Sequence Stratigraphy, Chemostratigraphy, and Diagenesis of the Miocene Carbonate-Evaporite Successions, Al-Jabal Al-Khdar Uplift and Soluq Trough, Cyrenaica, NE Libya*

Khaled S. Amrouni[1,3], Michael C. Pope[1], Ernest A. Mancini[2], and Ahmed S. El-Hawat[3]

Search and Discovery Article #51131 (2015)**
Posted August 31, 2015

*Adapted from oral presentation given at AAPG 2015 Annual Convention and Exhibition, Denver, Colorado, May 31 – June 3, 2015
**Datapages © 2015 Serial rights given by author. For all other rights contact author directly.

[1]Department of Geology and Geophysics, Texas A&M University, College Station, TX, USA (amrouni@neo.tamu.edu), (abcde_909@yahoo.com)
[2]The University of Alabama, Tuscaloosa, AL, USA
[3]Department of Earth Sciences, Garyounis University, Benghazi, Libya

Abstract

The Cyrenaican Miocene carbonate-evaporite platform of NE Libya is the focus of this sequence stratigraphic, chemostratigraphic and diagenetic study. The integrated study involves determining detailed regional facies relationships from field and lab observations. The fieldwork included 25 measured stratigraphic sections, 14 spectral gamma ray profiles constructed using a hand-held gamma-ray scintillometer at 0.5 m intervals, and annotated panoramic digital photomosaics. The lab work includes petrographic and diagenetic studies of 501 hand samples, thin sections and stable isotope ($\delta^{18}O$ and $\delta^{13}C$) analyses. The sequence stratigraphic framework is based on the sedimentological analysis, correlation of stratigraphic time surfaces and vertical stratigraphic sections, oxygen and carbon stable isotope profiles, and gamma-ray logs. The Ar-Rajmah Group Miocene carbonate rocks record two 2nd order supersequences (97 m maximum thickness); containing six 3rd order sequences, and at least 10 higher frequency 3rd order sequences. The TST of the younger 2nd order sequence is separated by a sharp disconformity surface from the preserved HST of the older 2nd order sequence, and by maximum flooding zone from the HST of the younger 2nd order sequence. The HST of the older 2nd sequence is the Early Miocene Benghazi Formation (46 m maximum thickness), and dominated by red algal reefs, and bioclastic packstones. The TST and HST of the younger 2nd order sequence occur in the Middle and Late Miocene Wadi Al-Qattarah Formation (26 m and 25m maximum thicknesses respectively), and dominated by continuous oolitic grainstones, microbialites that associated with evaporites and siliciclastics. The 3rd order sequences range in thickness from 5 m to more than 15 m. In the study area, the peritidal facies are dominant in the younger sequences, while the ramp crest-subtidal facies dominant in the older sequences. The chemostratigraphic data suggests the entire Miocene preserved. The Early Miocene is enriched in both $\delta^{18}O$ and $\delta^{13}C$, the Middle Miocene is enriched in $\delta^{13}C$ but depleted in $\delta^{18}O$, and the Late Miocene is depleted in both $\delta^{18}O$ and $\delta^{13}C$. The petrographic analysis shows two distinct lithological, textural and paragenetic patterns. The Langhian and older facies are dominated by silicified dedolomitized red algal and bioclastic packstones, the Serravallian and younger facies are dominated by silicified and recrystallized oolitic grainstone, microbial-bioclastic-oolitic grainstone.

Sequence Stratigraphy, Chemostratigraphy, and Diagenesis of the Miocene Carbonate-Evaporite Successions, Al-Jabal Al-Khdar Uplift and Soluq Trough, Cyrenaica, NE Libya

Garyounis University
Benghazi, Libya

AAPG-Talk-2015-Denver

Presented by

Khaled Saleh Amrouni

Khaled S. Amrouni[1&3], Michael C. Pope[1], Ernest A. Mancini[2], Ahmed S. El-Hawat[3]

(1)Department of Geology and Geophysics, Texas A&M University, College Station, TX 77843, (2) The University of Alabama, (3) Department of Earth Sciences, Garyounis University, Benghazi, Libya

amrouni@tamu.edu / abcde_909@yahoo.com , mcpope@geo.tamu.edu , emancini@as.ua.edu , ashawat@hotmail.com

Control ID: 2096186

Session Title: Theme 3: Modeling of Carbonate and Evaporite Systems (AAPG/SEPM)

Session Date: June-01-2015

Presentation Time: 10:30 AM to 10:50 AM

Session Location: Room 601/603

TEXAS A&M UNIVERSITY

Data:

(A)29 detailed measured sections, 503 samples

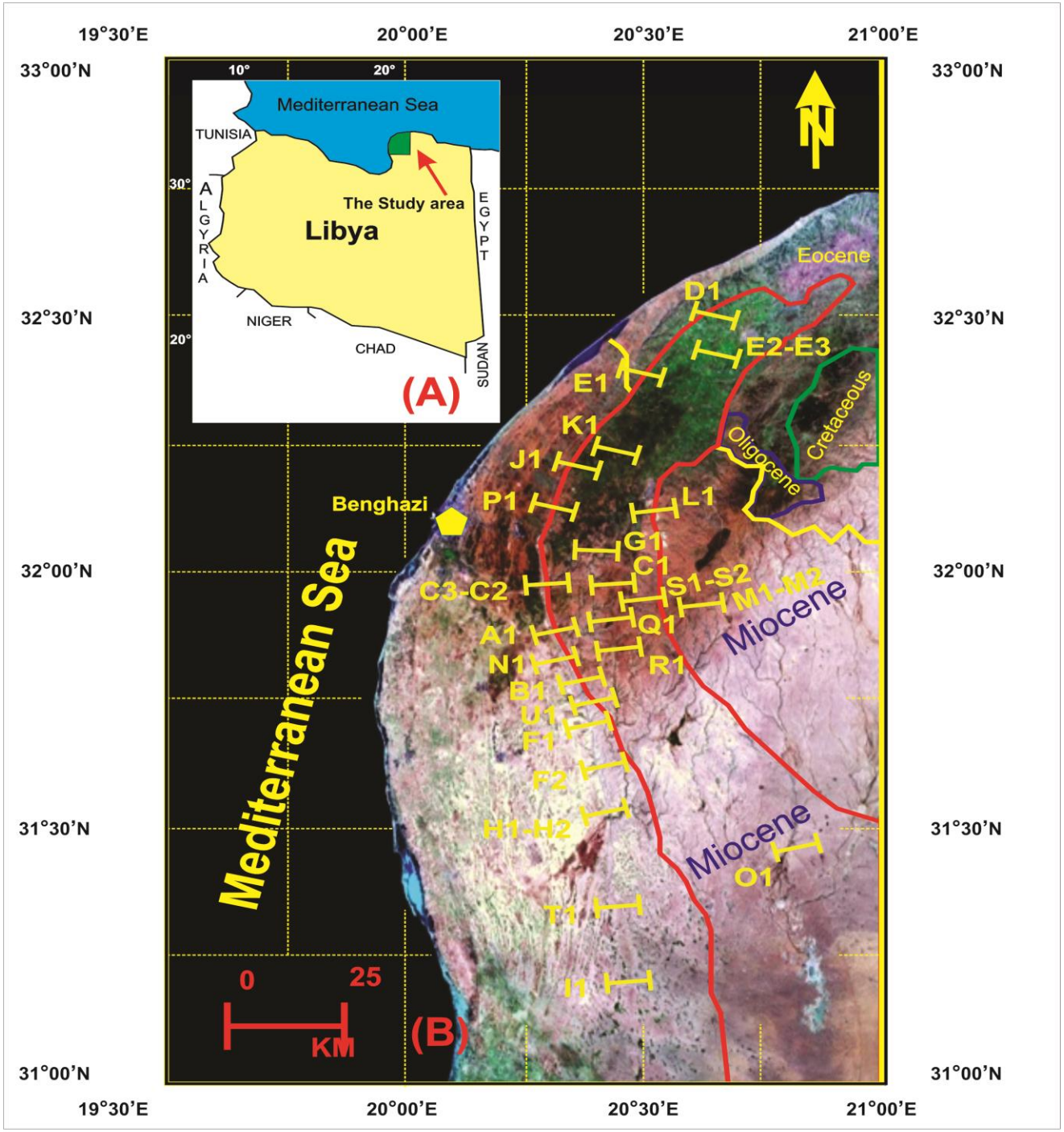
(B)14 hand-held gamma ray scintillometer profiles, and

(C)4 carbon stable isotope curves.

