EPH - International Journal of Applied Science
ISSN (Online): 2208-2182
Volume 06 Issue 04-Dec, 2020

DOI: https://doi.org/10.53555/eijas.v6i4.75

AGEDABIA FORMATION AND THE ENVIRONMENTAL IMPLICATION OF ITS BIOTA AT GARYOUNIS, SW BENGHAZI.

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Abstract:-

The main aim of this paper was to study the Quaternary Agedabia Formation in Garyounis area; this study is based on different paleontological evidences to deduce the various environmental conditions. One lithostratigraphic section have been measured and investigated. It consists mainly of calcarenite and clay. The thickness of the section is 2 m along the mouth of Wadi Al Qattarah at Garyounis area, SW Benghazi city. A number of samples have been studied and about 13 species of fauna and flora have been identified. They include three foraminifera, four bivalves, four Ostracodes, one gastropod and unidentified Bryozoans specimen have been observed also. The cement type (isopachous) of the studied section is confirming that the calcarenite is of subaqueous or marine in origin. The studied calcareous algae plus the associated foraminifer's points that the calcarenite was deposited under fairly warm (15-30^{o}C) shallow marine conditions with a suggested bathymetric range between 030m.

Keywords:-*Wadi Al Qattarah, Agedabia Formation, calcarenite, isopachous, foraminifera.*

INTRODUCTION

The term calcarenite is used as a general designation for the mechanically deposited carbonate rocks of sand grain size ($^{1}/_{16}$ to 2mm in diameter) that are composed of 50 per cent or more of carbonate fragments [1]. The carbonate fragments of sand size are usually of subaqueous origin and correspond to two main phases: a bioclastic one consisting of fossil materials, both entire and broken; and a lithoclastic phase formed by aggregation grains, oolites, and grains resulting from the reworking of fine grained limestones and calcilutites. It is classified according to grain size into the following:

Table (1): Scheme for the classification of limestones based on dominant grain-size [2].

Below 62 µm	Calcilutite
From 62 µm to 2 mm	Calcarenite
More than 2mm	Calcirudite

Calcarenites areseparated according to its composition into: Lithocalcarenites: Originated due to aggregation process and from subaqueous reworking of biochemical, chemical and fine grained detrital limestones (Calcilutites 0.062 mm). Biocalcarenites: are limestones composed of organic fragments of any kind, or the products of organic activity. Ooliticcalcarenites: are limestones composed grains which have been submitted in predominant proportion to oolitization processes of physicochemical origin [3].

Agedabia Formation has a wide geographic distribution practically along the coast of northern Cyrenaica of NE Libya. Similar time-equivalent rock unit known as 'Gargaresh Sandstone or Formation' occur along the coast of Tripolitania of NW Libya. The '*Panchina*' building stone quarried around Benghazi, and the *'Cardium Beds*' of Desio [4] are thought equivalent to the Agedabia calcareous sandstone [5] [6]. It is composed of marine calcarenite, grayish, moderately hard medium grained, and cross bedded at some places. The lower limestone part is rich in faunal content. The formation has an average thickness of 9-11 m, reduced to about 2 m at the Al Bardia coastal area of most northeastern Cyrenaica. The Agedabia Formation is unconformably overlies the Middle Miocene Benghazi Formation, or the Al Jaghbub Formation in the Al Bardia area. It is overlain at places by the younger alluvial sediments. Normally, the lower section of the studied sequence contains *Ostrea virleti* Deshayes, *Panopaea menarddi* Deshayes, *Tellina* cf. *submaveri* Hoernes, *Lucina multilamellata* Deshayes, *Venus reticulate* Michelloti, *Pecten erythraensis* Sowerby, and *Trochus maculates* Linnaeus. The calcarenite includes also some microfauna such as *Ammonia beccarii* Linnaeus, and *Elphidium macellum* Fichtel and Moll. Calcareous algal remains belonging to *Lithophyllum* are also reported [6].According to Burollet [7] a probable age is given as Quaternary (Tryrrhenian) for the Agdabia Formation, in the meanwhile [8] used crystalline calcite to determine the age of the calcarenites at Garyounis suburb, giving an age of Early-Late Calabrian (1.73-0.80 Ma) based on the $^{87}Sr/^{86}Sr$ ratio . The main objective of this contribution is to study Agdabia Formation at Garyounis area and its biotal contents. The results, however, have been used to deduce the various environmental conditions of the studied deposits. The study also aims to determine the depositional environment of the calcarenite and its biotal contents.

