A preliminary documentation of the coral reefs from Libya.

Belkasim Khameiss¹, William Hoyt¹, Saad K. El Ebaidi², Ahmed Muftah², James Klaus³ and Ann Budd⁴

¹University of Northern Colorado, Earth and Atmospheric Sciences, Campus Box 100, Greeley-CO 80631-USA. Bkb28_1981@yahoo.com
²University of Benghazi, Faculty of Science, Department of Earth Sciences, P.O. Box 9480, Benghazi-Libya.
³University of Miami, Department of Geological Science, 43 Cox, Science building, Coral Gables, FL 33124-0401-USA.
⁴University of Iowa, Department of Geoscience. Trowbridge Hall 121. Iowa City, IA 52242-USA

Abstract

Corals studies in Libya are very limited, although they play an important role in the oil exploration as they form excellent reservoirs of coral reef buildups at some oil fields of Sirt Basin (e.g. Intisar “Idris” and Sahabi Fields). Both fields are producing from Paleocene coral reefs. Meanwhile, in Cyrenaica corals are of less importance as they are not reported in subsurface Tertiary rocks, which probably to the environmental settings of these sediments out of the core of reef as occurred in the surface. Meanwhile, corals are reported from older (Jurassic) subsurface successions as in Concession NC-152, but the cementation diagenesis led to blocking and destroying the porosity.

This study presents the first surface documentation work of eight scleractinian coral species from the exposed sediments in northern Libya, where six taxa reported from Al Jabal al Akhdar region, these include a) an association of huge colonies of Caulastrea sp. and Stylophora sp., from the Middle Eocene Darnah Formation at West Darnah roadcut section. The co-existence of the fast Caulastrea sp. with the slow Stylophora sp. is due to the competition strategy; b) Antiguastrea? sp. is reported from the Oligocene Algal Limestone of Al Bayda Formation at Daryanah – Abyar roadcut section; c) Cyphastrea sp. and Aleveopora sp. from Oligo-Miocene Al Faidiyah Formation at Al Fatayah cement quarry and d) Tarbellastraea sp. from Middle Miocene Benghazi Formation at Benghazi cement Quarry. In addition to, two species Astraeaapora sp. and Actinacisparorai are reported from the Upper Miocene sediments of formation "M" in As Sahabi area.
**Introduction**

This paper deals with corals build up in the Cyrenaica. Coral refers to coral carbonate accumulation which has original topographic relief that lived in association with other organisms including algae and foraminifers as major contributor Guilcher, (1988). The differential pattern in these associations seems to be controlled by both the paleo-relief and the eustatic sea level (Guilcher, 1988).

The documented subsurface coral occurrences in Libya are very limited and mainly obtained from the oil exploration activities, where coral reef form an excellent reservoirs evidenced from some previous reports of oil fields in Sirt Basin (e.g. Intisar “Idris”) Brady et al., (1980). Examples is thereefal buildups (Rugose/cup coral with encrusted coralline red algae with excellent biomoldic porosity due to leaching as in Gheriat Formation along the eastern edge in Kutlagraben in Sirt Basin Addaloush et al., (2003).ii) the older Jurassic branching cup corals with the interior skeleton completely filled by calcite cement and lime-mud matrix resulted in blocking the porosity, which are occasionally reported from the base of core #7(16199’) in Well A1-NC152 by Daniels et al., (1993).

However, the most comprehensive surface coral occurrences in the previous works were that presented by Hladil et al., (1991), who reported about fifty species of corals, mostly of scleractinian type, from the Oligocene sections of Umm ad Dahiy Formation, Abu Hashish Formation, ArRahlah Member of Maradah Formation and Al Khums Formation from Al Hufrah and ArRaqubah Oil fields in Sirt Basin. Among the most important reef-builders species includes Madracis decaphylla, Stylophora parvistella, S. thirsiformis, Monticulastraex gr. daedalea, Athecastraeamaradahensis, Astraeoporadecaphylla, Agathiphyllia gregariaa and Actinacis rollei.

