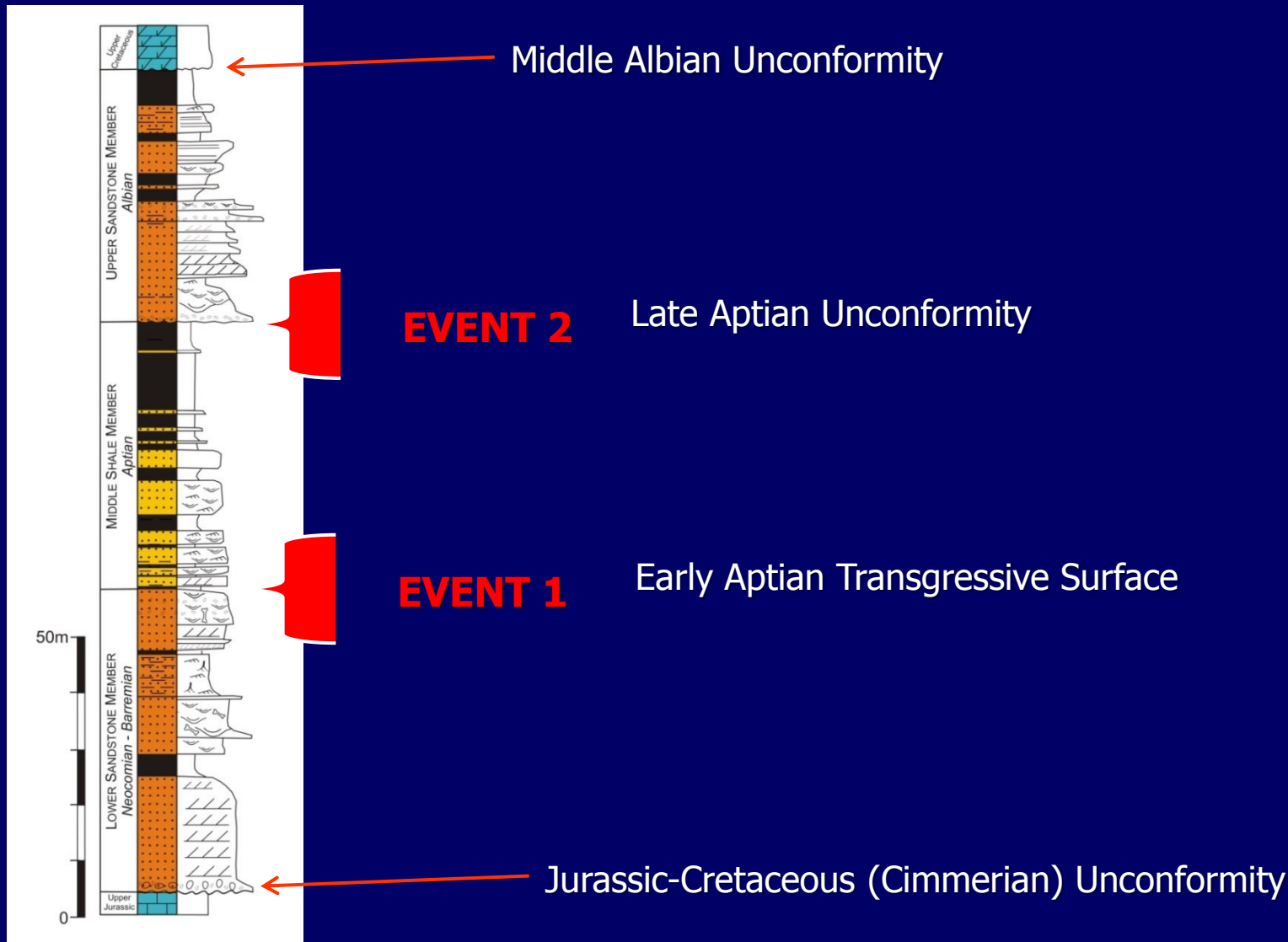


# The Sarir Sandstone Surface Analogue

## Jabal Nafusah, Jifarah Basin, N.W. Libya

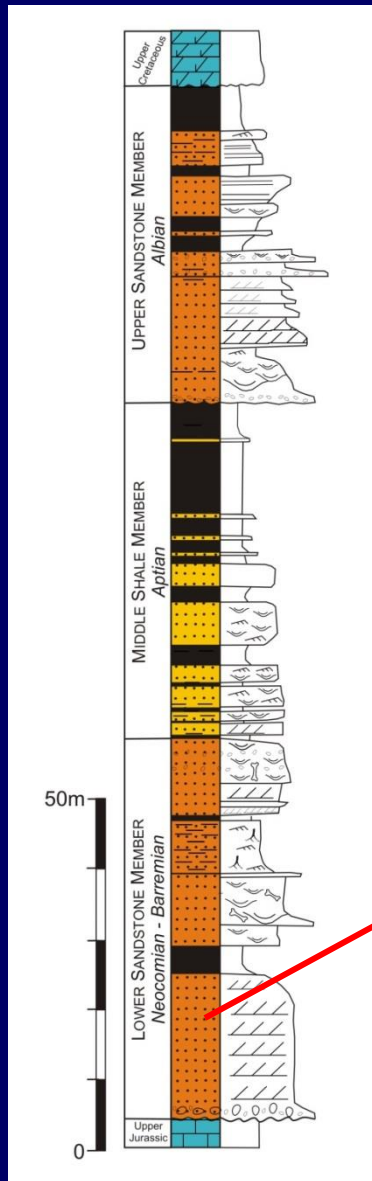


