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LITHOFACIES, SEQUENCE STRATIGRAPHY AND DEPOSITIONAL HISTORY OF THE ABU GHUSUN AND UM MAHARA FORMATIONS (OLIGO-MIOCENE) AT RAS BANAS, RED SEA COAST, EGYPT

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ABSTRACT

In Ras Banas Peninsula, two rock units represent the Oligocene to Lower Middle Miocene rocks, the Abu Ghusun Formation at the base and the Um Mahara Formation at the top. The Abu Ghusun Formation consists of fining-upward cycles, each of which starts with polymictic conglomerate, capped by litharenites. These cycles were deposited under fluvial system during the initiation of Red Sea rift. The Um Mahara Formation includes two depositional sequences. Each sequence involves transgressive systems tract at the base and highstand systems tract at the top. In both depositional sequences, the transgressive systems tracts consist of emergence (shallowing-upward) cycles that are made up of lime-mudstone, foraminiferal wackestone, capped by skeletal bioclastic packstone, algal and / or foraminiferal packstone. These cycles were deposited in shallow subtidal environment, indicating slow vibration in sea-level changes. On the other hand, the highstand systems tracts are composed of peritidal cycles, each of which begins with, lime-mudstone, foraminiferal wackestone, capped with dolomicrite and dedolostone. These cycles were deposited in shallow subtidal to supratidal zones. This indicates high vibration in sea level, where the rate of sedimentation was faster than the rise in sea level. The relation between sea-level changes and sedimentation rates are described in terms of gradual and non-gradual cycles.

1. INTRODUCTION

The Ras Banas Peninsula extends for about 50 km. in a west-northwest-east-southeast direction attached with the Red Sea with an average width of about 8.km (Fig.1).The name of this peninsula was attributed to the Sheikh Banas (Morocco nationality), who lived for some time in this area. The peninsula covers a total area of about 400km² and is occupied by the Precambrian basement rocks from its southwest side and the sedimentary rocks in the northeastern side (Fig.1).The basement rocks form chains of hills, in southeast end of the peninsula which hidden in the subsurface further to the southeast end of the peninsula (Pl.1-A). The basement rocks were most probably forming a submarine high before the deposition of the Miocene rocks. Later, during the uplift tectonics had affected some parts of the peninsula forming some flexures or rolls structures and gentle anticline; trending northeast-southwest direction. This caused the small embayment normal to the extension of the peninsula. Over the flexures crest, the sedimentary cover was eroded whereas in between these rolls structures, there are some gentle synclines in which the complete sequence was kept protected from denudation.

There are another two intrusions of basement within the sediments. The first phase produced black hills (may be basalt) having N50W, the southern east extension of such intrusion makes an emplacement of the Middle Miocene Abu Dabbab Formation. This intrusion cuts across the older main chain hills of basement rocks cutting the basal conglomerate zone between the

Abu Ghusun and Um Mahara formations. The third intrusion is intruded between the older chain hills and the Oligo- Miocene Abu Ghusun Formation, forming a narrow wadi trending in a northwest-southeast direction.

The Ras Banas Peninsula was mapped using aerial photographs scale 1: 40,000. Two stratigraphic sections have been measured, one section for the Abu Ghusun Formation and the other for the Um Mahara Formation (Fig.1). About, fifty thin sections were prepared and studied under the petrographic microscope. The Ras Banas peninsula was rarely subjected to stratigraphic and sedimentologic studies before. Felesteen et al., (1994) studied the faunal content of the Neogene and Quaternary sediments at Ras Banas.

The main aim of this work is to study the lithofacies the Abu Ghusun and Um Mahara formations based on field and petrographic investigations. The cyclicity of these rock units is described to unravel the sea level changes during sedimentation. Moreover, the sequence stratigraphy and the depositional history of the studied rock units are also discussed. In the present work, an attempt is made to subdivide the carbonate depositional sequences of the Um Mahara Formation based on the presence of dolostones and dedolostone instead of using another clues (e.g. paleokarsts, hard ground, paleosols, caliches and duricrust).