Location of the study area

A large area of Benghazi plain is covered with Quaternary calcarenite and has a maximum thickness of about 10 m at the southwestern part of Benghazi plain. In Garyounis the studied section, however it attains an elevation of about 25 m above sea level, forming a cliff parallel to the coast. The studied section is located at Wadi Al Qattarah mouth in the southwestern part of Benghazi city near the area of Garyounis, NE Libya. It is located broadly between latitudes 32°03´000" and 32°03´500"N and longitudes 20°01´30" and 20°03´000"E (Fig. 1).

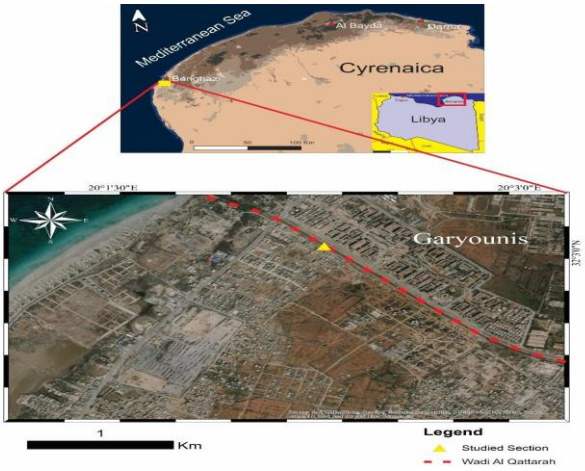


Fig. 1: Location map of the study area.

Methods and materials

Six rock samples have been collected from the studied outcrop at Garyounis area, the maximum interval between each sample, however, is about 3 m. The collected samples with hard lithology have been thin sectioned and studied under the polarized microscope to investigate the type of cement and other petrographical characteristics which responsible for the formation of calcarenites. Samples with soft lithology, however, have been processed for microfauna/macrofauna

analysis. Here, the samples with microfauna have been washed through 63µ sieve and then dried in normal room temperature for few days. One gram of the dried residue is taken out by cone to pick the most preserved microfauna. The picked-out specimens were mounted in micropalaeontological slides and then identified up to the species level where possible. Selected representative fauna and other selected skeletal elements were photographed using only a digital camera for macrofauna and a digital camera with binocular microscope for microfauna.Simple diversity and the relative abundance of the studied biota were investigated also in order to reveal their original environment and ecological importance in the Pleistocene times.

Stratigraphy and sedimentology:

The studied section is composed of marine calcarenite yellowish brown in color, moderately hard and separated by a marl and clay bed (Fig. 2 and 3). The latter is rich with O*strea* sp. On the other hand the calcarenites are rich with infaunal bivalves; *Cerastoderma edule*Linnaeus (previously known as *Cardium edule*),*Lucina* sp., *Venus* sp. and the byssally attached suspension feeder *Lima* sp.

The best developed calcarenite outcrop in Benghazi plain in west and southwest area is at the mouth of Wadi Al Qattarah (Fig .3).Calcarenite outcrops forms a terrace of about 25 m above sea level (a.s.l). These calcarenites are unconformably overlies the Middle Miocene Benghazi Formation; and it is overlain at places by the younger alluvial sediment. The studied section is about **2**m thick and it consists of three main units. The description of these units is summarized in the following order:

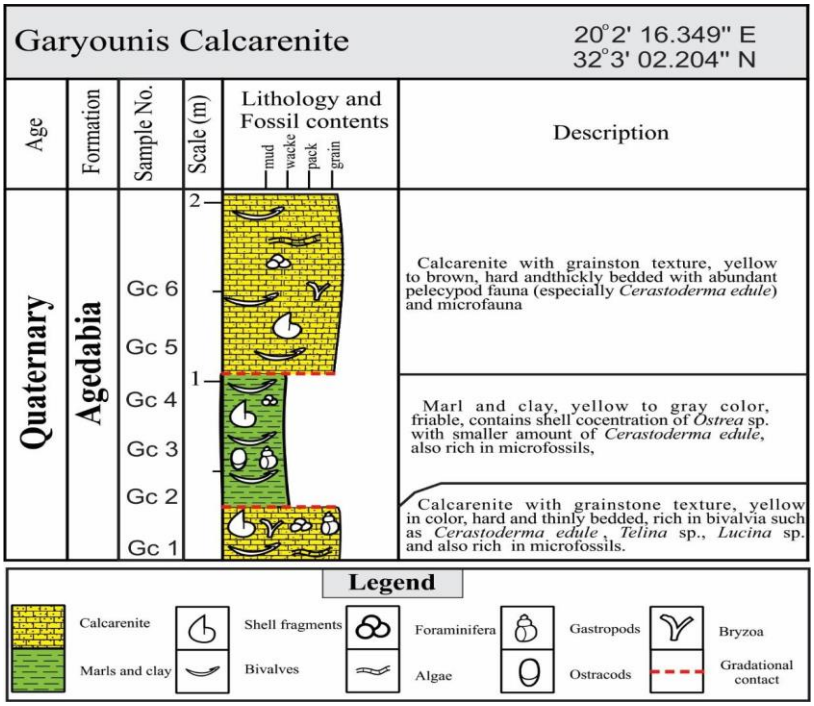


Fig. 2: Stratigraphic section of Agedabia Formation at Garyounis suburb.

