[PS]Sedimentology and Sequence Stratigraphy of the Middle to Late Miocene, Al-Jabal Al-Khdar Uplift and Soluq Trough, Cyrenaican NE Libya*

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Abstract

A sequence stratigraphic, chemostratigraphic and diagenetic study of the Middle to Late Miocene rocks in the Cyrenaica, northeast Libya, extends from the northwestern part of Al-Jabal Al-Khdar southwards to the Soluq trough, between 31°-33°N Latitude and 19°30'-21°E Longitude. The sequence stratigraphic study involves determining detailed regional facies relationships from field and lab observations. The fieldwork included measuring 25 stratigraphic sections bed-by-bed, 14 Spectral gamma-ray profiles constructed using a hand-held gamma-ray scintillometer at 0.5 m intervals, and annotating panoramic digital photomosaics. Special attention was given to identifying stratigraphic time surfaces. 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 will be 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 carbonate rocks record three parasequence sets separated by a sharp disconformity surface and maximum flooding zone respectively. The lower parasequence set is the Middle Miocene Benghazi Formation (40 m maximum thickness), the Middle and upper parasequence sets are the Late Miocene Wadi Al-Qattarah Formation (30 m and 31m maximum thicknesses respectively). The lower parasequence set is composed mainly of coral reefs, porites, red algae (rhodoliths), and open marine skeletal packstone containing large bivalves, gastropods, oysters, and echinoids. The Middle parasequence set has reworked red algae fragments at its base, shallowing upward into bioclastic grainstone, then cross-bedded oolitic grainstone. Microbialites (stromatolites, thrombolites, and laminites), and evaporites associated with pelletal mudstones, pelletal packstones, and siliciclastic fine to very fine quartz sandstone and green shale mark the upper part of this parasequence set. The siliciclastics appear only in the southern part of the field area. The upper sequence is dominated by continuous bodies of oolitic grainstone and microbialites associated with some bioclastic carbonates, red algae, and pellets. The shallowing upward parasequences range in thickness from 5 m to more than 15 m. This outcrop study of the Ar-Rajmah Group extends for more than 100 km along a dip profile and its excellent 3-D exposure makes it an analogue for ooid grainstone and microbial carbonate reservoirs in the subsurface within the Mediterranean region and globally.

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FACULTY OF SCIENCE - DEPARTMENT OF EARTH SCIENCES

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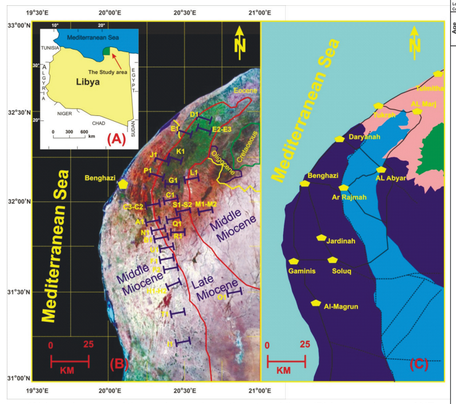
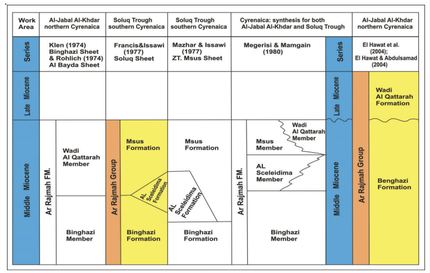
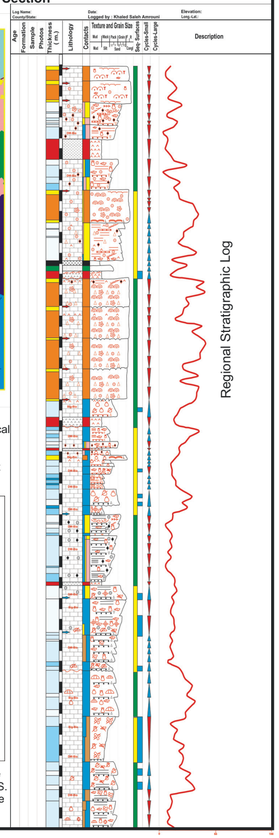
Map, Stratigraphic Chart and Regional Composite Stratigraphic Log Section



(A) Location map of the study area in northeastern Libya. (B) Landsat image of NE Libya showing the geological boundaries of Cretaceous- Tertiary rocks. The geological boundaries are based on the IRCs sheet-Benghazi (Klen, 1974) and sheet-Soluq (Francis and Issawi, 1977) that were later modified by (El-Hawat et al., 1987).
(C) Map showing roads that interconnect some of the main cities in the northern part of Cyrenaica.