**Locations**

The studied corals are obtained from two regions:

a) The Al Jabal al Akhdar region which is located in northern Cyrenaica. It is a huge anticlinorium extending in SW-ENE ridge located between 32° to 33°N and latitudes and 20° to 23°E longitudes. The documented corals herein are from four well known localities, these are: i) West Darnah roadcut section. ii) Daryanah – Abyarroadcut section; iii) Al Fatayah cement quarry; and iv) Benghazi (Hawari) cement Quarry (Fig.1).

b) The As Sahabiregion which is located in the northeastern corner of Sirt Basin, covering an area of about 375km². It is bounded by longitudes 20° 48’ 08” to 20°54’ 45” E and latitudes 30° 10’ 58” to 30°17’ 36” N, within a tectonic province called the Ajdabiyah Trough. The documented coral specimens came from the scattered clusters
of patch coral reef P53 and P119 area at the western edge of the Sabkhat al Qunayyin (Fig. 1).

Fig. 1: Location map of the studied coral-exposures in Northeast Libya, with As Sahabi “in the vicinity of P53” aerial photograph shows the coral patches. (source of aerial photograph, Boaz et al., 1987).

**Stratigraphic background**

The Al Jabal al Akhdar area in Cyrenaica region, northeastern Libya has a long geologic history ranging from the Paleozoic to Late Miocene. The Tertiary exposed rocks in this area are represented by nine rock units separated from each other by unconformity surfaces (Fig. 2), these are from bottom to top as follows:

1) **Al Uwayliah Formation** composes of chalky limestone, soft and enriched with planktic and calcareous nannofossils of Landenian age at its upper exposed section. However, it is well bedded and hard with rare planktic foraminifers of Danian age at its lower exposed part, although its middle part is not exposed, a series problem in the definition of Al Uwayliah Formation, this issue was discussed by Tmalla (2007). There is no reefal facies in this Formation.
2) Apollonia Formation is a well bedded chalky limestone, of mudstone-wackestone texture, with common chert nodules. The foraminifers are indicative of Ypresian – Lutetian age. There is no reefal facies in this Formation. This formation exhibit interfingering relationship with the overlying Darnah Formation.

3) Darnah Formation is a thick bedded to massive limestone of grainstone to Packstone locally becoming rudstone in texture, this Formation is enriched in larger benthic foraminifers (Nummulites, Discocyclina, Orbitolites, Sphaerogypsina, etc..) with coralline red algae and/or coral facies at some places. This formation is dated as Middle Eocene based on the Nummulites gizehensis as example. Corals are among the local bioclasts occurrence as in West Darnah road-cut section.

4) Shahhat Marl is dated as Late Eocene based on the presence of Nummulites fabianii and Gaziryinabolchellus (Muftah and Boukhary, 2013). There is no reefal facies in this Formation.

5) Al Bayda Formation, the lower Member “Algal Limestone Member” of Al Bayda Formation (El Hawat and Shelmani, 1994). It consists of algal limestone enriched in red algae and thick Oysters with some Nummulites fichteli and N. vascus (Muftah and Erhoma, 2002). This formation yields common corals enough to make reef at several places.

6) Al Abraq Formation is dated as Middle –Late Oligocene, it is skeletal limestone with abundant Operculinacomplanata O. africana and Lepidocuclina spp. It is deposited under shoal-channel complex (El Hawat and Shelmani, 1994). There is no reefal facies in this Formation.

7) Al Faidiyah Formation is dated as Late Oligocene – Early Miocene (Rholich, 1974) which was updated by El Hawat and Shelmani, (1994) to be Miocene age. Hence the age dating of this formation is still enigmatic. Lithologically, it is gradually changed upwards from glauconitic marl to skeletal marl and Limestone. Corals are among the reported local bioclasts in Al Fatayah Quarry section.

8) Benghazi Formation is dated as Early-Middle Miocene (El Hawat and Shelmani, 1994). It consists of massive fossiliferous limestone, made of fine crystalline, hard, enriched in red algae. Amphistegina sp., and Miogypsinaglobulaindicated a depositional settings under shallow marine
of mid ramp setting (Hassan and Muftah 2008), which is interrupted with lagoonal facies as interpreted by the occurrence of the peloidal-miliolid facies.