2. LTHOSTRATIGRAPHY

The sedimentary sequences that cover Ras Banas peninsula range in age from Oligo-Miocene up to the Pliocene-Pliestocene. The Oligocene-Lower Middle Miocene rocks that are the main target of this study are subdivided into two rock stratigraphic units, the Abu Ghusun Formation at the base and the Um Mahara Formation at the top (Pl.1.A).

Akkad and Dardir (1966) first described the Abu Ghusun and Um Mahara formations as one rock unit under the term Gebel El Rusas Formation. Later on, Tewfik and Burrough (1976) subdivided the Gebel El Rusas Formation into two units, the lower is clastic unit and the upper is carbonate unit. The lower clastic unit was named the Abu Ghusun Formation while the upper carbonate unit was named the Um Mahara Formation (Samuel and Saleeb-Roufaiel, 1977). Several authors used the terms Abu Ghusun and Um Mahara formations during their stratigraphic studies on the Red Sea coast, such as El Bassyony (1982), Philobbos El Haddad (1983), Said(1990), Philobbos et al. (1986,1993), Purser and Philobbos (1993) and El Shater and Philobbos(1998).

2.1. Abu Ghusun Formation: (Oligo-Miocene)

The type section of the Abu Ghusun Formation lies at Wadi Abu Ghusun south of Mersa Alam (about 70m thick). This formation was studied in different parts along the Red Sea coast especially south of Wadi Abu Ghusun by Philobbos et al.(1993), and Maharan et al.(1999).At these localities, this formation either nonconformably overlies the Precambrian basement rocks or unconformably underlies the Cretaceous-Tertiary rocks and unconformably underlies the Lower Miocene Ranga Formation or the Lower-Middle Miocene Um Mahara Formation(El Shater and Philobbos,1998).

In the investigated area, the Abu Ghusun Formation nonconformably overlies the Precambrian basement rocks (Fig.2). The upper contact also unconformably underlies the Um Mahara Formation. The lower unconformable contact of the Abu Ghusun Formation consists of polymictic conglomerate that comprises pebbles-sized lithoclasts derived from the basement and volcanic rocks (Fig.2). The upper unconformable contact is represented by reddish and dark brown lithoclasts in the form of discontinuous conglomerate zone that shows uprubt change

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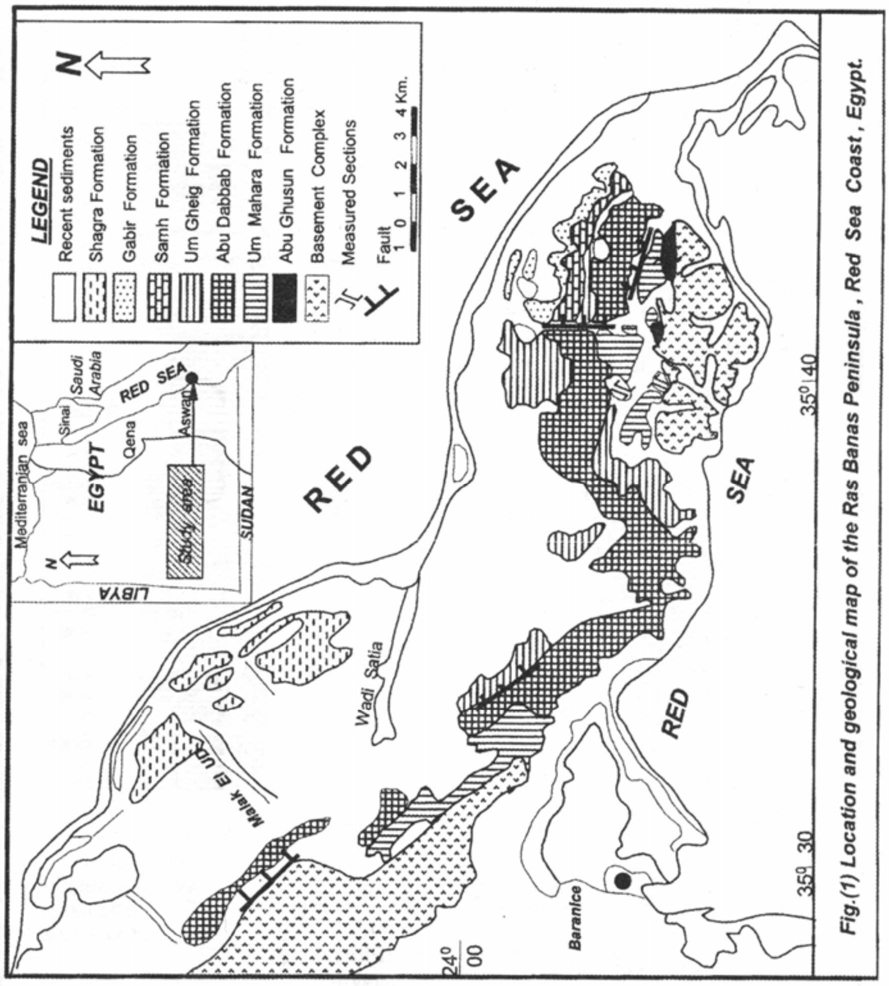