Stratigraphic correlation chart of Cyrenaican Miocene units, a Middle Miocene age was thought for the entire sequence of Ar-Rajmah Group (modified by Amrouni K.S. from El-Hawat and Salem, 1987). Now, it is thought to be Middle and Late Miocene (El-Hawat and Abdulsamad, 2004).



Objectives

1-To test the hypothesis that the Middle-Late Miocene rocks (Ar-Rajmah Group) of the Cyrenaica Platform, Libya were deposited on a carbonate ramp.

2- Intended to establish the detailed sequence stratigraphy, sedimentology, stable isotope chemostratigraphy, and diagenesis.

3-These rocks were previously studied at the local scale, but no regional scale integration has been undertaken.

4-These rocks are superbly exposed for greater than 100 km in a dip direction and the proposed study will provide a valuable analogue for oolitic and Microbial carbonate subsurface reservoirs.

Data/Methods:

The sequence stratigraphic study involves determining detailed regional facies relationships from field and lab observations.
The field work included measuring 25 stratigraphic sections bed-by-bed,
14 Spectral gamma-ray profiles constructed using a hand-held gamma-ray scintillometer at 0.5 m intervals, and annotating panoramic digital photomosaics.
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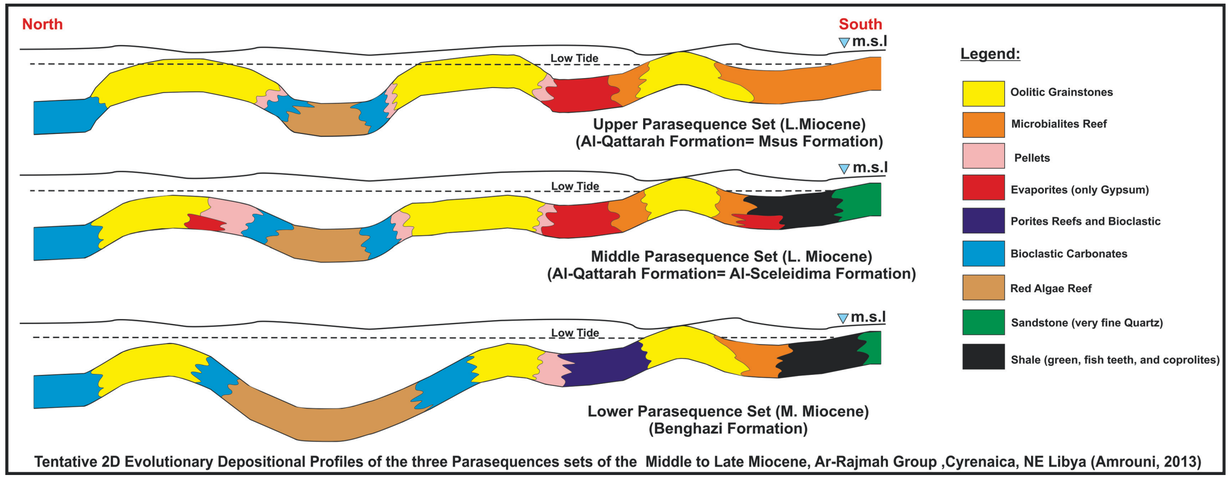
thin sections and stable isotope (δ 18O and δ 13C) analyses.
The sequence stratigraphic framework will be based on the sedimentological analysis,
correlation of stratigraphic time surfaces and vertical stratigraphic sections,
oxygen and carbon stable isotope profiles, and gamma-ray logs.

Gamma-Ray Profiles

The 14 Spectral gamma-ray profiles were constructed in the field, using a hand-held gamma-ray scintillometer at 0.5 m intervals.
The Gamma Ray gathered field data are four different types K, Th, U, and total

The gamma ray profiles have always been in agreement with the lithological description in the field. However, on some very numbered occasions and due to human errors there is a subtle shift between the gamma ray response and the field described rock data.

Besides the field indentified rocks time surfaces and the lithological changes, the Gamma-ray signature is a main tool in defying the parasequences boundaries and parasequences sets.