9) Wadi al Qattarah Formation is dated Late Miocene (El Hawat and Shelmani, 1994). It is composed of thin bedded of oolitic/peloidal grainstones with highly cross bedded at some levels changed upward to evaporitic facies with common giant gypsum crystals which referred to the Mediterranean salinity crisis during the Messinian (El Hawat and Shelmani, 1994).

| Age       | Formation | Litholog |
|-----------|-----------|----------|
| Miocene   | Messinian | Wadi al Qattarah |
|           | Tortonian | Benghazil |
|           | Serravallian | Al Faidiyah |
|           | Langhian | Al Abraq |
|           | Burdigalian | Al Bayda |
|           | Aquitanian | Shabhit mari |
|           |          | Apollonia |
| Oligocene | Chattian | Al Uwayliah |
|           | Rupelian | ? "not exposed" |
| Eocene    | Priabonian | Al Uwayliah |
|           | Bartonian | Al Uwayliah |
|           | Lutetian | Al Uwayliah |
|           | Ypresian | Al Uwayliah |
| Paleocene | Thanetian | Al Uwayliah |
|           | Selandian | Al Uwayliah |
|           | Danian  | Al Uwayliah |
| Cretaceous| Maastrichtian | Al Athrun |
|           | Campanian | Al Majerir |
|           | Santonian | Al Banlyah |
|           | Coniacian | Al Hilal |
|           | Turonian | Qasar Al Abdil |
|           | Cenomanian | Planktic foraminifera |
|           |          | Porcellaneous foraminifera |
|           |          | Nummulites |
|           |          | Coraline red algae |
|           |          | Glaucocine grain |
|           |          | Scleractinian corals |
|           |          | Lepidocyclina |
|           |          | Chert nodule |

Fig. 2: Stratigraphic chart of the exposed rock units in Al Jabal al Akhdar, NE Libya.

Stratigraphy of As Sahabi area:

The As Sahabi area according to Muftah (2013) consists of four superimposed rock units separated from each other by disconformity surface, these are from bottom to top:

1- Formation "M" (Tortonian); it consists of semi-consolidated bioclasts exposed in the floor of the Sebkhat, totally or partially decalcified and gypsified. Erosional relief of shallow Miocene coral reef, echinoids Clypeaster and Echinolampas and pelecypods, gastropods, bryozoans and Balanus.
2- Formation "P" (Messinian); it consists of lattice of gypsum crystals in a very sparse mineral matrix of dark sand and clay with very few fossils.

3- Sahabi Formation (Messinian-Pliocene); it was subdivided into six members:

i) Member “T”. It consists of cross bedded sand with abundant marine fauna and trace fossils (e.g. Ophiomorpha).

ii) Member T.X. Reddish clay and vertisol with cracks accessible in one area only.

iii) Member U-1. Sands with clay lenses and clay balls incorporating with common well preserved bones, teeth, jaws and skulls of land mammals.

iv) Member U-D. Cross bedded and bioturbated sandy dolostone.

v) Member U-2. Interbedded sand and clay with dolomitic crusts with mammals remains.

vi) Member V. Sands and sandy clays with lenses of dolomite and gypsum crystals common root casts.

4- Formation “Z” (Pleistocene); is the youngest formation and consists of very complex fossil soil with paleo-caliche and terrestrial snail (e.g. Helix sp.).

\[\text{a) Cyrenaican coral reef}\]

The collected coral specimens used in this study are mainly derived from four localities located in the North east Libya (Cyrenaica) and one locality in As Sahabi area (Fig. 1). These are 1) Benghazi Cement Quarry section where, one species has been collected from Benghazi Formation (Middle Miocene); 2) Al Fatayah cement Quarry section, where, one species has been collected from Al Faidiyah Formation (Late Oligocene); 3) West Darnah Roadcut section, where three species have been collected from Darnah Formation (Middle Eocene); 4) Daryanah-Abyar Road-cut section, where one species has been collected from the Algal Limestone Member of Al Bayda Formation (Early Oligocene); and 5) As Sahabi where, two species have been collected from formation “M” (Late Miocene). The documented coral reefs from these localities are listed below in chronostratigraphical order:

\[\text{Eocene reef}\]

The Eocene rocks of Al Jabal al Akhdar (Fig. 2) are composed of two formations, the older Apollonia Formation which was deposited in open marine waters as suggested by the planktic foraminifera and the mudstone textured facies as well as the presence of chert nodules with sponge spicules?. The upper Darnah Formation on the other hand are deposited in more shallower neritic water with warm water conditions allowing to the accumulation and growth of the Nummulites (nummulitic bank) and corals (coral reef) at some areas such the vicinity of Darnah city (West Darnah Road-cut section Lat. 32° 53’ 00”N and long. 21° 55’ 01”E). At this section, two species are
documented the species are left as open named because more statistical work needed for the future work. The *Caulastrea* sp. (Figs. 3 and 4a-b) dominates the colony as it is considered the fast growing coral over the low growing *Stylophora* sp. (Figs. 4b-c and 5).