- **Sedimentology, Sequence Stratigraphy**
- **Chemostratigraphy**
- **Diagenesis**

Location

Cyrenaican Miocene, Al-Jabal Al-Khdar Uplift and Soluq Trough, NE Libya



Sedimentology and Sequence Stratigraphy

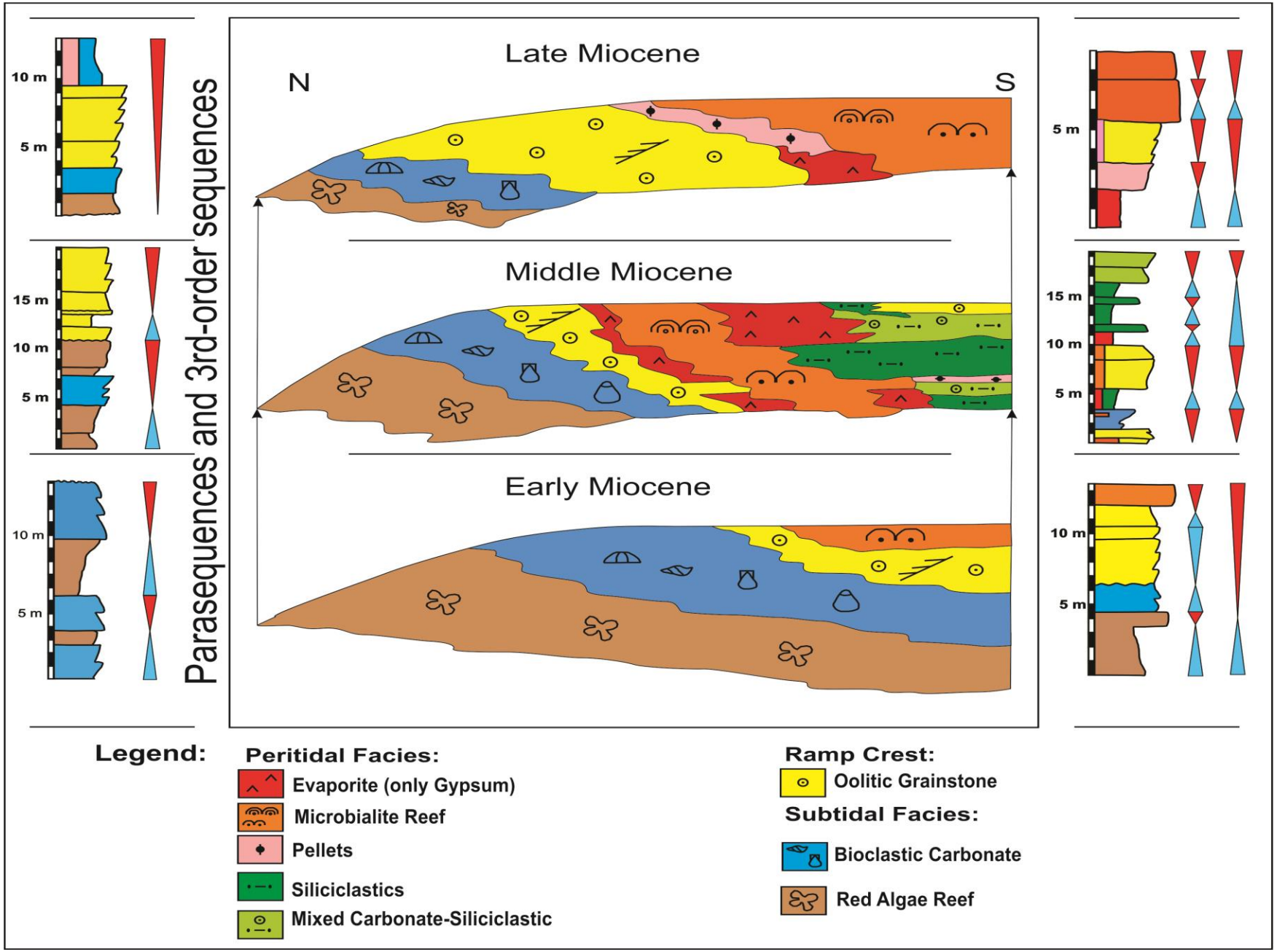
The Ar-Rajmah Group: nine **carbonate** facies and two **siliciclastic** facies, deposited on a gently sloping **ramp**.

- **The peritidal facies** : 1) evaporite, 2) microbialite (stromatolites, thrombolites, and laminite), 3) pelletal wackestone/packstone, 4) porites reefs and bioclastic packstone, 5) very fine to fine quartz sandstone, 6) green shale.

- **The ramp crest facies**: 1) oolitic grainstone.

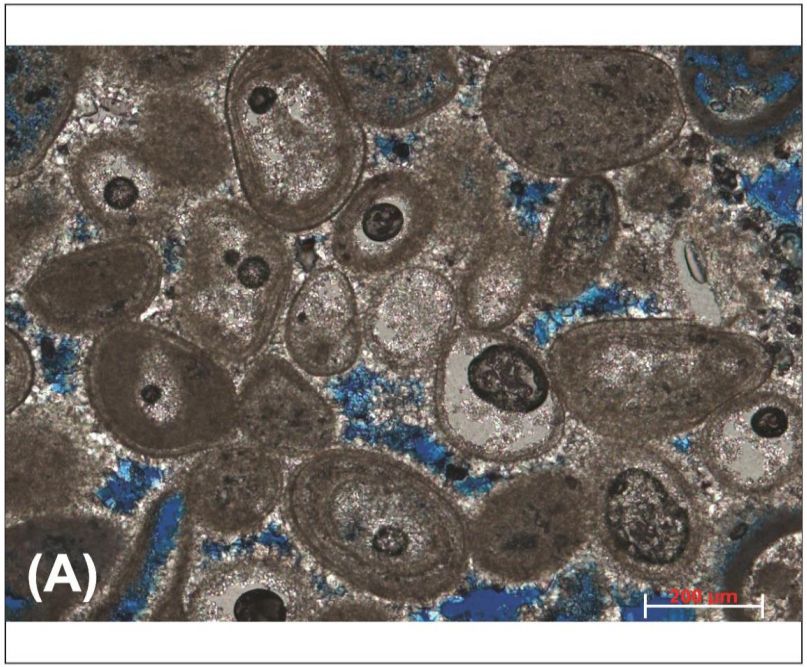
- **The subtidal facies** : 1) bioclastic carbonate, 2) reworked bioclastic carbonate, 3) red algae reefs, 4) reworked red algae.

