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The Importance of Rhodoliths Bearing Beds in Paleoenvironmental Analysis of (the Middle Miocene) Benghazi Formation, NE Libya.

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Highlights

- **Rodolith bed was reported twice in the middle Miocene Benghazi Formation at Daryanah-Al Abyar roadcut, Farkash Quarry, and Majdoub Lake measured sections in Al Jabal al Akhdar, Northeast Libya.**
- **The rhodoliths bearing beds of Benghazi Formation is interpreted to be deposited in the proximal part of the middle ramp on the basis of the size and the internal structure of the reported nodular rhodoliths..**

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ABSTRACT

Abstract: Two Rhodoliths bearing beds have been recognized in the Middle Miocene rocks of the Benghazi Formation at Al Jabal al Akhdar in Northeastern Libya. Three sections, the Daryanah-Abyar (DA) road cut and the Farkash Quarry in the vicinity of Daryanah village, and Majdoub Lake east of Benghazi city have been sampled and studied based on the faunal and floral (algal) evidences with integration of lithofacis characteristic in order to evaluate the environmental setting of Benghazi Formation at these locations. The repetition of Rhodoliths bearing beds is recognized twice in the Daryanah –Abyar (DA) road cut section and Farkash Quarry (FQ) section, whereas only once in Majdoub Lake section. The established Miocene units are spreadout in the range of ramp paleoenvironmental model. A lithological correlation has been built in to trace the lateral extension of the rhodoliths bearing-beds. The presence of the nodular rhodoliths below FWWB (i.e. >50 m water depth) indicates a proximal part of the middle ramp. Based on presence of *Borelis melo* and Miogypsinids the Benghazi Formation is dated as Miocene.

1. Introduction

Libya is located along the Mediterranean Sea in north-central Africa; the Al Jabal al Akhdar is an anticlinorium located in Northeastern Cyrenaica with a NE – SW axis. The present study is focused on the middle Miocene Bengahzi Formation that exposed in the uppermost part of Al Jabal al Akhdar's first (lower) escarpment (Figs. 1, 2). The exposed rock units in Al Jabal al Akhdar are illustrated in Fig. 3, for further information; see Röhlich (1974), El Hawat and Shelmani (1993), El-Werfalli *et al*., (2000), El Hawat and Abdulsamad (2004). Rhodoliths are formed by coralline red alga (Lithophyllum, Lithothamnion, and Neogoniolithon) that deposit calcium carbonate within their cell walls to form hard structures or nodules which are forming reefoidal beds resembling coral. They do not attach themselves to the rocky seabed; they incorporated into a semi-continuous algal mat or form an algal build-up in the photic zone of the sea. Rhodolith bed has been found throughout the world's oceans, including in the Arctic near Greenland, in waters off British Columbia, Canada, the Gulf of California, Mexico, the Mediterranean and eastern Australia, Wikipedia (2023), (https://www.google.com/search?q=Rhodolith+bed+found+throughoutworld%20Wikipedia).

1.1. Objectives of this study

1. To determine the petrographical and paleontological characteristics of the measured sections using petrographical thin sections particularly, the Rhodoliths bearing beds found in the Benghazi Formation in the vicinity of the Daryanah village area and Farkash Quarry (FQ) and the Majdoub Lake (ML).
2. To compare temporal differences in faunal relationships between Rhodoliths bearing beds and other sedimentary successions.
3. To map out the spatial distribution of Rhodoliths bearing beds in the investigated areas.

1.2. Location

The study has been conducted in three localities:

i) The Daryanah-Abyar (DA) road cut which is located between Lat. 32º17'48" N and Long. 20º26'30" E (Fig. 1).

ii) The Farkash Quarry (FQ) which is located between Lat. 32º13'26" N and Long. 20º22'14" E (Fig. 1).

iii) The Majdoub Lake (ML) which is located east to Benghazi city between Lat. 32º 09'21.8" N and Long. 20º 07'48.2" E (Fig. 1).

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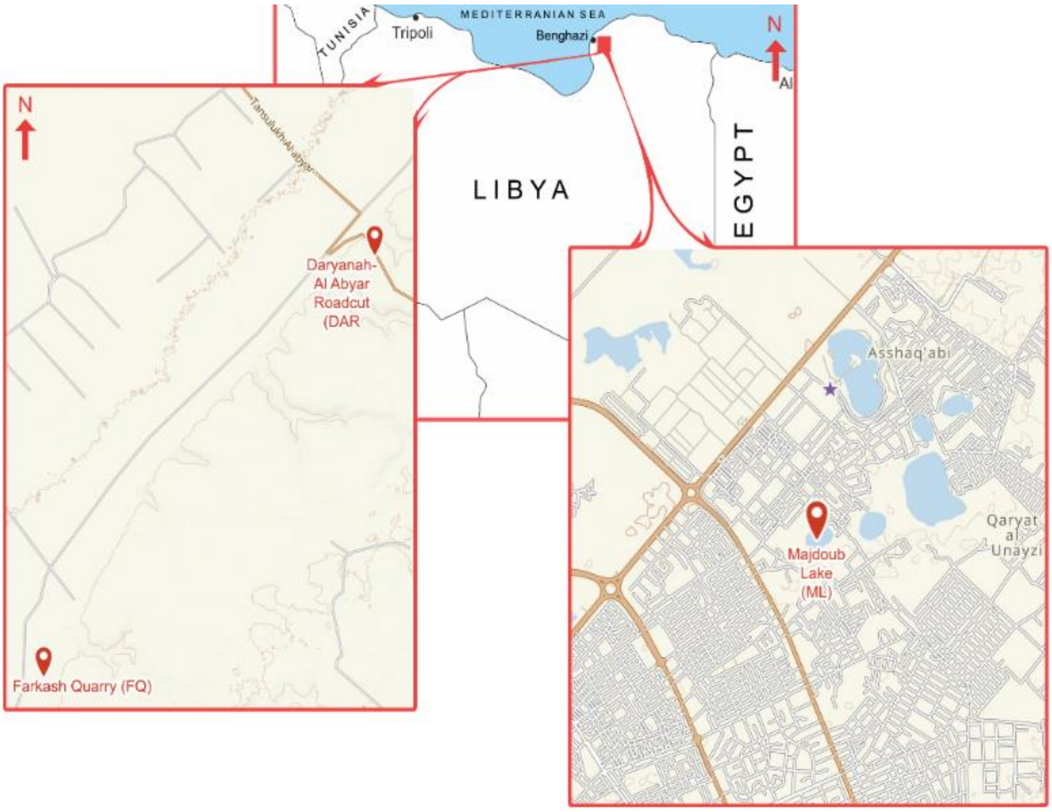

Fig. 1. Location Map of Libya showing the three localities (Daryanah-Abyar (DA) Roadcut; Farkash Quarry (FQ); and Majdoub Lake (ML)

