Coralline red algae from the Pliocene Shagra Formation of Wadi Wizer, Red Sea coast, Egypt: Systematics, biofacies analysis and palaeoenvironmental implications

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Abstract
Coralline red algae are highly abundant and well diversified in the exposed carbonate deposits of the Pliocene Shagra Formation at Wadi Wizer, Red Sea coast, Egypt. Lithostratigraphically, the Shagra Formation unconformably overlies the Late Miocene Marsa Alam Formation and unconformably underlies the Samadai Formation (Plio-Pleistocene). This formation included two members, from base to top: 1) Dashet El Dabaa 2) Sharm El Arab members. The coralline red algae and foraminifera are important constituents of these deposits and highly abundant. This carbonate facies is dominated by different assemblage of coralline red algae in the form of in situ crusts, rhodoliths, fragments and corals, bivalve shell fragments, bryozoans, benthonic and palnktonic foraminifera. The systematic study and the taxonomic investigations carried out on the coralline red algae led to the recognition of twenty one coralline algal species that described for the first time in the studied area. Seven non-geniculated coralline algal genera are documented and described. These include Lithothamnion, Mesophyllum, Spongites, Lithophyllum, Neogoniolithon, Sporolithon, and Lithoporella. The geniculated coralline algae is described and represented by Corallina sp. One species of green algae (Chlorophyaceae) depicted in the genus Halimeda sp. On the basis of the stratigraphic distribution of these coralline algae, the studied Pliocene Shagra Formation could be subdivided into two local coralline algal assemblage zones from base to top: 1) Neogoniolithon sp. / Mesophyllum lemoinaea Assemlgae Zone and 2)Lithothamnion saipanense / Lithophyllum prelichenoides Assemblage Zone. The detailed microfacies analysis carried out on the studied sequence led to the recognition of eight microfacies types (six of carbonate facies and two of siliciclastic facies) indicating that the Pliocene Shagra sequence was deposited in near shore, warm shallow water environments with clear water and normal salinity favorable for development of reefal facies. Paleoecologically, it is noted that both of Lithophullum, Neogoniolithon and Spongites are dominated in the reefal carbonate facies. However, the Mesophyllum, Lithothamnion and Sporolithon are main components of the relatively deeper carbonate facies.

Keywords: *Coralline Algae, Pliocene, Wadi Wizer, Shagra Formation, Egypt.*

Introduction

Coralline red algae are important constituents of the shallow water marine carbonates and also cosmopolitan in distribution. The distribution of coralline algae is mainly controlled by ecological factors such as temperature, depth, salinity, substrate and energy (Adey & MacIntyre, 1973; Braga & Martin, 1988; Bosence, 1983 & 1990). Non-geniculated crustose coralline forms namely *Mesophyllum* and *Lithothamnion* are primarily of relative deep and cold water genera (Steneck, 1985), but they are also known to occur in warm water in relatively deep environments. However, the nongeniculate *Lithophyllum* and *Spongite* are restricted to tropical and subtropical marine water environments (Buchbinder, 1977; Edgell & Basson 1975). On the contrary, geniculated coralline algae e.g. genus *Corallina* is generally cosmopolitan and commonly recorded in tropical and subtopical marine water environment. The present day *Corallina* occurs in association with *Amphiora* (Rasser & Pillar, 1996; Bassi, 1995 & 1998; Nebelsick *et al.,* 2003). Both crustose (non-geniculated) and articulated (geniculated) coralline algae grow principally in normal, marine, saline water. Members of Corallinaceae are considered to be important Cenozoic reef builders in tropical and subtropical realms (Wray, 1977; Woelkerling, 1988; Littler *et al*., 1991; Woelkerling *et al.* 1993), both as frame-building organisms and as sediment producers.

The Pliocene sequence in the Red Sea area is well exposed and widely distributed. It is represented predominantly by carbonate with subordinate mixed siliciclastic lithofacies types. In this succession the planktonic foraminifera are generally scarce, less frequent and diversified. The stratigraphy of the Red Sea coast have attracted the attentions of many workers so several straigraphical and paleontological studies carried out on the Neogene sequence in the Red Sea area and their neighboring areas, among the authors who dealt with are: Beadnell, 1924, Said 1962; Souaya, 1963, Akkad & Dardir, 1966; Cherif, 1966; Ghorab &

Marzouk,1967; Cherif *et al.,* 1977; El Gamal, 1971; Philobbos & El Haddad, 1983; Hermina *et al.,* 1989; Youssef & Abu Khadra 1984; Mahran, 1990 & 1996; Philobbos *et al.* 1993; kheider & Felesteen 1991; Moussavian & Kuss, 1990; Said, 1990; Felesteen *et al.,* 1994; Hamza, 1992; Nebelsick, 1992; Hathout & Orabi 1995; Pillar & Rasser 1993 &1996; Kora & Abdel-fattah, 2000; Nebelsick & Kroh, 2002; EL Sorogy *et al*, 2004 and Kora *et al*., 2013. The Pliocene carbonates of Wadi Wizer, Red Sea coast (Fig.1 a, b) are found to contain a highly abundant, richly diversified and well preserved coralline red algae that have been not described well. This led to make detailed investigations of this type of microfossils. The main target of this study is to make a full systematic, taxonomic investigations and identification of the coralline red algae with special emphasis on the non- geniculate coralline algal taxa and their different growth forms as well as comparison of the present algal association with their counterparts of other coralline algal species in the circum of the Red Sea area and the Mediterranean. The detailed investigation of the Shagra Formation allowed recognizing two local coralline assemblage zones from base to top: *Neogoniolithon sp. / Mesophyllum lemoinaea* Assemlgae Zone and *Lithothamnion saipanense / Lithophyllum prelichenoides* Assemblage Zone. The planktonic and benthonic foraminiferal biostratigraphic investigations led to the recognition of four foraminiferal zones from base to top: *Borelis melo* melo zone (Late Miocene, Tortonian), Non- Distinctive zone (Late Miocene, Messanian), *Globorotalia margaritae* and *Globorotalia puncticulata* zones of Pliocene (Zanclean) age. Also this study allowed to recognize different microfacies associations and to deduce the main depositional events that prevailed during the deposition of that Pliocene sequence.

Lithostratigraphy

The lithostratigraphic subdivision of the Pliocene sequence is based mainly on the recent reviewed stratigraphic scheme of the Red Sea coastal area that established by Philobbos & El Haddad (1983); Philobbos *et al.* (1993) and Prurser & Philobbos (1993). One formation and two members representing the Pliocene deposits were recognized in Wadi Wizer (40 Km south of Quseir), Red Sea area (Figs. 1 a, b). This rock unit will be discussed from their lithological characters and stratigraphic thickness as follows:

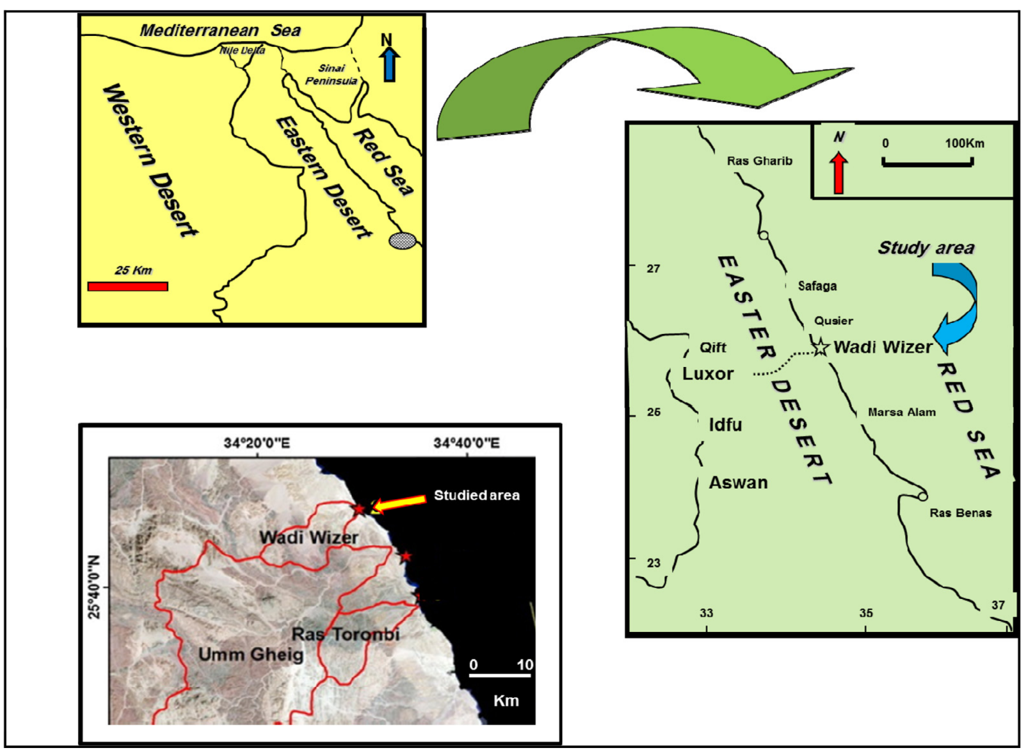

Figure 1. Location map showing the study area

The Shagra Formation:

It is the oldest marine Pliocene rock unit exposed in the study area and first established and described by Akkad and Dardir (1966) in the Red Sea coastal area. This rock unit overlies unconformably the Late Miocene Marsa Alam Formation (Fig. 2, 3) and underlies unconformably the Pleistocene Samadai Formation. Lithologically, it is differentiated into two members. The lower member (Dashet El Dabaa Member) that represented commonly by biogenic algal carbonate facies with subordinate silicicalstic (represented by two beds) deposits and the upper member (Sharm El Arab Member) that dominate also with coral algal carbonate of reefal facies and less siliciclastic facies represented by minor beds of calcareous sandstone and thin calcareous shale laminae. The Shagra Formation is best developed in Wadi Wizer attaining thickness of 56 m while it measures a relatively high thickness, 75 m in Wadi Marsa Alam (unmeasured section). On the basis of the planktonic foraminiferal biostratigraphy, two Pliocene planktonic foraminiferal zones were recognized by the present author, from base to top: *Globorotalia margaritae* and *Globorotalia puncticulata* zones. Moreover, the occurrence of *Borelis pygmaeus*, *Archias adancus* and other Indo-Pacific benthonic foraminiferal species strongly assigned this sequence to Pliocene age. The presence of *Crassostrea gryphyoides*, *Crassostrea gingensis* and other macrofossils assemblage such as *Strombus persicus, Brachiodontes pharonis*, *Pecten erythraeus* and *Spondyllus spinousus* of the Indo- Pacific affinities assigned also this rock unit to Pliocene age.

Description of the coralline algal taxa recorded in the area:

The Investigation of the coralline red algae is based on a detailed sampling of the Pliocene Shagra Formation outcropping in Wadi Wizer, Red Sea coast. The terminology used here in the present study is according to Woelkerling, 1988 using "core filaments " instead of "hypothallus" and "peripheral filaments" instead of "perithallus" is adopted. Moreover, the taxonomic features of Braga et al. 1993 and the different growth forms of Woelkerling *et al*, 1993, are adopted in the taxonomy and identification of the present fossil material. Measurements of cells and conceptacles dimensions are adopted following Chamberlain *et al*. (1988).

