JOURNAL OF MARINE SCIENCES & ENVIRONMENTAL TECHNOLOGIES
Vol. 4, Issue No. 2 (December-2018)

ISSN: 2413-5267

Stratigraphy and Microfacies Analyses of The Al Faidiyah and Benghazi Formations at Al Fatiah, Al Huarry and Al Abyar Quarries, NE Libya

Osama R. Shaltami[1], Fares F. Fares[1], Ahmed M. Muftah[1], Saad K. El Ebaidi[1,*], Mohamed M. Alriayad[1], Farag M. EL Oshebi[1], and Hwedi Errishi[2]

[1]Department of Earth Sciences, Faculty of Science, University of Benghazi, Benghazi city, Libya.

[2]Department of Geography, Faculty of Arts, University of Benghazi, Benghazi city, Libya.

[*]**Corresponding author:** saad.elebaidi@uob.edu.ly

تحليل الطبقات والسحنات الدقيقة لتشكيلات الفايدية وبنغازي في محاجر الفتائح والهواري والأبيار، شمال شرق ليبيا

أسامة شالتامي[1]، فارس فارس[1]، أحمد مفتاح[1]، سعد العبيدي[1،*]، محمد الرياض[1]، فرج العشيبي[1]، هويدي الريشي[2]

[1]قسم علوم الأرض، كلية العلوم، جامعة بنغازي، مدينة بنغازي، ليبيا.

[2]قسم الجغرافيا، كلية الآداب، جامعة بنغازي، مدينة بنغازي، ليبيا.

Abstract

Three quarries named Al Fatiah Cement, Al Huarry Cement, and Al Abyar are located in the northeastern part of Libya and consist of carbonate rocks of Miocene age. The main objectives of this study based on microfacies analyses are to construct the depositional environment with a comprehensive stratigraphical correlation of the study areas. The Al Fatiah Quarry has been divided into three microfacies which are operculinid packstone microfacies, algal packstone microfacies, and moluskan packstone grading to grainstone microfacies, one species of large benthic foraminifera is found to be abundant (Operculina complanata). Accordingly, the Al Faidiyah Formation was deposited in a continental shelf (outer to middle neritic zones) environment. Al Huarry Cement Quarry has been divided into five microfacies which are algal boundstone microfacies, amphisteginid - algae packstone microfacies, amphisteginid grainstone microfacies, algal - bryozan packstone microfacies and amphisteginiid - bryozoan - algal boundstone microfacies, one species of large benthic foraminifera is found to be abundant and well preserved (Amphestegina cf. lessonii). Accordingly, the Benghazi Formation was deposited in an inner self to open a marine shelf environment. On the other hand, the Al Abyar Quarry has been divided into two microfacies which are pelloidal packstone microfacies and miliolid wackestone–packstone microfacies, suggesting that the sedimentation was of low energy under very shallow marine to the restricted environment.

Keywords: *Microfacies analysis, Stratigraphic correlation, Depositional environment, Al Fatiah Al Huarry and Al Abyar Quarries, NE, Libya.*

الملخص

ثلاث محاجر للإسمنت (الفتايح – الهواري – الأبيار) والواقعة في الجزء الشمالي الشرقي من ليبيا تكونت من صخور جيرية تعود للعصر الميوسيني. الأهداف الرئيسية لهذه الدراسة المبنية على تحليل السحنات للصخور تمثلت في بناء البيئة الترسيبية ومضاهاة الطبقية الشاملة لمنطقة الدراسة. قُسم محجر الفتايح إلى ثلاثة سحنات دقيقة تمثلت في سحنة operculinid packstone ; سحنة algal packstone ; وسحنة moluskan packstones المتدرجة إلى grainstone)، تواجد بوفرة نوع واحد من المنخربات القاعية الكبيرة متمثل في (*Operculina complanata*) وبناء على ذلك، ترسب تكوين الفايدية في بيئة بحرية واقعة في حرف قاري (النطاق النيريتي المتوسطي الى الخارجي).وقُسم محجر الهوارى إلى خمسة سحنات دقيقة وهي: سحنة ; algal boundstone سحنة amphisteginid packstone سحنة ; algae سحنة ;amphisteginid grainstone سحنة ;algal – سحنة

ISSN: 2413-5267

bryozan packstone؛ سحنة amphisteginiid / bryozoan / algal boundston. حيث تواجد بوفرة وبحفظ جيد نوع واحد من المنخربات القاعية الكبيرة متمثل في (*Amphestegina cf. lessonii*) وبناء على ذلك ترسب تكوين بنغازي في بيئة بحرية واقعة مل بين الجرف القاري الضحل إلى العميق.

من ناحية أخرى، تم تقسيم محجر الأبيار إلى سحنتين صخريتين وهي: سحنة pelloida packstone ; وسحنة wackestone/ miliolid packstone ، مما يشير إلى أن الترسيب يقترح أن يكون بفعل طاقة منخفضة في بيئة بحرية ضحلة جدا إلى بيئة مغلقة.

الكلمات الدالة: تحليل السحنات، مضاهاة طبقية، بيئة ترسبية، الفتايح، محاجر الهوارى والأبيار، شمال شرق ليبيا.

1. Introduction

Al Jabal Al Khdar is a highland area which encompasses the northern most part of Cyrenaica north east Libya, it is consists of Upper Cretaceous to Tertiary marine deposits, but Jurassic and Lower Cretaceous marine deposits are known from the exploratory oil wells. The Al Jabal Al Khdar is more than 200 *km* long and 75 *km* wide. Al Faidiyah and Benghazi formations represent a portion of Al Jabal Al Akhdar region. The Al Faidiyah Formation was introduced by Pietersz (1968) it ranges in age (Aquitanian–Burdigalian) and Benghazi was introduced by Gregory (1911) it ranges in age (Langhian–serravalian) these two formations were deposits in shallow marine environments (Klen,1974).

Figure (1) shows that the first section is located at Al Fatiah Cement Quarry between latitude 32°35’46″ N and longitude 22°43’21″ E (about 25 km east of Dernah city). The second section is located at Al Huarry Cement Quarry (about 18 *km* south west of Benghazi city). This section is represented by limestone and terra rossa soil between latitude 75°31’59″ N and longitude 73°32’00″ E. The third section is located at Al Abyar Quarry between latitude 32°37′60″ N and longitude 20°36′98″ E (of about 60 *km* east of Benghazi city). This section is represented only by limestone.