# A tripartite stratigraphic units bound by events surfaces



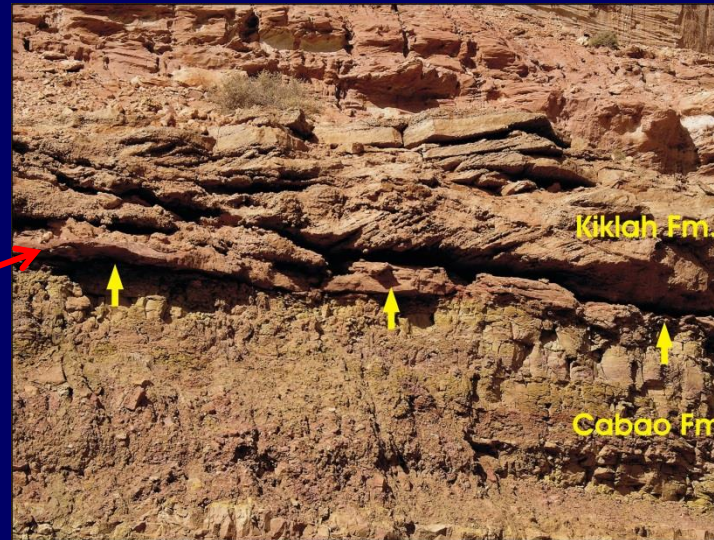
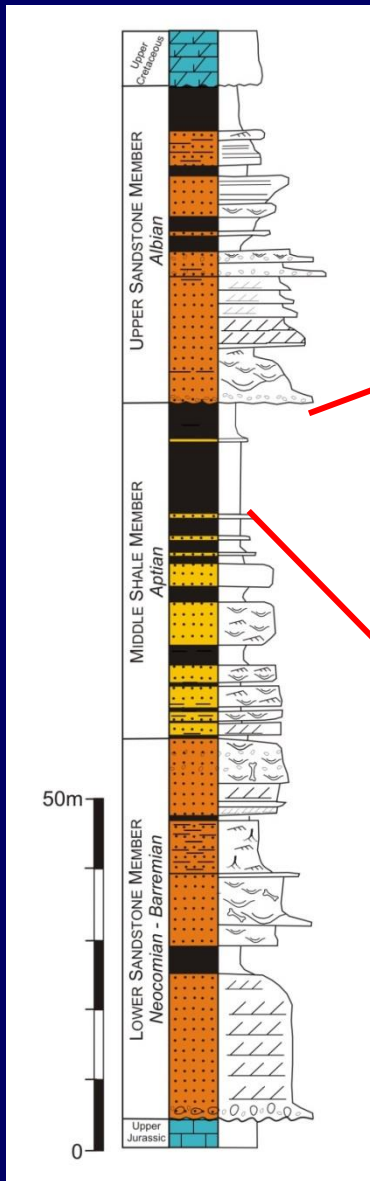