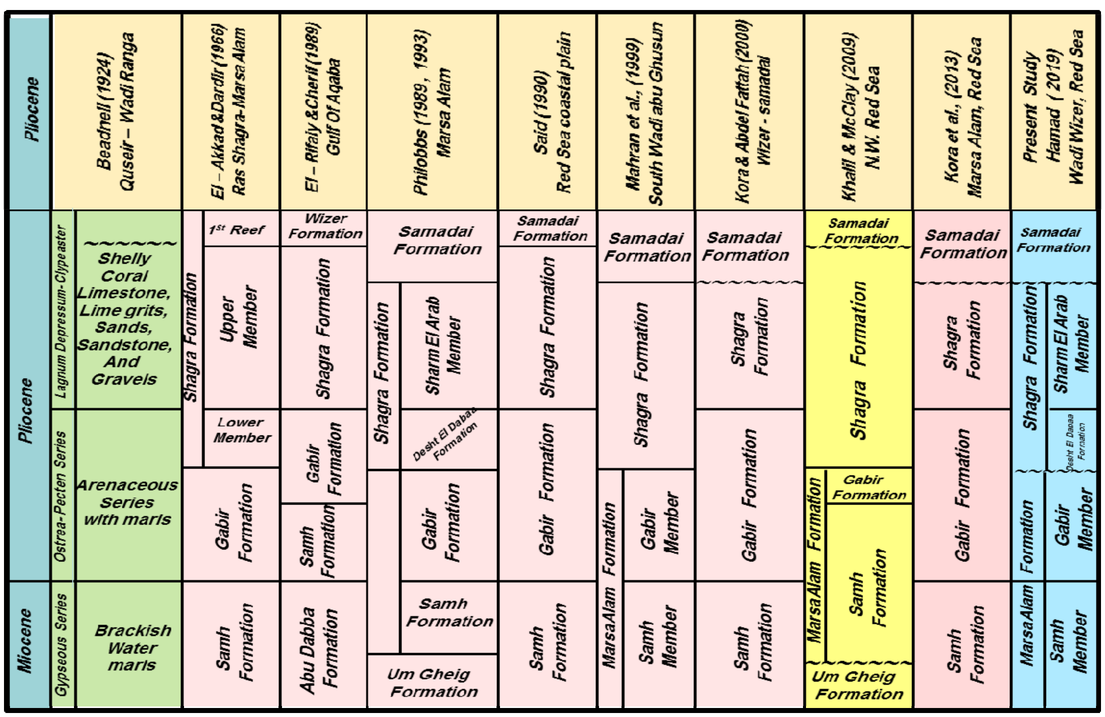

Figure 2. Correlation chart showing the different Miocene-Pliocene lithostratigraphic units along the Red Sea coastal plain, Egypt (Modified after Kora *et al*., 2013)

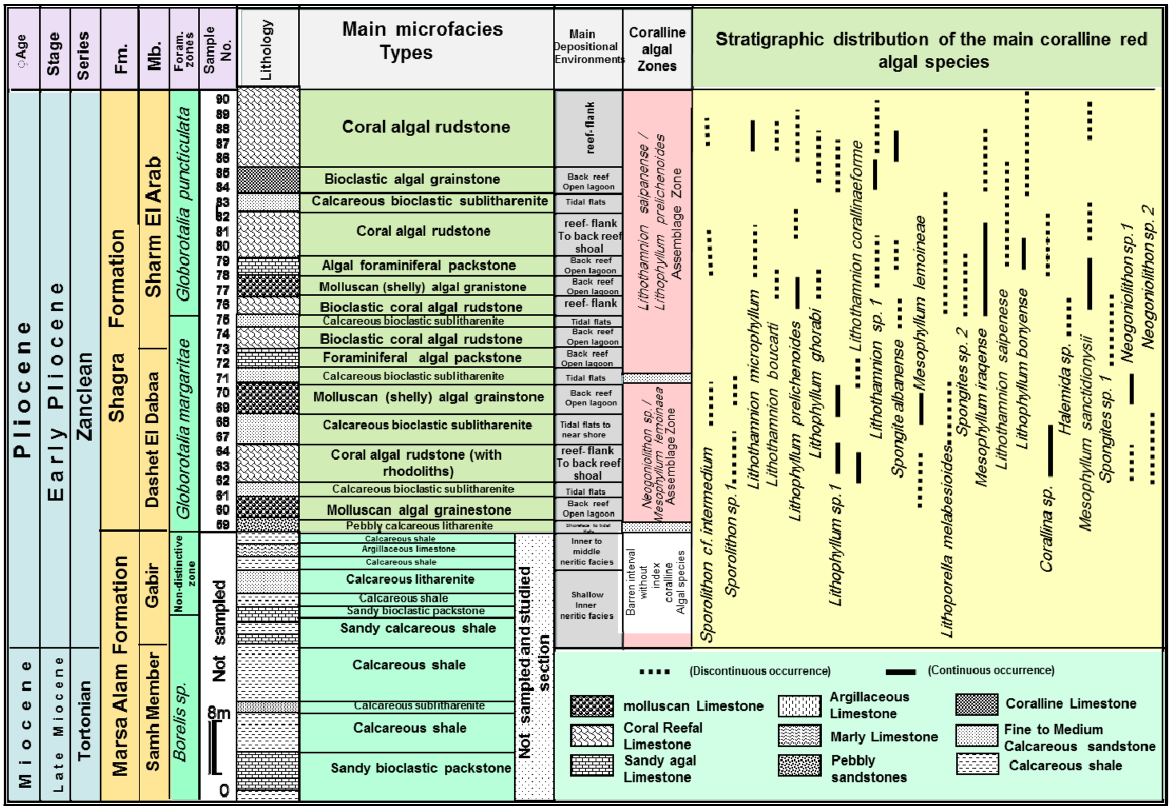

Figure 3. Stratigraphic section of the Pliocene sequence showing the main microfacies types, distribution of coralline red algae at Wadi Wizer, Red Sea coast, Egypt.

In the following paragraphs the main anatomical and morphological terms of coralline algal species will be discussed from their different growth forms of algal thalli arrangement and characters of the core filaments and peripheral filaments (shape of cells and their arrangement), shape of the reproductive organs (conceptacles and sporangia).

Division: Rhodophyta Wettstein, 1901
Class: Rhodophyceae Rabenhorst*, 1863*
Order: Corallinales Silva & Johansen*, 1986*
Family: Corallinaceae Lamouroux*, 1816*
Subfamily Melobesioideae Bizzorzero, 1897
Genus *Lithothamnion* Heydrich, 1897
Lithothamnion microphyllum Maslov, 1956
(Plate 1, Figure 1)

Description: Encrusting to warty plants with growth form not exceeds 0.5 mm long and 0.7 mm wide protuberances, sometimes these protuberance are tapering upward (Pl.1, Fig. 1). The core filaments are plumose with monomerous thallus measuring 130 µm to 190 µm thick. Cells have slightly arched rectangular shape and measure 7 – 14 µm in diameter and 9 - 22 µm in length. The core cell filaments curve upward toward the thallus surface. The peripheral filaments are well developed in the form of growth zones; consist of irregular lenticular growth zones, cells of neighboring filaments are connected by laterally fusions. Cells are 7 – 10 µm in diameter and 9- 12 µm in length. No flat epithallial cells are encountered. The tetra/ bisporangial conceptacles are slightly multiporate, measuring in rare specimens 180 – 410 µm in diameter and 100 – 120µm in height.

Remarks: This species shows great resemblances to *Lithothamnion saxorum* in the conceptacle sizes, shape of the tetra/ bisporangial conceptacle roof and the number of conceptacle roofs cell filaments but differ in the lager multiporate tetra/ bisporangial conceptacles and lacking of the conceptacle roof features. This species is commonly recorded in the foraminiferal algal packstone and rare in the coral algal rudstone facies in the Pliocene Sharm El Arab Member of Shagra Formation.

Lithothamnion corallinaeforme Lemoine, 1923
(Plate 1, Figure 2)

Description: Crustose thalli mammillae, usually massive, show dense encrusting talli. Internally showing longitudinal radial organization. The central core filaments are thin to moderately developed, measuring about 120 -150 µm in thickness. The core cells consisting of rounded to rectangular shape measuring 11 – 13 µm in length and 8 –10 µm in diameter. The peripheral filaments consist of irregular growth zones. Cells arranged in fairly regular vertical rows. They are 8 – 18 µm in diameter and 9- 15 µm in length. Cell fusions connecting the contiguous filaments are not observed. The tetra/ bisporangial conceptacles are uniporate with conical pore observed in the upper part of the thallus surface. The pore canal may reach 50 µm to 70 µm long and 30 µm in diameter. These cells are lined by very small cells arranged subparallel to the pore canal. The conceptacles are abundantly occurred, measuring 290 – 650 µm in diameter and 110 – 140µm in height.

Remarks: The original description of the *Lithothamnion corallinaeforme* Lemoine given by Lemoine (1923) was incomplete as recorded by Imam (1996) and Basso *et al.,* (1997). So the notification of this species is based partially on the additional remarks given by Imam (1996). The large conceptacle and shape, size of pore canal makes this species is easily to identify. Maslov (1956) figured poorly preserved thalli devoid of peripheral cell filaments. This species is recorded in the coral algal rudstone facies of Pliocene Dashet El Dabaa Member of Shagra Formation.

Lithothamnion bourcarti Lemoine, 1923
(Plate 1, Figure 3)

Description: Warty to lumpy, usually showing growth forms of layered structure. The present specimen shows protuberance reaching up 1.6mm long and 1mm in diameter (Pl. 1. Fig. 3). Other specimens showing crustose thalli of plumose basal core filaments and well-developed peripheral filaments. The core filaments consist of non-coaxial thallus, the core portion may reach 30 µm thick. The cells are upward curved cell rows of rectangular shape measuring 12 – 27 µm in length and 10-15 µm in diameter. The peripheral filaments are composed of regular tissue with pronounced vertical cell threads and growth zones. Cells are 10 – 18 µm in length and 7-11 µ in diameter. The tetra / bisporangial conceptacles are rare and showing multiporate conceptacle chambers. The conceptacles are measure 260 – 320 µm in diameter and 110 - 140 µ in height. The pore diameter may reach 10 – 13 µm.

Remaks: The recorded species shows great similarities in vegetative affinities to the *Lithothamnion lichenoides* originally described by Hamad (2009) from the Miocene deposits of Sadat area of Egypt, but differs in their concepatcles being smaller in diameter. This species is also common in the moullscan algal rudstone facies and coral algal grainstone (with rhodoliths) facies of Pliocene Sharm El Arab Member of Shagra Formation

Lithothamnion saipanense Johnson, 1957
(Plate 1, Figure 4)

Description: Warty growth forms with protuberance of 1.2 mm long and 2.3 mm wide. Usually crusts with warty protuberance of undulating appearance or branches are recoded in rare specimens. The non – coaxial, core portion ranging in thickness from 340 µm to 420 µm in thickness. The basal core cell filaments predominantly curve towards the thallus surface. Cells are 7 – 12 µm in diameter and 10 - 15 µm in length. The peripheral filaments show slightly well-developed thallus, contorted appearance and lenticular growth zones. The Tetra / bisporangial conceptacles abundant, strongly varied in shape and size, multiporate. Most frequently ellipsoidal, 290 – 420 µm in diameter and 140 – 170 µm in height and recorded in rare specimens.

Remarks: The specimen under disposal is consistent with *Lithothamnion saipanense* Johnson and shows great similarities in the structure, shape and dimensions of thallus, but differ in the conceptacle shape and sizes, where the nominated specimen shows less sizes and dimensions. The specimen referred by Hamad (2009) from the Sadat are, Gulf of Suez region, Egypt also show some similarities except of the absence of conceptacles. This species is also common in the coral algal rudstone facies and bioclastic algal grainstone facies of Pliocene Sharm El Arab Member of Shagra Formation

Lithothamnion sp.
(Plate 2, Figure 6)

Description: Encrusting to warty protuberance growth form measuring 1.2 mm long and 0.6 mm wide. The dorsiventral cell filaments are radial in protuberance, where the core filaments are non–coaxial. The basal core filaments predominantly curve towards the dorsal. The core portion is relatively thin 50 – 90 µm. Cells are 8 – 12 µm in diameter and 10 - 19 µm in length. The peripheral filaments show tissue of well developed, and of contorted appearance with lenticular growth zones. The Tetra / bisoprangial are rarely recorded and if they recognized, they did not exceed two or three in number and sometimes aborted. Conceptacles are multiporated and varied in shape and size. Most frequently ellipsoidal, 290 – 420 μm in diameter and 140 – 170 μm in height.