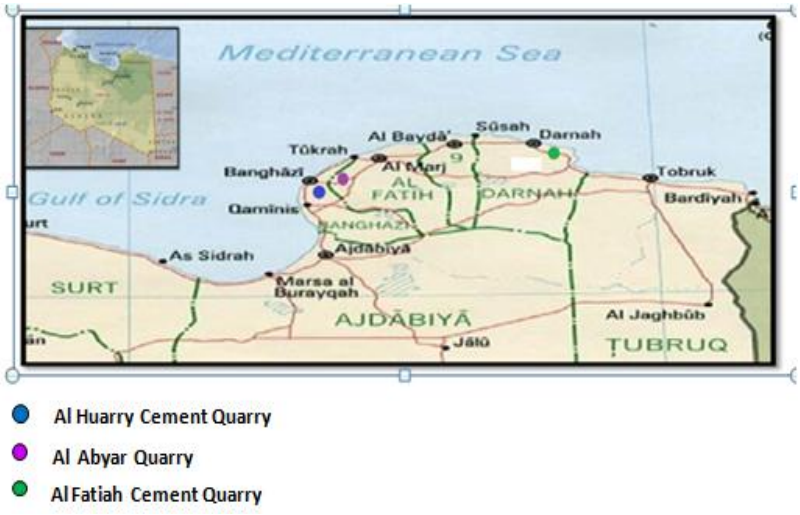

Figure 1. Location map of the study area.

ISSN: 2413-5267

2. Objective

The purpose of this study to discuss the microfacies analyses in order to construct the depositional environment with comprehensive stratigraphical correlation of the study quarries.

3. Methodology

About 20 surface samples were collected at a maximum interval 10 *m* from three quarries and were subjected to thin sections to determine the differential sedimentological and diagenetical features an according to Dunham classification (1962). The analysis was done in laboratory at Arabian Gulf Oil Company.

4. Al Fatiah Cement Quarry (Al Faidiyah Formation)-lower Miocene (Middle Aquitanian)

Al Fatiah Cement Quarry is represented by 35 m thick sequence of Al Faidiyah Formation. The name was introduced by Pietersz (1968) from the village of Al Faidiyah about 16 *km* southeast of Shahhat (Cyrene) city. Al Faidiyah Formation received several paleontological works such as El Safori and Muftah (2007) and Muftah (2014).

The stratigraphic sequence of the Al Fatiah Cement Quarry has been examined in three traverses (as shown in Figure 2). These traverses have been divided into-three microfacies which are operculinid packstone microfacies, algal packstone microfacies and molluskan packstone grading to grainstone microfacies and correlated in them in traverses have been difficult.

The Al Faidiyah Formation in the study area is characterized by grain supported fabric (packstone texture), white to off white colored, moderately hard, medium to coarse grains, thickly bedded with local moderately fractured due to tectonic events and may industrial activities, with some micritic matrix, rare gypsum and calcite cements, rarely glauconitic, with some bioclasts which are represented by Operculina, worm tubes, bryozoan, pelecypods, gastropods, algae, echinoids, and undifferentiated shell fragments.

Traverse I:

Two microfacies have been established at this traverse from bottom to top:

Operculinid packstone microfacies:

It characterized by white colored, fine grained, soft to moderately hard, thickly bed with local highly fractured, some micritic matrix, rare gypsum and calcite cements, rare glauconite grains. The bioclasts are represented by presence of the benthonic foraminifera Operculina complanata, with serpulid worm tubes, rare algae peloids, molluskan (mainly Oysters and some gastropods) fragments (Figure 3a) and a few echinoides embedded within the micritic matrix. Porosity is of intercrystalline type and the thickness reaches up to 5.5 *m*.

ISSN: 2413-5267

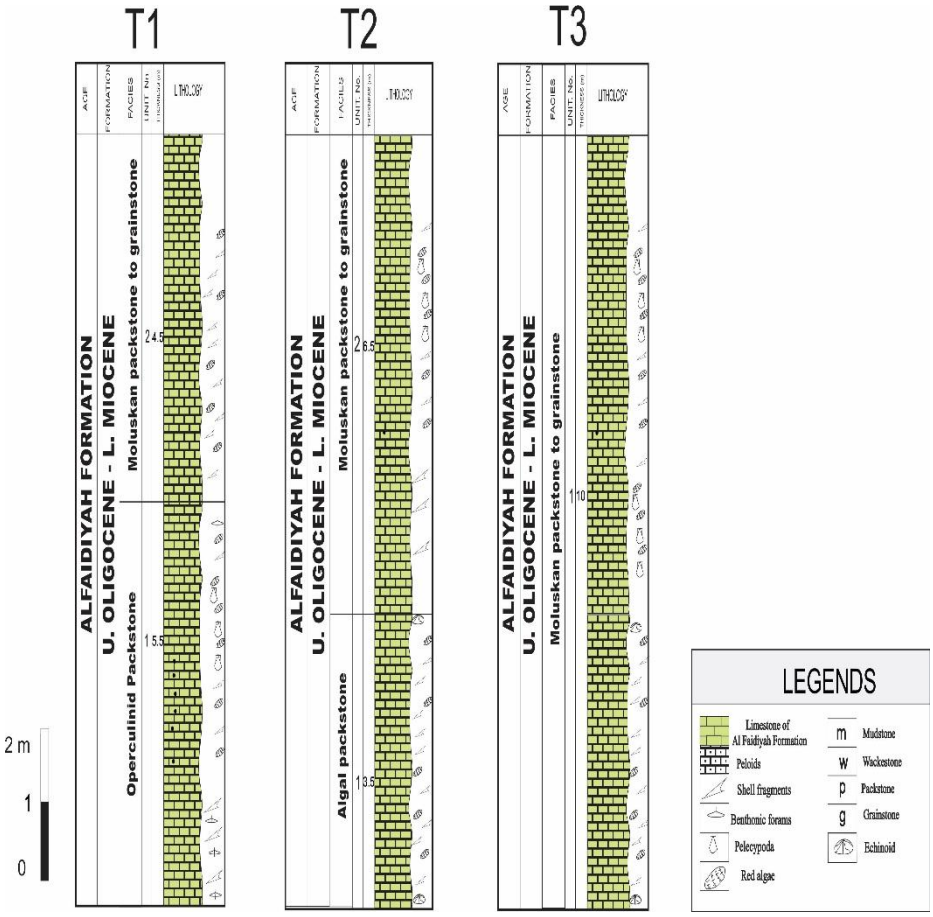

Figure 2. Columnar sections of T1, T2 and T3of Al Fatiah Cement Quarry

Molluskan packstone grading to grainstone microfacies:

It characterized by milky to white coloured, medium grained, moderately hard, thickly bedded with local fractured and slightly krastified, micritic matrix. The bioclasts are represented by common recrystallized mollusks, Serpulid worm tubes, bryozoan debris and some shell fragments within micritic matrix. This microfacies shows diagenesis process mainly on fossils due to dissolution effect (Figure 3b). The porosity is of moldic to shelter types and the thickness reaches up to 4.5 *m* .