Fig.(1) Location and geological map of the Ras Banas Peninsula , Red Sea Coast , Egypt.

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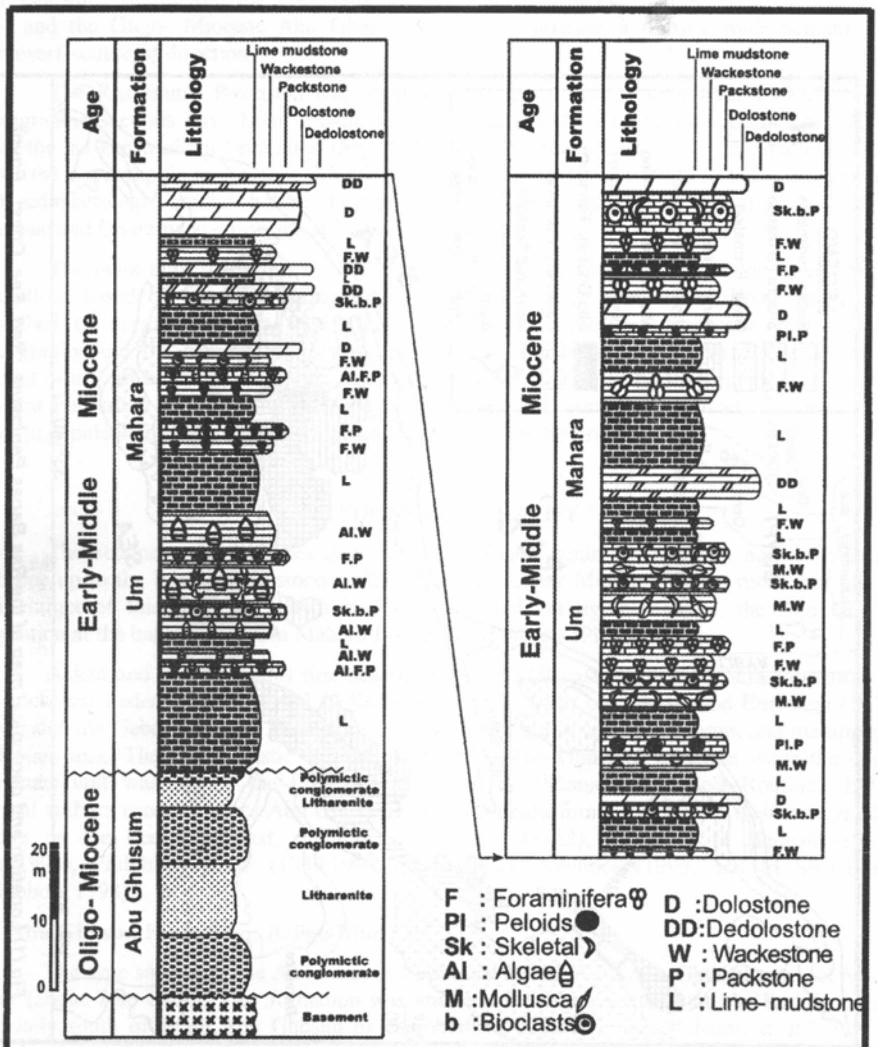

Fig.(2) Lithofacies associations of the Abu Ghusun and Um Mahara formations at Ras Banas Peninsula.