Fig. 3: Close-up view of *Caulastrea* sp. at West Darnah Road-cut section.

Fig. 4.a- *Caulastrea* sp.; b - *Caulastrea* with *Stylophora* sp.; and c *Stylophora*sp. at West Darnahroadcut.
Fig. 5: Close-up view of *Stylophorasp.* at West Darnah Roadcut section.

**Oligocene reef**

The Oligocene rocks of Al Jabal al Akhdar (Fig. 2) are composed of two formations, the older Al Baydah Formation which was deposited in mid ramp waters as suggested by the common presence of larger benthic foraminifers in addition to common red algae and coral *Antiquastrea ?sp.* (Fig. 6). The documented coral reef in Al Bayda Formation played an important role in the development of the caves and dolines and other small scale karstic features in the area Muftah *et al.*, (2010).

Fig. 6. Coral species *Antiquastrea ?sp.* from Al Baydah Formation at Daryanah- Al raod-cut Abyar

*Upper Oligocene reef*

The reef framework in Upper Oligocene Al Faidiyah Formation at Al Fatayah cement quarry is constructed of two genera of corals *Cyphastrea* sp. (Figs. 7a-b) and
Aleveopora sp. (Fig. 8a-b) with encrusted red algae, shell fragments, bryozoans and larger foraminifers (nummulitids and lepidocyclinids).

Fig. 7. (a) Cyphastrea sp. from Al Faidiyah Formation at Al Fatayah Quarry, b) thin section from the same colony shows mouldic porosity (in black). Field of view = 6mm, (XPL).

Fig. 8. (a) Aleveopora sp. from Al Faidiyah Formation at Al Fatayah Quarry, b) thin section from the same colony shows boring by bivalves (Bu) mouldic porosity (in black). Note: Wall has been replaced by Calcite. Field of view = 6mm, (XPL).

Miocene reef (Al Jabal al Akhdar, Cyrenaica)

The Miocene Tarbellastraea sp. coral of Benghazi Formation (Fig. 9) is reported locally at Benghazi (Al Hawari) cement Quarry.
Miocene reef (As Sahabi Area)

The As Sahabicoral reef is mainly of scleractinian type. They are growing in forms of small scale patch reefs extending parallel to the western edge of Sabkhat al Qunayyin, in NNE-SSW trending pattern. The diversity of the As Sahabi corals is very low, restricted to only two species in the Tortonian formation "M". The first type is Astraeaopora sp. (Fig. 10a; Fig. 11a-b) it is completely replaced by gypsum at some levels. The other coral type present in As Sahabiis Actinacisparorai, shown here in (Fig. 10b and Fig. 11c-d). It is closely similar to the specimen figured by Hladilet al., (1991) from the Rupelian Wadi ArRijl in Al Hufra Oil field of Sirt Basin. It was previously misidentified as Stromatolites by De Heinzen and El-Arnauti (1982). In addition to rare occurrences of encrusted coral growing on Persististrombuscoronatus as substrate (Fig. 12a-b).

Fig. 10: a) Astraeaopora sp., b) Actinacisparorai (Bar scale= 2cm), As Sahabi area.
Fig. 11: A - B: *Astraeaopora* sp.: A) transverse section and B) longitudinal section. C - D: *Actinacisparorai*: C) transverse section and D) longitudinal section.

Fig. 12: a-b: Encrusted corals on *Persististrombuscoronatu*. (Bar scale= 2cm)
Conclusion

The Al Jabal al Akhdar area and As Sahabi area display conspicuous exposures of scleractinian coral reef. Only eight species are documented herein, six from The Al Jabal al Akhdar area and two from the As Sahabi area.

The reefal facies of Al Jabal al Akhdar is restricted to the Middle Eocene Darnah Formation; Early Oligocene Al Bayda Formation; Upper Oligocene Al Faidiyah Formation and Middle Miocene Benghazi Formation. Only the Upper Miocene formation “M” is developed in As Sahabi area.

Diagenetic processes at some subsurface records ruled the effectiveness of coral buildups to be good reservoirs, although in the surface show excellent porosity and permeability.

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