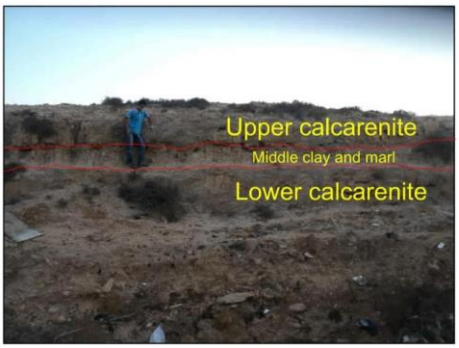


Fig. 3: field view of the Agedabia Formation at Garyounis suburb (Looking NW).

Unit (1):

In the field, this unit consists of calcarenite, yellowish white in color, hard, thickly bedded (0.3 m), and characterized by shell concentration made of *Cerastoderma edule*.

In thin section, the calcarenite is made of 70% biograins or bioclasts where calcareous red algae, bryozoans, pelecypods fragments and the small benthic foraminifera are the main contributors. Normally the grains are medium to coarse grained, well rounded, with scattered subangular to subrounded pelecypods and calcareous red algae grains. Lithoclasitcs are

represented by peloids(Fig.4). The cement type in this unit is made of sequence of micritic rim and isopachous cement. The texture of this unit according to Dunham classification is grainstone texture.

Unit (2):
In the field this unit consists of marls and clays, yellow to gray in color, soft, friable, thickly bedded (0.75 m), this unit also characterized by shell concentration made of *ostrea* sp.(Fig. 3) and (Fig.7).The washed residue of this unit is made of ostracodes, *Elphidium macellum* Fichtel & Molland *Ammonia* cf. *tepida*Cushman.