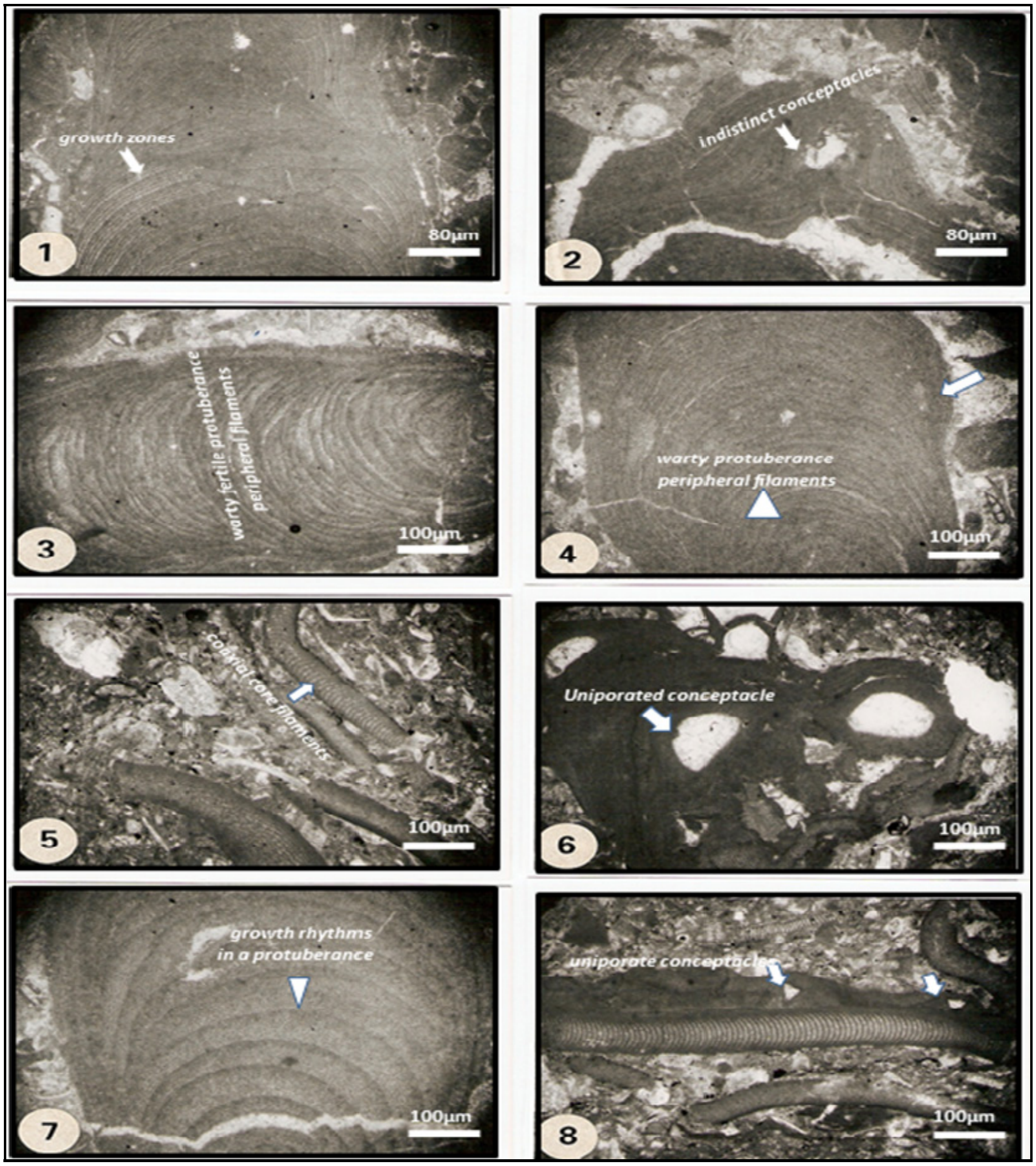

Plate 1. Fig. 1. *Lithothamnion microphyllum* Maslov, longitudinal section through a protuberance showing rhythmic pattern of growth zones (arrow), sample 84, Sharm El Arab Mb., Shagra Fm., Fig. 2. *Lithothamnion corallinaeforme Lemoine,* Thallus protuberance showing sterile filaments with indistinct conceptacles (arrow), sample 85, Sharm El Arab Mb., Shagra Fm., Fig. 3. *Lithothamnion bourcarti* Lemoine*,* warty fertile protuberance of sterile peripheral filaments, sample 84, Sharm El Arab Mb., Shagra Fm., Fig. 4. *Lithothamnion saipanense* Johnson. Lumpy growth forms of non – coaxial core filaments (arrow), sample 83, Sharm El Arab Mb., Shagra Fm. Fig. 5. *Mesophyllum iraqense* Johnson, longitudinal section of a single branch showing coaxial cell arrangement in the adjacent core filaments (arrow) with no conceptacle, sample 76, Dashet El Dabaa Mb., Shagra Fm., Wadi Wizer,. Fig. 6. *Mesophyllum lemoinaea* Souaya, protuberance with distinct growth zones and several conceptacles (arrow) showing sterile filaments, sample 76, Dashet El Dabaa Mb., Shagra Fm., Fig. 7. *Mesophyllum sanctidionysii* Lemoine, distinct growth rhythms in a protuberance (arrow) with multiporate conceptacles, sample 83, Dashet El Dabaa Mb., Shagra Fm., Fig. 8. *Neogoniolithon* sp.1, longitudinal section of thick monomerous thallus showing uniporate conceptacles (arrow), sample 83, Dashet El Dabaa Mb., Shagra Fm.

Remarks: The specimen under disposal is consistent with the genus *Lithothamnion* and shows great similarities in the structure, shape and dimensions of thallus to *Lithothanmion anderusovi* Lemoine, but differ in the cell arrangement and absence of conceptacle. This species is also common in the bioclastic algal grainstone, algal foraminiferal packstone and coral algal rudstone facies of the Pliocene Sharm El Arab Member of Shagra Formation.

Genus *Mesophyllum* Lemoine, 1928
Mesophyllum iraqense Johnson, 1964
(Plate 1, Figure 5)

Description: Fruticose thallus with branching (slender branches) forms up to 180 µm in diameter. Monomerous thallus with radial internal structure. In longitudinal section (Pl.1, Fig. 5) the core filaments consisting of central coaxial core with arching tiers of cells measuring 7 – 11 µm in diameter and 15 - 22 µm in length. The marginal peripheral filaments are sometimes worn. No epithallial cells have been recorded. Tetra / bisporangial conceptacles are rarely recognized. The conceptcale roofs formed by peripheral filaments. They are measure 230 – 310 µm in diameter and 110 - 140 µ in height. The pore diameter may reach 10 – 13 µm.
Remarks: The presence of the monomerous coaxial tahllus and the tetra/ bisporangial multiporate conceptacles assigned this specimen to the genus *Mesophyllum*. It is particularly important to note the change from branching to crustose form. The specimen under disposal is consistent in their internal tahllus structure with the descriptions and figures given by Jonson (1964) and also Edgell & Basson (1975) as well as Imam (1991&1996). This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Hamad (2009), but differ in the conceptacle shape and sizes, where the nominated specimen shows less sizes and dimensions. This species is also common in the moullscan algal grainstone facies and algal foraminiferal packstone facies of Pliocene Sharm El Arab Member of Shagra Formation.

Mesophyllum lemoineae Souaya , 1963
(Plate 1, Figure 6)

Description: This species is recorded as small warty protuberance to fruticose thallus. The crustose forms occur as relatively thick thallus ranging from 300 – 450 µm. Thallus is monomerous, the core filaments are poorly developed with cells not arranged in regular rows and gradually passing to the peripheral filaments. The peripheral region is well developed. Irregularly peripheral filaments often lenticularly owing to the presence of conceptacles. Their cells are 8 – 13 µm in diameter and 15 - 22 µm in length. Cell fusions are distinctly observed. The tetra/ bisporangial conceptacles are distinct and distributed in the peripheral part of the growth zone. They are measuring 420 – 510 µm in diameter and 137 – 190 µm in height.
Remarks: The presence of the distinct tetra/bisporangial multiporate conceptacles and thallus appearance affirmed that this species is assigned to *Mesophyllum lemoineae*, where it is distinguished by large conceptacles and thick regularly peripheral filaments. This species is consistent with description of Edgell & Basson (1975), Buchbinder (1977), Johnson (1964), Mastrorilli (1967), Imam (1996) as well as Hamad *et al*. (2015). This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Hamad (2009, P. 2, Fig. 1) from the Early Miocene Sadat Formation, Northwest of the Gulf of Suez, Egypt, but differ in the conceptacle shape and sizes, where the nominated specimen shows less sizes and dimensions. This species is also common in the moullscan (shelly) algal grainstone facies and coral algal rudstone (with rhodoliths) facies of Pliocene Dashet El Dabaa Member of Shagra Formation.

Mesophyllum sanctidionysii Lemoine, 1939
(Plate. 1, Figure 7)

Description: This species ranging from lumpy to encrusting thallus, with distinct protuberance of 1.5 mm wide to 2.4 mm long. Several mammillae crusts composed of partly developed core filaments and strongly zoned peripheral filaments with numerous conceptacles. The core portion is co axial cell filaments and ranging in thickness from 34 µm to 67 µm, the cells of the core filaments are 8 – 10 µm in diameter and 15 - 18 µm in length. The peripheral filaments is distinct with growth zones and composed of strong lenticular growth zones with cells measuring 8 – 12 µm in diameter and 17 - 21 µm in length. The tetra / biosporangia multiporate conceptacles embedded in the center of each growth zone, measuring 220 – 400 µm in diameter and 140 – 180 µm in height.
Remarks: The monomerous thallus with the central

coaxial core and the tetra / bisporangial multiporate conceptacles ascribed this specimen to the genus *Mesophyllum* (Woelkering & Irvine, 1986; Chamberlain, 1996). The specimen under disposal is consistent in their internal tahllus structure with the descriptions and figures given by Jonson (1964), Edgell & Basson (1975), Studencki (1988), Imam (1991 & 1996 & 2003) and Hamad (2008 a, b) as well as Hamad *et al*. (2015).

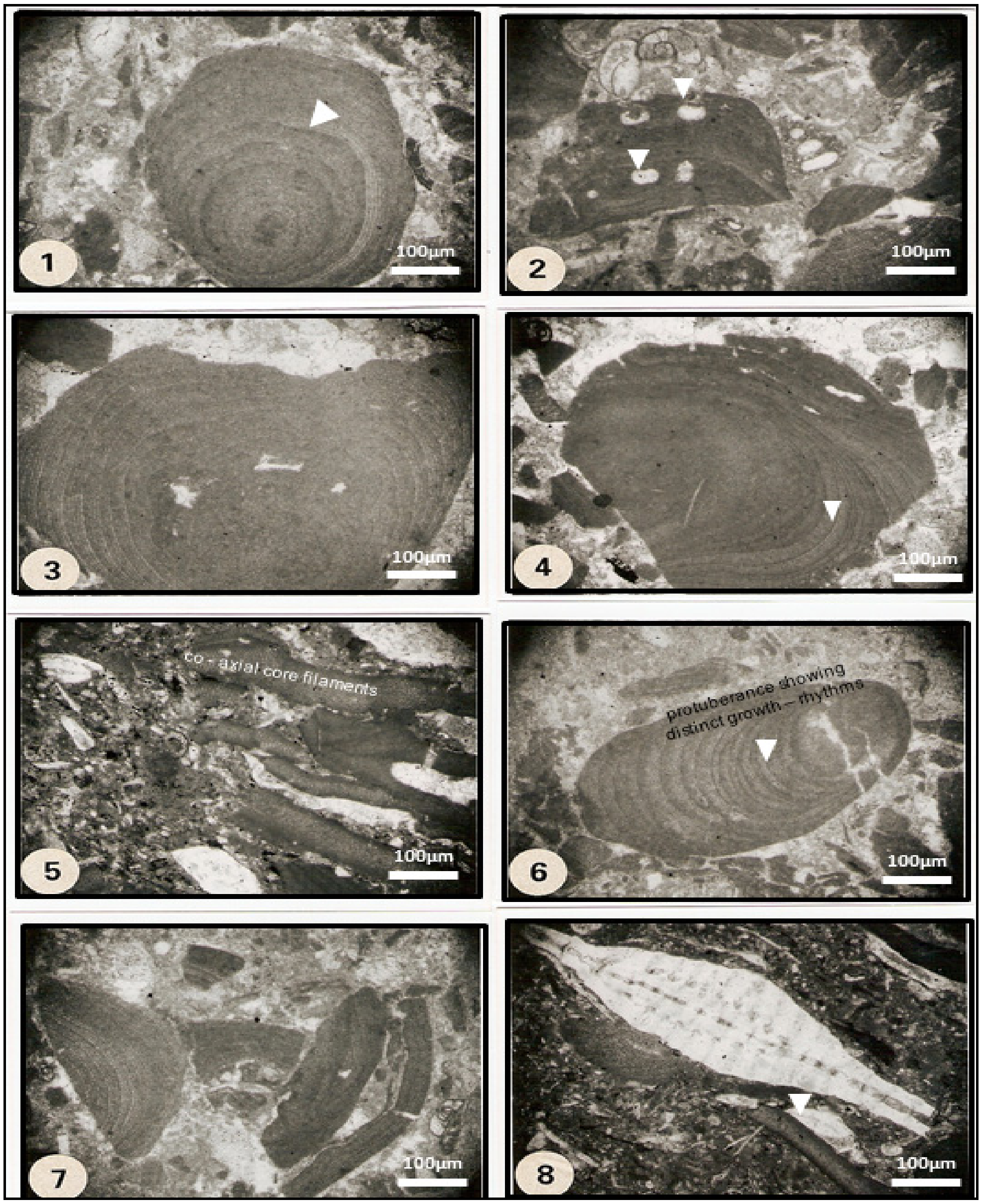

Plate 2. Fig. 1. *Spongites albanense* Lemoine*,* Warty protuberance of poorly developed core filaments at base distinct peripheral filaments (arrow), sample 83, Sharm El Arab Mb., Shagra Fm., Fig. 2. *Spongites* sp. 1, monomerous thalli, with with large tetra / biosporanial conceptacles (arrow), sample 88, Sharm El Arab Mb., Shagra Fm. Fig. 3. *Spongites* sp. 2, non- coaxial core filaments with protuberance and distinct peripheral filaments, sample 85, Sharm El Arab Mb., Shagra Fm. Fig. 4. *Lithophyllum ghorabi* Souay, long branch protuberance (arrow) with medium uniporate conceptacles, sample 83, Sharm El Arab Mb., Shagra Fm .Fig. 5. *Lithophyllum prelichenioides* Lemoine, longitudinal section showing co - axial core filaments with well-developed arched cells and thin peripheral filaments, sample 86, Sharm El Arab Mb., Shagra Fm. Fig. 6. *Lithothamnion* sp*.*, high protuberance showing distinct growth – rythms (arrow), sample 83, Dashet El Dabaa Mb., Shagra Fm. Fig. 7. *Lithophyllum bonyense* Johnson, fragement of branche thalli showing protuberance with small size conceptacle, sample 87, Sharm El Arab Mb., Shagra Fm. Fig. 8. *Lithophyllum sp.* 1*,* long branch of coaxial core filaments (arrow) and thin outer peripheral filaments, sample 76, Dashet El Dabaa Mb., Shagra Fm.