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... Abu Dabbab Formation. This intrusion cuts across the older main chain hills of basement rocks cutting the basal conglomerate zone between the between the lower continental sediments (Abu Ghusun Formation) and a marine facies (Um Mahara Formation) (Fig.2). The Abu Ghusun Formation consists exclusively of fluviatile red sandstones and pebbly-sized conglomerate derived mainly from the basement rocks. The conglomerate comprises rounded to angular pebble-sized lithoclasts. These lithoclasts that are embedded in a red-brown sandy clay matrix occur above the basement rocks. The sandstone is made up of quartz, rock fragments that are poorly sorted, massive and cemented by red matrix. The intercalation of conglomerates and sandstones exhibit a sort of fining upward cycles. In the studied area, the thickness of the Abu Ghusun Formation is about 30m.

2.2. Um Mahara Formation: (Early-Middle Miocene)

Samuel and Saleeb-Roufaiel (1977) were the first to introduce the term Um Mahara Formation in the stratigraphic sequence of the Miocene rocks in the Red Sea coast. The Um Mahara Formation is equivalent to the upper carbonate unit of Twefik and Burrough (1976) and the Abu Hamra Formation of El Bassyony (1982). Later, El Bassyony (1982) further distinguished the coralline limestone beds, the remnants of which overlie the basement rocks in many areas in the south into a separate rock unit which is termed the Ghadir Formation. In the opinion of Said (1990) the Ghadir Formation is considered a part of the Um Mahara complex. The Um Mahara Formation rests unconformably over the Abu Ghusun Formation. The unconformity zone consists of a conglomerate bed (Fig.2) that ranges in thickness in the study area from 2.m-to5.m.The conglomerate bed comprises polymictic pebbly-sized rock fragments or lithoclasts, most of which are composed of igneous and metamorphic lithoclasts with some minerals associations such as feldspars and quartz. .Laterally, the conglomerate bed wedges out where the basal part of the Um Mahara Formation directly overlies the reddish sandstone facies of the Abu Ghusun Formation. The upper boundary of the Um Mahara Formation shows sharp contact to uneven surface with the evaporites of the overlying Abu Dabbab Formation. The maximum thickness of this unit is 181m. at the Abu Ghusun area (Samuel and Saleeb-Roufaiel, 1977). In the studied area, the thickness of this unit is about 175m. The unit thins out towards the north and assumes a thickness of 60m at Um Gheig area. In Wadi Essel, this rock unit measures about 27m in thickness (Issawi et al., 1971). Lithologically, the Um Mahara Formation consists mainly of limestones, dolostones and dolomitic limestones. They vary in colour from yellowish-grey to dark grey. The formation contains mega fauna of different genera of mollusks and corals which assign the age of this formation to the Middle Miocene (Siad, 1990).

3. LITHOFACIES ASSOCIATIONS

The studied rocks of the Miocene sediments at Ras Banas area were examined under the polarized microscope using the Alizarine Red–S stain. They were classified into twelve lithofacies. Two lithofacies of them are clastics and the rest consists of carbonates lithofacies. The terminology of Pettijhon (1975), Dunham (1962) and Friedman (1965) are used in the petrographic description.

3.1. Clastic lithofacies:

3.1.1. Polymictic conglomerate lithofacies:-

This lithofacies forms the basal parts of the submergence or fining-upward depositional cycles of the Abu Ghusun Formation, its thickness ranges from 5m to 6m (Fig.2). Rocks belonging to this lithofacies are yellow, grey, and reddish-brown in colour, with pebbly sized lithoclasts. The rock is composed mainly of rock fragments or lithoclasts, and binding materials. The rock fragments range in size from granule to pebbly-sized. They are composed of both igneous and metamorphic rocks. Few of which consist of basaltic rocks. Most of these lithclasts are poor to fair sorted. Feldspars that are essentially plagioclase are altered to sericite, epidot and clay minerals. The matrix is iron oxides, fine-grained quartz and mudstone.