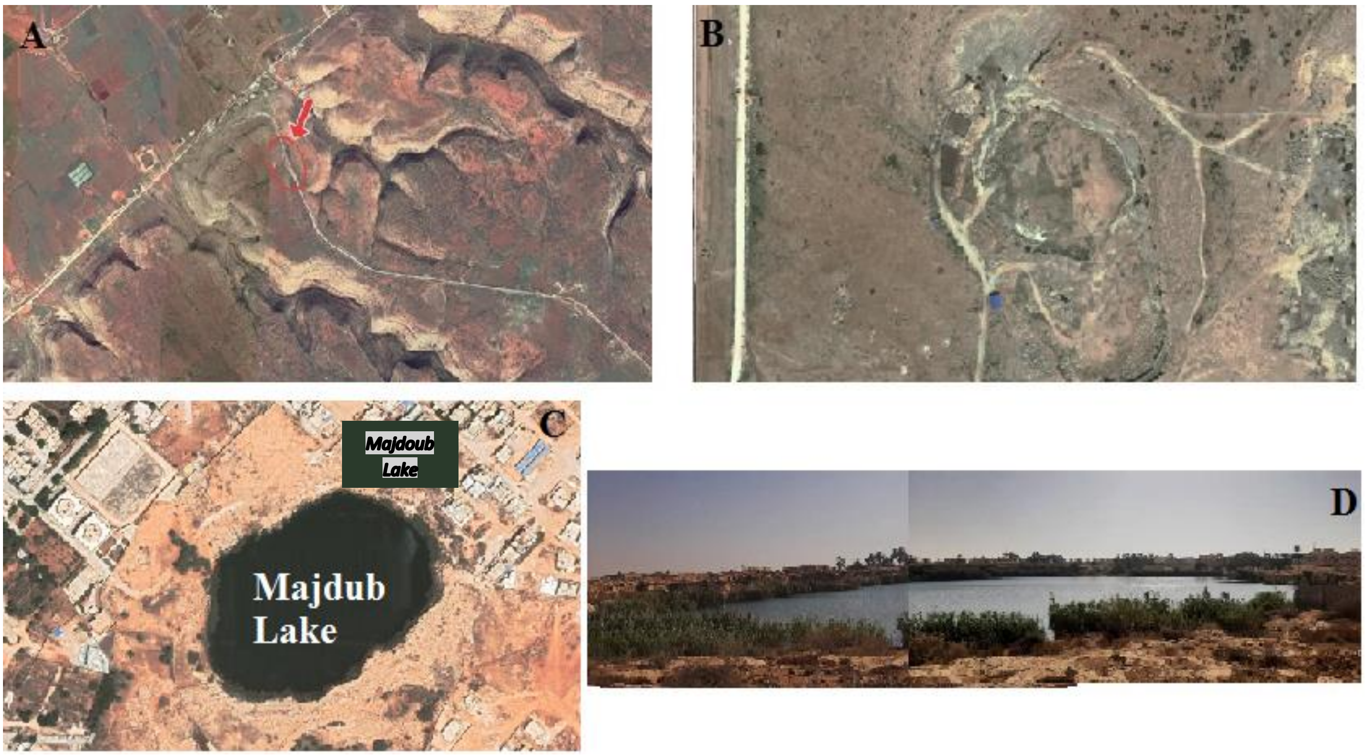

Fig. 2. Satellite images of A) Daryanah-Abyar (DA) roadcut (red arrow); B) Farkash Quarry (FQ); C) Majdoub Lake (ML). D) a general view of the Majdoub Lake (ML).

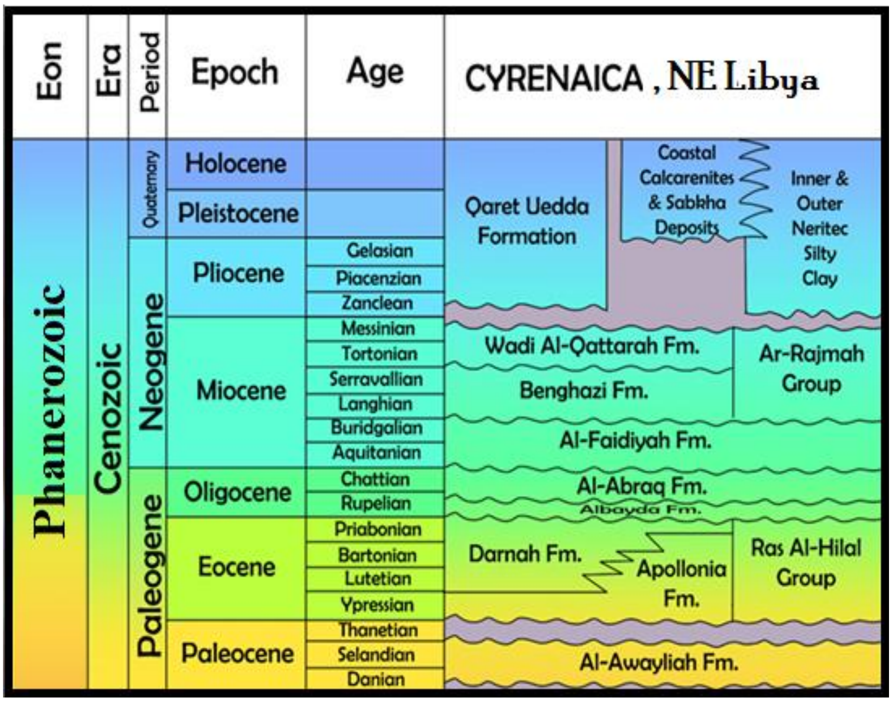

Fig. 3. Stratigraphic chart of northern Cyrenaica (after El Hawat and Abdulsamad, 2004).

1.3 Previous Works

Pietersz (1968) proposed nomenclature of rock units in Al Jabal Al Akhdar and defined Al Faidiyah Formation as Miocene age. El-Hawat (1980) studied the middle Miocene of Wadi Al Qattarah Member of Ar Rajma Formation, and suggested that this member is deposited under intertidal and storm environment. Abdulsamad and Bu-Argoub (2006) and Abdulsamad *et al.* (2009) used stratigraphic and paleontological data for Benghazi Formation in the Al Jabal al Akhdar. Later, Abdulsamad and El Zanati, (2013) are found the diagnostic larger foraminifers *(Miogypsinoides complanatus*, *Nephrolepidina* sp. and *Miogypsina cf. globulina*) and assigned the Aquitanian - Burdigalian age to Benghazi Formation of Ar Rajmah Group in Soluq area, Northeast Libya. Other studies dealt with the rhodoliths in Al Jabal al Akhdar are published by Muftah and Erhoma (2002) on the exposed part of Al Bayda Formation at Susah-Shahhat ro adcut section and established six sedimentological microfacies on basis of textural and paleontological contents, where the studied section reflect different depositional settings of reefal—controlled affinity. Additionally, Hassan and Muftah (2008) examined the coralline red algae of Al Bayda Formation, the lower Marly facies (Shahhat Marl Member) is deposited under outer ramp settings and the upper bioclastic algal facies. The latter facies has been subdivided into three microfacies, (Foramol bryozoan wackestone; Rhodalgal Rudstone; and foramolrudstone, in response to water energy within the range of middle – inner ramp setting. The Al Faidiyah Formation which is unconformably underlain Benghazi Formation has been dated late Oligocene – early Miocene by Röhlich (1974), Zert (1974)**,** Megerisi & Mamgain (1980) based on occurrence of *Nummulites fichtelli* which conflicted with the previous worker such Pietersz (1968), Eliagoubi (1972) and El Hawat & Shelmani (1993) who dated it as Miocene.