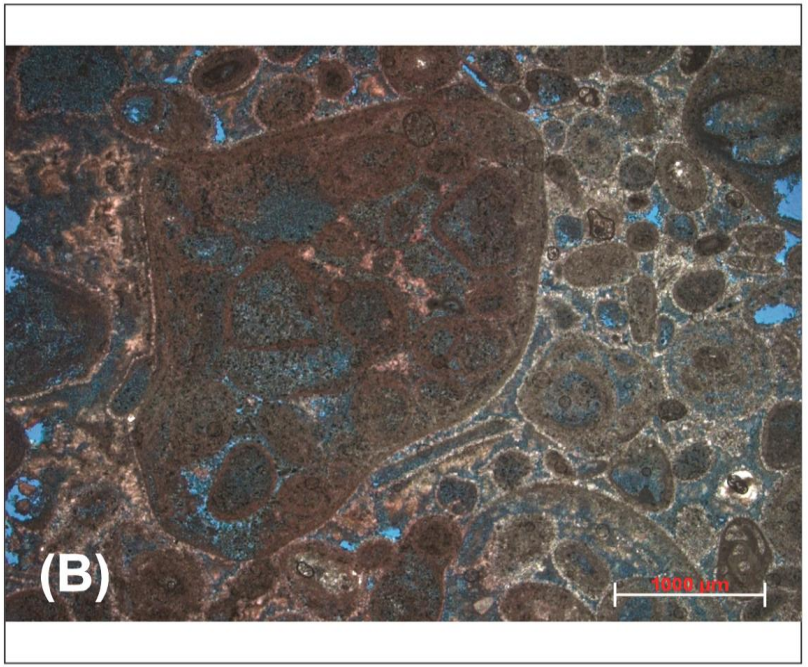
Ramp Evolutionary Depositional model



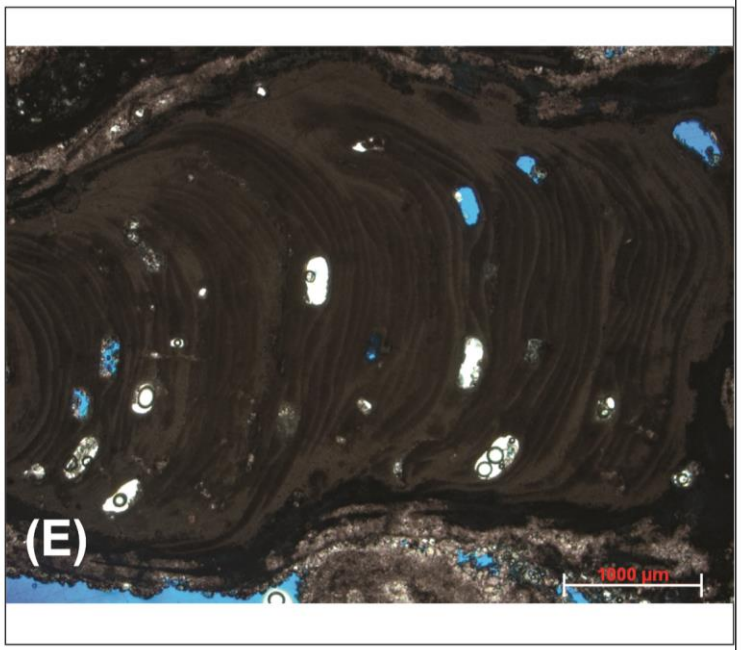
Peritidal Facies

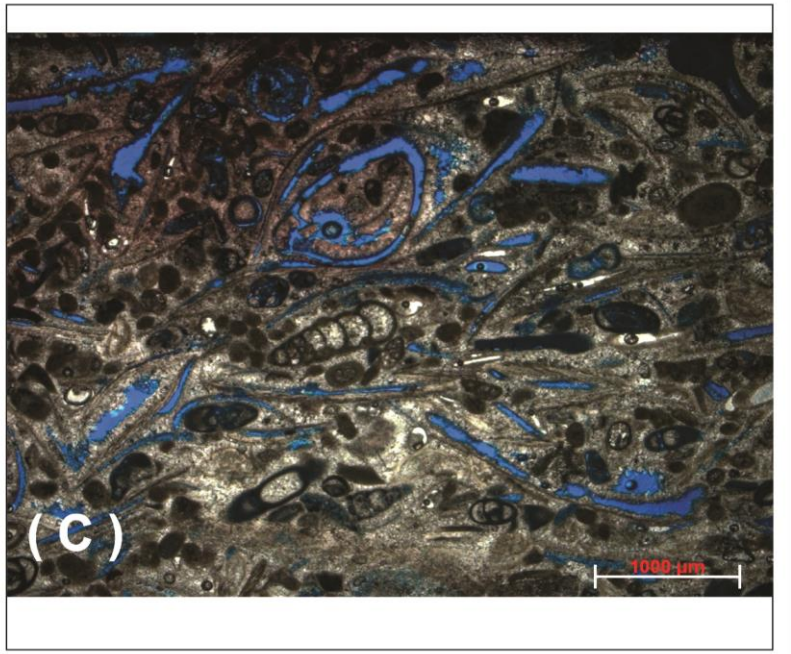
Ramp Crest





Subtidal Facies





Measured section F1

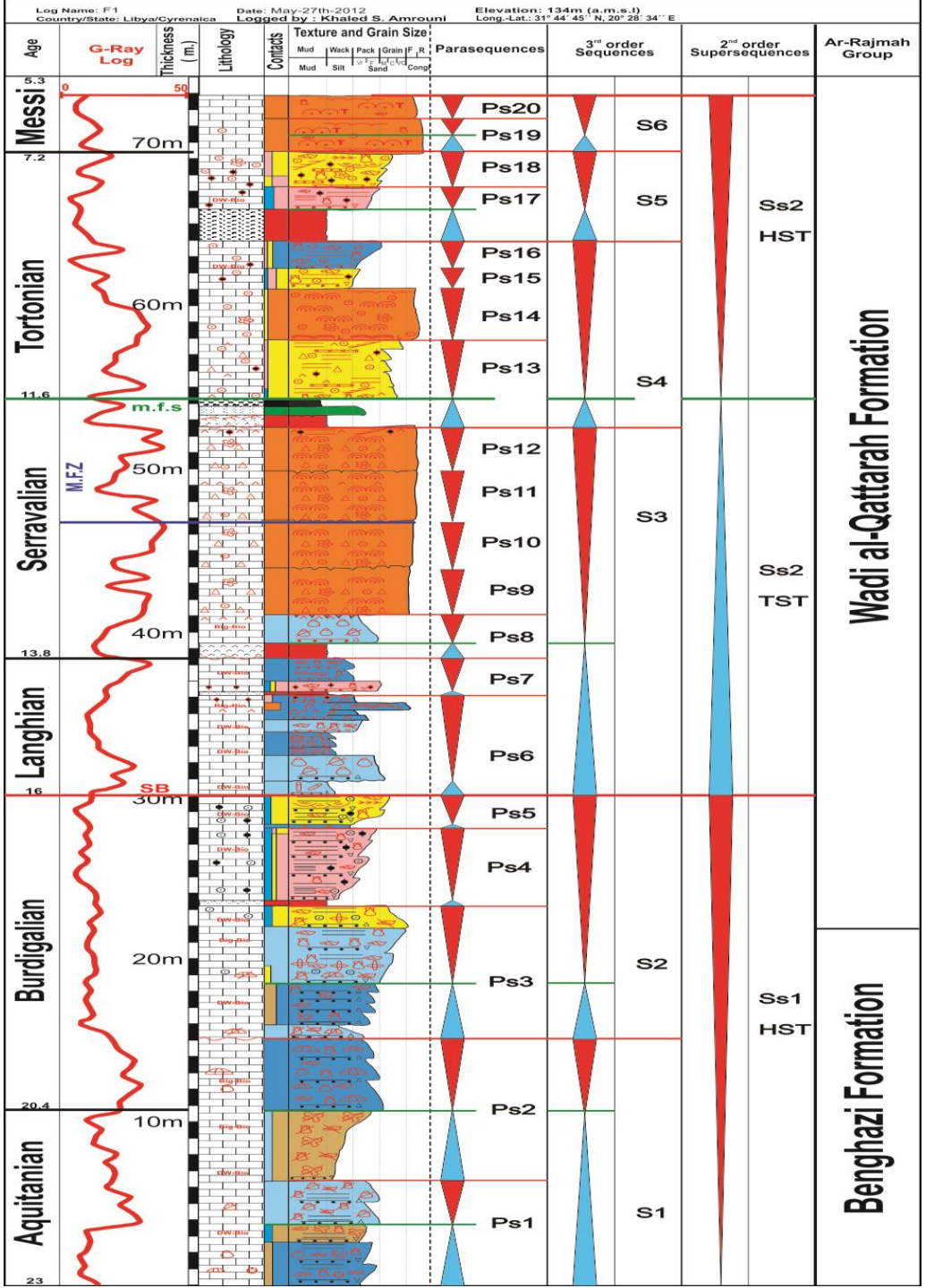
-F1 representative profile.

-73 m thick.

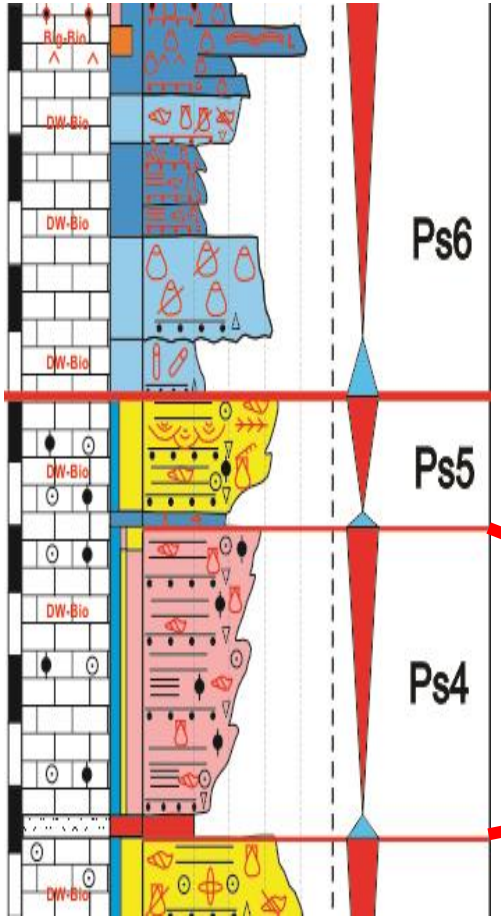
-Two 2nd-order supersequences (SS1-SS2),

-Six 3rd-order sequences (S1-S6),

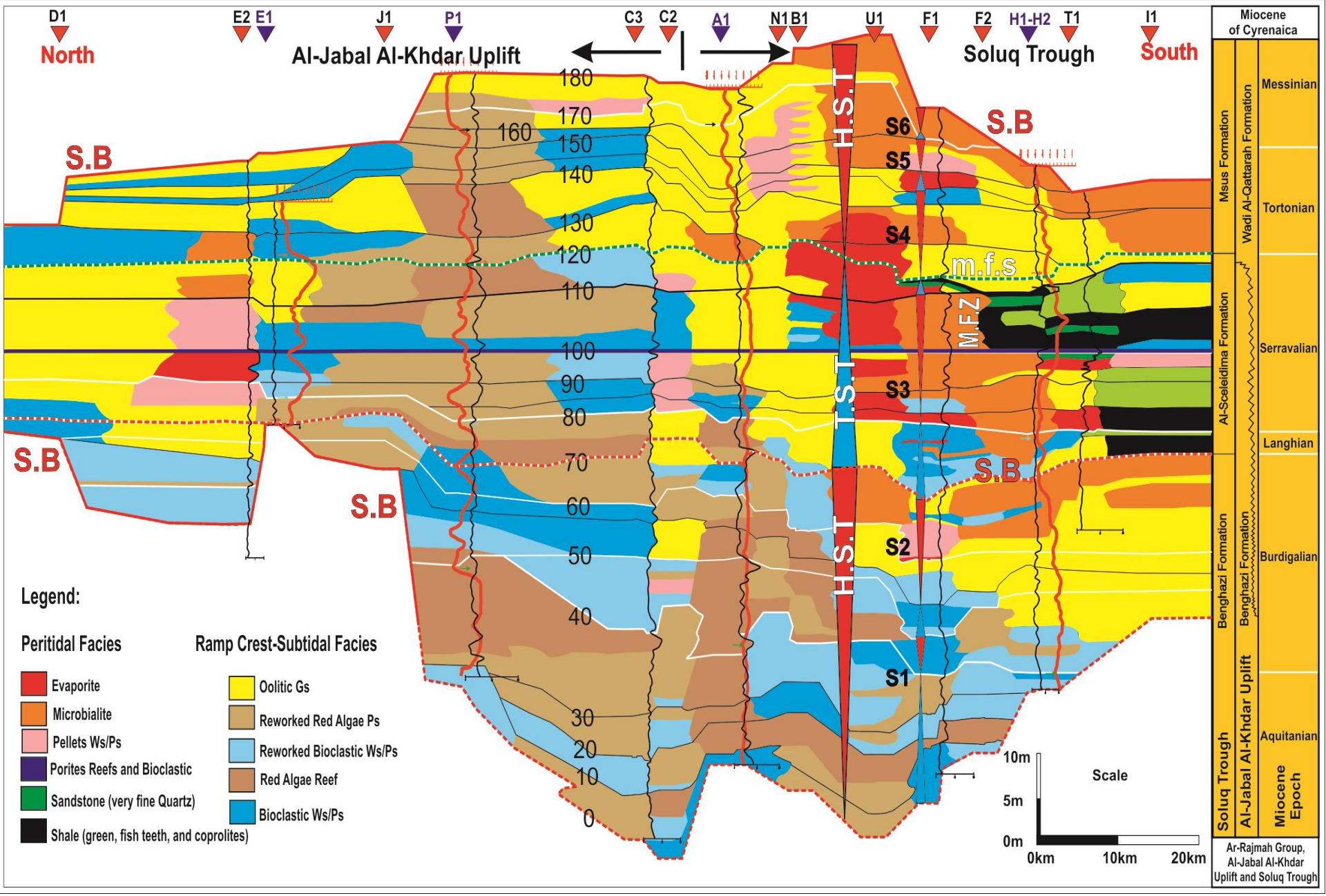
-20 parasequences (PS1-PS20).