This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Hamad (2009), but differ in the conceptacle shape and sizes, where the nominated specimen shows less sizes and dimensions. This species is also common in the moullscan algal grainstone facies and coral algal rudstone (with rhodoliths) facies of Pliocene Sharm El Arab Member of Shagra Formation.

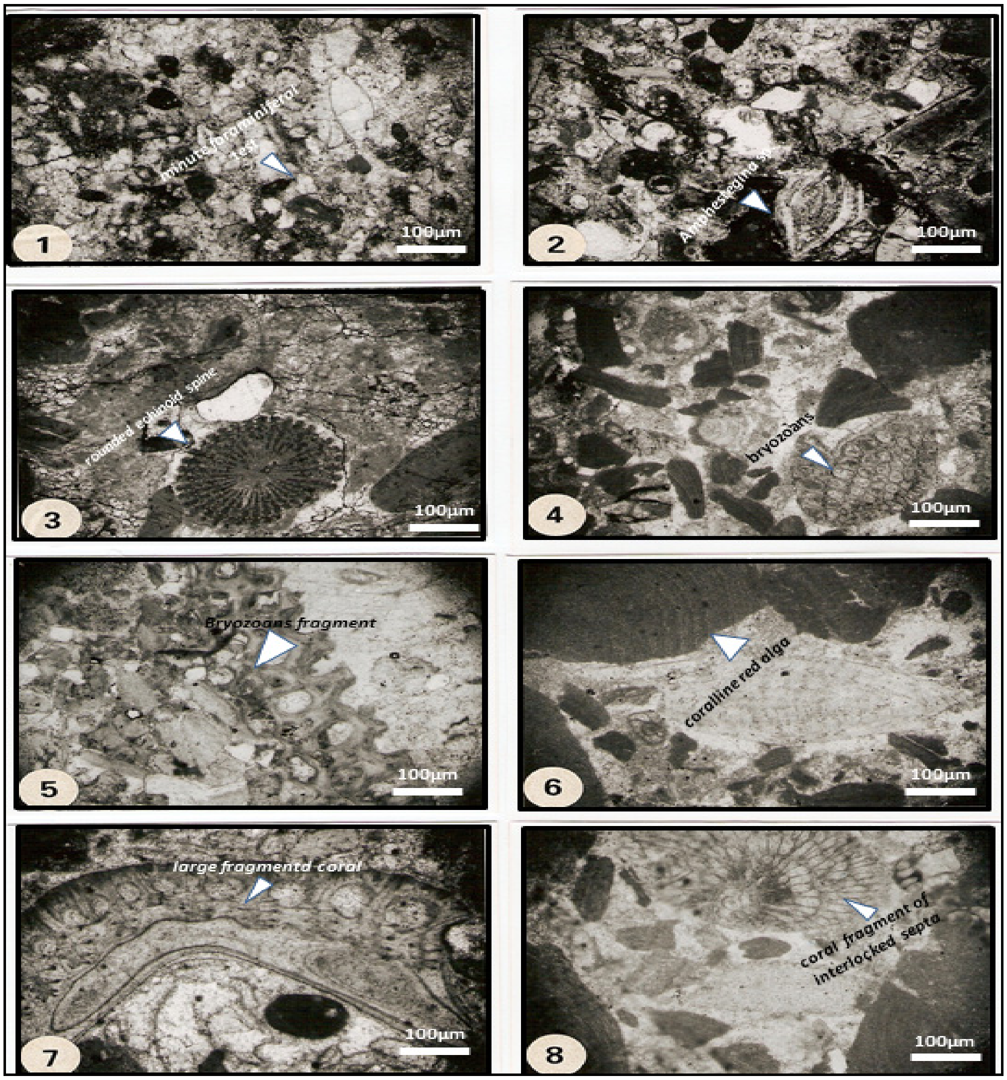

Plate 3. Fig.1. Algal foraminiferal Packstone Facies, subrounded dark micritic intraclasts, with subangular detrital quarz grains associated with minute foraminiferal tests (arrow) in sparry micrite matrix, sample 79, Sharm El Arab Mb., Shagra Fm., Fig. 2. Algal foraminiferal Packstone Facies, dark micritic intraclast, angular chert lithoclast and large benthonic foraminifera (*Amphistegina* sp., (arrow)) associated small tests of foraminifera embedded in sparry micrite matrix, sample 79, Sharm El Arab Mb., Shagra Fm. Figs. 3. Molluscan (Shelly) Algal Grainstone Facies, large subrounded badly preserved coralline algae with rounded echinoid spine (arrow) and recyrstallized bivalved shell fragments in sparry calcite cement, sample 78, Sharm El Arab Mb., Shagra Fm. Figs. 4. Bioclastic algal Grainstone Facies, large subrounded dark micritic intraclasts with reworked coralline algae and bryozoans fragement (arrow), sample 85, Sharm El Arab Mb., Shagra Fm. Fig. 5. Bioclastic coral algal Rudstone Facies, large bryozoans with recrysatllized shell fragments and minute subangular quartz grains embedded in sparry micritic matrix, sample 76, Sharm El Arab Mb., Shagra Fm. Fig. 6. Bioclastic algal Grainstone Facies, large benthonic foraminifera of *Amphestegina* sp. with reworked coralline red algae (arrow) and milliolid entobded in partialy recrystallized micritic matrix, sample 84, Sharm El Arab Mb., Shagra Fm. Fig. 7. Coral algal Rudstone (with rhodoliths) Facies, large fragmentd coral (arrow) with subrounded micritic intraclasts embedded in sparry micritic matrix, sample 63, Dashet El Dabaa Mb., Shagra Fm., Fig. 8. Coral algal Rudstone Facies, coral fragment of well-developed interlocked septa (arrow) and fragments of coralline red algae in sparry calcite cement, sample 81, Sharm El Arab Mb., Shagra Fm.

Subfamily Mastrophoroideae Setchell, 1943
Genus *Spongites* Kützing, 1841
Spongites albanense Lemoine, 1924
(Plate 2, Figure 1)

Description: Irregular crustose to warty with unbranched rectangular cells measuring 11 –19µm in length and 9-14 µm in diameter protuberance, thalli thickness varying from 0.5 – 1.6 mm . The dorsoventral filaments composed of rectangular cells measuring 11 – 17µm in length and 8-12 µm in diameter and sometimes indistinct basal core filaments. The peripheral filaments composed of also rectangle cells measuring 12 – 20µm in length and 12 - 14µm in diameter. Tetra/bisporangial conceptacles are observed, uniporate with conical pore and ovoid shape, measuring 210 – 340 µm in diameter and 150 – 180 µm in height. This species ascribed before to *Lithophyllum albanense*, but the thalli of this species shows clear and abundant cell fusions and therefore belongs to subfamily Mastrophoroideae and not to the Lithophylloideae.

Remarks: The presence of the monomerous non-coaxial tahllus and the tetra/bisporangial uniporate conceptacles assigned this specimen to the genus *Mesophyllum*. It is particularly important to note the change from branching to crustose form. The specimen under disposal is consistent in their internal tahllus structure with the descriptions and figures given by Aguirre & Braga (1998) and also and Imam (1991&1996). This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Hamad (2009), but differ in the conceptacle shape and sizes, where the nominated specimen shows less dimensions. This species is also common in the moullscan algal grainstone facies and algal foraminiferal packstone facies of Pliocene Sharm El Arab Member of Shagra Formation.

Spongites sp. 1
(Plate 2, Figure 2)

Description: Crustose thalli warty, and encrusting bioclastics and other coralline algae. The core filament unistratose, curving upward toward the peripheral region forming non –coaxial core filaments with thin thickness, cells having 14 – 26 µm in length and 11 – 23 µm in diameter. The peripheral filaments show cells with irregular cell walls. The cell sizes are 12 – 28 µm in length and 12 -19 µm in diameter. Cell fusion are not observed. The tetra / bisporangial conceptacles uniporate with flask – shaped pore canal. Conceptacles are 330 – 560 µm in diameter and 150 – 170 µm in height.

Remarks: This species show some similarities with *Lithophyllum lithothamnioides* Maslov (1962) in the general appearance of the thalli and conceptacle sizes, but differ in the presence of non – coaxial core filaments and thick peripheral filaments and the sizes of the thalli. Addationally, The presence of the monomerous non -coaxial tahllus and the tetra/sporangial uniporate conceptacles assigned this specimen to the genus *Spongites.* It is particularly important to note the change from branching to crustose form. The specimen under disposal is consistent in their internal tahllus structure with the descriptions and figures given by Bassi & Nebelsick (2000) from the Lower Oligocene of Northern Solvenia*.* This specimen also shows great similarities in the shape and dimensions of thallus to that figured by Hamad (2009), but differs in the conceptacle shape and sizes, where the nominated specimen shows larger dimensions. This species is also common in the moullscan algal rudstone facies and bioclastic coral algal rudstone of the Pliocene Sharm El Arab Member of Shagra Formation.

Spongites sp. 2
(Plate 2, Figure 3)

Description: Lumpy to warty and sometimes of layered growth forms, usually with warty protuberance measuring up to 0.9 mm long and 1.4 mm in diameter. Monomerous thallus pattern with non coaxial core filaments. Cells are 12 – 17 µm in length and 10 – 12 µm in diameter. Cell fusions are recognized between cell of contiguous filaments. No epithallic cellas are identified. The tetra / bisporangial conceptacles uniporate with semicylindrical pores, where filaments around the conceptacles are grown in semi- parallel manner. Conceptacles are 265 – 360 µm in diameter and 176 – 180 µm in height. Sometimes aborted conceptacles are recognized. No columella found.

Remarks: The presence of the monomerous non - coaxial tahllus and the tetra/bisporangial uniporate conceptacles assigned this specimen to the genus *Spongites*. The specimen under consideration shows similarities in its internal tahllus structure with *Lithophyllum duplex* that descriped and figured given by Maslov (1962) but differ in the core filament morophology and conceptacle shape and sizes, where the nominated specimen shows larger dimensions. This species is also common in the coral algal rudstone and bioclastic coral rudstone facies Pliocene Dashet El Dabaa and Sharm El Arab Members of Shagra Formation.

Genus *Lithoporella* (Foslie) Foslie, 1909
Lithoporella melobesioides (Foslie) Foslie, 1909
(Plate 1, Figure 8)

Description: Thin unistratose thallus of encrusting growth forms of single overgrowth of cell filaments. It is dimerous thallus of primigenous filaments composed of palisade cells measruring 28 - 57 µm in length and 17 – 26 µm in diameter. Cell fusions are present. The tetra / bisporangial conceptacles are uniporate and rarely recognized and poorly preserved.

Remarks: The thin dimerous filaments with distinct large cells as well as cell fusions and uniporate conceptacles ascribed this specimen to the genus *Lithoporella*. (Woelkerling, 1988, Braga *et al*., 1993, Bassi & Nebelsick, 2000 and Hamad 2006).Moreover the specimen under consideration is consistent in their internal tahllus structure with the descriptions and figures given by Masterorilli, 1968; Rasser, 1994; Bassi, 1995, 1998). This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Hamad (2009), but differ in sizes of thallus, where the nominated specimen shows less dimensions. This species is also common in the moullscan algal grainstone facies and algal foraminiferal packstone facies of the Pliocene Shagra Formation.