1.4. Miocene of Al Jabal Al Akhdar

The Middle Miocene transgression covered most of north Africa including Cyrenaica and Sirt Basin of Libya and Western Desert of Egypt, (Fig. 4), which allowed to the deposition of the shallow marine facies of Benghazi Formation to the east laterally equivalent the Marada Formation in North central Libya (Marada) and to Al-Khums Formation in western Libya the Al-Khums area. Miocene in Al Jabal Al Akhdar was studied by: EL-Hawat (1980), Sherif (1991), El Hawat and Shelmeni (1993); El Werfalli et al (2000), El Hawat and Abdulsamad (2004), Abdulsamad and Bu-Argoub, (2006), Abdulsamad and El Zanati (2013) and El Qot, et al., 2017), Abdulsamad et al, (2021).

The marine regression that took place throughout northern Libya, lead to the development of a regional disconformity surface extending from western Libya, Sirt Basin, Al Jabal al Akhdar, the Western Desert, the Nile delta and Sinai (El Hawat and Shelmeni, 1993; El Hawat and Abdulsamad, 2004). This disconformity is timed with the separation of the Tethys from the paratethys, and the closure of the Mediterranean (El Hawat and Shelmeni, 1993).

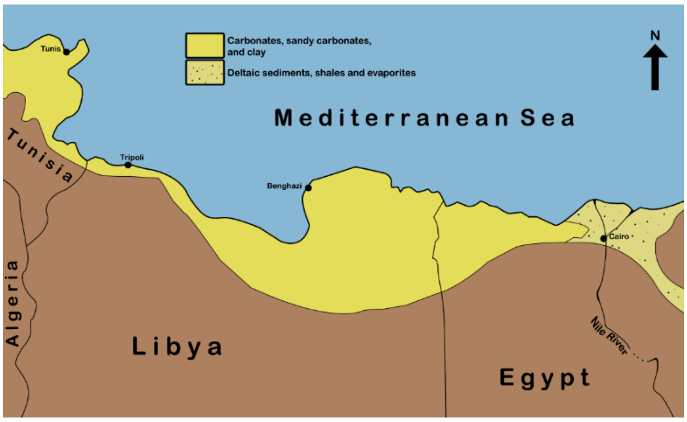

Fig. 4. Facies map showing the different sedimentary facies of the middle Miocene invaded sea deposits in North Africa (modified after Sherif, 1991).

In Al Jabal al Akhdar the Upper Miocene sequence Wadi al Qattarah Formation consists of Tortonian oolitic shoals followed by the Messinian carbonates and evaporites (El Hawat and Shelmeni, 1993). A depositional model of Upper Miocene Wadi al Qattarah Formation that is exposed in the area between Ar Rajmah and Al Abyar villages has been studied by El Hawat (1980), who interpreted as a restricted pond or lake as represented by coarsely crystalline gypsum which exposed in an area between the villages of Ar Rajmah and Al Abyar (facies-1); tidal channels to allow limited water circulation represented by pelletal and mudstone which found above and below the lenses of crystalline (facies-2); Storm-formed barrier beach where high energy near shore environment as represented by conglomeratic oolitic grainstone (facies-3) which is pitted by numerous shallow ephemeral ponds, and hyper-saline pools

2. Materials and Methods

The three measured sections have been investigated and differentiated in the field by the repetition of the Rhodoliths bearing beds and non-Rhodoloths bearing beds, as well as the other field observations including induration and other macro-fossils assemblages (Mollusks).

Twenty-two surface rock samples have been collected from the three studied areas (Figs. 1, 2), from which seven petrographic thin sections have been prepared in mostly from Farkash Quarry (FQ). The thin sections were examined under a transmitted light petrographic Microscope. Selected thin sections have been photomicrographed to show the depositional texture and fossils contents. Dunham (1962) classification modifications for depositional carbonate environment are applied during this work. Micropaleontological slides are also prepared from the Majdoub Lake rock samples for age confirmation at the micropaleontological laboratory in department of Earth Sciences, university of Benghazi.

3. Lithostratigraphy

3.1. Ar Rajmah Group (Middle Miocene):

The whole Middle Miocene sequence was named as "Regima Formation" by Pietersz (1968); Kleinsmeide and Van Den Berg (1968); and Barr and Weegar (1972).

Klen (1974) and Röhlich (1974) modified the name to Ar Rajmah Formation (based on more recent Arabic transcription) and subdivided it into two members; Wadi al Qattarah Member and Benghazi Member. This division is due to upper member (Wadi al Qattarah) being somewhat poorer in fossils with the gradual transition to the lower algal member (Benghazi Member). El Hawat and Abdulsamad (2004) up-ranked the Benghazi and Wadi al Qattarah members to be Benghazi and Wadi al Qattarah formations based on the presence of hard ground in between them and in turn Ar Rajmah Formation has been raised to Group.

The Benghazi Formation rests unconformable on the Al Faidiyah Formation and unconformable overlain by Wadi al Qattarah Formation.

3.2. Lithostratigraphy of the studied sections

3.2.1. Farkash Quarry (FQ) Section

The exposed unit of the Benghazi Formation in the Farkash Quarry (FQ) (Fig. 5) can be differentiated into six facies from base to top are as follows:

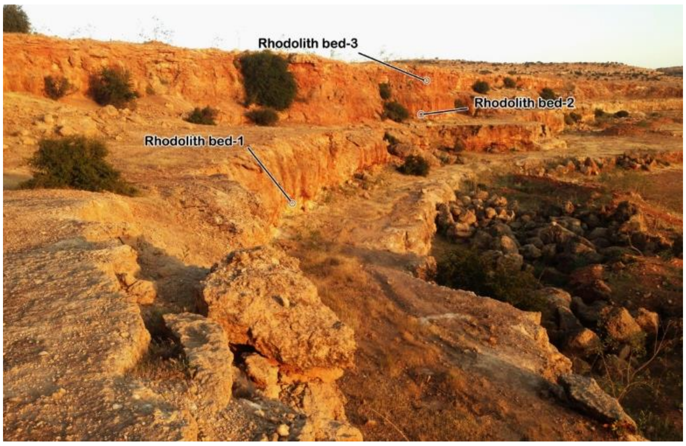

Fig. 5. General view of the Farkash Quarry (FQ), shows the recognised Rhodoliths bearing beds

Dolomitic Limestone Facies: It consists of light grey to grey, common fine euhedral dolomite crystals increase in size upwards, medium-hard to hard, massive, few algal rhodoliths (<2.5 cm in diameter) partially leached and rare pelecypod fragments (Fig. 6). Porosity is few and of solutional type (Figs. 6, 13a).