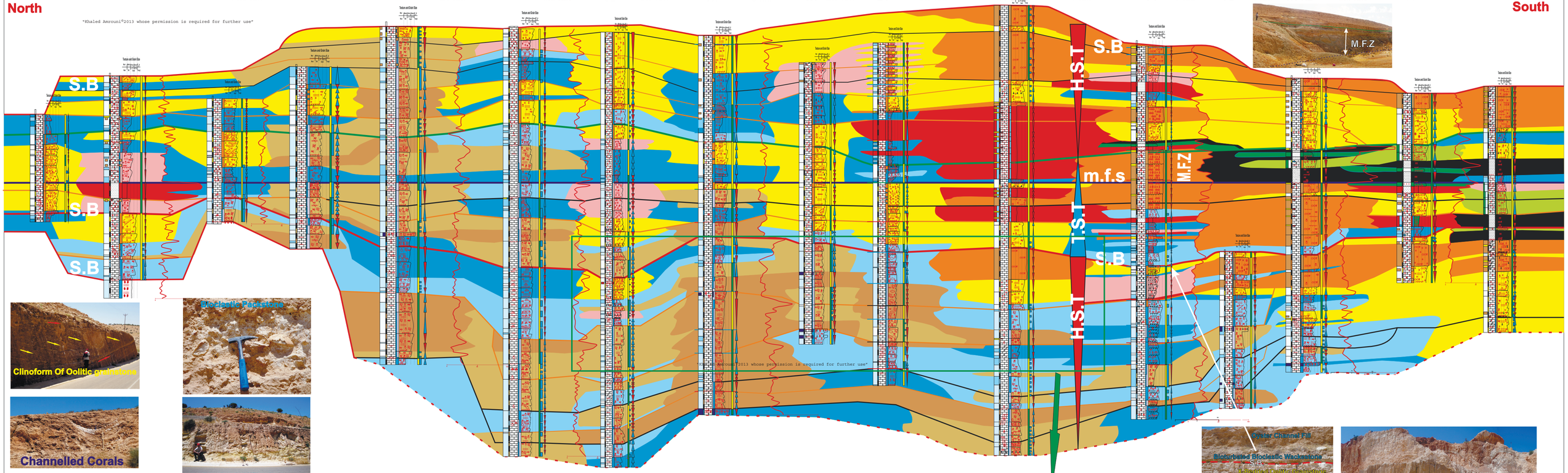


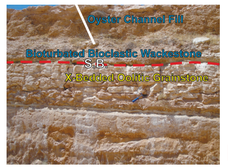
Tentative 2D Evolutionary Depositional Profiles of the three Parasequences sets of the Middle to Late Miocene, Ar-Rajmah Group ,Cyrenaica, NE Libya (Amrouni, 2013)

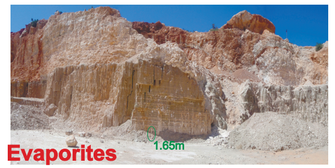
North

D1 22.5 km E2 3 km E1 14.5 km J1 9 km P1 25 km C3 0.3 km C2 9.5 km A1 5 km N1 2.5 km B1 9.5 km U1 6 km F1 7 km F2 6 km H1-H2 5.5 km T1 9 km I1

South

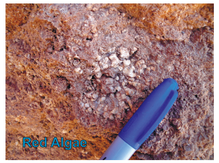






Legend:

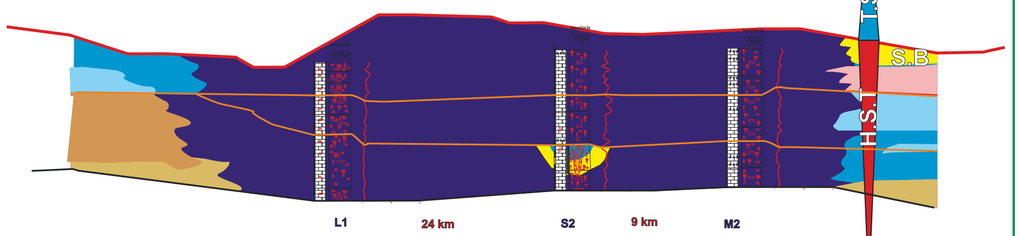
- Oolitic Grainstones
- Microbialites Reef
- Pellets
- Evaporites (only Gypsum)
- Porites Reefs and Bioclastic
- Bioclastic Carbonates
- Reworked Bioclastic Carbonates
- Reworked Red Algae Reef
- Red Algae Reef
- Sandstone (very fine Quartz)
- Shale (green, fish teeth, and coprolites)



N

Middle Miocene Updip Sequence Stratigraphic Cross Section

S

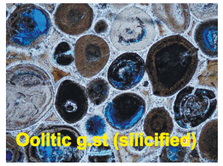


Porites (Corals) exposures represent the updip section of the Middle Miocene and topped by the major unconformity surface.