Genus Neogoniolithon Setchell & Mason, 1943
Neogoniolithon sp.1
(Plate 1, Figure 8)

Description: Encrusting thalli ranging in thickness from 1.3 mm to 1.9 mm, with rare occurrence of protuberance. The monomerous thallus composed of coaxial core filaments about 150 µm in thickness, cells are 10 – 14 µm in diameter and 13 - 19 µm in length. The peripheral filaments with cells are 13 – 17 µm in diameter and 18 - 23 µm in length. Regular spine like branch composed of completely of peripheral filaments with strong irregular growth zones. Cell fusions connecting the contiguous filaments. The tetra / biosporangia uniporate conceptacles are rarely recognized and embedded in the peripheral filaments, measuring 250 – 480 µm in diameter and 160 – 190 µm in height.

Remarks: The specimens under disposal correspond to thalli of the *Mesophyllum vaughani* (Howe) described by Lemoine (1928) and Edgell & Basson(1975) but differ in having smaller core filament cells and uiporate conceptacle. The presence of the monomerous coaxial tahllus and the tetra/bisporangial uniporate conceptacles ascribed this specimen to the genus *Neogoniolithon*. This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Hamad (2009), but differ in the conceptacle sizes and core filaments, where the nominated specimen shows greater dimensions. This species is also common in the coral algal rudstone facies and algal foraminiferal packstone facies of Pliocene Dashet El Dabaa Member of Shagra Formation.

Neogoniolithon sp.2
(Plate 1, Figure 5)

Description: Encrusting and layered thalli with thickness up to 480 µm. Monomerous coaxial thallus composed of coaxial core filaments about 180 µm in thickness, cells are 10 – 14 µm in diameter and 13 - 19 µm in length. The peripheral filaments with cells are 13 – 19 µm in diameter and 22 - 29 µm in length. The peripheral filaments are thin thickness, with cell fusions connecting the contiguous filaments. The tetra / biosporangia uniporate conceptacles are rarely recognized, angular in shape and conical pore canal, the conceptacles are measuring 150 – 370 µm in diameter and 100 – 140 µm in height.

Remarks: The specimens under disposal correspond to thalli of the *Neogoniolithon sp.1* described by Bassi & Nebelsick (2000), from the Lower Oligocene Gornji Grad beds of Northern Solvenia, but differ in having smaller core filament cells and uiporate conceptacle sizes. The presence of the monomerous coaxial tahllus and the tetra/bisporangial uniporate conceptacles ascribed this specimen to the genus *Neogoniolithon*. This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Hamad (2009), but differ in the conceptacle sizes and core filaments, where the nominated specimen shows greater dimensions. This species is also common in the coral algal Rudstone facies and algal molluscan algal grainstone facies of the Pliocene Dashet El Dabaa Member of Shagra Formation.

Subfamily: Lithophylloideae Setchell*, 1943*

Genus Lithophyllum Philippi*, 1837*
Lithophyllum ghorabi Souaya*, 1963.*
(Plate 2, Figure 4)

Description**:** encrusting thalli with well-developed protuberance (Pl.2, Fig. 4) usually of crustose to fruticose plants varying in thickness from 546 – 827 µm. Monomerous to dimerous thallus. The central core filaments is thick (190 –279 µm thick) showing arching tiers of cells. It is composed of regular co - axial rectangular cells measuring 11 - 25 µm in diameter and 21 – 46 µm in length where the cells becomes smaller toward the peripheries and larger toward the tip of the protuberance. The peripheral filaments (465 - 920µm) composed also of rectangular cells measuring 19 – 38 µm in length and 13 – 20 µm in diameter. The tetra / bisporangial conceptacles are rarely observed and if recognized, they have triangular shape with relict columella.

Remarks: *Lithophyllum ghorabi* could be distinguished from *lithophyllum prelichenoides* by the well-developed thickness of core filaments and the small triangular shape of the nominated taxon. This species are widely recorded in the circum of the Tethyian and Red Sea area, it has been recognized before by Souaya (1963) from Cairo – Suez district of Egypt and also from Red Sea coast(1966) , from the Middle Miocene of Lebanon Edgell & Basson (1975), Late Miocene of Isreal (Bushbinder, 1975) and the Middle Miocene of West – central Sinai, Egypt (El Sayed *et al*., 1988; Imam, 1991, 1996) and Lower Miocene of North eastern Desert, Sadat area (Hamad, 2006). The presence of the monomerous coaxial tahllus and the tetra/bisporangial uniporate conceptacles assigned this specimen to the genus *Lithophyllum* It is. The specimen under disposal is consistent in their internal tahllus structure with the descriptions and figures given by Souaya (1963) and also Edgell & Basson (1975) as well as Imam (1996). This species is also common in the moullscan algal grainstone facies and bioclastic algal foraminiferal grainstone facies of the Pliocene Sharm El Arab Member of Shagra Formation.

Lithophyllum prelichenioides Lemoine, 1917
(Plate 2, Figure 5)

Description: several crustose to long branched forms are recorded. It is monomerous thallus that composed structurally of co-axial core filaments and indistinct of variable thin peripheral filaments. The core filaments composed of regular co-axial cell rows. Cells are 12 –16 µm in length and 15 – 23 µm in diameter. The peripheral filaments are relativel thin and consist of rectangular cells, measuring 15 –26 µm in length and 13 – 18 µm in diameter. The tetra / bisporangial conceptacles are not observed in some of the studied materials.

Remarks: There are much similarities between the species under disposal and *Lithophyllum prelichenoides* that described and figured by Lemoine (1917), Edgell & bassoon (1975) and Buchbinder (1977) particularly in the thickness of the core filaments and its morphology. This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Imam (1996) and Hamad (2006), but differ in the absence of conceptacle. This species is also common in the moullscan algal grainstone and coral algal rudstone facies of the Pliocene Sharm El Arab Member of Shagra Formation.

Lithophyllum bonyense Johnson, 1964
(Plate 2, Figure 7)

Description: Encrusting plants, with relatively warty protuberance. Monomerous thallus with fairly developed core filaments, that composed co-axial core portion (400 µm thick)., cells are 20 – 37 µm in length and 8 – 13 µm in diameter, arranged in regular rows of fan – like appearance. The pripheral filaments (800 µm thick) composed of cells of thick walled, measuring 17 – 20 µm in length and 10 – 14 µm in diameter. The tetra / bisporangial conceptacles are observed in rare specimens of the studied materials, they are small, flask shape, in some of the studied materials, measuring 60 – 100 µm in diameter and 20 – 50 µm in height.

Remarks: The growth form, thallus arrangement of the described specimens and shape and sizes of the tetra/bispragial conceptacles are correspond to great extent that *Lithophyllum bonyense* described by Edgell & Basson (1975) and Buchbinder (1977) and differ in the absence of the conceptacles in the specimens of Buchbinder (1977). This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Jonson (1964), but differ in the absence conceptacle. This species is also common in the coral algal rudstone and bioclastic algal grainstone facies of the Pliocene Sharm El Arab Member of Shagra Formation.

Lithophyllum sp.
(Plate 2, Figure 8)

Description: Crustose thallus with small mamillae protuberance varies in thickness from 340 to 530 µm, commonly encrusting fragmented corals and bryozoa and other molluscan shell fragments. The core filaments are thin (160 – 210 µm thick) and composed of concentric coaxial arched layers where the cells are rectangle and become thick in the middle part and thin towards the peripheries. Cells are 16 – 29 µm in length and 10 – 18 µm in diameter. The outer peripheral filaments are inconspicuous and fairly developed with relative thickness of 180 – 230 µm, with rectangular cells 10 – 16 µm in length and 10 – 12 µm in diameter. The tetra / biosprangial conceptacles are observed in rare specimens, uniporate with conical pore canal tapering toward the uppermost part of the conceptacle, they are measuring 250 – 329 µm in diameter and 100 – 140 µm in height.
Remarks: The presence of the monomerous coaxial tahllus and the tetra/bisporangial uniporate conceptacles assigned this specimen to the genus *Lithophyllum*. This species is also common in the moullscan algal grainstone facies and Algal foraminiferal Packstone facies of the Pliocene Dashet El Dabaa Member of Shagra Formation.

Family Sporolithaceae Verheij, 1993
Genus *Sporolithon* Heydrich, 1897
Sporolithon cf. intermedium Raineri

Description: encrusting to lumby growth forms, usually crustose dorsiventeral and monomerous thalli with rounded protuberance measuring 230µm in height. Thickness of encrusting thalli (up to 3 mm), The ventral core filaments is commonly strongly curved with cell filaments measuring 13 – 24 µm in length and 11 – 17 µm in diameter. The peripheral filaments are usually regular measuring thickness of 90- 180 µm, cells are rectangular with irregular cell layers. Cells are measuring 15 – 27 µm in length and 10 - 19 µm in diameter, where cell fusion are scarce.
Tetra / biosporangial conceptacles are arranged in sori. The sori consists of 19 – 28 tetra / biosporangia that sometimes arise from layer of elongated cells. The shape of conceptacles is elongated ellipsoidal measuring 130 – 160 µm in height and 78 – 85 µm in diameter.
Remarks: The presence of the noncoaxial coe filaments and the sporangial arrangement (arranged in sori), the consided specimenis consistent with the genus *Sporolithon* (Woelkerling, 1988 & 1996; Braga *et al*., 1993; Braga & Aguirre, 1998). This species is also common in the moullscan algal grainstone facies and coral algal rudstone facies of the Pliocene Shagra Formation.

Subfamily Corallinoideae Foslie, 1898
Genus Corallina Linnaeus, 1759
Corallina sp.

Description: Dichotomous thalli with arboescent branching measuring 1.6 mm long and 210 – 260 µm in diameter. Several fragments of segmented stems are observed (560m thick) composed exclusively of core filaments, cells are 45 – 59 µ m in length and 10 –15 µm in diameter. Peripheral filaments weakly developed on the margins of segments. Cell fusion are recognized. Conceptacles are not observed in the present specimens.
Remarks: The presence or absence of genicula is taken as informally subdivision for Corallinaceae into geniculate (articulated) and nongeniculate (non- articulated) groups (Woelkerling, 1988; Bassi, 1996 & 1998; Imam, 2003; Bassi et al., 2006). The absence of the genicular cells hinders the species identification, as they are preserved in the fossil state. This type of geniculate coralline red algae is commonly recorded in the Cenozoic carbonate deposits of many regions and that contributing to the formation of the rock type (Norris & Johanson, 1981; Gischler & Pisera, 1999; *Hetzinger et al.,* 2006). Due to the non-preservation of the conceptacles and geniculate cells in the studied materials, our considered speciemens are referred to the genus *Corallina (sensu lato)*. This species is commonly recorded in the moullscan algal grainstone facies and bioclastic algal grainstone as well as coral algal rudstone facies of Pliocene Dashet El Dabaa and Sharm El Arab Members of Shagra Formation.

Phyllum: Chlorophyta Pasher, 1914
Class: Cholorophyceae Kutzing, 1843
Order: Siphonals Wille, In Warming, 1884
Family: Codiaceae Zanardini, 1843
Genus: *Halimeda* Lamouroux, 1812
Halimeda sp.

Description: Thallus strongly branched and calcified with elliptically elongated segments of about 0.5 to 1.9 mm in diameter and 1.5 – 2.6 mm in length. Filaments slightly oblique with non – distinctive layers.
Remarks: The present specimen is consistent in their thallus morphology and dimensions to the described and figured by Bassi & Nebelsick (2000).

This species as been described by Johnson (1961), Edgell & Basson (1975), Flugel (1988), Mu (1991), Imam (1991 & 1996) from Cretaceous to Recent. Edgell & Basson (1975) as well as Imam (1991&1996). This specimen also shows great similarities in the structure, shape and dimensions of thallus to that figured by Hamad (2009). This species is also common in the moullscan algal grainstone facies and algal foraminiferal packstone facies of the Pliocene Sharm El Arab Member of Shagra Formation.

Coralline red algal biostratigraphy

Although shallow marine coralline red algae are generally of limited use in the high – resolution biostratigraphy owing to their restricted habitat and typically long stratigraphic range, they can be used in conjunction of the planktonic and benthonic foraminifers from the deeper, open shelf intervals within the same stratigraphic section to refine the biostratigraphy. Coralline red algal species dominate the shallow marine segments, whereas the intervening deep, open marine segments are characterized by a moderate abundance of planktonic and benthonic foraminiferal taxa. The preservation of coralline algae varies from moderate espcially in the lower parts of Shagra Foramtion (Dashet El Dabaa Member) good at the top of the section (Sharm El Arab Member of Shagra Formation) allowed the biostratigraphic study. For the identification of the Neogene coralline red algal genera and species, the works of Johnson (1955, 1957, 1961, 1964, 1966); Souaya (1965); Mastrorilli (1968); Boscence (1991); Woelkerling *et al*. (1993); Bassi (1995); and Braga & Aguirre (1995), Wehrmann *et al.,* (1995),
Aguirre, *et al.* (2012), Sakar, *et al.* 2016, were adopted in the present work.