Algal Boundstone Facies (Rhodoliths bearing bed-1): It consists of dolomitic limestone, brownish cream, medium hard, with some dolomite crystals, It yields algal rhodoliths (up to 10cm in diameter) and pelecypod fragments, common vuggy to solutional porosity. (Figs. 5, 6, 7, 8, 13b).

Foraminiferal Packstone/Grainstone: It consists of limestone light grey, medium hard to hard, sparite cement, local hematite cement, with common algal fragments (non-rhodolith), oysters, and benthic foraminifera (*Amphistegina*, *Operculina*, and miliolids) with rare porosity and scaphopods.. Porosity is common of Intraskeletal to vuggy type (Figs.6, 7, 13c, d, e).

Algal Boundstone Facies (Rhodoliths bearing bed-2): It consists of dolomitic limestone, light grey to cream, soft to medium hard, with some dolomite crystals, It yields algal rhodoliths and pelecypods (*Pecten*). Porosity is common of vuggy type (Figs. 6, 7).

Peloidal Grainstone Facies: It consists of Limestone, cream, hard, rare fine subhedral dolomite crystals, locally zoned, with few pelecypods (*Pecten*) and some algal fragments and peloids. Porosity is common and characterized by intraskeletal and intercrystalline type (Fig. 6).

Algal Boundstone Facies (Rhodoliths bearing bed-3): It consists of limestone, grey to light grey, soft, with common algal rhodoliths (up to 7 cm in diameter) the rhodoliths concentration is increasing upwards (Fig. 5, 6, 9). Porosity is few and shows vuggy type.

3.3 Daryanah- Al Abyar (DA) roadcut section

Outcrop along the Daryanah-Abyar (DA) section is exposed on the southern extension of the roadcut, where beds dip a few degrees to the southwest. This section consists of Eocene, Oligocene, and Miocene beds. At the Daryanah-Abyar (DA) roadcut, the Benghazi Formation is approximately 10m thick (Fig. 10). It is bounded by an unconformity with the underlying Al-Faidiyah Formation and another unconformity with the overlying Wadi Al Qattarah Formation. However, the unconformity surface with the overlying Wadi Al Qattarah Formation is not observed, but the break in the slope "plateau" may represent an unconformity surface.

The exposed units of Benghazi Formation in the Daryanah-Abyar (DA) roadcut can be differentiated into six recognised lithofacies from base to top as follows:

Marly limestone Facies: It consists of marly limestone, yellow, soft, massive, common branched red algae, *Lepidocyclina, Operculina*, and echinoid fragments. Rare echinoid *Scutella* sp., *Balanus* sp., and corals. No observed porosity (Fig. 10).

Dolostone Facies: It consists of cream, very fine dolomite crystals, soft, massive with leached bivalves. Porosity is common of intercrystalline type (Fig. 10).

Algal Boundstone Facies (Rhodoliths bearing bed-1): It consists of, cream, hard, massive, rich on algal rhodoliths (up to 7 cm in diameter), with common bivalves, and rare *Balanus* sp. (Figs. 10, 11).

Foraminiferal Grainstone Facies: It consists of cream, very hard, massive, common algae (non-rhodolith), larger foraminifera (*Operculina, Lepidocyclina*, and *Amphistegina*) embedded in sparite cement. Porosity is excellent and show intra/intercrystalline (Fig. 10, Fig. 13f, g, h).

Peloidal pack/grainstone Facies: It consists of cream, medium hard, massive, common algal peloids, rare *Quinqueloculina* sp. Porosity is few to rare of intergranular and vuggy types (Fig. 9, Fig 13i)

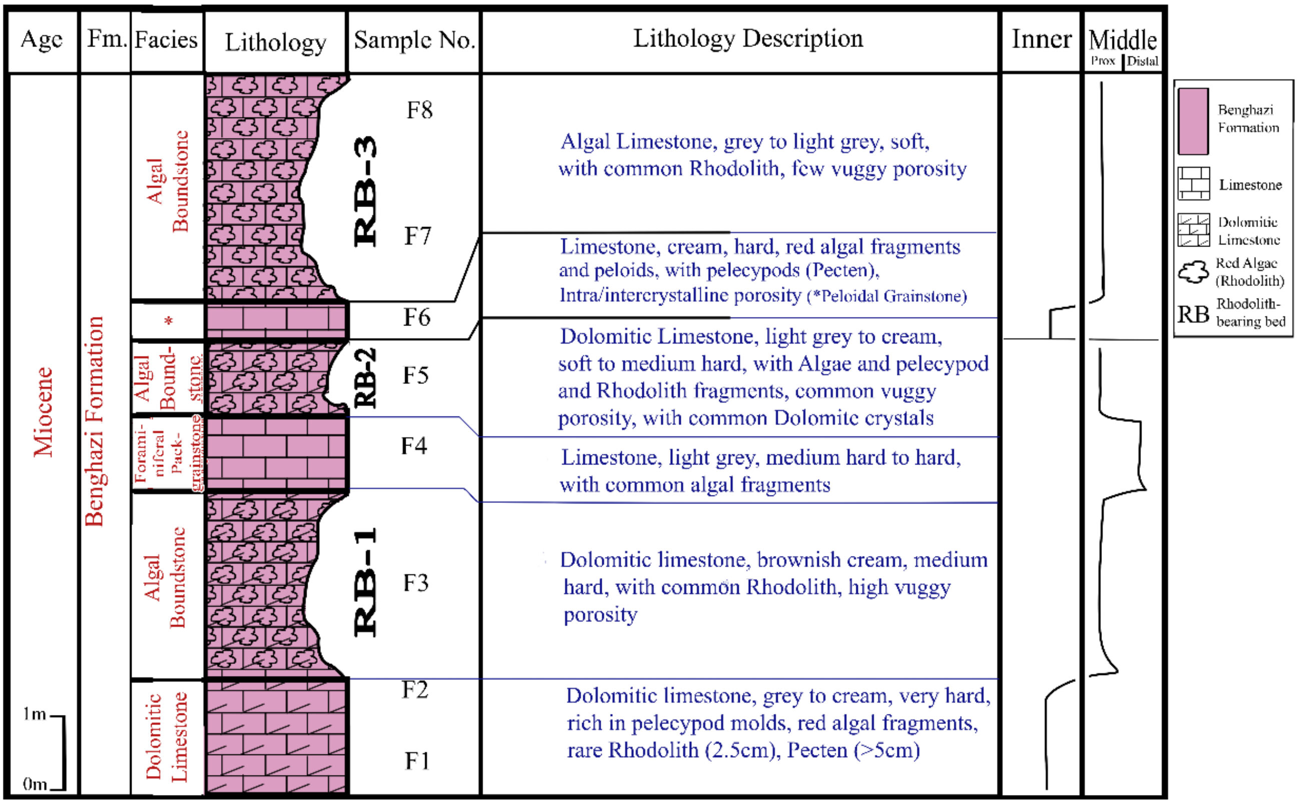

Fig. 6. Lithological column of the Farkash Quarry (FQ) showing the lithological facies against the depositional environment curve.