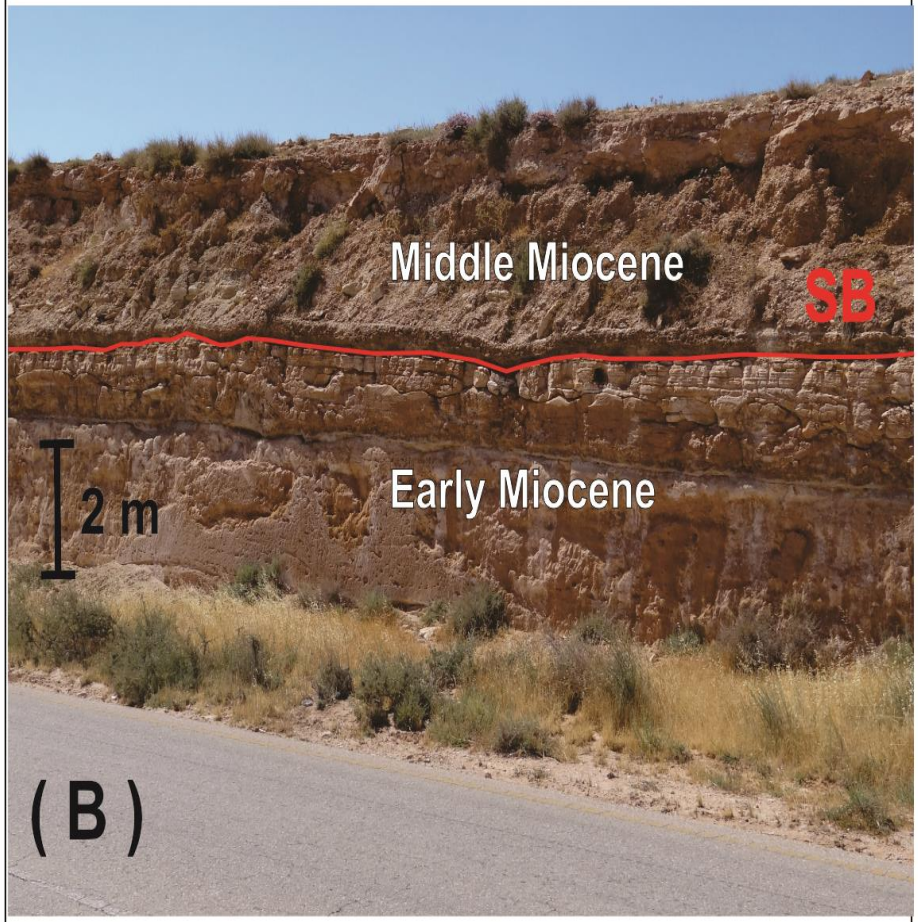
Parasequences in the Cyrenaican Miocene Field

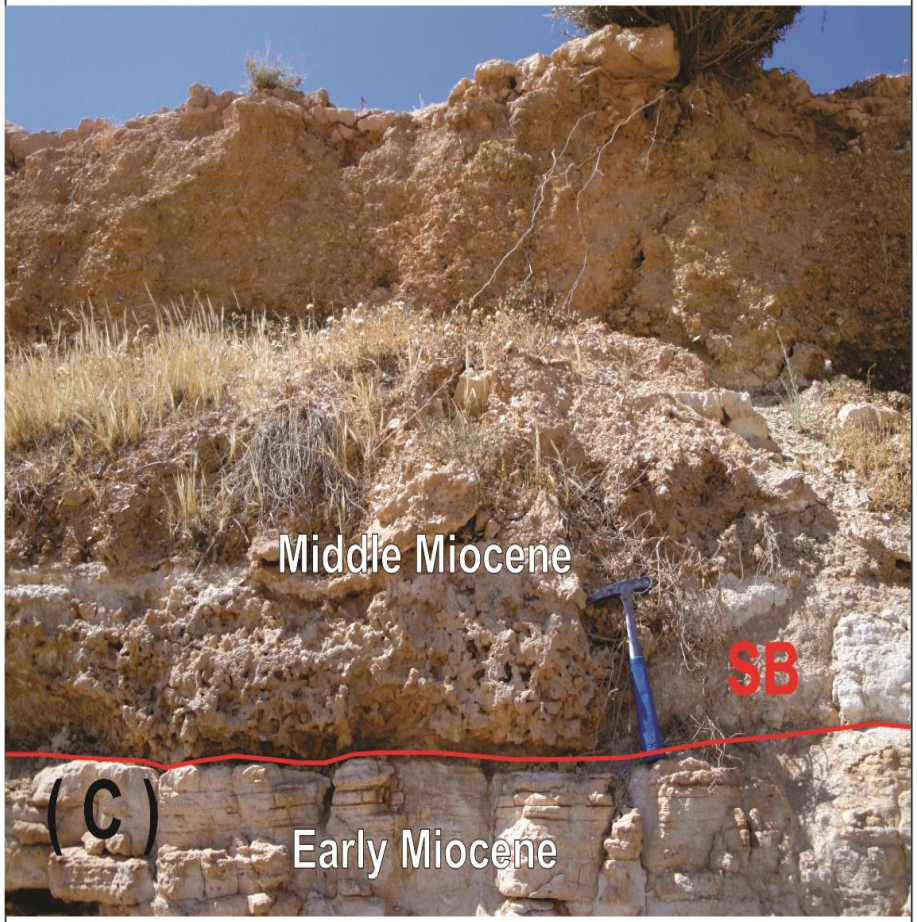


Sequence Stratigraphic Framework of the Cyrenaican Miocene



Sequence Stratigraphic Surfaces In the Field:
SB between the Early Miocene and the Middle Miocene.





Conclusions: Sequence Stratigraphy

- The Ar-Rajmah Group of the Cyrenaica Platform was deposited on a **ramp** and records **multiple orders** (2^{nd}-4^{th}) of cyclicity.

- The Early Miocene dominated by Red algae and Porites.

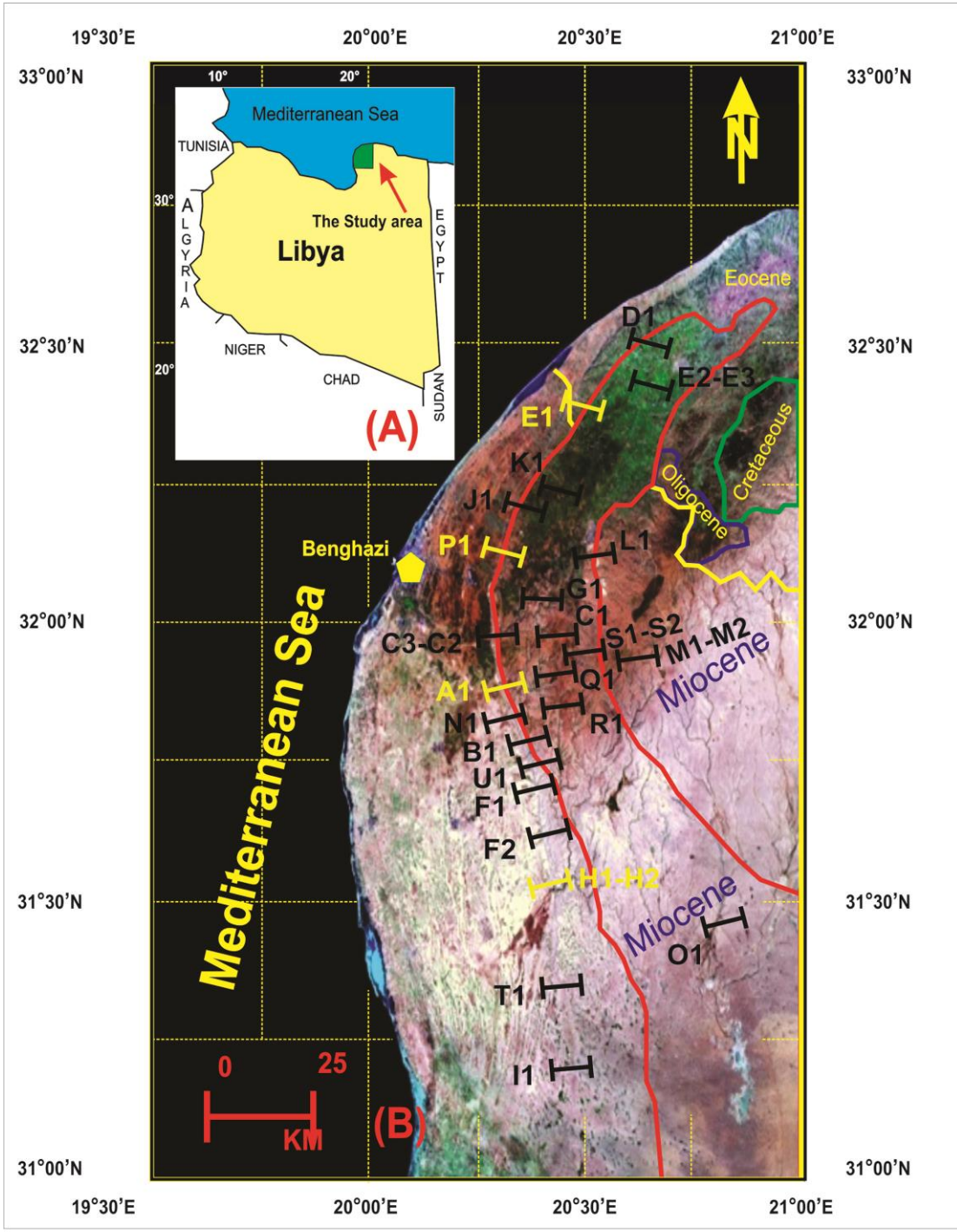
- Middle and Late Miocene predominantly microbial-oolitic-evaporite facies.