Traverse II:

Two microfacies have been established at this traverse from bottom to top:

Algal packstone microfacies:

It characterized by white to light grey colored, fine grained, medium hard, thickly bedded with local fractured and poorly karstified, isopacheous cement rimmed algal grains, glauconitic in part. The bioclasts are represented by presence fragments of coralline red algae etching by dolomite crystals and filling pore spaces, few echinoids and pelecypods (Figure 3c). The porosity is of interskeletal type and the thickness reaches up to 3.5 *m*.

ISSN: 2413-5267

Molluskan packstone–gainstone microfaceous:

It characterized by white to yellowish colored, medium to coarse grained, medium hard, thinly bedded with local fractured and karstified, micritic matrix in part, rare dolomite and gypsum crystals, (Figure 3d) isopacheous calcite cement. The bioclast is represented by mainly mollusks (Oysters) fragments. Porosity is of interskeletal–intercrystalline type and the thickness reaches to 6.5 *m*.

Travers III:

One microfacie has been established at this traverse:

Molluskan packstone with local grading to grainstone microfacies:

It characterized by white to off white colored, fine to medium grained, soft to medium hard, thickly bedded with local fractured, common micritic matrix, common calcite and a few dolomite cements. Bioclasts are represented by common partially recrystallized mollusks (oysters), gastropoda, serpulid worm tubes and echinoides with rare undifferentiated fossils fragments. Common replacement of calcite to oyster shells (Figure 3f). Porosity is poorly intercrystalline type and the thickness reaches up to 10 *m*.

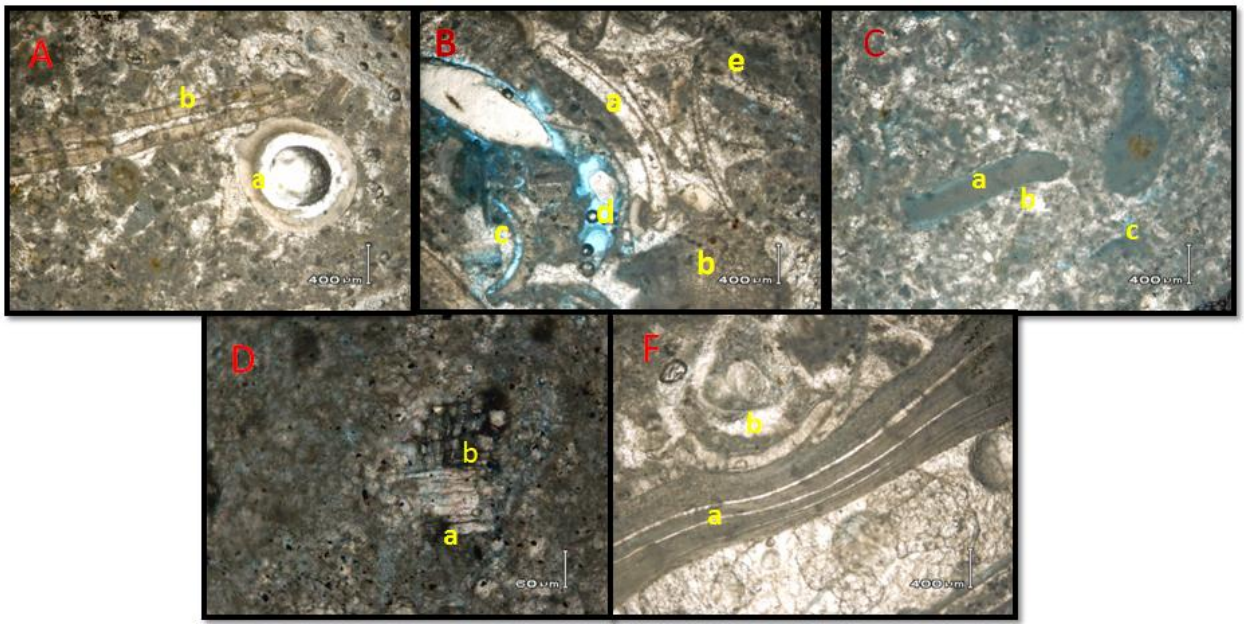

Figure 3. Thin section photomicrographs (A) operculinid packstone microfacies of Al Faidiyah Formation shows; a) Serpulid worm tubes, b) Operculina complanata,(B) molluskan packstone grading to grainstone microfacies of Al Faidiyah Formation shows; a) molluska fragment, b) bryozoan colony fragmment, c) moldic porosity, d) shelter porosity, e- micritic matrix.(C) algal packstone microfacies of Al Faidiyah Formation shows; a) red algal grain, b) isopachous cement, c) interskeletal porosity.(D) molluskan packstone – gainstone microfaies of Al Faidiyah Formation shows; a) gypsum crystals, b) intercrystalline porosity.(F) molluskan packstone grading to grainstone microfacies of Al Faidiyah Formation shows; a) partially recrystallized oyster, b) undifferentiated fossil fragment.

ISSN: 2413-5267

4.1. Stratigraphic Correlation

During field work the stratigraphic correlation were made in Al Fatiah Cement Quarry (Figure 4) this correlation obtained by measure two traverses T1, T2, and T3 is unexposed of the bottom and difficult to tie this term with own correlation (it is doubtful). The datum is lower part of molluskan packstone grading to grainstone microfacies. The correlations between them were constructed in order to identify lateral or vertical lithological changes along the study area. The traverses being correlated are approximately along 700 *km* from NE–SW. This correlation indicates the following observations :

A. Al Faidiyah Formation is recorded in all studied sections, with maximum thickness (about 35 *m*) as recorded in the Al Fatiah Cement Quarry and generally shows gradual thickness increases toward NE direction.
B. The established microfacies have been correlated, considering the base of molluskan packstone grading to grainstone microfacies as datum of this correlation. The upper microfacies is increased towards T2 at SW. On the other hand, the operculinid packstone microfacies laterally changed to algal packstone microfacies at T2.