Fig. 7. Close view of the contact between algal boundstone facies (Rhodoliths bearing bed - 1) and the overlying foraminiferal packstone-grainstone facies of Benghazi Formation at Farkash Quarry (FQ) section.

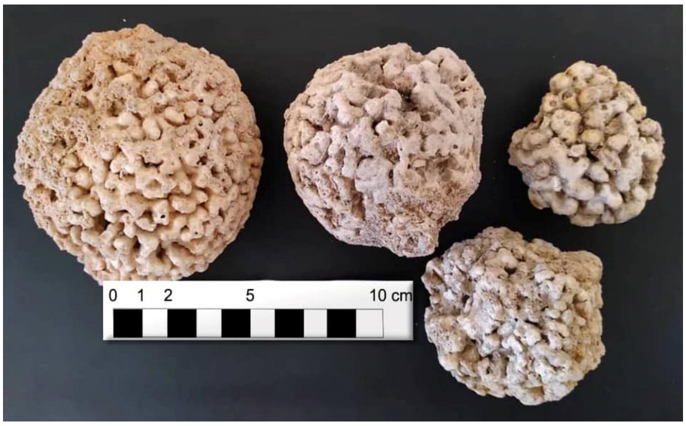

Fig. 8. Rhodoliths from the Algal Boundstone facies "Rhodoliths bearing bed -1" of the Benghazi Formation at Farkash Quarry (FQ) section.

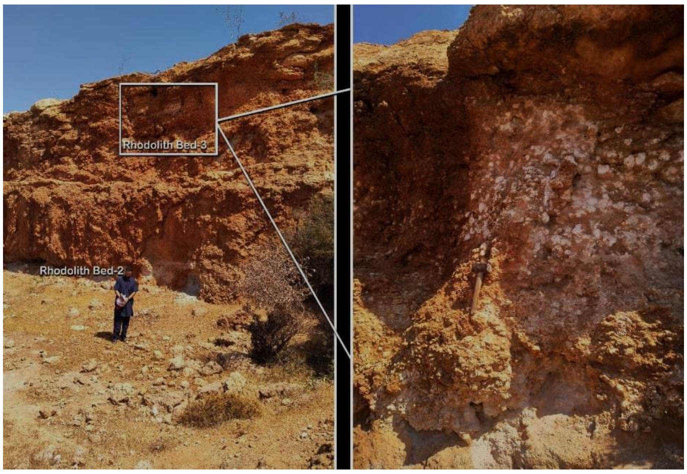

Fig. 9. The algal boundstone facies of Rhodoliths bearing bed -3 at Farkash Quarry (FQ) section with closer view showing the rhodoliths (in white).

Algal Boundstone Facies (Rhodoliths bearing bed-3): It consists of, creamish white, medium hard, with common algal rhodoliths (up to 7cm in diameter) decreased in abundance upwards, It yields bivalves, and *Clypeaster* echinoids at its top (Figs. 10, 11).

3.4. Majdoub Lake (ML) Section

The exposed units of the Benghazi Formation in the studied Majdoub Lake (ML) can be differentiated into five recognized lithofacies from base to top are as follows:

Foraminiferal packstone/grainstone Facies: It consists of limestone, grey to cream, hard, massive, common echinoids (*Clypeaster* sp,), few algal rhodoliths (<3 cm in diameter), with common benthic foraminifers (*Amphistegina* sp., *Operculina* sp., *Spiroclypeus* sp., and *Heterostegina* sp.) and, rare pelecypods including oyster, and serpulid worm tubes. Porosity is few of vuggy type (Fig. 12).

Algal Boundstone Facies: (Rhodoliths bearing bed-1): It consists of limestone, grey to cream, soft – medium hard, massive. It yields ommon algal rhodolith (< 3 m in diameter), *Clypesater* echinoids, and oyster, serpulid worm tubes, and foraminifers (*Amphistegina* sp., *Operculina* sp., *Spiroclypeus* sp., *Heterostegina* sp., and *Miogypsinids*). Porosity is few of vuggy to solutional types. (Fig. 12).

Bioturbated packstone/grainstone Facies: Limestone, cream, soft to medium hard, with common bioturbation, root casts, and echinoderm fragments (Fig. 12)

Algal Boundstone Facies (Rhodoliths bearing bed-2): It consists of limestone, white, soft, massive. It yields algal common rhodoliths (≈ 10cm in diameter), with few small benthic foraminifera (*Amphistegina* sp)., and gastropods. Porosity is few of vuggy types. (Fig. 12).

Foraminiferal Grainstone Facies: It consists of limestone, white, hard, massive, and chalky, with benthic foraminifers *Ammonia beccarii*, ostracodes, and rare pelecypods. Porosity is rare of vuggy to solutional types (Fig. 12).

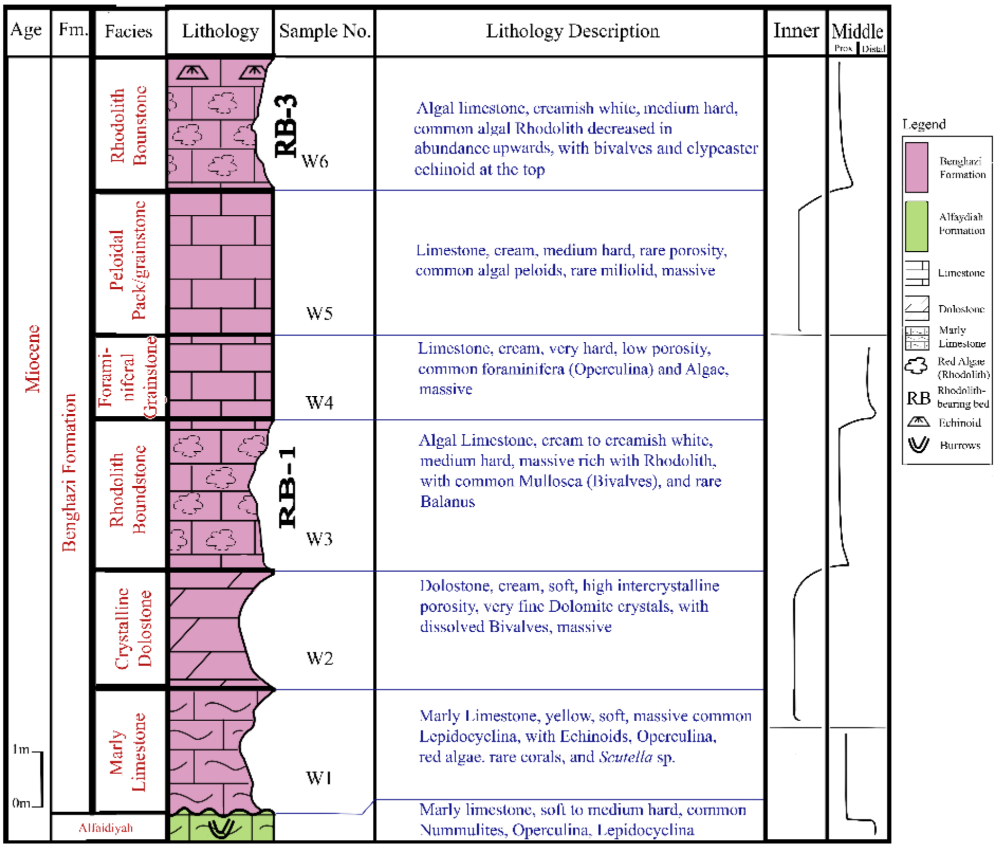

Fig. 10. Lithological column of the Daryanah-Abyar (DA) Roadcut Section showing the lithological facies against the depositional environment curve.