- Excellent 3-D **analogue** for ooid grainstone, microbial carbonate, and red algae **reservoirs in the subsurface** within the Mediterranean region and globally.

Chemostratigraphy

$\delta^{13}C$ and $\delta^{18}O$

- 4 measured sections, 0.5 m.
- $\delta^{18}O$ ranges -9.2 to 3.7 ‰ VPDB.
- $\delta^{13}C$ ranges -6.7 to 3.0 ‰ VPDB.
- E-Miocene enriched in both.
- M-Miocene $\delta^{13}C$ enriched, $\delta^{18}O$ depleted.
- L-Miocene depleted in both.



OBJECTIVES

- Determine $\delta^{18}O$ and $\delta^{13}C$ stable isotope curves for Cyrenaican Miocene carbonate rocks

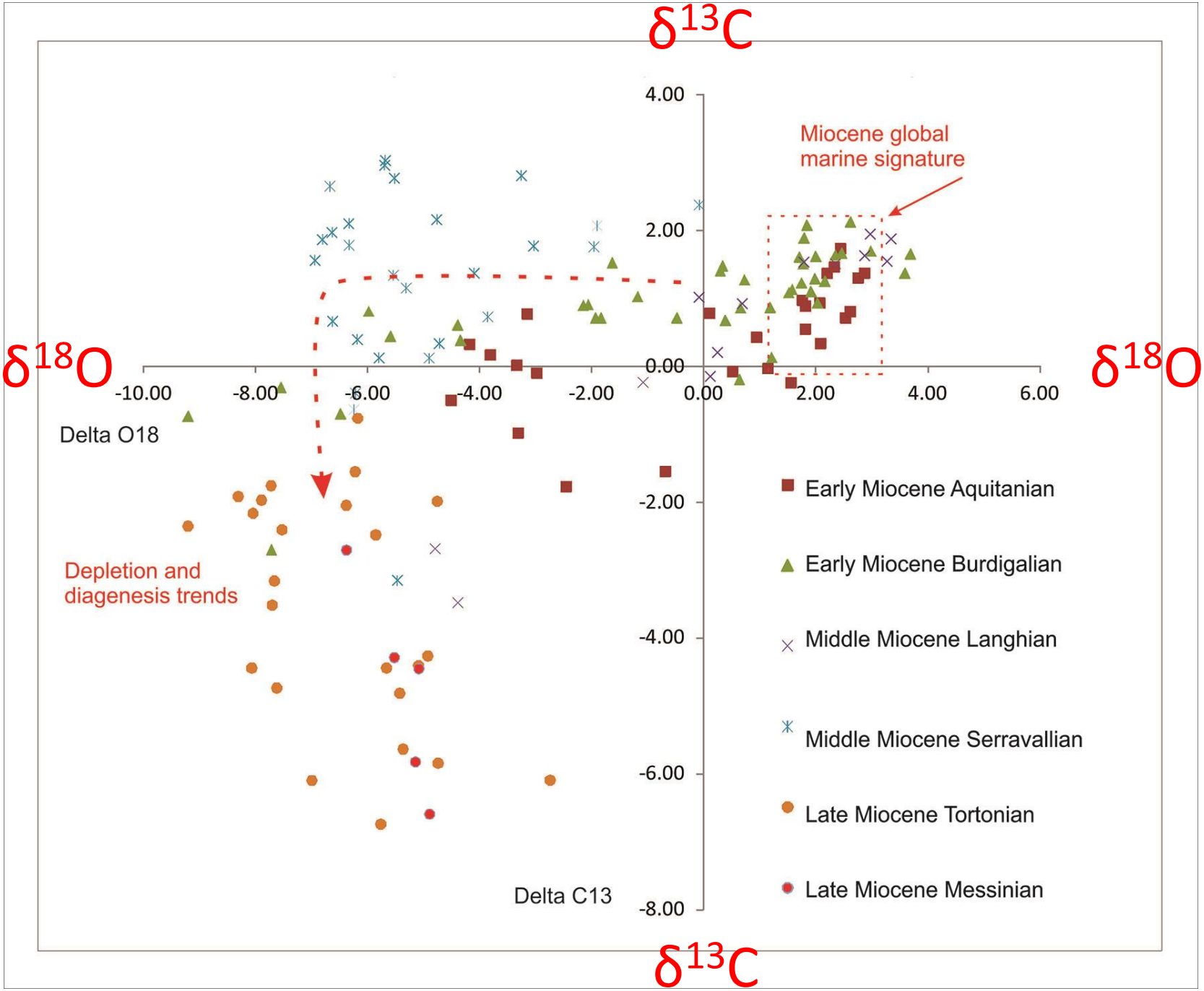
- Compare the regional and global Miocene $\delta^{18}O$ and $\delta^{13}C$ curves, trends, and values with those of the Cyrenaican Carbonate platform,

- Provide better age constraints.

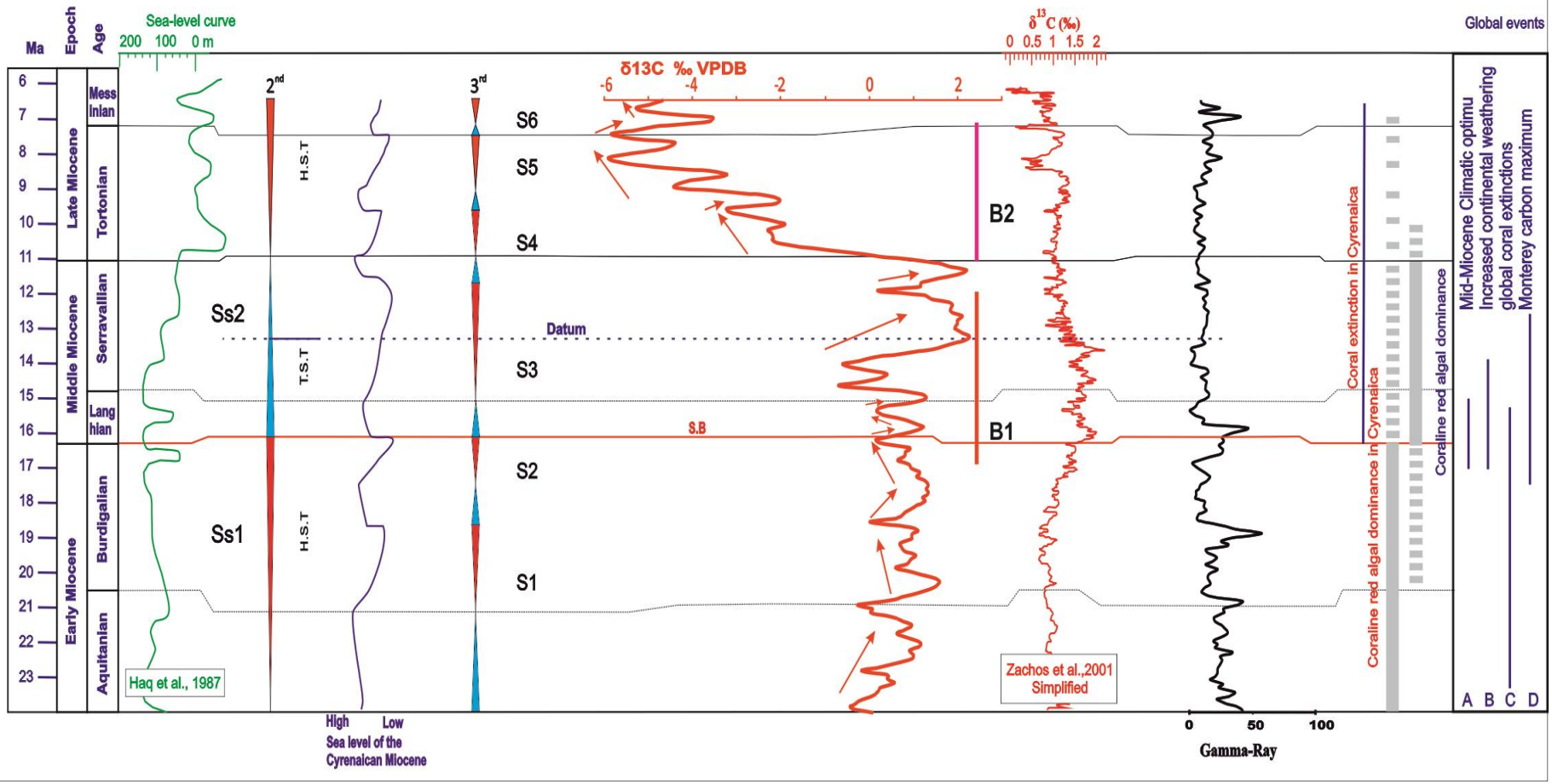
Chemostratigraphic Methods

- The **503** whole-rock samples of 0.5 m interval, micro-drilled for the $\delta^{18}O$ and $\delta^{13}C$ isotopic analysis in the Stable Isotope Geosciences Facility at Texas A&M University.