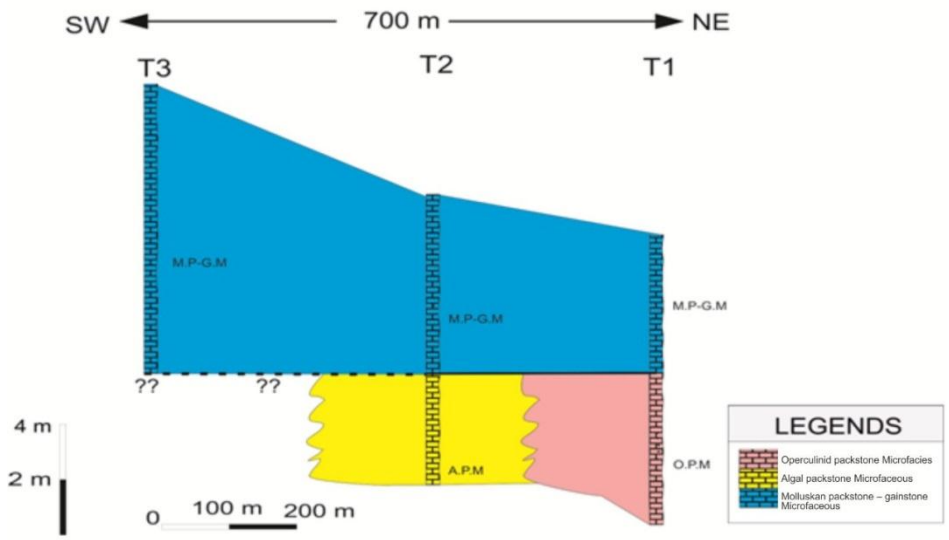

Figure 4. Stratigraphic correlation of Al Faidiyah Formation at Al Fatiah Cement Quarry.

4.2. Age of Al Faidiyah Formation

The Al Faidiyah Formation dated as Late Oligocene–Early Miocene by Rohlich (1974) and El Mehdawi and El Beialy (2008). However, Early Miocene age is according to El Hawat and Shelmani (1993), and El Hawat *et al.* (2008) by considering the Nummulites fichtelli as reworked elements from the nearby paleohighs. The stratigraphical position as well as the common occurrences of Operculina complanata in the Al Faidiyah Formation at this locality is indicative to Early Miocene. Shaltami *et al.* (2018a) determined the isotope age for Al

ISSN: 2413-5267

Faidiyah Formation, the age derived from the Sr ratios is Early Miocene (Middle Aquitanian, 21.40-22.13 Ma).

5. Al Huarry Cement Quarry (Benghazi Formation)-Middle Miocene (Late Burdigalian-Early Serravallian)

Al Huarry Cement Quarry is represented by 35 *m* thick sequence of Benghazi Formation. The name was introduced by Gregory (1911) as Benghazi limestone for a sequence of massive fossiliferous limestone of Middle Miocene age. Klen (1974) divided Ar Rajmah Formation with in to two members the lower Benghazi Member and the upper Wadi al Qattarah Member and El Hawat and Shelmani (1993) is upranked to Ar Rajmah Group by El Hawat and Abdulsamad, (2004) and raised Benghazi Member to Benghazi Formation based on the recognized hard grounds and rock grounds.

The stratigraphic sequence of the studied Al Huarry Cement Quarry has been examined in three as shown in Figure (5). These traverses have been divided into five microfacies which are algae boundstone microfacies, amphisteginid-algae packstone microfacies, amphisteginid grainstone microfacies, algal–bryozan packstone microfacies, and amphsiteginiid–bryozoan-algal boundstone microfacies.

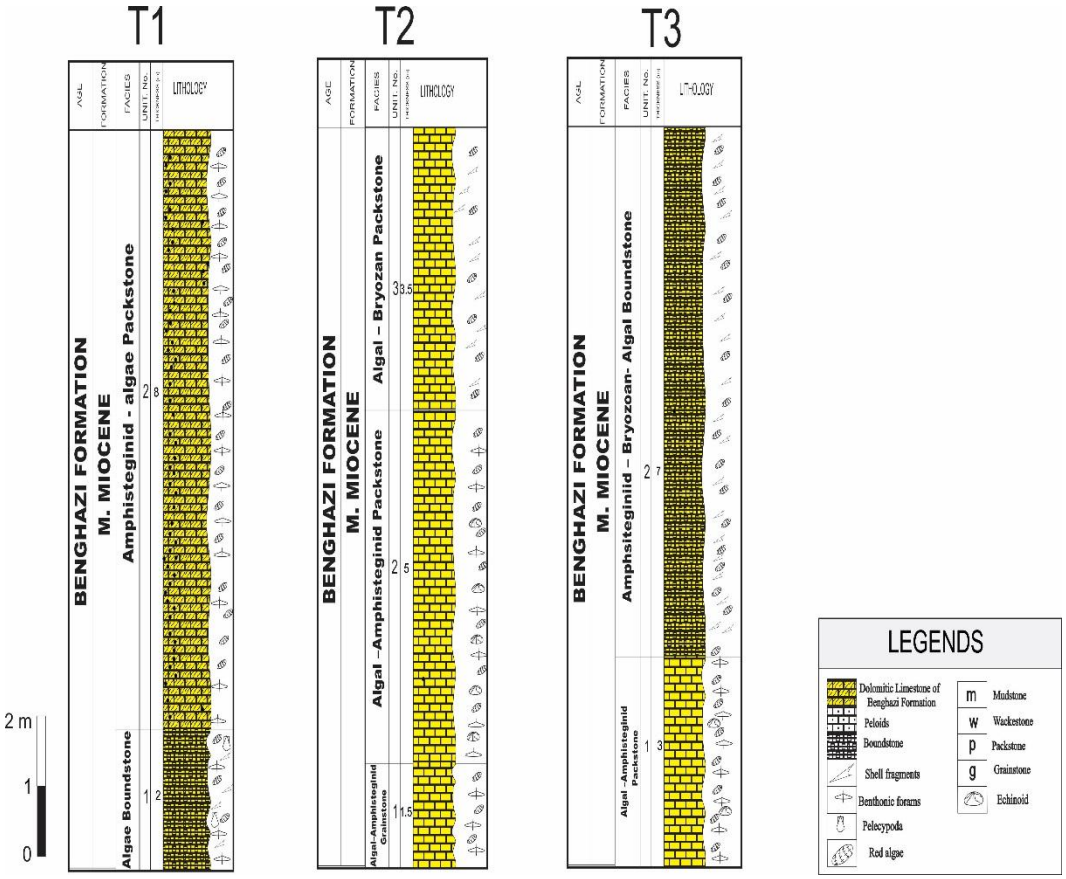

Figure 5. Columnar sections of T1,T2 and T3 of Al Huarry Cement Quarry.