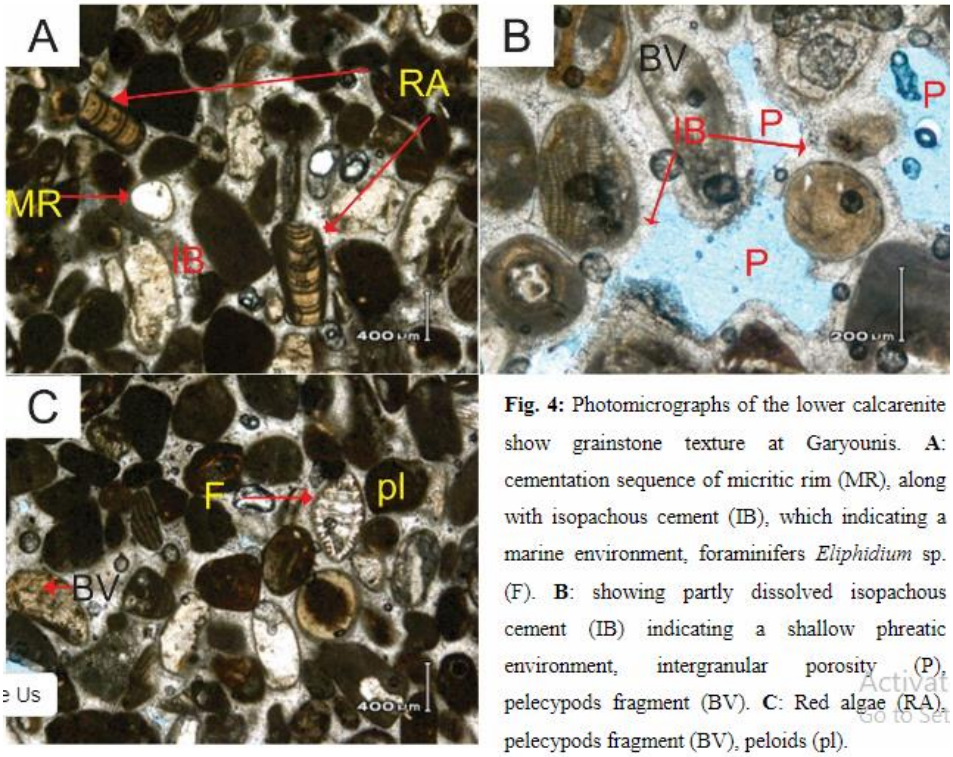


Fig. 4: Photomicrographs of the lower calcarenite show grainstone texture at Garyounis. **A**: cementation sequence of micritic rim (MR), along with isopachous cement (IB), which indicating a marine environment, foraminifers *Eliphidium* sp. (F). **B**: showing partly dissolved isopachous cement (IB) indicating a shallow phreatic environment, intergranular porosity (P), pelecypods fragment (BV). **C**: Red algae (RA), pelecypods fragment (BV), peloids (pl).

Unit (3):
The upper calcarenite unit consists of yellow to brown calcarenite, moderately hard to hard and very thick bedded (1m), this unit is also characterized by shell concentration made of *Cerastoderma edule*Linnaeus, (Fig.5).
In thin section, this unit is made of 80% of biograins or bioclaste such as calcareous red algae, bryozoans, pelecypods fragments and foraminifera. The bioclasts are medium to coarse grained typically 0.6 mm but up to 1.4 mm in diameter, well rounded grains, with scattered subangular pelecypods grains. The matrix in this unit is represented by micritic rim and fill. The texture of this unit according to Dunham classification is grainstone texture.

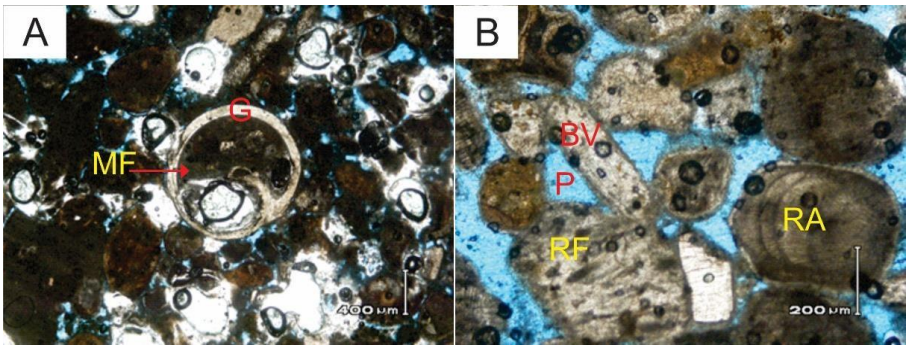


Fig. 5: Photomicrographs of upper calcarenite with grainstone texture from Garyounis section. A: Micritic fill (MF), gastropod (G), intergranular porosity (P). B: rock fragment (RF), red algae (RA), pelecypods fragment (BV), intergranular porosity (P).

Palaeontology:
The studdied biota is consisting of four groups and include (molluscs which includspelecypodsand gastropods), foraminfira, bryozoans, and algea. The distribution of these biota is shown in (Fig. 6).About thirteen species belonging to four groups have been recovered from the Garyounis section and six important genera and three species have been described in terms of environmental imp

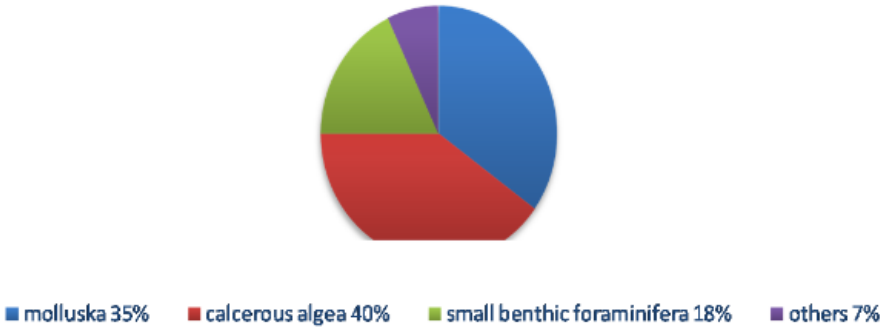


Fig.6: Pi diagramshows the distribution of the biological content of Garyounis calcarenite.

Molluska:

- ***Cerastoderma edule* (Linneaus, 1758) (Fig.8) and Plate (1).**

It tolerates a wide range of salinity (euryhaline), and wide range of temperatures (eurythermic), which helps to explain its very extensive range.The Euro-Mediterranean cockle, *Cerastoderma edule* is a shallow burrowing suspension feeder and uses its short siphons to draw in and expel water, it's a euryhaline species whose upper and lower limits of salinity are 3% and 60%. The species also lives in water containing as much as three to four times more calcium and potassium than normal sea water. The species is known to live in waters the temperatures of which from 0°-30°C, but it appears that a minimum temperature of 20°C is necessary for successful breeding [9]. This species is quit abundant in Benghazi plain especially in the SW Benghazi calcarenite *as describedCardium* beds by Desio, 1935 [4].