- The carbon stable isotope curves were plotted with a datum in the Middle Miocene that has both high gamma ray values and a positive carbon isotope excursion.


δ13C
δ18O
δ18O
δ13C
Miocene global marine signature
Depletion and diagenesis trends
Delta O18
Delta C13
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Early Miocene Aquitanian
Early Miocene Burdigalian
Middle Miocene Langhian
Middle Miocene Serravallian
Late Miocene Tortonian
Late Miocene Messinian

Events in the Miocene sequence

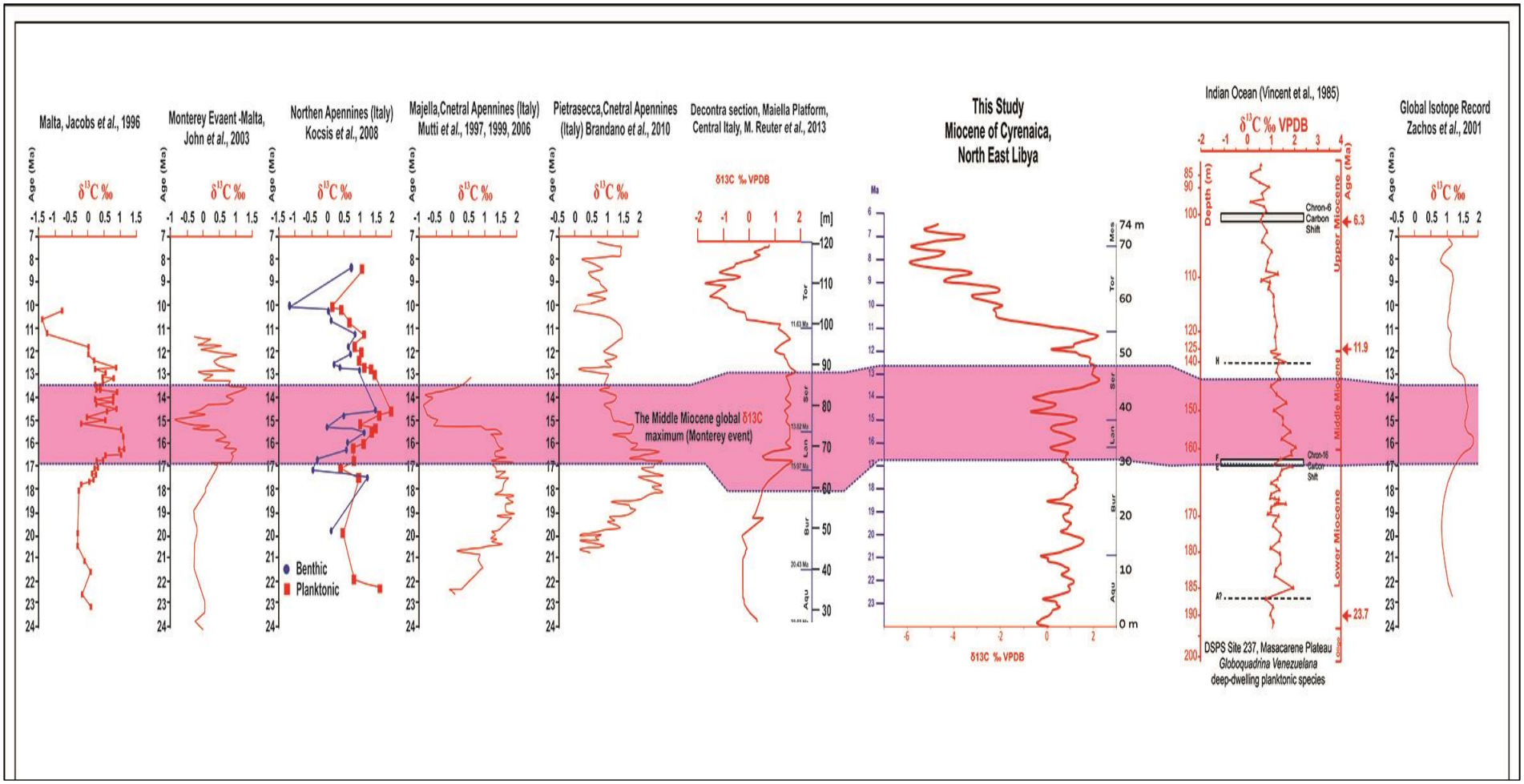


Events in the Cyrenaican Miocene

B2 d13C depletion
Weathering of organic rich rocks,
Platform final emergence
progressively shallowing and
restricted (Mediterranean-Cyrenaica)

B1 d13C enrichment
Monterey Event (Vincent and Berger, 1985)
(Global-Mediterranean-Cyrenaica)

Cyrenaican, Mediterranean, Indian Ocean, and Global



Middle Miocene Monterey Event

Conclusions: Chemostratigraphic Events

1- M-Miocene S3 coincides with Monterey positive carbon event.

2- Section beneath the Monterey event is Lower Miocene

3- Tortonian-Messinian depleted $\delta^{13}C$ due to the emergence of the progressively shallowing restricted shallow-water carbonate platform.

Methods of Diagenesis

1- Blue dye, Alizarin Red-S stain, and potassium ferricyanide stain.

(A) Quantitative: type and percentage of grains, matrix, cement, and pores

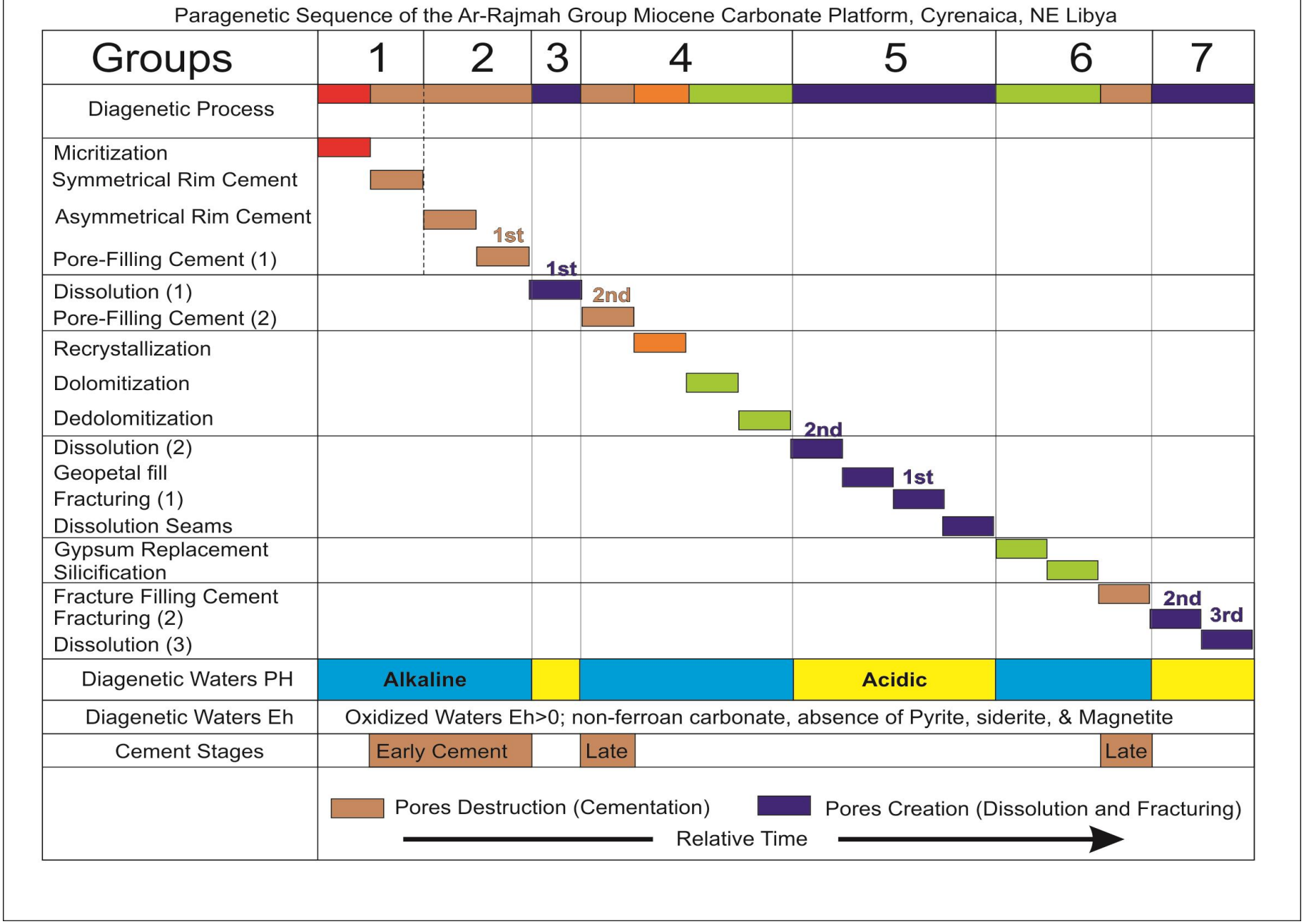
(B) **Qualitative**: rocks textures (fabrics and grain size), sedimentary structures (primary and secondary), and trace fossils.