ISSN: 2413-5267

The Benghazi Formation in the study area is characterized by grain supported fabric (packstone to boundstone textures), white to grey colored, moderately hard, medium to coarse grains, thickly bedded with local highly fractured due to tectonic events and may industrial activities) and karstified filling by celestite, with some micritic matrix, and calcite cement, rare gypsum and glauconite grains, with some bioclasts which are represented by common algae, *Operculina,* worm tubes, bryozoan and rare pelecypods, gastropods, echinoids, and undifferentiated shell fragments embedded within micritic matrix.

Traverse I:

Two microfacies have been established at this traverse from bottom to top:

Algae boundstone microfacies:

It characterized by white colored, medium to hard, thinly bedded with highly local fractured. The bioclasts represented by coralline red algae with rare *Amphistegina* sp. operculinid fragments and molluskan (pelecypoda–gastropoda) fragments (Figure 6a). Porosity is of intra-skeletal type and the thickness reaches up to 2 *m*.

Algae-amphisteginid packstone microfacies*:*

It characterized by white to light grey in part colored, medium to coarse grained, thickly bedded with highly fractured, karstified and solution cavities filled by celestite, dolomite and calcite crystals, glauconitic in part. The bioclasts represented by common benthonic foraminifera *Operculina* sp., *Amphistegina* sp., algal pelloids and a few fossils debris embedded within micritic matrix (Figure 6b). Porosity is of interskeletal type and the thickness reaches upto 8 *m*.

Traverse II:

Three microfacies have been established at this traverse from bottom to top:

Algal-amphisteginid grainstone microfacies:

It characterized by milky to white colored, occasionally gray in part. Thinly bedded and highly fractured in part with and highly solution filled by celestite. Common dolomite euhedral crystals, with rare in gypsum. The bioclasts represented by common reworked red algae (Figure 6c), rare *Amphistegina* and *Operculina* fragments in parts. Porosity is of intercrystalline type and thickness reaches upto 1.5 *m*.

Algal–amphisteginid packstone microfacies:

It characterized by white to light grey in part colored, fine to medium grained, soft – medium hard, thickly bedded which with local fractured, macritic matrix with dolomite and calcite crystals. The bioclasts represented by common *Amphistegina* sp. and algal debris with rare in echinoid fragments (Figure 6d). Porosity is of interskeletal type and the thickness reaches upto 5 *m*.

ISSN: 2413-5267

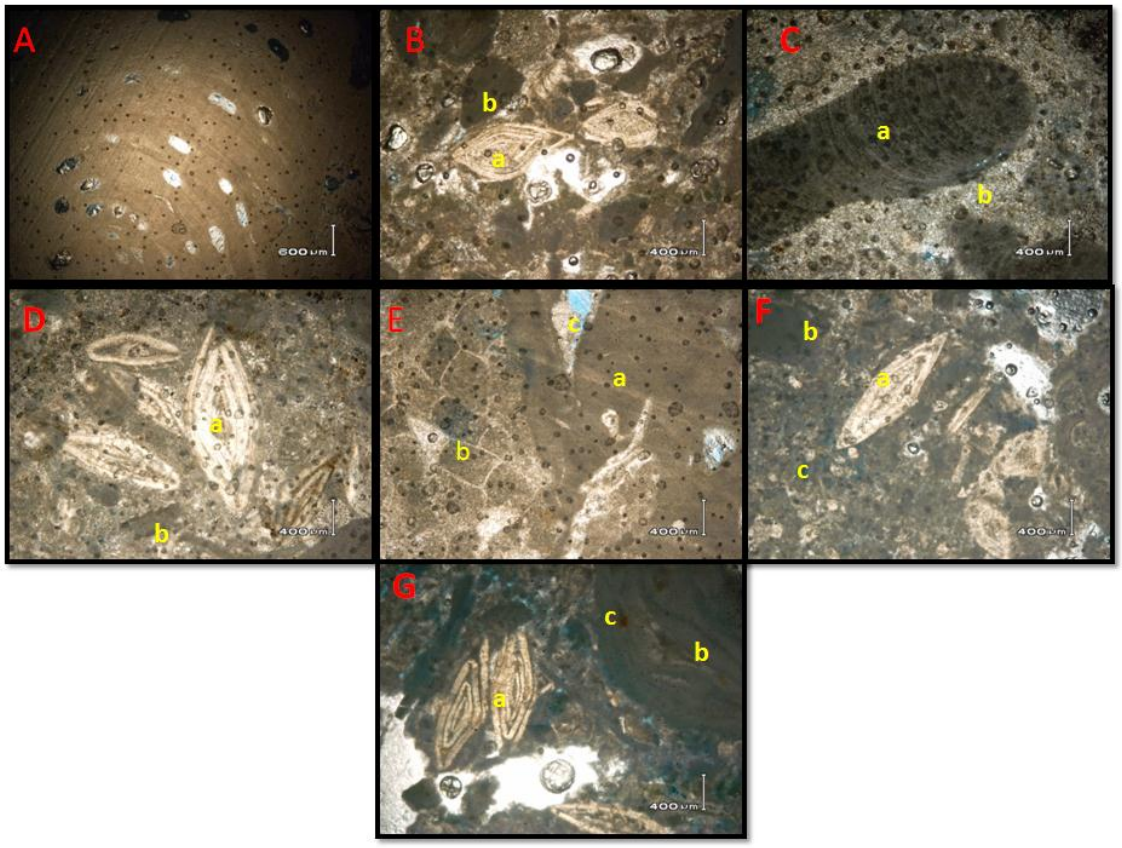

Figure 6. Thin section photomicrographs (A) enlarged view of Coralline red algae from algal boundstone microfacies of Benghazi Formation shows conceptacles. (B) amphisteginid - algal Packstone microfacies of Benghazi Formation shows; a) Amphistegina sp., b) algal pelloids.(C) algal – amphisteginid grainstone microfacies of Benghazi Formation shows; a) coralline red algae, b) dolomite and calcite crystals.(D) algal–amphisteginid packstone microfacies of Benghazi Formation shows; a) Amphistegina sp, b) algal debris.(E) algal–bryozoan packstone microfacies of Benghazi Formation shows; a) coralline red algae, b) bryozoan fragment, c) vuggy porosity. (F) algal–amphisteginid packstone microfacies of Benghazi Formation shows; a) Amphistegina sp., b) algal debris, c) intercrysalline porosity. (G) amphsiteginiid–bryozoan-algal boundstone microfacies. of Benghazi Formation shows; a) Amphistegina sp., b) coralline red algae, c) glauconite infilled the cellular tissue.