- ***Ostrea (oyster)* sp.**

Oysters are marine bivalves with a rough, flattened, irregularly oval shell, epifaunal cemented. They present in large numbers and preserved in their natural life position generally they lives at shallow depths. Oysters in Garyounis calcarenite are taking the shape of biostrome in the middle part of the section (Fig. 7), and they lie in a belt parallel to the shoreline,furthermore, they can be used in determining the paleoshore line position.

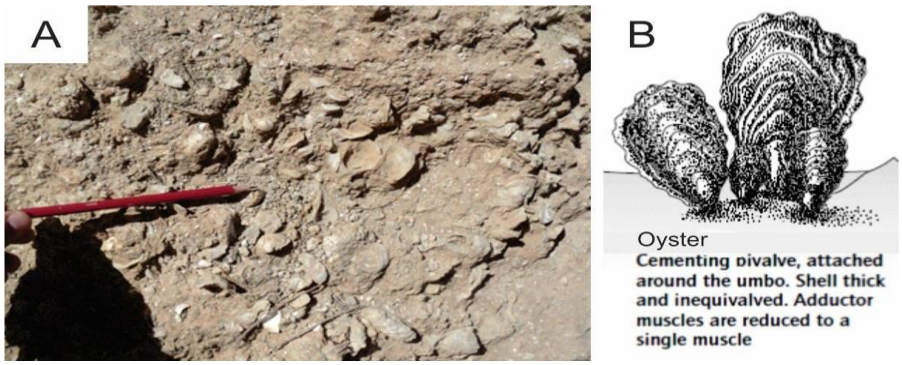


Fig. 7: A) Shell concentration of Oysters on the middle part of Garyounis calcarenite.
B) Mode of life of Oysters [10].

- ***Tellina* sp**.

It is a shallow burrower bivalve (Fig.8), a deposit feeder with long slender siphon which suck up water and particles close to the surface of the sediment and it found along with *Cerastoderma edule*and *Venus* sp. in shallow marine water (Plate 1).

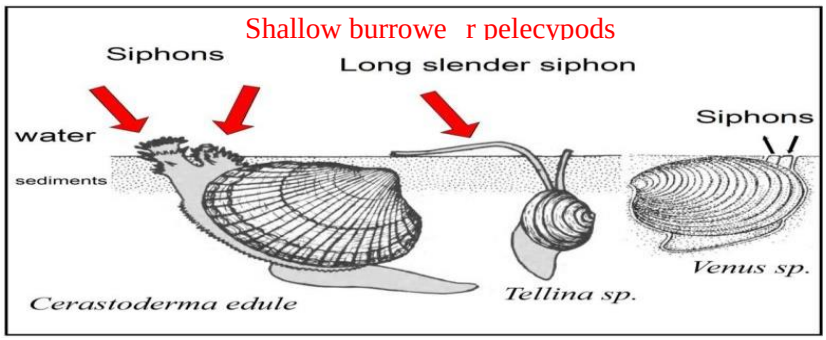


Fig. 8: showing the mode of life of the recovered pelecypods from the studied section. [10].

a) Foraminifers:

The foraminifera that have been recovered from the calcarenite of Garyounis is represented by three species belonging to two genera and theses species are *Ammonia beccarii* Linnaeus, *Elphidium macellum* Fichtelli and Molli and *Elphidium*

cf. *advenum* Cushman. These species are quite abundant in the calcarenite of Benghazi and especially in Garyounis calcarenite. Murray 1973 [11] has stated that *Ammonia* was typical of brackish to hypersaline environment, 15-30º C, at depth ranges between 0-50 m. The brackish forms of *Ammonia*lack the umbonal plug [12] and the presence of a distinct plug in the present material suggests normal near shore conditions, [13] reported that *Ammonia beccarii*Linnaeus and *Elphidium macellum*Fichtelli and Molli are dominant at normal salinity and are common in near shore and brackish water(Plate 2 and 3).

b) Calcareous algae:

- **Marine green algae**: Dasycladacean green algae consist of segmented, branching shrubs that stand several centimeters tall. Most segments separate on death of the organism and form isolated, generally spherical, hollow grains with radially oriented tubules or wall perforations (utricles) [14] (Fig. 9 A).