(C) **Diagenetic** processes:

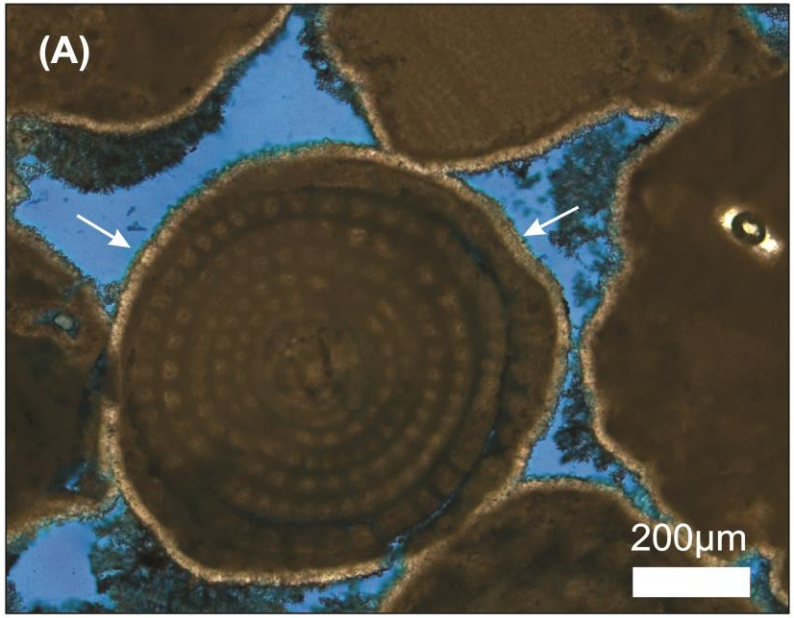
Pore creation: dissolution/leaching,

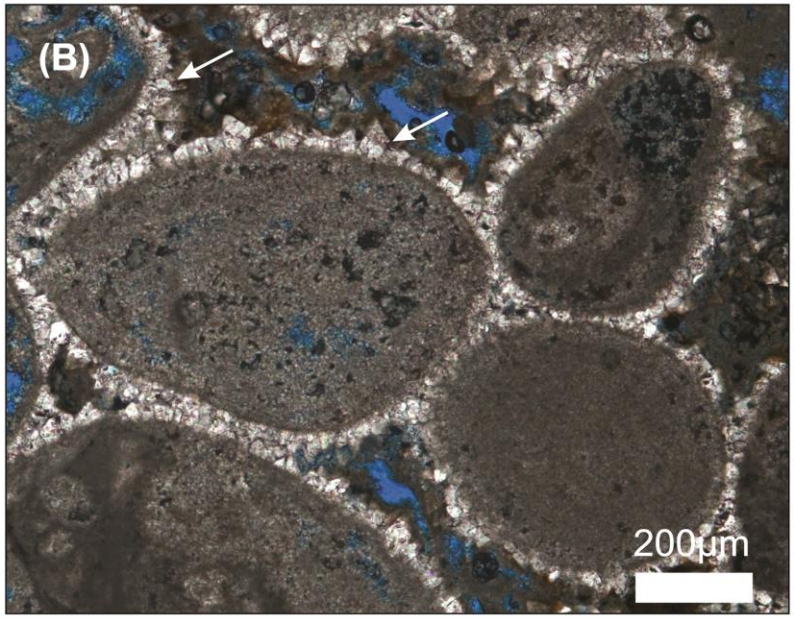
Pore destruction: cementation, compaction (mechanical and chemical), neomorphism