Fig. 11. Close views of the Rhodoliths bearing beds (1 and 3) in the Daryanah-Abyar (DA) roadcut section.

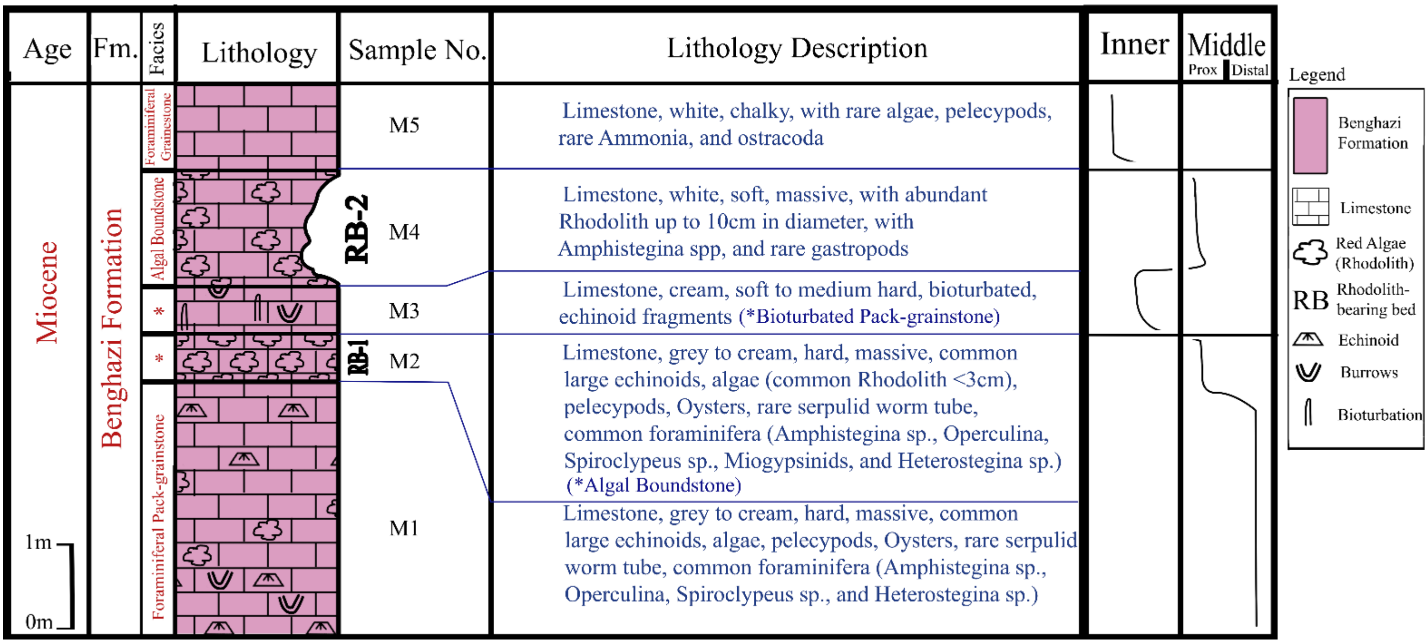

Fig. 12. Lithological column of Majdoub Lake (ML) section showing the lithological facies against the depositional environment curve.

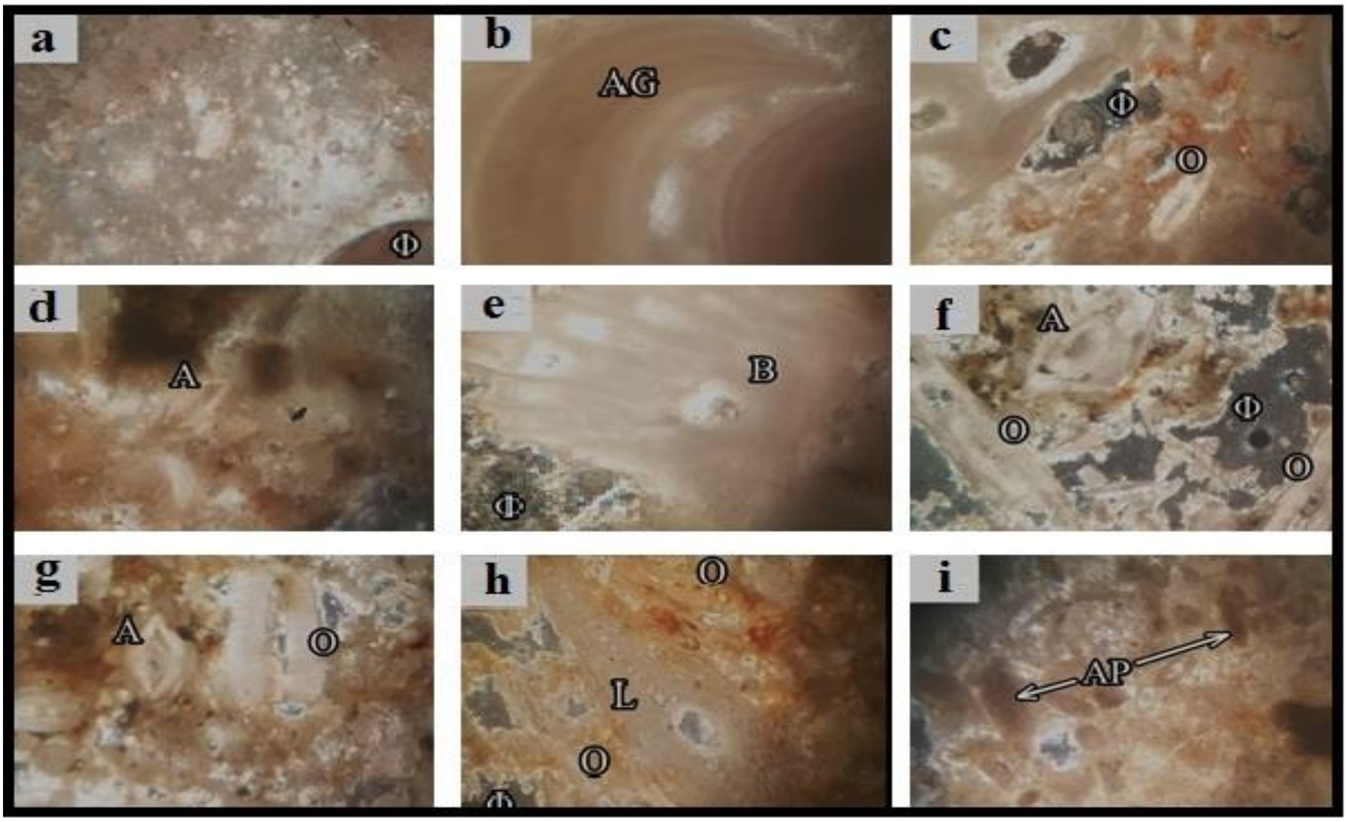

Fig. 13. Photomicrographs of Benghazi Formation: a) Dolomitic Limestone Facies; b) Algal Boundstone Facies; c,d,e) Foraminiferal packstone/grainstone Facies at FQ Section; f, g, h) Foraminiferal Grainstone Facies*;* and i) Peloidal Packstone/Grainstone Facies at DA roadcut Section. (Note: O=*Operculina* ; A=*Amphistegina* ; L=*Lepidocyclina*; AG=Algae ; B=Bryozoa; AP= Algal Peloids ; ϕ=Porosity). *All photos are XPL, x40*