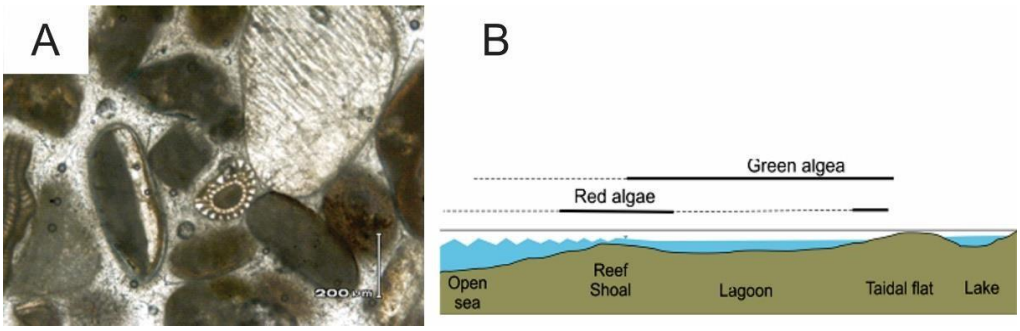


Fig. 9: A) Photomicrograph showingDesycladacean green algae (a).
B) Generalized environmental distribution of calcareous algae.

Green algae arephotosynthetic and thus require light and most common at depths of 2 to 30 m. it has a wide salinity tolerance ranging from strongly hypersaline to brackish. Most calcified forms grow mainly in warm temperate areas with near-normal salinity waters. Also common in reef and nearbackreef areas and can even form biohermal thickets or mounds. Important contributors to sand- and mud-sized fractions of modern and ancient carbonate deposits of warm water regions [14].

- **Red algae:** are fragile, branching forms can be found in moderate wave energy areas. Encrusting, nodular, and robust branching forms can with stand very high wave energy. Photosynthetic and require light. Dominantly marine, most live in waters with salinities ranging from 33-42 ppt [14].
  Wide temperature latitude allows them to be an important component of both cold- and warm water carbonates [14].

c) Bryozoans:

They live as benthic filter feeders, attached and sometimes free lying.Individuals are typically less than 1 mm in size, but colonies can approach 1 m in diameter. Bryozoans are dominant members of shallow benthic communities in temperate latitudes, with normal salinity and low to moderate rates of sedimentation. They occur at water depths of 40–90 m [14]. Encrusting forms are more common than erect shapes in shallow water as in Garyounis calcarenites(Plate 4).

d) Ostracods:

Ostracodes are aquatic organisms with benthic lifestyle. Many burrow into muddy sediment and most are omnivorous scavengers. Ostracodes are common in fresh, brackish and marine waters and extend into hypersaline settings as well. They rarely are major sediment formers [14], however the recovered ostracodes for the middle part of the studied section are with smooth carapaces (Plate 4).

Results and discussion:

Paleoecology:

The Environmental condition that was present in Pleistocene times in Garyounis calcarenite can be interpreted based on the recovered biota as follows:

1. **Temperature**:

Temperature range is about 15 to 30^{0}C based on *Cerastoderma edule*Linnaeus and benthic foraminifera such as *Ammonia beccarii*Linnaeus and *Elphidium macellum*Fichtelli and Molli.

2. **Salinity**:

Evidence based on *Cerastoderma edule* and calcareous algae has suggest that the Salinity ranges from brackish to normal marine with lower and upper limits (3% to 60%). The presence of foraminifera such as *Ammonia beccarii*Linnaeus with *Elphidium macellum*Fichtelli and Molliisan evidenceof more or less brackish to normal salinity at near shore and lagoon environment.

3. **Depth**:
Green algae and red algae are photosynthetic and thus require light. Calcareous algae are most common at depths of 2 to 30 m. while bryozoans occur at water depths of 30to 90 m. and the recovered foraminifer suggest that the depth is ranging between 0 to 50 m. Then the paleobathymetry for the section based on biota was ranging between 0 to 30 m.

4. Energy levels:
Based on the thick shell of *Cerastoderma edule*Linneaus and encrusting, nodular, and robust branching forms of red algae we can suggest that the area was subjected to high wave energy.

Depositional environment:
According to the previous information; the depositional environment of the calcarenites in study area are included to be mainly of Lagoon to a shallow marine environment (Fig. 10), this indicated by the presence of entire shallow marine microbiota and macrobiota and confirmed by the cement type. These calcarenites were subjected to migration for a short distance along the coast line by eolian current before lithification. This biocalcarenite have been exposed to transportationby multiple agents, which worked as a mechanical agent in abrasion,furthermore, bioerosion worked alongside the other agents to make the biograins more rounded and sorted.