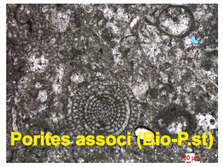
Sequence Stratigraphic Framework of the Middle to Late Miocene, Ar-Rajmah Group , Cyrenaica, NE Libya (Amrouni, 2013)

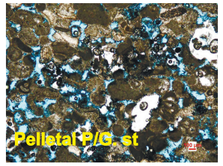
Facies Microscopic Identification:

Oolitic grainstone

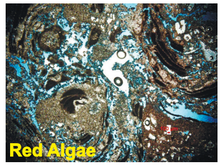


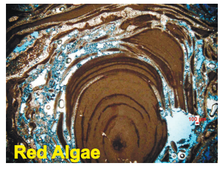
Pellets and Porites associated bioclastics



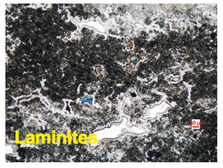


Red Algae

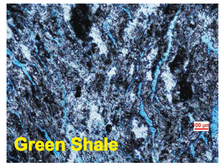




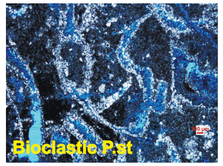
Microbialites



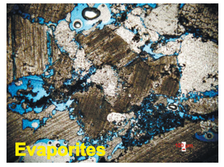
Siliciclastics: Sandstone, and Green Shale



Bioclastic Facies



Dolomite/Evaporite Facies



Discussion

The 2-D tentative evolutionary depositional model(s) of this current study revealed the dominant - depositional theme on the Cyrenaican ramp system. It highlighted the dominant and laterally continuous bodies of oolitic grainstones, microbial carbonates, and red algae that are important targets as subsurface oil reservoirs.

The sequence stratigraphic framework of the Ar-Rajmah Group carbonate rocks record three - parasequences sets separated by a sharp disconformity surface and a maximum flooding zone respectively. The Lower and the Middle Parasequences sets are separated by unconformity surface, while the Middle and the Upper parasequences sets are separated by maximum flooding zone.
The lower parasequence set is the Middle Miocene Benghazi Formation (40 m maximum thickness), - the Middle and upper parasequences sets are the Late Miocene Wadi Al-Qattarah Formation (30 m and 31m maximum thicknesses respectively).
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The upper sequence is dominated by continuous bodies of oolitic grainstone and microbialites - associated with some bioclastic carbonates, red algae, and pellets. The basal parasequence of this upper parasequences set shows downlap geometry over the maximum flooding zone.

The shallowing upward parasequences range in thickness from 5 m to more than 15 m. This outcrop - study of the Ar-Rajmah Group extends for more than 100 km along a dip profile and its excellent 3-D exposure makes it an analogue for ooid grainstone and microbial carbonate reservoirs in the subsurface within the Mediterranean region and globally.

On a regional scale, the Middle and Late Miocene carbonate rocks of the Cyrenaica have similar - facies and parasequences patterns of the Mediterranean region. The Cyrenaican Middle Miocene is dominated by red algae, while the late Miocene is dominated by oolitic grainstone and microbialites. On the Mediterranean region, the Middle Miocene rocks are coral reefs that change vertically into red algae, while the Late Miocene is evaporites and coral reefs (Franseen, 1996).
In this study gamma ray, responses and patterns, is a very important tool to construct the detailed - regional sequence stratigraphic framework besides the field measured lithostratigraphic sections and the field identified rock time surfaces. The gamma ray responses are always in agreement with the field measured lithological data, except for some occasions where some minor shifts due to human errors.
The stable isotopes chemostratigraphy and diagenesis is the next intended future work. The stable - isotope data will help us to have a better control over our sequence stratigraphic frame work and to understand the ocean chemistry during the Middle and Late Miocene rocks in the Cyrenaica Platform.

Conclusions

-The Ar-Rajmah Group of the Cyrenaica Platform is a ramp system with irregular palaeotopography.
-The platform has three major parasequences sets that separated by a sharp unconformity surface and a maximum flooding zone.

-The lower parasequences set represents the Benghazi Formation of the Middle Miocene.

-The Middle and Upper two parasequences sets represent the Al-Qattarah Formation and its lateral equivalents Al-Sceleidima Formation and Msus Formation.

-The shallowing upward parasequences range in thickness from 5 m to more than 15 m.

-This outcrop study of the Ar-Rajmah Group extends for more than 100 km along a dip profile and its excellent 3-D exposure makes it an analogue for ooid grainstone, microbial carbonate, and red algae reservoirs in the subsurface within the Mediterranean region and globally

Future Work (if funded)

The future work based on our plan is the petrographic work and the oxygen and carbonate stable isotope analysis. These two lab analysis steps will strengthen and give more crideability to the sequence stratigraphic work. In addition, they will give a better understanding for both the ocean paleochemistry and paleoclimate.

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