1. Results and Discussion

A lithological correlation has been performed between the eastern studied sections in Daryanah-Abyar (DA) roadcut and Farkash Quarry (FQ) sections with a distance of 10.5 km in between, and the western section in Majdoub Lake (ML) with a distance of 24km far from Farkash Quarry (Figs. 1, 2, 14). The datum in this correlation is the top of the lowermost Rhodoliths bearing bed in tall three sections (Fig. 14).

Only at Daryanah-Abyar (DA) measured section, the underlying Al Faidiyah Formation is reported, however, is not exposed in neither Farkash Quarry (FQ) nor Majdoub Lake (ML) sections. The Rhodoliths bearing bed -1 is reported in all sections, while Rhodoliths bearing bed – 2 has not developed in the Daryanah-Abyar (DA) section. The Rhodoliths bearing bed- 3 is only developed in the Farkash Quarry (FQ) section. These established Rhodoliths bearing beds at the three sections are spatially correlated. This could be related to the eustatic sea level rise as the main factor for their lateral continuity apart from the thickness variations as speculated from Fig. 14.

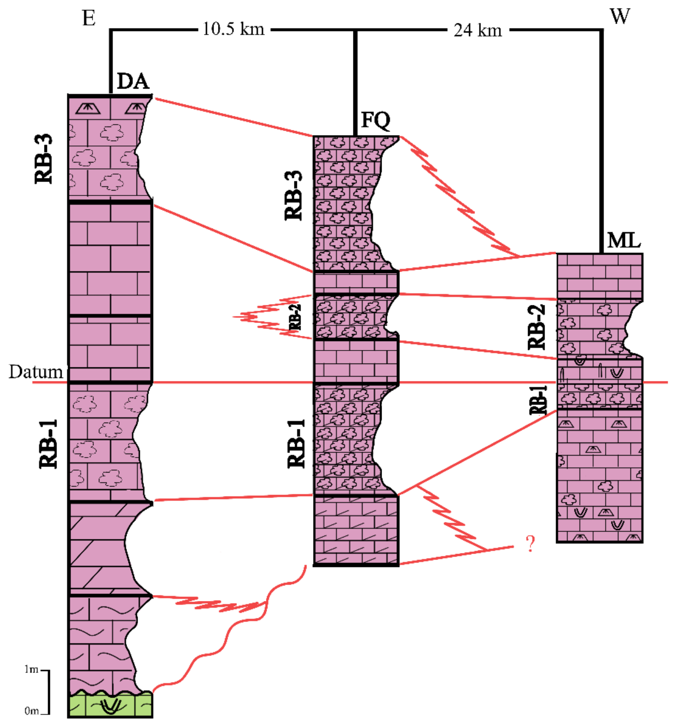

Fig. 14. Lithological correlation between the studied sections (Daryanah-Abyar (DA), Farkash Quarry (FQ) and Majdoub Lake (ML) sections). The top of the first Rhodoliths bearing bed -1 is used as datum.

2. Depositional Environment of the Rhodoliths bearing Beds

Rhodoliths are a valuable source of paleoenvironmental information because of their sensitivity to ecological dynamics (Nalin *et al.*, 2007). In fact, changes in the taxonomical composition and internal structure of rhodoliths are related closely to the conditions characterizing the depositional setting (Bosence, 1976, 1983; Basso, 1998; Nebelsick and Bassi, 2000).

Rhodoliths are considered as nodular structures composed of concentric superimposed thalli of calcareous red algae, usually occurring in the proximal part of the middle ramp (Nalin et al., 2007, Bassi *et al.*, 2007). The mid-ramp is a zone of ramp deposition between Fair-Weather Wave Base (FWWB) and Storm-Wave Base (SWB), in which bottom sediment is frequently reworked by storm waves and swells (Burchette and Wright, 1992). Teichert *et al.* (2012) found that Rhodoliths are covering large area from tropical to polar latitudes and from the lower intertidal zone to water depths of 150 m, also noticed the fully developed rhodoliths are generally contained lithoclastic nucleus, however, the hollow rhodoliths are lacking the lithoclastic nucleus. He believed the hollow rhodoliths have lost their lithoclastic nucleus at an earlier growth stage. Nalin *et al.* (2007) recognized two types of transgressive rhodolith-bearing deposits on the basis of rhodolith internal structure: (i) Type-A deposits are clast-supported rhodolithic rudstones containing abundant pebbles and cobbles reworked from the substrate, and are characterized by rhodoliths with a compact concentric to columnar internal structure and a high nucleus to algal cover ratio; (ii) Type-B deposits are rhodolithic with a matrix usually consisting of bryozoan fragments, benthic foraminifera and echinoid fragments or terrigenous silty fine sand (Fig. 15).

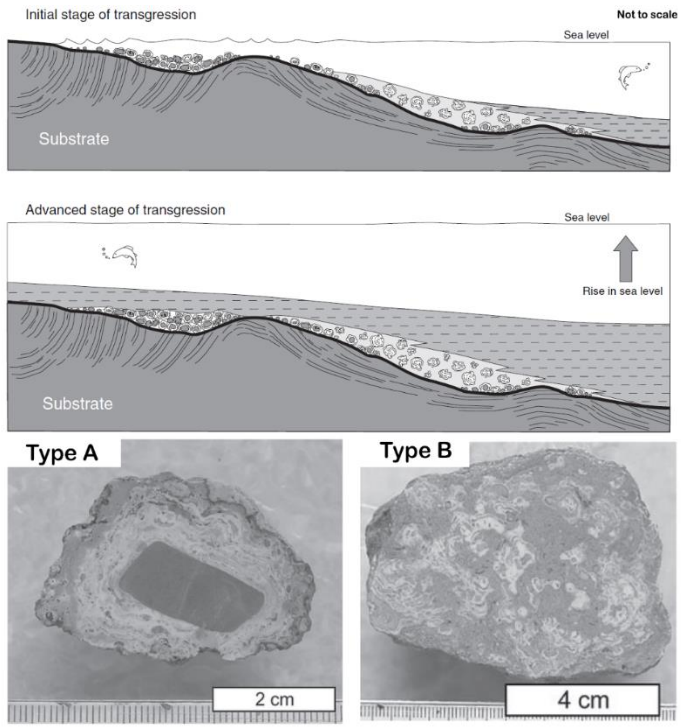

Fig. 15. Depositional model of the transgressive rhodolithic units.In the initial stage of transgression, Type-A of rhodolith form in shallow high-energy settings and are often localized in topographic depressions of the substrate. Type B units develop in calmer, possibly deeper waters and present a matrix-supported texture with rhodoliths showing a loose internal structure. In the advanced stage of transgression, basinal fine-grained units are deposited directly above the rhodolithic accumulations. The result in succession rests above a major unconformity and is characterized by a deepening upwards trend. The size of Rhodoliths increases gradually by depth and distance from the shore line (After Nalin *et al.*, 2007).