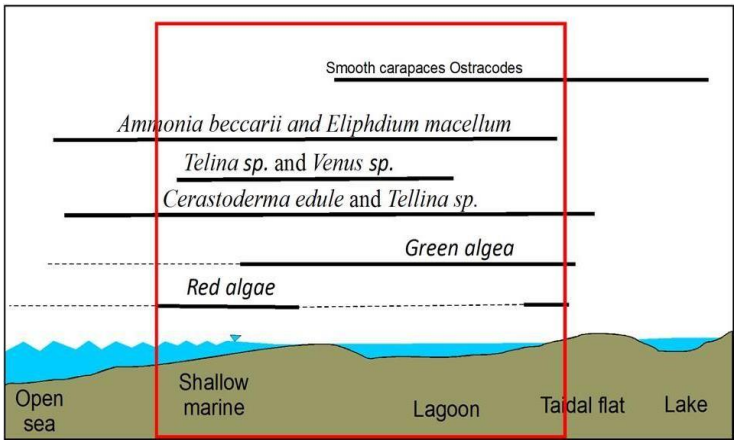


Fig. 10: Depositional settings of Garyounis calcarenite based on biota.

Conclusion:
The studied calcarenite and its recovered biota suggest that:
1- The calcarenite was deposited under fairly warm (20-30º C) shallow marine conditions with a suggested bathymetric range of about 0-30 m.
2- The cement sequence (isopachous and micritic rim) of the studied section is confirming that the calcarenite is of subaqueous and marine in origin.
3- The depositional environment of the calcarenites in study area are included to be mainly of Lagoon to a shallow marine environment.
4- From the thin section studies. However, the angular pelecypods and red algae fragments has suggest that the calcarenite was subjected to high environmental energy levels, which also indicated by thethick shell of *Cerastoderma edule*.
5- The lower and upper limits of salinity are 3% and 60% according to the studied biota. This indicates that the environment of the deposition ranges from brackish to normal marine environment.
6- The position of shore in the Pleistocene times was successfully determined based on oysters because they live in a belt parallel to the shorelineand located near the study area at about +25m above the present sea level and.

Description of plates 1 to 4
Plate 1:
1-2 *Venus* sp.
3-4 *Tellina* sp.
5-9 *Ostrea* sp.
10 *Cerastoderma edule* (Linneaus, 1758).

Plate 2:
1-3 *Elphidium macellum*(Fichtelli &Molli). 60-70X
4-6 *Elphidium advenum* (Cushman). 60-70X 7-12 *Ammonia* cf. *beccari* (Linneaus). 60-70X

Plate 3:
1-4 *Ammonia* cf.*tepida* (Cushman). 60-70X
5-6 *Elphidiummacellum* (Fichtelli &Molli). 60-70X
7 Ostracod G1- sp. 1. 60-70X
8 Ostracod G1- sp. 2. 60-70X
9-10 Ostracod G1- sp. 3. 60-70X 11-12 Ostracod G1- sp. 4. 60-70X