Algal–bryozan packstone microfacies:

It characterized by white to light gray in part, medium grained, soft–medium hard, thickly bedded which with local fractured and karstified filled by celestite. Macritic matrix with dolomite and calcite crystals. The bioclasts represented by common coralline red algae and bryozoan and few scleractinian corals. It shows diagenesis process mainly on fossils due to dissolution effect (Figure 6e). Porosity is of vuggy-interskeletal types. Thickness reaches up to 3.5 m.

Travers III:

Two microfacies have been established at this traverse from bottom to top:

ISSN: 2413-5267

Algae–amphisteginid packstone microfacies:

It characterized by white to smoky colored, medium grained, hard thickly bedded with local fractured and highly krastified filled by stalactite, micrtic matrix, dolomite, calcite and rare gypsum crystals. The bioclasts represented by common coralline red algae, with few echinoid and shell fragments which are embedded within micritic matrix (Figure 6f). Porosity is intercrysalline and micro vuggy types and the thickness reaches upto 3 *m*.

Amphsiteginid–bryozoan-algal boundstone microfacies:

It characterized by white to milky colored, hard, thickly bedded with local fractured and poorly krastified filled by celestite, micrtic matrix, glauconite grains. The bioclasts represented by common coralline red algae, *Amphistegina* sp. algal pelloids and some fossil fragments serpulid worm tubes and bryozoa, encrustation of bryozoa with red algae is also common phenomena at this microfacies which is indicating a slow rate of sedimentation (Figure 6g).

5.1. Stratigraphic Correlation

During field work the stratigraphic correlation were made in Al Huarry Cement Quarry (Figure 7) this correlation obtained by measure tow traverses T1, T2 and T3 is unexposed of the bottom and difficult to tie this tram with own correlation (it is doubtful). The datum is lower part of algae–amphisteginid packstone microfacies, the correlation between them was constructed in order to indentify lateral or vertical lithological changing along the study area. The traverses being correlated are approximately along 600 *km* from NE–SW. This correlation indicates the following observations:

A. Benghazi Formation is recorded in all studied sections with maximum thickness of (about 35 m as recorded in the Al Huarry Cement Quarry and generally shows gradual thickness increased toward SW direction.
B. The established microfacies have been correlated, considering the base of algae–amphisteginid packstone microfacies as datum of this correlation. This microfacies is increased towards T1 at SW. On the other hand, algae–amphisteginid packstone microfacies is underlain by algal boundstone microfacies at T1 traverse which is laterally changed to algal-amphisteginid graistone microfacies at T2. The amphestegined contained microfacies are suggested to be deposited under shallow platform of for reef setting.

5.2. Age of Benghazi Formation

The stratigraphic position and fossil assemblage suggest that the Benghazi Formation was deposited during Middle Miocene (Rohlich, 1974), Shaltami *et al.* (2018b) found that the ages derived from strontium isotope analysis of crystalline calcites are gave an age Late Burdigalian-Early Serravallian (13.24-17.45 Ma) for the Benghazi Formation.

ISSN: 2413-5267

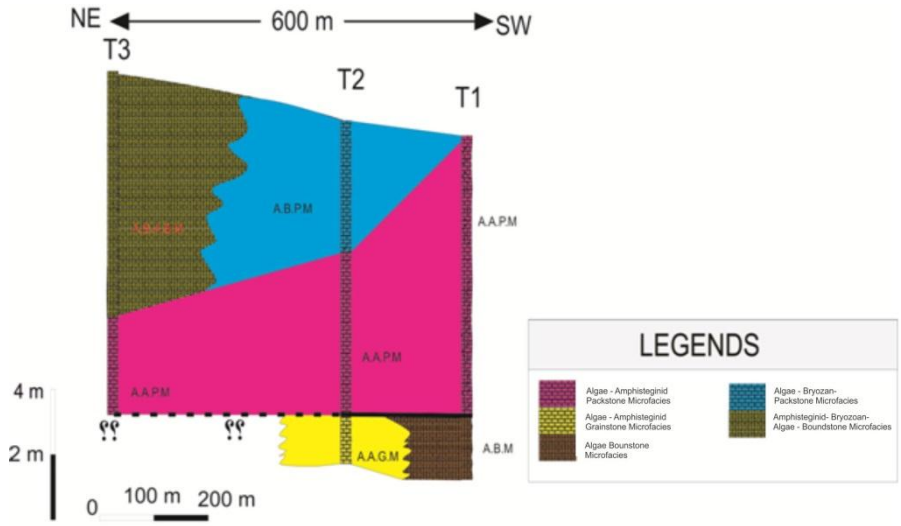

Figure 7. Shows Stratigraphic correlation of Benghazi Formation at Al Huarry Cement Quarry.

6. Al Abyar Quarry (Benghazi Formation)-Middle Miocene (Late Burdigalian-Early Serravallian)

Al Abyar Quarry is represented by 10 *m* thick sequence of Benghazi Formation. The stratigraphic sequence of the studied Al Abyar Quarry has been examined in one traverse. This traverse has been divided into two microfacies which are Pelloidal packstone microfacies and Miliolid wackestone–packstone microfacies (Figure 8).

Traverse I:

Two microfacies have been established at this traverse from bottom to top:

Pelloidal packstone microfacies:

This microfacies exhibits grain supported fabric (dolostone packstone texture).Which is characterized by gray to dark gray, smoky in part, medium to coarse crystalline,thickly bedded with high fractured and krastified, micritic matrix with dolomite crystal, The bioclasts represented by common pelloids, ostracoda, *Amphistegina* sp. (Figure 9a), and undifferentiated miliolids, pelacypoda including *Pecten*, and gastropoda fragments. The porosity is of intercrystalline locally becomes becoming vuggy type, and the thickness reaches upto 4 m.

Miliolid wackestone microfacies:

This microfacies exhibits mud-grain supported fabric (wackestone texture); which is characterized by light gray to gray and occasionally dark gray in part, medium crystalline grained, very hard, massive bed with high fractured, micritic matrix with dolomite crystals, The bioclasts are represented by common miliolids (*Quinqueloculina* spp., *Borelis melo*, *Triloculina* spp., *Spirolina* sp., and few molluskan, ostracoda and pelloids (Figure 9b). Porosity is of interskeletal type becoming vuggy in parts and the thickness reaches upto 4 m.