The Rhodoliths bearing beds in the present study are all believed herein to inhabit the proximal end of middle ramp as suggested by the coarser size in-between 5-10cm with a mean of 5cm with no obvious central lithoclasts or bioclasts (Figs. 8, 15) with matrix yielded bryozoan foraminifera and echinoidal fragments, in calm water conditions, according to Nalin *et al.*, (2007) this type of rhodoliths is considered as Type B. The Rhodoliths bearing beds herein is an indicator to a transgressive episode (Nalin *et al.* 2007).

Distally, the Benghazi Formation (Foraminiferal Packstone facies) manifested larger foraminifers (*Lepidocyclina* and *Operculina*), that is characterized by branched non-rhodoliths bed which was reported in Farkash Quarry (FQ) and Daryanah-Abyar (DA) sections is deposited under shallower setting of distal inner ramp indicating relatively deeper depositional settings (Fig. 16) (Give reference). This formation in the neighboring areas is unconformably overlain by Wadi al Qattarah Formation indicating restricted environments of hypersaline pond, tidal flat and oolitic shoal (Fig. 16) (El Hawat and Shelmani, 1993; El Hawat and Abdulsamad, 2004).

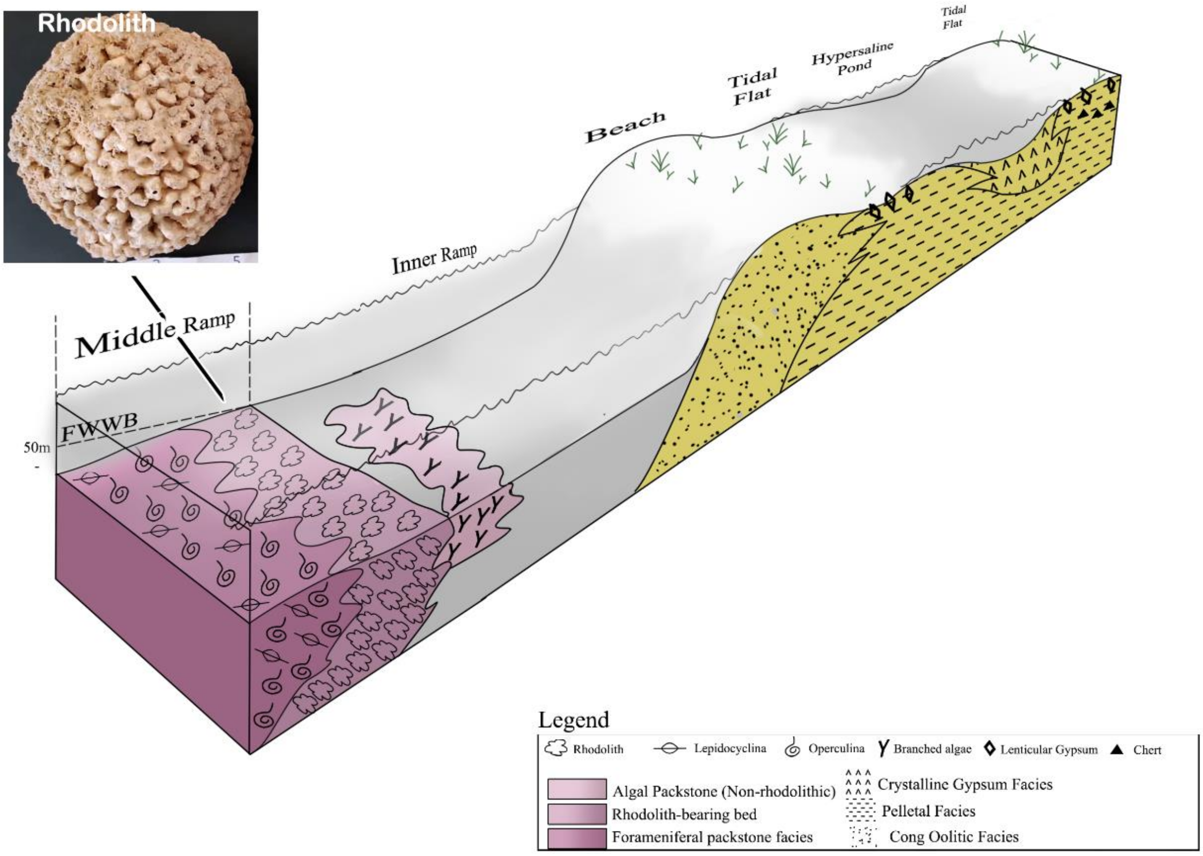

Fig. 16. Depositional model shows the different-environmental settings of the Rhodoliths bearing beds of the Benghazi Formation.

6. Conclusions

The Rhodoliths bearing beds in the Benghazi Formation are studied in three localities (Daryanah-Abyar (DA) roadcut, Farkash Quarry (FQ), and Majdoub Lake (ML), and the results have been summarized as:

- Daryanah-Abyar (DA) roadcut section consists of six lithofacies from bottom to top; i) Marly limestone, ii) Crystalline dolostone, iii) Rhodolith algal boundstone "Rhodoliths bearing bed-1", iv) Foraminiferal grainstone, v) Peloidal packstone/grainstone, and vi) Rhodolith algal boundstone "Rhodoliths bearing bed -3".
- Farkash Quarry (FQ) section consists of six lithofacies from bottom to top are i) Dolomitic limestone; ii) Boundstone (Rhodoliths bearing bed-1):; iii) Foraminiferal packstone/grainstone; iv) Algal Boundstone (Rhodoliths bearing bed-2; v) Peloidal grainstone; vi) Algal boundstone (Rhodolith bearing bed-3)
- Majdoub Lake (ML) section consists of five lithofacies from bottom to top are i) Foraminiferal packstone/grainstone; ii) Algal boundstone (Rhodoliths bearing bed-1); iii) Bioturbated packstone/prainstone; iv) Algal boundstone (Rhodoliths bearing bed-2); and v) Foraminiferal grainstone.
- Three Rhodoliths bearing beds and non-rhodoliths interbeds may be used in the interpretation of the depositional environment. The dolomitic limestone and/or branched coralline red algae characterize the inner ramp settings. The rhodoths bearing beds are indicating the proximal middle ramp depositional settings characterized by the size and the internal structure of the reported rhodoliths, whereas, the flat larger foraminifers (*Operculina*, *Lepidocyclina*, *Heterostegina* and *Spiroclypeus*) are indicating the distal setting of the middle ramp (Fig. 16).

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