# The Lower Sandstone Member Barremian-Berriasian



Fluvio-Estuarine  
Facies

# Middle Shale Member Aptian



**EVENT 2**

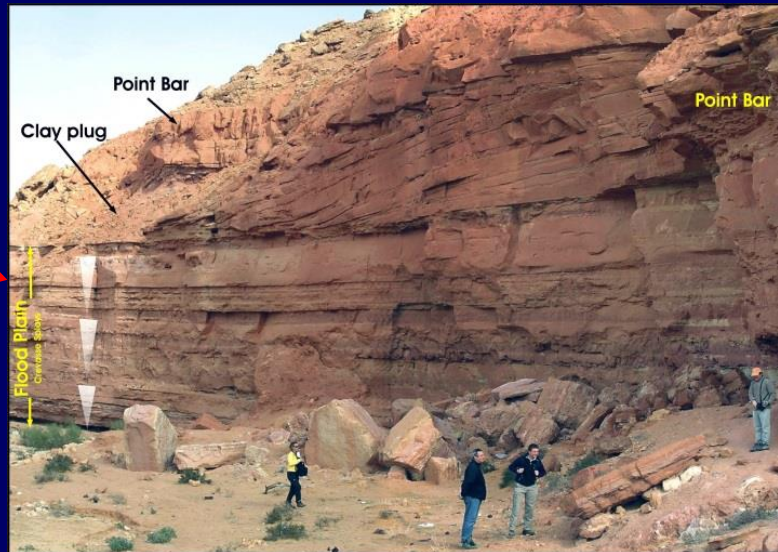
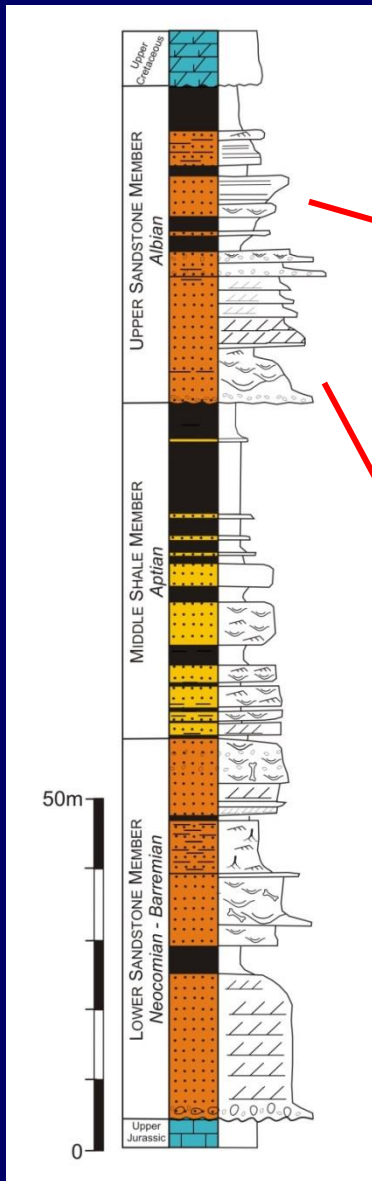


Lacustrine  
Facies



# The Upper Sandstone Member Facies

## Albian



Meander  
stream  
facies

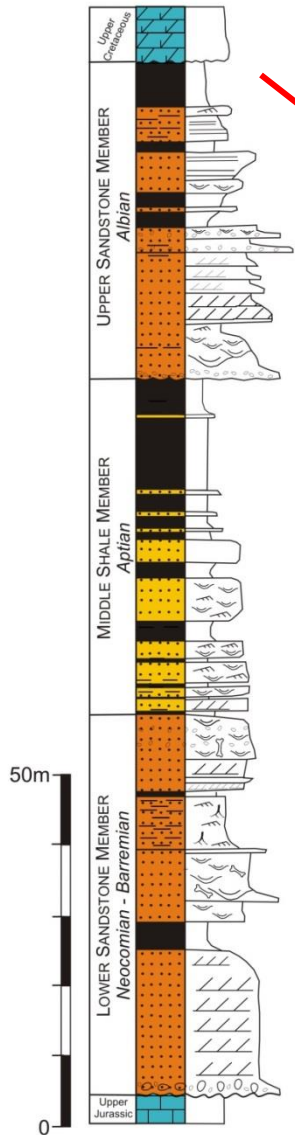


Braided  
stream  
facies



# The Upper Sandstone Member Facies

## The Albian – Cenomanian Boundary



# The Sarir Sandstone and its Correlatives: Interplay of Regional Tectonics & Global Eustasy

The Early Cretaceous is globally a transgressive cycle. In N. Africa and Sirt Basin it is a regressive cycle overprinted by the Aptian transgression event.