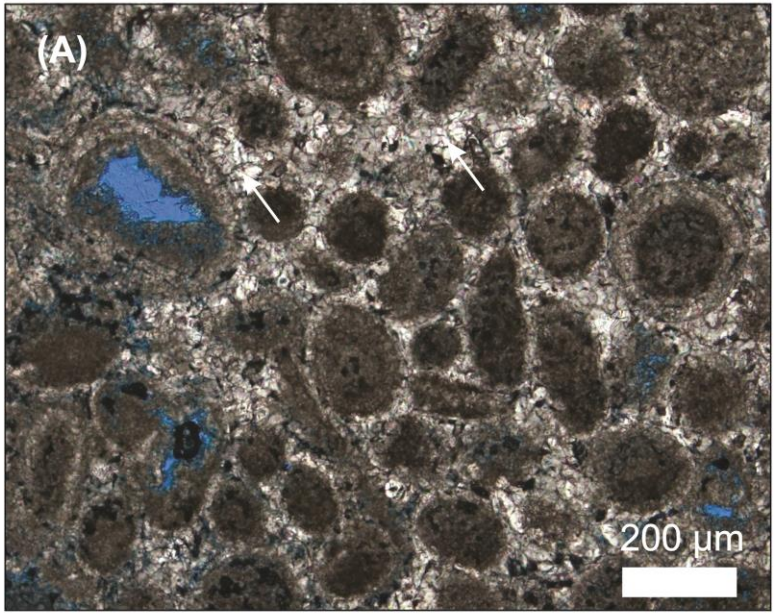
Cyrenaican Miocene Paragenetic Sequence

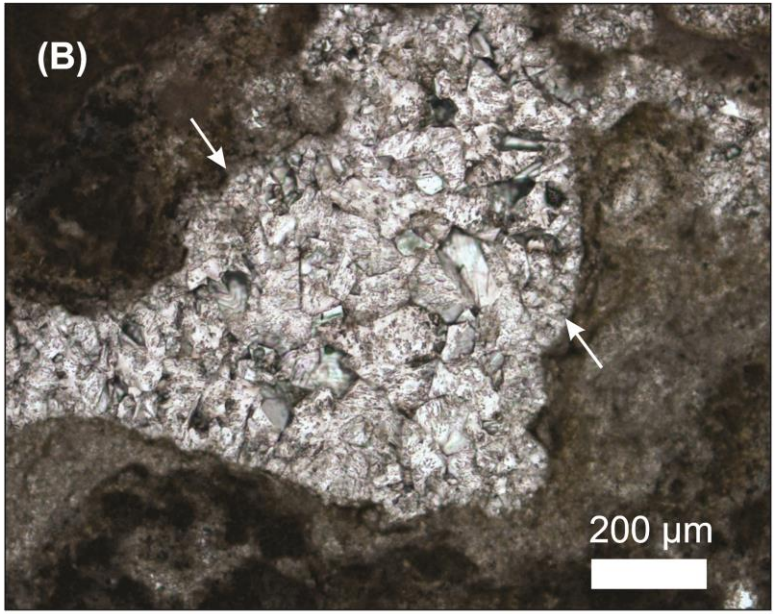


Symmetrical Rim and Pore-Filling Cement

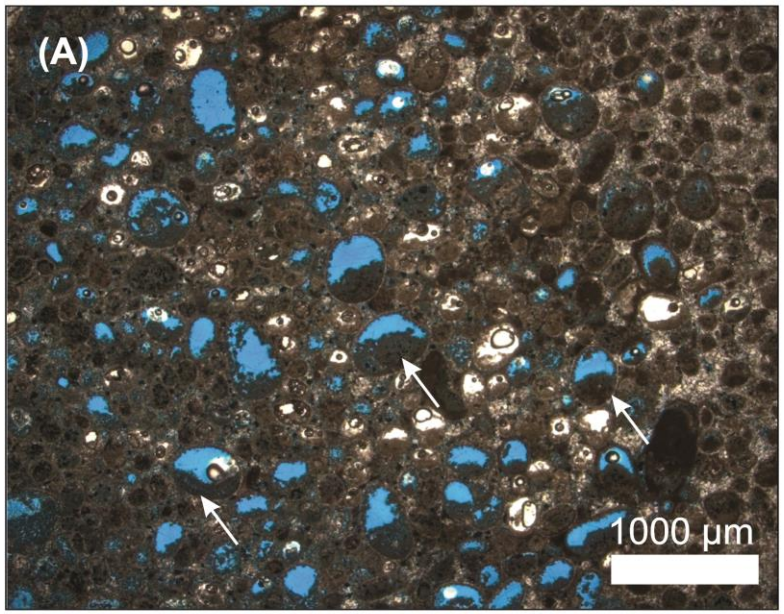


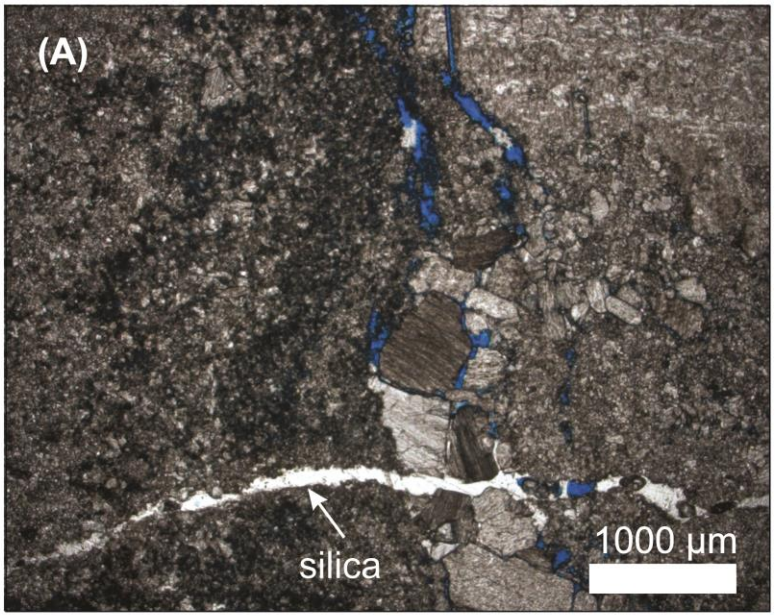


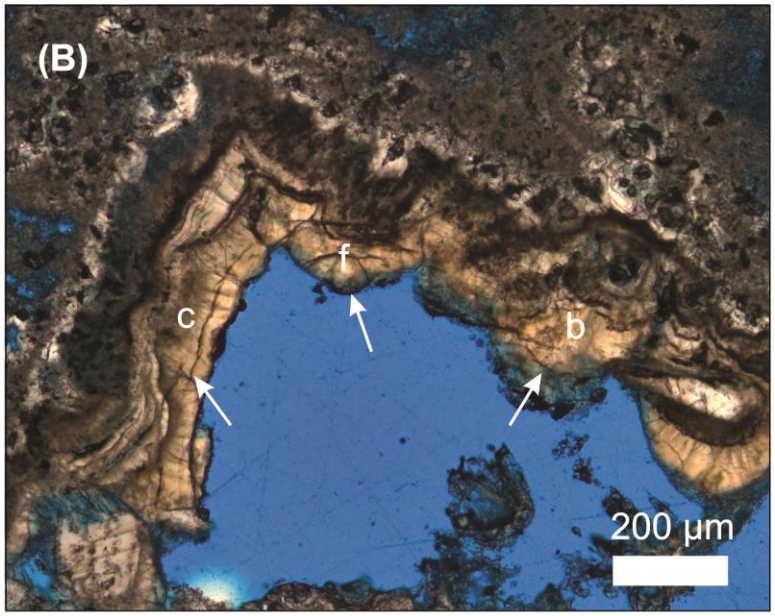




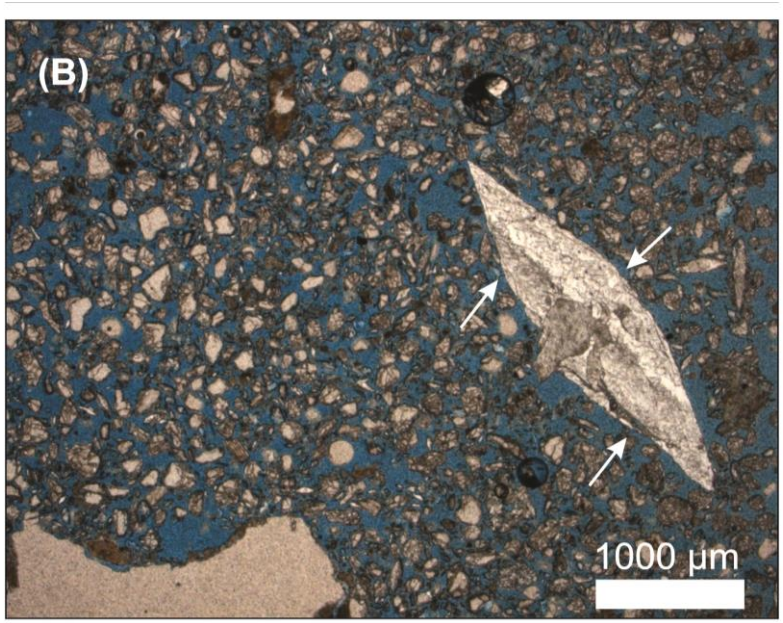
Oomoldic, biomoldic porosity and Fracture fill, crust, and Fan-shape cement

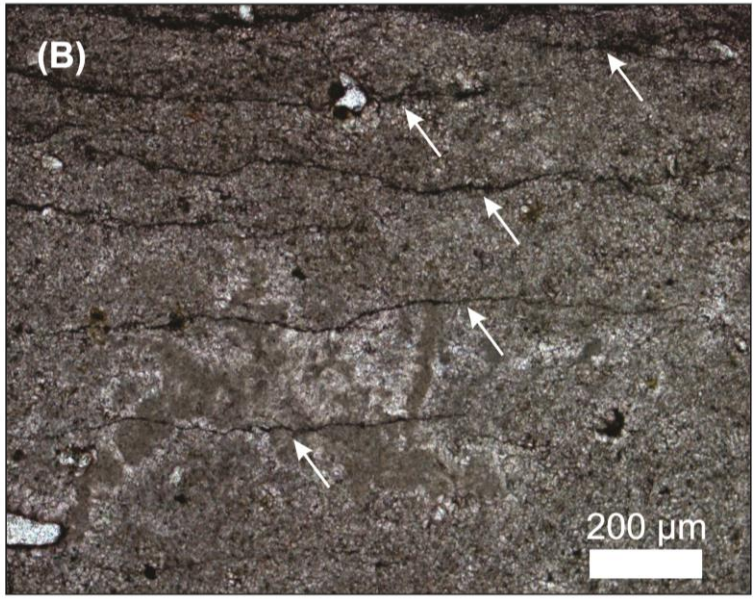


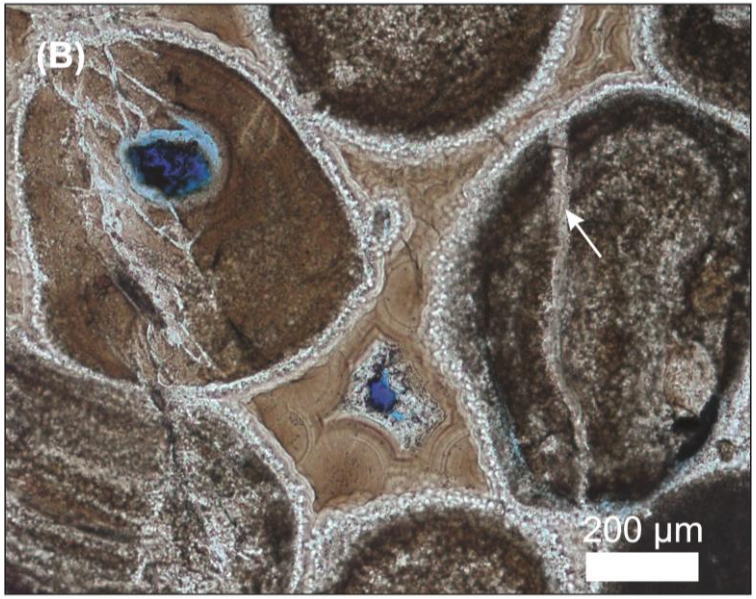


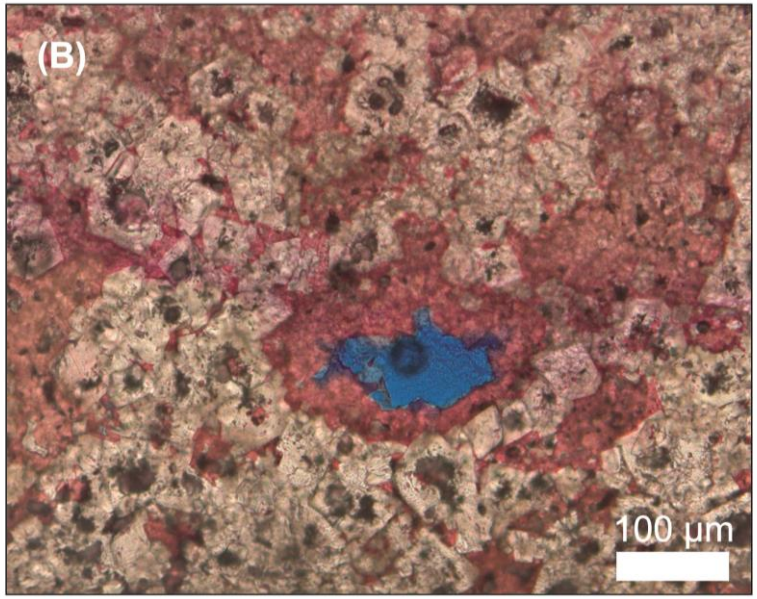


Silica Replaced gypsum, Fracture silica-fill, Dissolution Seams, De-dolomitization









Conclusions: Diagenesis

- **18 Shallow diagenetic events (never subjected to deep burial).**

- **Two distinct lithological, textural and paragenetic patterns:**

- **1** The lower part is dominated by silicified dedolomitized bioclastic-rich, bryozoan, and red algal packstone beds.

- **2** The upper part is dominated by silicified and recrystallized oolitic grainstone, and microbial-bioclastic-oolitic grainstone.

Recap: the Cyrenaican Miocene

- 1- Multiple orders of cyclicity correlated regionally.
- 2- Chemostratigraphy can be correlated regionally and globally
- 3- Age is more complete than previously thought
- 4- Diagenesis is mainly shallow marine events (cementation, dissolution) since never buried deeply.

Thanks

Any Questions?!