ISSN: 2413-5267

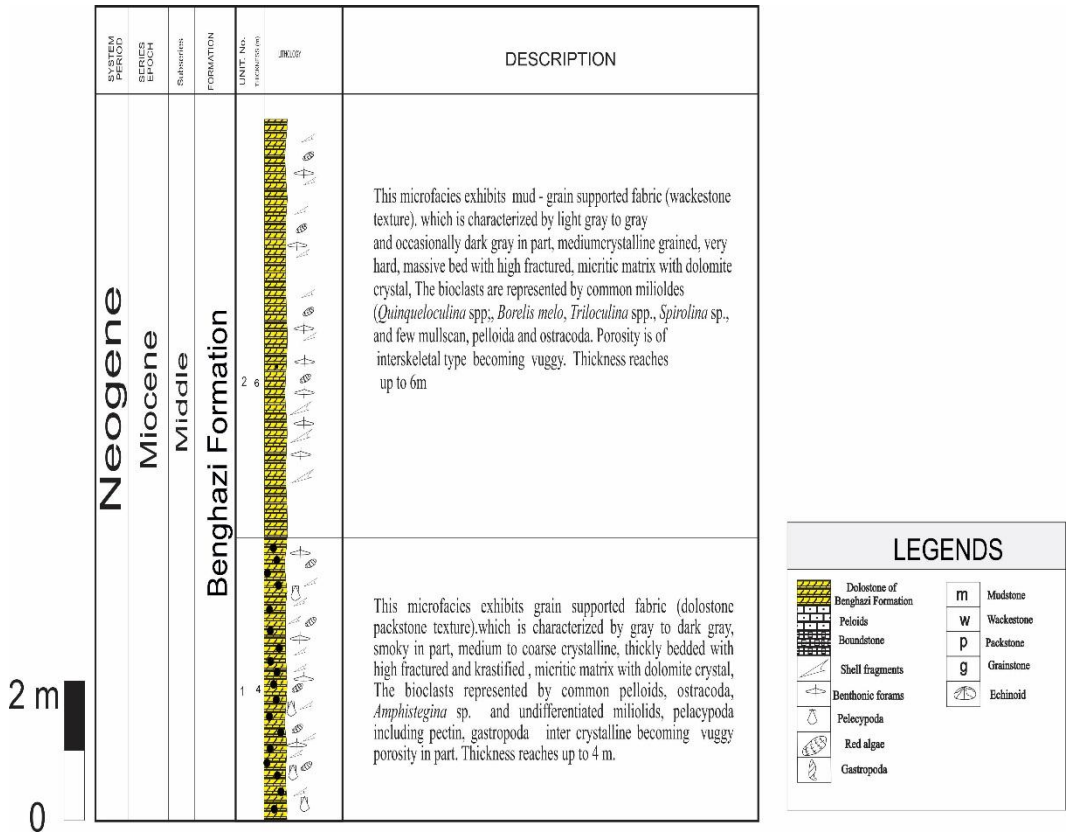

Figure 8. shows a composite columnar section of Al Abyar Quarry.

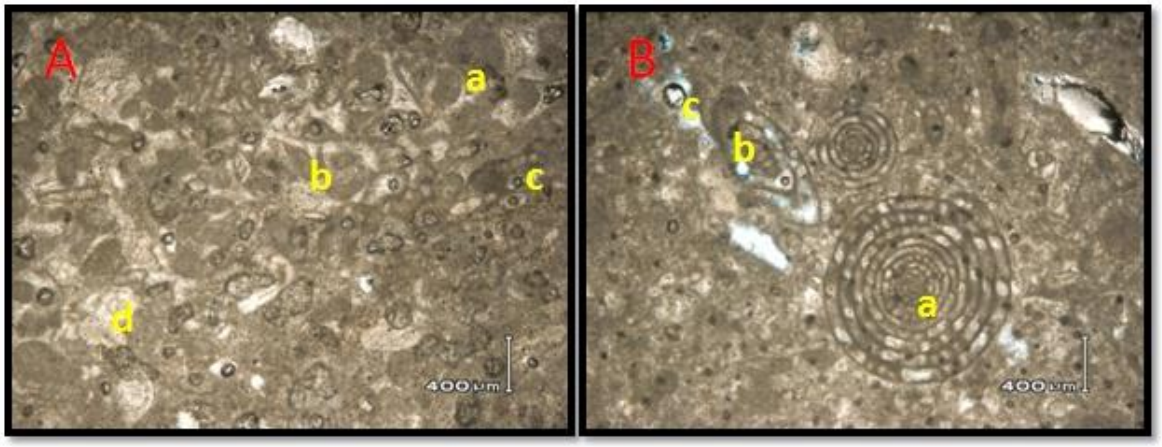

Figure 9. Thin section Photomicrographs (A) pelloidal packstone microfacies of Benghazi Formation shows; a) algal pelloids, b) molluskan fragments, c) ostracodes, d) Amphisteginid fragment.(B) miliolid wackestone – packstone microfacies of Benghazi Formation shows; a) Borelis melo, b) Spirolina sp., c) vuggy porosity.

ISSN: 2413-5267

7. Depositional Environment

7.1. Depositional environment of Al Faidiyah Formation at Al Fatiah Quarry

Al Faidiyah Formation in Al Jabal Al Akhdar represents a series of coarsening-up cycles that suggest sedimentation in high-energy sand shoal bar and channel (El Hawat and Shelmani, 1993). However, Rohlich (1974) suggests that the depositional environment was in shelf environment with local brackish element based on the paleontological contents and the lithological type of the formation. In the study area, this formation contains organisms of shallow marine as commonly represented by coralline red algae and *Operculina complanata* with some mollusks, echinoids, pelloids, bryozoans and other benthonic foraminifers, according to these the Al Faidiyah Formation was deposited in continental shelf (outer to middle neritic) with local brackish affinity (Figure 10).

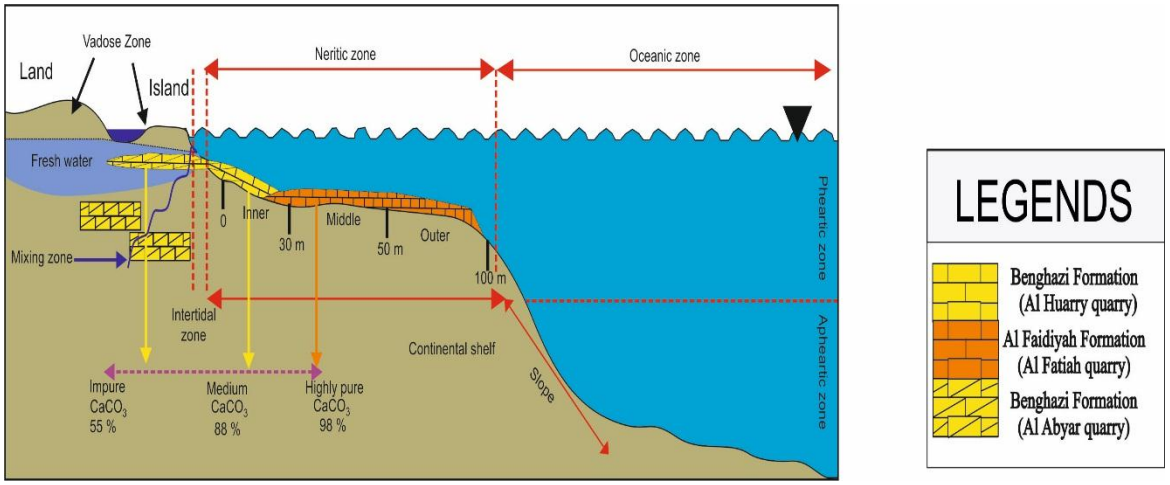

Figure 10. Shows the depositional environment of the study area.