Concerning the coralline algal biostratigraphy in Egypt, little has been published on that topic. Few researchers tackled on this study and quite number of coralline algae have been reported, among them are Souaya (1963 a, b) who introduced two local coralline algal zones in Gebel Gharra, Cairo – Suez road, from base to top: *Lithophyllum ghorabi* Souaya and *Archaeolithothamnium cyrenicum* Raineri and assigned these two zones as Middle Miocene. El Gamal (1971) studied

The coralline red algae from some different sections in northern Egypt but his work did not touch the biostratigraphic issue. Imam & Refaat (2000) studied the coralline red algal assemblages of the Miocene rocks of the Hamam Faroun Member of Belayium Formation in Wadi Abura, Sinai and subdivided the sequence into two local algal zones from base to top: *Lithothamnium undulatum* and *Mesophyllum sanctidionysii* zones. Recently Hamad (2008 a, b) studied also the coralline algal assemblage of Gabal Genefa, Cairo – Suez Road, Egypt and recognized two local zones from base to top: *Lithophyllum ghorabi* and *Mesophyllum iraqense* zones.

About thirty surface samples were examined in order to determine the ages of the individual members of Shagra Formation (Fig. 2). Ages were primarily established on the basis of the planktonic and benthonic foraminiferal assemblages that will be discussed in another work by the present author. The careful examination of the coralline algae distribution in the studied section (Figs. 2 &3) allowed subdividing the Pliocene sequence in Wadi Wizer, Red Sea coast into two local coralline algal zones. Each zone is characterized by its peculiar association of coralline algal species. They are from base to top as follows:

1- Neogoniolithon sp. / Mesophyllum lemoinaea Assemblage Zone:

This zone is recorded in the lower two thirds of Dashet El Dabaa Member of Shagra Formation, covering the interval form sample 60 to 69 in Wadi Wizer (Fig. 2). The most common recorded coralline algal species are: *Lithothamnion sp.1, Lithothamnion corallinaeforme, Mesophyllum lemoinaea*, *Spongites* sp. 1, *Lithophyllum* sp., *Lithoporella melabesioidea*, *Neogoniolithon* sp.1, *Neogoniolithon* sp.2, *Sporolithon cf. intermedium, Corallina* sp. *and Halime*a sp. (Fig. 2).

2-Lithothamnion saipanense / Lithophyllum prelichenoides Assemblage Zone:This zone is characterized by the total range of *Lithothamnion saipanense / Lithophyllum prelichenoides*. It is recorded in the Pliocene sequence constituting the uppermost part of Dashet El Dabaa Member and the whole Sharm El Arab Member of Shagra Formation, covering the stratigraphic interval from sample 72 to 90 in Wadi Wizer. This zone is characterized by remarkable occurrence of coralline algal assemblage of species such as *Lithothamnion saipanense* (zonal marker), *Lithophyllum ghorabi* (zonal marker), *Lithophyllum prelichenoides*, *Spongites albanense*, *Lithothamnion boucarti, Lithothamnion microphyllum, Lithothamnion* sp, *Mesophyllum sanctidionysii, Lithophyllum* *prelichenoides*. The distributional pattern of these species are partially resrticted to this zone and some of them are cosmopolitan such as *Spongites albanense, Mesophyllum sanctidionysii* but the other types showed limited distribution forming endemic species and commonly reported from the Middle East countries (eastern parts of the Tethys) such as *Lithophyllum ghorabi*, and (Fig. 4)

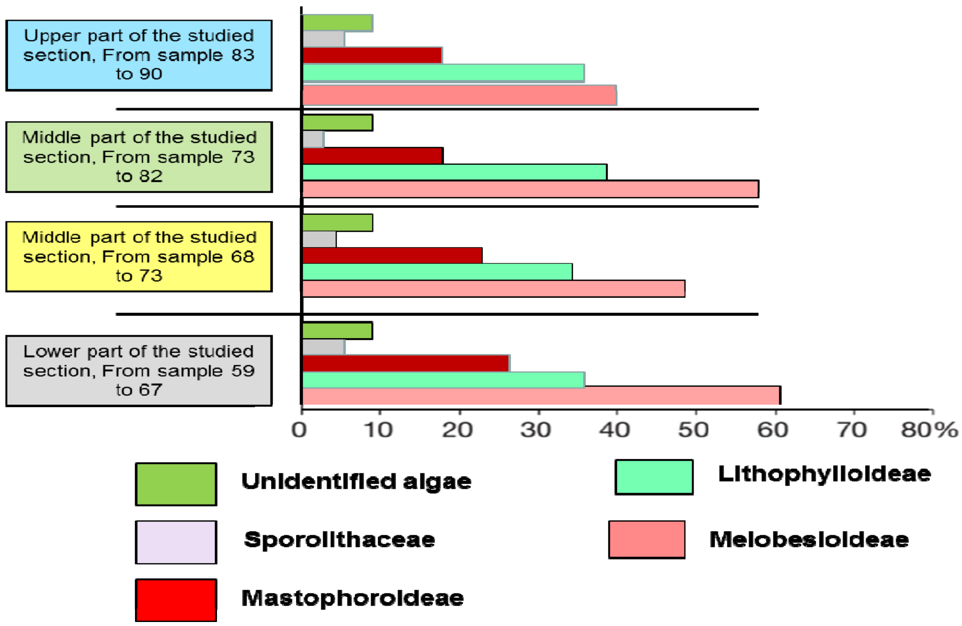

Figure 4. Abundance, in percentages, of different families and subfamilies constituents in the studied beds.

Microfacies analysis and paleoecology

The paleocological conditions that prevailed during the deposition of the Pliocene deposits exposed in the studied section have been interpreted on the basis of microfossil assemblage (coralline red algal assemblage, planktonic and benthonic foraminiferal and other different bioclatic content) as well as the lithologic types included the rock fabric (sorting, grain sizes) and field relationships. Six distinct carbonate microfacies types were identified using the carbonate classification used by Folk (1959); Dunham (1962); Wilson (1975) and Flügel (1982). While two siliciclastic microfacies types were recognized and described following the classification of Folk (1956) and Pettijohn (1975). These microfacies types are commonly repeated in the Pliocene Shagra Formation (Fig. 2) and grouped in two main groups (carbonate and siliciclastic types).

Carbonate microfacies types

Molluscan (Shelly) Algal Grainston Facies

This facies type is characterized in the field by forming prominent ledges of 2 to 3.5 m in thickness, less common in Sharm El Arab Member of Shagra Formation but prediomenate in Dashet El Dabaa Member. It is represented by three distinct beds constituting 25% of the carbonate facies. It is yellowish to brownish white in color, massive and compact, moderately fossiliferous limestone with abundant shell fragments, coralline red algae, benthonic and planktonic foraminiferal tests. It is recorded in the studied section, commonly interbedded with calcareous bioclastic sublitharenite and the algal foraminiferal packstone facies. Petrographic investigations revealed that the skeletal components of this facies consists largely of medium to small sized molluscan shell fragments, in situ and fragmented coralline red algal (*Lithophyllum sp. and Spngnites sp.*), smaller miliolid benthonic foraminifera are represented by *Pyrgoa* spp., *Borelis* spp., and *Elphidium* spp., planktonic foraminiferal tests, bryozoa and ostracods as well as large echinoid spines (Pl. 3, Fig. 3). The non-skeletal constituents are depicted in the form of reworked subrounded carbonate intraclasts of micrite composition and subrounded, poorly sorted, terregenous quartz grains. These allochems are embedded in calcareous sparry calcite cement. Such type of facies indicates deposition in near shore shoal conditions with high energy, normal salinity, and shallow marine environments.

Coral Algal Rudstone Facies
This facies type is represented in the field by coralline reefal deposits located in the uppermost of Shagra Formation. The geometry of this bedded facies suggests a biohermal development rather than biostromal one that locally developed above the submarine paleohighs. It is located in the whole Shagra Formation forming 40% of the carbonate facies. This facies is represented by fairly high proportion, thick accumulation of organic organisms commonly contain scattered in situ hermatypic corals (*Porites sp., Pavona trinitatis*, *Orbicella sp.*, *Mycetophyllia* sp. and *Stylophora sp.*), molluscan shell fragments, bryozoans, ostrcods, large benthonic foraminifers (*Borelis* spp., *Amphistegina spp, Operculina spp* and *Ammonia beccarii* Linne`) and small sized rhodoliths (up to 1.8 cm in diameter) bounded by highly diversified coralline red algae in the form of *Lithophyllum* spp., *Neogoniolithon* spp., and *Lithoporella* sp.It is noteworthy of mention that some remains of bivalve shells, echinoids and even corals are bioeroded with *Lithophaga* borings. Petrographic investigation revealed that the ground mass of this microfacies type is composed essentially of coral fragments of well-developed septa filled with sparry calcite cement (30%) (Pl. 3, Fig. 7), coralline red algae in the form of *Lithophyllum* sp. and *Neogonilithon* sp. (40%) and 10% of bioclastic components of bivalve shell fragments, echinoids spines and (10 % of the skeletal components). The lithoclastic (non – skeletal components) are represented by subrounded micritic intraclasts and subrangular detrital quartz grains packed in granular sparry micrite matrix. The presence of in situ and fragmented corals denotes shallow, clear and warm water marine environments with open circulation (reef flank to back reef facies).

Bioclastic Algal Grainstone Facies
This facies type is characterized in the field by forming prominent beds of 2 to 2.5 m in thickness. It is yellowish white in color, consolidated to massive, highly fossiliferous with bivalved shells, coralline algal rhodoliths, subordinate coral fragments, enchinoides and bryozoa, benthonic foraminiferal tests, as well as shell fragments. It is recorded in the studied section, commonly interbedded with the coral algal Rudstone facies in Shagra Formation. Thin section investigation revealed that this facies consists mainly of moderately to badly preserved to partially recrystallised colonial forms with ill-defined septa that recrystallized in microspars. These type of corals are commonly fragmented and the others are formed in situ and showing Indo-Pacific affinity. Coralline red algae constitutes the second majority of these components, they are encrusting the corals and. other bivalve shell fragments. Large sized molluscan fragments, large benthonic foraminifera are represented by *Amphistegina* spp., *Ammonia* spp., and *Borelis* spp., small planktonic foraminiferal tests, shell fragments, ostracods and bryozoans (Pl. 3, Fig. 4) as well as echinoid spines are also recognized. The non-skeletal constituents are presented in the form of reworked subrounded carbonate intraclasts of micrite composition and subangular to subrounded, poorly sorted, detrital quartz grains. These allochems are preserved in sparry calcite cement (Pl. 3, Fig. 6). Such type of facies indicates deposition in clear normal, high energy shallow marine environments with normal salinity and open circulation conditions. This facies represents deposition in reef – flank environments.

Coral Algal Rudstone Facies (with Rhodoliths):
This facies type is predominantly recorded in the lower part of Shagra Formation. It is recognized also in several horizons in Sharm Dashet El Dabaa Member. It is typified by white to yellowish white color, massive to hard, compact, fossiliferous, bioclastic algal limestone with spherical to elliptical rhodoliths ranging from 2 - 5.6 cm in diameter. The prominent dicrimnation of this facies from the coral algal rudstone facies is the presence of large sized rhodoliths. Two different types of rhodoliths accumulation are distinguished, they differ in the growth form, shape, size and nuclei as well as the taxonomic composition (they will be discussed in details in another paper by the present author). The first one is up to 5.6 cm, columnar rhodoliths with short stubby protuberance, dominated with thick contiuous crusts of *Lithothamnion and Neogoniolithon* spp. with nuclei of fragmented corals and their internal thalli structures are obliterated with borings. The other type is characterized by laminar to columnar rhodoliths, ranging in diameter from 3 – 5.6 cm, ellipsoidal shape and dominated with *Spongites, Mesophyllum* and *Lithoporella* spp. As well as *Lithophyllum* spp. with nuclei of fragmented reworked bioclasts or other large benthonic foraminifera. Microscopic investigation revealed that this facies is mainly composed coralline red algal rhodoliths forming

60% of the main allochems. Bioclasts are moderately abundant and represented by common occurrence of bivalved shell fragments in addition to reworked and in situ coral fragments, echinoid spines, bryozoa. Subrounded, well sorted quartz grains of single type with straight extinction, with skeletal grains in the form of large and small milliolid test as well as benthonic and planktonic foraminiferal tests (Pl. 3, Fig. 7). These skeletal and lithoclastsics components are embedded in microsparite aggreded into sparry calcite. The presence of the rhodoliths and the coral and other skeletal fragments with the materials indicate that this facies was deposited in shallow warm marine water environments with high-energy currents.