Plate 4:
1 Bryozoans. 60-70X
2 Micro sea shells. 60-70X

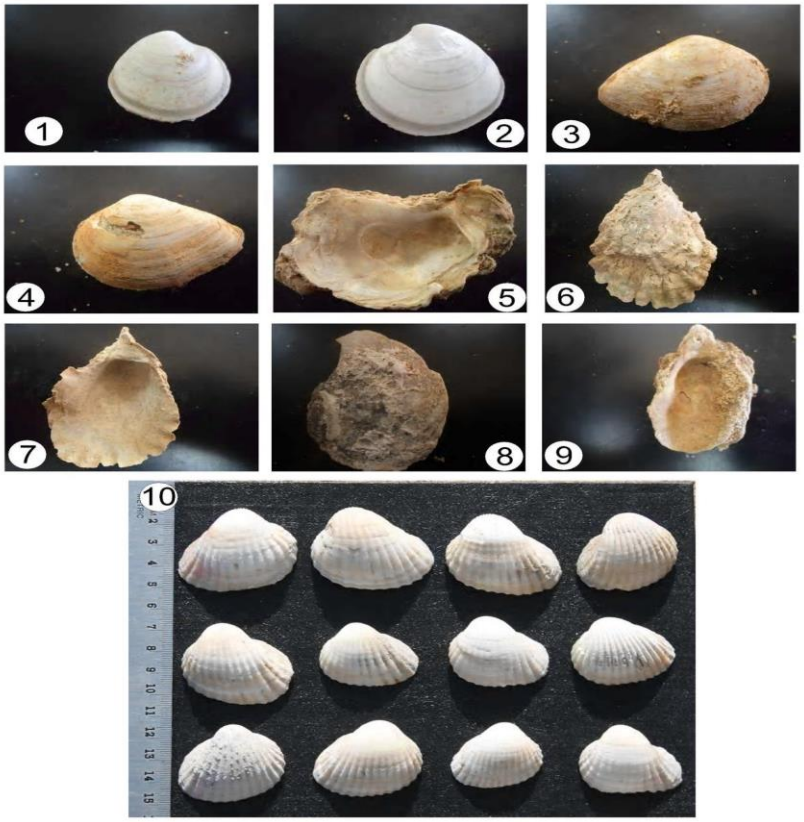


Plate 2

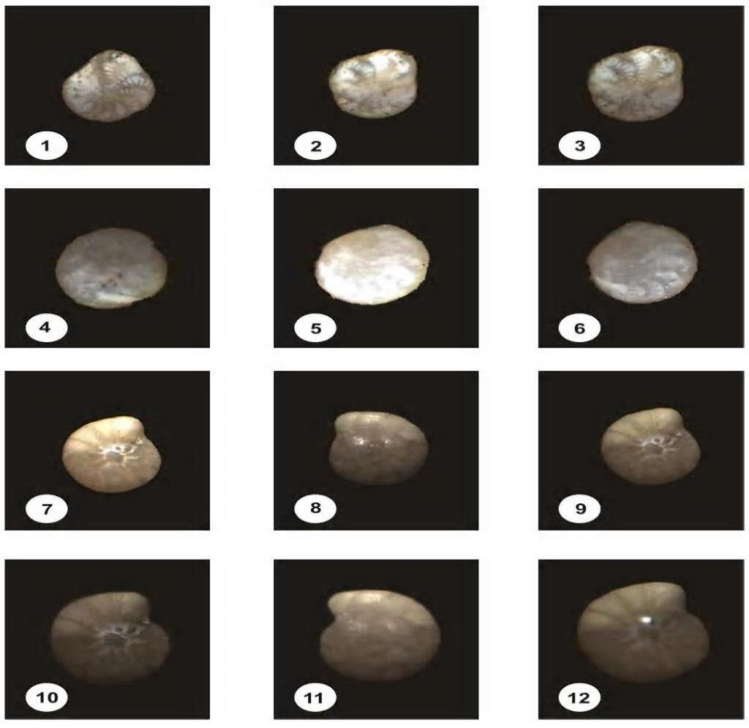
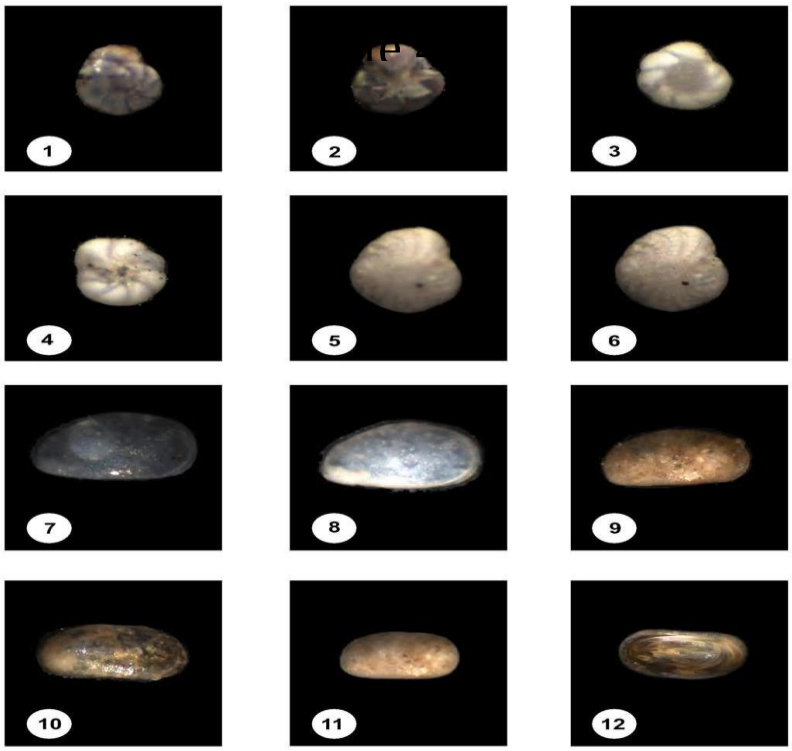


Plate 3



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