7.2. Depositional Environment of Benghazi Formation at Al Huarry Quarry

The depositional environment of Benghazi Formation was previously studied by several authors. Abdulsamad and Bu-Argoub (2006) suggested this Formation was deposited on an open shallow marine shelf environment. In the study area, this Formation contains shallow marine organisms however the lower part represented by common algae microfacies and amphistigind microfacies with red algae, echinoids, bryozoans, mollusks and benthic foraminifera while the upper part is composed of boundstone alternating with grainstone where, debris of echinoids, bryozoans and mollusks are common, accordingly the Benghazi Formation was deposited under an inner self to open marine shelf environment (Figure 10).

ISSN: 2413-5267

7.3. Depositional Environment of Benghazi Formation at Al Abyar Quarry

Pelloids are generally formed in shallow marine low energy platform carbonate setting such as in the lagoon area of Bahama bank (Prothero and Schwab, 2004). Benthonic foraminifers (for example miliolids) suggest restricted low energy depositional environment; Prothero and Schwab (2004) indicated that Benghazi Formation represents an open shelf grading upwards to restricted platform and restricted lagoon-salina condition of Wadi al Qattarah Formation at Soluq area. In the study area, the Benghazi Formation at Al Abyar quarry contains organisms of restricted shallow marine as in the algae-pelloidal microfacies and miliolids microfacies where, few mollusks, ostracods and pelloids are present. Accordingly, the Benghazi Formation at the study area is deposited under lagoonal environment (Figure 10).

8. Conclusion

Three microfacies at Al Fatiah Quarry which are operculinid packstone microfacies, algal packstone microfacies and molluskan packstone grading to grainstone microfacies have been recognized at this section. The suggested depositional environment of Al Faidiyah Formation is continental self of outer to middle neritic environment.

Five microfacies at Al Huarry Quarry, algae boundstone microfacies, amphisteginid - algae packstone microfacies, amphisteginid grainstone microfacies, algal-bryozan packstone microfacies, and amphsiteginid-bryozoan-algal boundstone microfacies have been recognized at this locality. The suggested depositional environment of Benghazi Formation is ranged from inner self to open marine shelf environment.

Two microfacies at Al Abyar Quarry, pelloidal packstone microfacies and miliolid wackestone – packstone microfacies have been recognized at this locality. The suggested depositional environment of Benghazi Formation is under an inner shelf environment.

References

Abdulsamad E.O., and Bu-Argoub F.M. (2006). Sedimentary facies and foraminifera of the Miocene carbonate of the Ar Rajmah group in Cyrenaica, NE Libya. *Petroleum Research Journal*, 19: 49-60.

Dunham R.J. (1962). Classification of carbonate rocks according to Depositional texture. In *Classification of carbonate rocks*, (Ed. By W.E. Ham) Mem. Am. Ass. Petrol. Geol., Tulsa.

EL Hawat A.S., and Abdulsamad E.O. (2004). A field guide to the geology and archaeology of Cyrenaica. In: Guerrier L., Rischia I., and Serva L. (Eds.). *32nd International Geological Congress*, Special Public.

El Hawat A S., and Shelmani M.A. (1993). *Short notes and guidebook on the geology of Al Jabal al Akhdar, Cyrenaica, NE Libya*. Earth Science Society of Libya.

ISSN: 2413-5267

El Hawat A.S., Jorry S., Caline P., Davuad E., and Masse P. (2008). The Ypresian Early Lutetian Facies, Sequences and Unconformities of Cyrenaica: Their Correlation and Implications in North Africa. *Geology of East Libya*, 1: 85-120 .

El Mehdawi A.D., and El Beialy S.Y. (2008). Palynological Contribution to the Stratigraphy of Al Faidiyah Formation, Al Jabal al Akhdar, NE Libya. *Geology of East Libya*, 3: 171-186.

El Safori Y.A., and Muftah A.M. (2007). Oligocene bryozoans from Al Jabal Al Akhdar, Libya. *Egypt. Jour. Paleont.*, 7: 315-334.

Gregory J.W. (1911). Contributions to the geology of Cyrenaica Quart. *J. Geol. Sco*, London, p. 36.

Klen I. (1974). Geological map of Libya 1:250 000. Sheet Benghazi: NI 34-14, Explanatory Booklet. Industrial Research Centre. Tripoli. 49 p.

Muftah A.M. (2014). Upper Cretaceous - Lower Tertiary foraminiferal biozones of Al Jabal al Akhdar, NE Libya. *3rd Annual International Conference on Geological & Earth Sciences (GEOS 2014)*, Singapore.

Pietersz C.R. (1968). Proposed nomenclature for rock units in northern Cyrenaica. In *Petroleum Exploration Society of Libya*, 10th Annual Field Conference, Tripoli, Libya .

Prothero D.R., and Schwab F. (2004). *Sedimentary geology, an introduction to sedimentary rocks and stratigraphy*, 2nd edition, W. H. Freeman and company New York.

Rohlich P. (1974). Geological map of Libya 1:250 000. Sheet. Al Bayda: NI 34-15, Explanatory Booklet. Industrial Research Centre. Tripoli. 70 p.

Shaltami O.R., Fares F.F., EL Oshebi F.M., Errishi H., and Santos P. (2018a). New high-precision 87Sr/86Sr ages on LateOligocene-Early Miocene rocks in the Al Jabal Al Akhdar, NE Libya. *International Conference on Advances in Chronostratigraphy (ICAC 2018)*, Bangkok, Thailand, Proceeding Book.

Shaltami O.R., Fares F.F., EL Oshebi F.M., Errishi H., Bustany I., Salloum F.M., El Shawaihdi M., and Musa M.M. (2018b). Absolute Age Of The Miocene Deposits In The Cyrenaica Basin, NE Libya: Implications For The Messinian Salinity Crisis. *Irish Association For Economic Geology. Iaeg Annual Conference 2018-Geochemistry*. Proceeding Book, 62-76.