Algal Foraminiferal Packstone Facies:
This facies type is intercalated with the previous facies and characterized in the field by forming prominent beds of 1.5 to 2 m in thickness. It is yellowish white in color, massive, highly fossiliferous with palnktonic and benthonic foraminiferal tests, as well as shell fragments. It is recorded in the studied section in Shagra Formation. Thin section investigation revealed that this facies consists mainly of palnktonic and benthonic foraminifera, small sized molluscan fragments, and are represented by Ammonia spp., *Elphidium* spp., and *Discorbis* spp., (Pl. 3, Fig. 1), planktonic foraminiferal tests are depicted in the presence of *Globorotalia* spp., *Globigerina* and *Globigerinoides* spp., Shell fragments, bryozoa and ostracods as well as echinoid spines. The non-skeletal constituents are depicted in the form of reworked carbonate intraclasts of micrite composition and subangular to subrounded, poorly sorted, terrigenous quartz grains. These skeletal and non skeletal allochems are embedded in microspar calcite cement (Pl. 3, Fig. 2). Such type of facies indicates deposition in normal shallow marine environments.

Foraminiferal Algal Wackestone/ Packstone Facies:
The rock of this facies is characterized in the field by its yellowish white to greyish color, partly massiv, gypsiferous, fossiliferous with macrofauna, algal limestone. It is the less common microfacies type recorded in the studied sections, especially recorded in Dashet El Dabaa Member of Shagra Formation attaining a thickness of about 10 to 30 cm. The matrix consists primarily of microcrystalline micrite with relatively orthosparite cement. The Skeletal grains are represented prediomentatly by planktonic foraminiferal tests of *Globigerina* spp. and *Globigerinoides* spp. with subordinate fragmented coralline red algae (Pl. 2, Fig. 7 & Pl. 1. Figs. 3 & 4), small miliolides, ostracod, serpulids, echinoid spines and shell fragments. The intraclasts are extremely few, moderately sorted and disoriented, composed mainly of subrounded reworked carbonate pellets and foraminiferal limestone fragments with very fine terrigenous quartz grains. Recrystallization of the micrite into pseudosparite is rather common and few shell fragments are replaced with silica solution.

Bioclastic coral Algal Rudstone Facies:
This facies type is characterized in the field by forming prominent beds of 2 to 4 m in thickness. It is yellowish white in color, consolidated to massive, highly fossiliferous with subordinate fragments of bivalved shells, coralline algae, in situ and fragmented corals, enchinoides bryozoa, and benthonic foraminiferal tests. It is less commom in the studied section, interbedded with the algal foraminiferal packstone facies in Shagra Formation. The petrographic analysis revealed that this facies consists mainly of moderately to badly preserved to partially recrystallised bryozoans usually filled with microspars. Corals are commonly fragmented and the others are formed in situ and showing Indo-Pacific affinity. Coralline red algae constitutes the second majority of these components. They are encrusting the fragmented corals and other bivalved shell fragments. Small sized molluscan fragments, larger foraminifera are represented by *Operculinides* spp., *Ammonia* spp. and planktonic foraminifera, ostracods, bryozoans that filled with sparry calcite (Pl. 3, Fig. 5) as well as echinoid spines are also identified. The non-skeletal constituents are presented in the form of reworked subrounded micritic carbonate intraclasts and subrounded, terregious qartz grains. All these constituents are well preserved in sparry micritic matrix. This facies denotes near shore shoals (shelf lagoonal deposits).

Siliciclastic microfacies types:
Pebbly Calcareous litharenite Facies:
This microfacies type is well developed in the basal part of Shagra Formation at Wadi Wizer surface section (sample No.59) and pinch out in the

outcrped section, attaining 2 m in thickness and consitituting less than 3% of the formation thickness. They are dark yellow to brownish yellow, pebbly, semiconsolidated, relatively massive, poorly to moderately sorted, mostly of different lithoclasts (carbonates, chert and subordinate fragments of sandstone) sandstones. The clasts are in the form of pebble sizes, rounded to subrounded, disoriented. Petrographically, the matrix is made up of medium to coarse, subangular to subrounded, moderately sorted detrital quartz grains cemented by carbonate (micrite matrix that partially recrystallized into pseudospars and minute dolomite rhombs) material. This microfacies type is characterized by diversified bioclastic content such as fragmented oyster shells of minute sizes and and echinoids spines as well as reworked large benthonic foraminifers.

Calcareous Bioclastic Sublitharenite Facies:
This type of facies is recorded overlying the molluscan (shelly) algal grainstone facies, represented by four separate interbesd in both members of Shagra Formation. It constitutes about 15% of the formation thickness, characterized in the field by its brownish yellow color, massive, dense, usually pebbly, partly argillaceous, calcareous sandstone. Microscopically this facies composed of medium to fine, subangular to subrounded, poorly to medium sorted, mono- to polycrystalline detrital quartz grains (70% of the framework) with some chert and bioclastic carbonate fragments (in the form of fine debris of molluscan shell fragments, fragemented echinoids plates, benthonic forams and micritized coralline algae). All these components are embedded in microsparite cement. The overall shape of this facies suggests deposition in relatively very shallow marine environments (tidal flates to near shore shoals).

Summary and conclusion

Th Pliocene biogenic carbonate - siliciclastic deposits from Wadi Wizer, Red Sea coast, Egypt are studied and investigated in details. These Pliocene deposits form part of a transgressive and regressive succession overlying the late Miocene rocks (Marsa Alam Formation). One startigraphic surface section representing the Lower Pliocen succession is investigated and described. Lithostratigraphically, one formation and two members were recognized, Shagra Formation (Pliocene) that contained from base to top: 1) Dashet El Dabaa Member and 2) Sharm El Arab Member. The coralline red algae are important constituents of these deposits and highly abundant and diversified. The study of the coralline red algae from the Pliocene deposits of Wadi Wizer, led to the recognition of twenty one coralline algal species belonging mainly to nine genera and two subfamilies of the Phyllum Rhodophyta (Corallinacae). The recognized species have been taxonomically studied and their occurrence is also mentioned. The taxonomy and growth forms of these species of seven non- geniculate coralline red algal genera from the reefal limestone and coralline algal limestone are described, they represented by the following: *Spongites, Mesophyllum, Lithothamnion, Sporolithon, Lithophyllum, Neogoniolithon, and Lithoporella.* Additionally, one species of geniculated algae is recognized and represented by *Corallina* sp. besides one species of green algae (Clorophyceae) has been identified (*Halimeda* sp.). On the basis of the stratigraphic distribution of the coralline red algae, the studied Pliocene sequence could be subdivided into two local coralline algal assemblage zones from base to top: *Neogoniolithon sp. / Mesophyllum lemoinaea* Assemlgae Zon and *Lithothamnion saipanense / Lithophyllum prelichenoides* Assemblage Zone.

The paleocological interpretation is based on the study of different microfacies associations, coralline red algae and foraminiferal microfossils assemblage as well as the field observations. Seven main microfacies types were recorded. The study of the different microfacies associations encountered in the Pliocene sequence indicated that the earliest Pliocene sediments (basal part of Dashet El Dabaa of Shagra Formation that overlies uncoformably on the Gabir Member of Marsa Alam Formation) are mainly marine carbonate facies with minor siliciclastic and indicative of very shallow marine environments and. Whereas going upwards the sequence till the topmost Sharm El Arab Member of Shagra Formation, the reefal limestone facies with coral patch reefs and rhodoliths, becoming more abundant reflecting more shallower environments. The study of microfacies association showed that the coral algal rudstone and bioclastic algal grainstone facies are commonly characterised by coralline red algal assemblages dominated by lithophylloids (*Lithophyllum*) and mastophoroids (*Spongites* and *Neogoniolithon*). The distinction is less marked in the relativelly deep carbonate deposits such as algal foraminiferal packstone, shelly algal grainstone and foraminiferal algal packstone facies where the melobesioids (*Lithothamnion*, *Mesophyllum*) are the major coralline algal spcies in these facies. *Sporolithon*, the only representative of the family Sporolithaceae, is frequent in reef deposits but very rare in the studied microfacies types.

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References

Adey, W. H., MacIntyre, I. G. 1973. Crustose coralline algae: A re – evaluation in the geologic sciences. Geological Society of American Bulletin, 84: 883 – 904.

Aguirre J., Braga J. C., Martín J. M., Betzler C. 2012. Palaeoenvironmental and stratigraphic significance of Pliocene rhodolith beds and coralline algal bioconstructions from the Carboneras Basin (SE Spain). Geodiversitas, 34 (1): 115-136.

Al-Rifaiy, I. A., Cherif, O. H., 1989. Paleogeographic significance of Pliocene and Pleistocene mega- invertebrates of the Red Sea and the Gulf of Aqaba.- J. Univ. Kuwait (Sci.), 16 (2): 367–399.

Akkad, S., Dardir, A. 1966. Geology of the Red Sea coast in the area between Ras Shagra and Marsa Alam, with short not on result of exploratory work of Gabal El Rusas lead – Zinc deposits. Geological Survey of Egypt,. 3, 67p.

Bassi, D., 1995. Curstose Coralline algal pavement from Late Eocene, Colli Berici of Northern Italy. Riv . Italiana Paleont. Strat. 101: 81 – 92.

Bassi, D., 1998. Coralline algal facies and their paleoenvironments in the Late Eocene of Northern Italy. Facies, 39: 179 – 202.

Bassi, D., Nebelsick, J. H. 2000. Calcareous algae from the lower Oligocene Gornji beds of northern Solvenia. Revista Italiana di Paleontologia e Startigrafia, 106 (1): 99 –122

Bassi, D., Carannante, G., Murru, M., Simone, L. Toscano, F., 2006. Rodoalgal / bryomol assemblage in temperate – type carbonate, channelized depositional systems: The LowerMiocene of the Sarcidano area (Sardinia, Italy*).* Geological Society of London Special Publication, 35 – 52.

Basso, D., Fravega, P., Vanucci, G. 1997. The taxonomy of Lithothaminum ramossimum (Gumbel non Reuss) Conti and Lithothamnium operculatum (Conti) Conti (Rhodophyta, Corallinaceae). Facies, 37: 167 – 182.

Beadnell, H. J. 1924. Report on the geology of the region of the Red Sea coast between Qusier and Wadi Ranga. Petroleum Research Bull., 13, 23p, Cairo.

Bosence, D. W. J., 1983. Coralline algae from the Miocene of Malta. Paleontology, 26 (1): 147 – 173.

Bosence, D. W. J., 1991. Coralline algae: mineralization, taxonomy and paleocology. In: Riding, J. (ed.). Calcareous Algae and Stromatolites. Springer Verlag, Heidelberg.

Braga, J. C., Aguirre, J. 1995. Taxnomy of fossil coralline algal species: Neogene Lithophylloideae (Rhodophyta, Corallinceae) from southern Spain. Rev. Paleobot. Palynol., 86: 265 – 285.

Braga, J. C., Aguirre, J. 1998. Redescription of Lemoine's (1939) types of coralline algal species from Algeria. Paleontology, 41 (3): 489 – 507.

Braga, J. C., Martin, J. M., 1988. Neogene coralline red algal growth forms and their paleoenvironments in the Almanzora river valley (Almeria, Spain). Paleogeogr., Paeoeclimatol., Paleecol., 67: 285 – 305.

Buchbinder, B., 1977. Systematic and paleoenvironments of the calacreous algae from the Miocene deposits of Israel. Marine Micropaleontology, 42 (2): 321 – 342.

Cherif, O. H. 1966. Geology of the Sadat area, southwest of Suez, Egypt. M. Sc. Thesis, Ain Shams, 242p.

Cherif, O. H. 1, & Yehia, M. A. 1977. Stratigraphy of the area between Wadi Gimal and Wadi Hommath, Gulf of Suez, Egypt. Egyptian Journal of Geology, 21 (2): 185 – 202.

Edgell, H. S., Basson, P. W. 1975. Calcareous algae from the Miocene of Lebanon. Micropaleontology, 21 (2): 165 – 184.

El-Akkad, S., Dardir, A. 1966. Geology of the Red Sea coast between Ras Shagra and Marsa Alam with short notes on the exploratory work at Gebel El- Rusas lead-zinc deposits.- Geol. Surv. Egypt, Paper, 35: 1–67.

El Gamal, M. M. 1971. Paleontoloical and Stratigraphical studies on some Miocene reefal facies in Egypt with special emphasis on the calcareous algae. Ph. D. Thesis, Faculty of Science, Cairo University, 209p.

El Sayed, A. A. Y, Fahmy, S. E., Imam, M. M. 1988. Startigraphy and microfacies of the Miocene sequence at Gebel Sarbut El Gamal, West Central Sinai, Egypt. N. Jb. Geol. Palaeont. Abh., 177 (2): 225 – 242.

EL Sorogy, A. S., Abdelwahab, M., Ziko A., El-Dera, N., Saber, N., Abu Elkheer, N. (2004). Recent bryozoans from southern safaga bay, Red Sea coast, Egypt. Egypt. Jour. Paleontol., 4: 199-230.

Felesteen, A., Kheidr, E., Abu Magd, K., 1994. The Neogene – Quaternary sequence of Ras Benas Peninsula: Stratigraphic studies. Egyptian Journal of Geology, 38 (1): 267 – 287.
Flügel, E. 1988. *Halimeda*: Paleontological record and paleoenvironmental significance. Coral Reefs, 6:123 – 130, Berlin
Ghorab, M. A., Marzouk, I. M., 1967. A summary report on the rock stratigraphic classification of the Miocene non – marine and coastal facies in the Gulf of Suez and Red sea coast. Unpublished Internal Report, General Petroleum Company, E. R. 601, Cairo.
Gischler, E., Pisera, A., 1999. Shallow water rhodoliths from Belize reefs. N. Jb. Geol. Palaont. Abh., 214 (1/2): 71-93, Stuttgart.
Hamad, M. M., 2008 a. Algal Biostratigraphy of some Lower Miocene Sequences, North Eastern Desert, Egypt. International Journal of algae, 10 (1):79 – 102
Hamad, M. M. 2008 b. Coralline red algae from the Early Pliocene Shagra Formation at Wadi Wizer, Red Sea coast, Egypt. And their implications in biostratigraphy and paleoecology - International journal of Algae, 10 (2): 179 – 208.
Hamad, M. M., 2009. Coralline red algae from the Lower Miocene Sadat Foramtion, Sadat area, Northwestern part of the Eastern Desert, Egypt. Egyptian Journal of paleontology, 9:183–22.
Hamza, F. H., 1992. Contribution to the Neogene biostratigraphy of the eastern part of Egypt. Middle East Research Center, Ain Shams University, Earth Science Series. 6: 151 – 166.
Hamad, M. M., El Gammal, R. M., Maryam, N. 2015. Coralline Red Algae From The Early Miocene Qom Formation, Bagh Section, Northern Isfahan, Iran. Australian Journal of Basic and Applied Sciences, 9(33): 467-480
Hathout, N, H., Orabi, H. O., 1995. Contribution to the lithofacies, geochemistry and paleoecology of some Miocene – Pliocene exposures in Marsa Alam area, Red Sea coast, Egypt. Egyptian Journal of Geology, 39 (2): 769 – 792.
Hermina, M., Klitzsch, E., List, F. K. (1989). Stratigraphic Lexicon and Explanatory Notes on the Geologic map of Egypt 1: 500.000 – Conco Inc., 263p.
Hetzinger, S., Halfer, J., Riegel, B., Orta, L. G., 2006. Sediemtology and acoustic mapping of the modern rhodoliths facies on a non- tropical carbonate shelfs, Gulf of California, Mexico. Journal of Sedimentary Research, 76 (4): 670 – 682.
Imam, M. M., 1991. Geological studies of The Miocene Sequence at the area between Wadi El Tayiba and Wadi Sidri, West – Central Sinai, Egypt. Ph.D. thesis, Faculty of sciences, Cairo University, 265 pages.
Imam, M. M., 1996. Coralline red algae from the Middle Miocene deposits of Gebel Gushia, West – central Sinai, Egypt. N. Jb. Geol. Palaont. Abh. , 199 (1), 1–15, Stuttgart.
Imam, M. M., Refaat, A. A., 2000. Stratigraphy and Microfacies analysis of the Miocene Sequence in the area between Gabal Hammam Sayidna Musa and Wadi Abura, southern Sinai, Egypt. N. Jb. Geol. Palaont. Abh., 7: 385 – 409.
Issawi, B., Francis, M., El Hinnawy, M., Mahanna, A., El Deftar, I., 1971. Geology of Safaga – Qusier coastal plain and Rabab area, Egypt. Ann. Geological Survey of Egypt, 1: 1–20.
Johnson, J. H. 1955. LowerTertiary Corallinae algae from Trinidad, British West Indies. Eclogae Geol. Helv., 48 (1): 69 – 78.
Johnson, J. H. 1957. Calcareous algae from Saipan Mariana Islands, part 3. Paleont. U.S.Geol. Surv. Prof. Pap., 208E: 209 – 246.
Johnson, J. H. 1961. Fossil algae from Eniwetok, Funafuti, and Kita – Daito – Jima. Professional. Paper of U. S. Geoogical Survey, 260: 907 – 950.
Johnson, J. H. 1964. Miocene coralline algae from northern Iraq. Micropaleontology, 10 (4): 477 – 485.
Johnson, J. H. 1965. Tertiary red algae from Borneo. Bull. British Mus (Natural History), Geology, 11 (6): 257 – 280.
Khalil, S. M. and McClay, K. R. 2009. Structural control on syn-rift sedimentation northwestern Red Sea margin, Egypt. - Marine and Petroleum Geology, 26: 1018–1034.
Kheider, E. S., Felesteen, A. W. 1991. Neogene coastal Sabhas from the Red Sea marginal area, southern Egypt. Egyptian Journal of Geology, 34: 171 – 195.
Kora, M., Abdel-fattah, Z., 2000. Pliocene and Plio-Pleistocene macrofauna from the Red Sea coastal plain (Egypt): Biostratigraphy and biogeography Geologica et Palaeontologica 4 Abb., 2 Tab., 3 Taf.
Kora, M., Ayyad, A., El-Desouky, H., 2013. Microfacies and environmental interpretation of the Pliocene-Pleistocene carbonates in the Marsa Alam area, Red Sea coastal plain, Egypt. Journal of Environmental Sciences, 42 (1): 155 -182.
Littler, M. M., Littler, D. S., Hanisak, M. D. 1991. Deep water rhodoliths distribution, productivity, and growth form history at sites of formation and subsequent degradation. Jorunal of Marine Biology and Ecology, 150: 163 – 182.
Pettijohn, F. J., 1975. Sedimentary rocks - Third edition, harper and Row, New York, 286p.
Pillar, W.E., Rasser, M., 1993. Reef related rhodoliths formation in the Northern Bay of Safaga, Red Sea , Egypt. First Europ Reg Meeting, Vienna, Abstact 47.
Pillar, W.E., Rasser, M., 1996. Rhodoliths formation induced by reef erosion in The Red Sea, Egypt. Coral Reef, 15: 191 – 198.
Philobbos, E. R.; El-Haddad, A. A., Mahran, T. M., 1989. Sedimentology of syn-rift Upper Miocene (?)-Pliocene

sediments of the Red Sea area: A model from the environs of Marsa Alam, Egypt.- Egypt. J. Geol., 33 (1–2): 201–227.

Philobbos, E. R.; El-Haddad, A. A.; Luger, P.; Bekir, R. and Mahran, T. M., 1993. Syn-rift Miocene sedimentation around faultblocks in the Abu Ghusun-Wadi El Gemal area, Red Sea, Egypt.- Geol. Soc. Egypt, Spec. Publ.1, 115-142.

Mahran, T. M., 1990. Sedimentology and general stratigraphy of the Pliocene sediments of the Red Sea coastal area., Egypt. Ph. D. Thesis, Assuit University, 345p.

Mahran, T. M., 1996. Evolution of Quaternary rift sedimentsin relation to tectonic framework of the Egyptian Red Sea coastal Area, Egypt. Egyptian Journal of Geology, 40: 87 – 118.

Mahran, T. M. 2000. Cyclicity and sequence stratigraphy of syn-rift Late Neogene mixed carbonates-siliciclastics of the area between Wadi Zug El-Bohar and Wadi Dabr, Red Sea, Egypt.- Egypt . J. Geol., 44 (2): 237–275.

Mahran, T. M.; Philobbos, E. R.; Bekir, R., and Hassan, A., 1999. Facies, textural and mineralogical characterestics of syn-rift Oligocene (?)-Neogene siliciclastics south of Wadi Abu Ghusun, Red Sea coastal area: Implications to provenance and paleoclimate.- Egypt. J. Geol., 43 (2): 395–433.

Moussavian, E. & Kuss, J., 1990. Typification and status of *Lithothamnium aschersonii* Schwager, 1883 (Corallinaceae, Rhodophyta) from the Paleocene limestones of Egypt. A contribution to the synonymy and priority of the genera *Archeolithothamnium* Rothpletz and *Sporolithon* Hedydrich. Berliner geowissenschaftliche Abhandlungen, 120: 929 – 943.

Mu, X. 1991. Fossil Udoteaceae and Gymnocodiaceae. In Riding, R. (Ed.) - calcareous Alagl and Stromatolites. Springer, 146 – 166, Berlin

Nebelsick, J., Kroh, A. 2002. The stormy path from life to death assemblages: The Formation and preservation of Mass accumulations of fossil sand dollars, Red Sea area, Egypt*.* Palaios, 17: 378 – 393.

Nebelsick, J., 1992. Echinoid distribution by fragment identification in the Northern Bay of Safaga, Red Sea. Palaios, 7: 316 – 328.

Nebelsick, J., Rasser, M. W., Bassi, D., 2003. The Development of Facies Patterns of Middle Eocene to Lower Oligocene Circum-Alpine, Shallow Water Carbonate Environments. In: Prothero, D.R. (ed.) Greenhouse to Icehouse: The Marine Eocene-Oligocene Transition (Columbia Univ. Press).

Philobbos, E. R., El Haddad, M. 1983. Tectonic control on Neogene sedimentation along the Egyptian part of the Red Sea Coastal area. 5th Inernational Conference on the basement tectonics, Cairo (Abstract).

Philobbos, E. R., El Haddad, M; Luger, P., Bekir, R. & Mahran, T., 1993. Synrift Miocene sedimentation around the fault blocks in the Abu Ghusun – Wadi El Gemal area, Red Sea coast, Egypt. Egyptian Geological Society, Egypt*,* Spec. Publ., 1: 115 – 141.

Rasser, M., Piller, W. E., 1994. Re- documentation of Paleocene coralline red algae of Austria, described by Lemoine (1930*).* Beitrage zur Palaontologie, 19: 219 – 225.

Said, R., 1990. Cenozoic. In: Said, R. (Ed.), The Geology of Egypt. A. A. Balkema, Rotterdam, pp. 451 – 486.

Sakar, S., Ghosh, A. & Rao, G. 2016. Coralline algae and benthic foraminifera from the long formation (middle Miocene) of the Little Andaman Island, India: Biofacies analysis, systematics and palaeoenvironmental implications, Journal of Geological Society of India, 87(1):69-84.

Souaya, F. J. 1963a. Micropaleontology of four sections south of Qusier, Egypt, Micropaleontology, 9 (3): 233 – 266.

Souaya, F. J. 1963b. On the calcareous algae (Melobesoideae) of Gebel Genefe (Cairo – Suez road) with local zonation and some possible correlations. Journal of Paleontology, 37 (6): 1204 – 1216.

Steneck, R. S., 1985. Adapation of crustose coarlline algae to herbivory: patterns in space and time, In: Toomey, D. F. & Nitecki, M. H. (eds.), Paleoalgology Contemporary research and applications, 352 – 366, Springer Verlag, Berlin.

Verhij, E. 1993. The genus Sporolithon (Sporolithaceae fam. Nov., Corallinales, Rhodophyta) from the Spermonde Archipelago, Indonesia. Phycologia, 32: 148 – 196.

Wehrmann, A., Freiwals, A., Zanki, H. 1995. Formation of cold – temperature water multispecies rhodoliths in intertidal gravel pools from Northern Brittany, France. Senckenbergiana maritima 26 (1–2): 51 – 71. Frankfurt.

Woelkerling, W. J. 1988. The Coralline Red Alage: An Analysis of the Genera and subfamilies of the Nongeniculate Corallinaceae. Oxford University Press, 268pp.

Woelkerling, W. J., Irvine, L. M., Harvey, A. S., 1993. Growth forms in non - geniculate coralline red algae (Corallinales, Rhodophyta). Austeralian Systematical Botany, 6: 277 – 293.

Wray, J. L., 1977. Calcareous algae. Elsevier Scientific, Amsterdam. 185pp.

Youssef, E. A. A., Abu Khadra, A. M., 1984. Lithofacies and paleoecology of Gabal El Rusas Formation, Marsa Alam area, Red Sea coast, Egypt. Egyptian Journal of Geology, 28: 314 – 319.