Interpretation: As this lithofacies consists of polymictic conglomerate and is massive without sedimentary structures, this suggests that they were deposited an alluvial fan regime. They were eroded from the basement rocks especially during active tectonic movements. This is in harmony with Steel and Thompson (1983) who suggested that a coarsening-upward succession is deposited immediately after fault movements. In addition, coarse clastics could be formed only when tectonics have created sufficient relief to generate coarse detritus (Sopena and Sanchez-Moya, 1997). The presence of iron oxides matrix gave the reddish colour of the lithofacies. The reddish colour is the result of oxidation of iron minerals during percolation with of water.

3.1.2. Litharenite lithofacies:

This lithofacies constitutes the tops of submergence or fining-upward cycles in the Abu Ghusun Formation. .Its thickness ranges from 5m to 7m. The rock is massive, hard with veinlets of clays. It has yellowish brown, red and grey colour. The rock comprises quartz (60 %), rock fragments (20 %), feldspars (7 %) and matrix (13 %)(Pl.1.C). The majority of quartz grains are angular to subrounded, monoctystalline to polycrystalline, with different types of inclusions. Few grains show wavy extinction. Quartz grains range in size from very coarse to fine sand-sized and is randomly distributed. The contacts among quartz grains are serrated and concavo-convex. Rock fragments range in size from granule to pebbly-sized and are moderately well rounded and fair sorted. Most of them were derived from the basement rocks. .

Feldspars are essentially plagioclase minerals. They vary in size from fine to coarse sand-sized and angular to subrounded. Most of these grains are altered to sericite and kaolines. The binding material between the quartz, rock fragments and the feldspar grains are composed of fine-grained, reddish-brown, ferruginous materials. These materials are hematite, giving its reddish appearance.

Interpretation: This lithofacies was deposited in a fluvial environment forming the end of depositional cycles. This is evidenced by the poor sorting, immaturity in compositions and texture. The poor sorting is indicative of short distance of transportation from the source area. The presence of coarse-grained feldspars is a good indicator for a dry climate that dominated during their separation from source rocks and their transportation. This interpretation is in harmony with Mahran et al., (1999) who mentioned that the Abu Ghusun Formation at Wadi Abu Ghusun contains unstable heavy minerals (pyroxenes and amphiboles) that indicate arid climatic conditions. Moreover, the dominant reddish colour of this lithofacies indicates oxidation of the associated iron oxide minerals in the subaerial zone. In general the litharenite can be deposited during flash floods or by braided streams. This occurred when fault movement decreased or even ceased, where large volumes of reworked coarse, well rounded clasts, were introduced by streams from mature source areas (Sopena and Sanchez-Moya, 1997).

3.2. Carbonates lithofacies

Limestone lithofacies constitutes the entire sequence of the Um Mahara Formation, most of which are lime mudstones, wackestones, packstones, and dolostones lithofacies.

3.2.1. Lime-mudstone:(L)

This lithofacies is widely distributed in the Um Mahara Formation. It usually occurs at µdolostone or dedolostone lithofacies (Fig.2). The lime- mudstone ranges in thickness from 2.5 m. to 4.m. Rocks belonging to this lithofacies are grey, porous, lithoclastic with black patches of manganese and vertical gypsum veinlets, fine grained and compact.

The rock comprises mainly of fine-grained microcrystalline calcite (micrite with less than 4µm) This lithofacies is widely distributed in the Um Mahara Formation. It usually occurs at dolostone or dedolostone lithofacies (Fig.2). The lime-mudstone ranges in thickness from 2.5 m. to 4.m. Rocks belonging to this lithofacies are grey, porous, lithoclastic with black patches of manganese and vertical gypsum veinlets, fine grained and compact.

This lithofacies is widely distributed in the Um Mahara Formation. It usually occurs at dolostone or dedolostone lithofacies (Fig.2). The lime- mudstone ranges in thickness from 2.5 m. to 4.m. Rocks belonging to this lithofacies are grey, porous, lithoclastic with black patches of manganese and vertical gypsum veinlets, fine grained and compact. Aggrading neomorphism to microspars, pseudospars and sparry calcite (Pl.1.D) has changed micrite. In some parts, microsparry calcite and blocky calcite were recognized near fissures and cracks. The microspar crystals decrease in size away from dedolostones

The lime-mudstone which consists of microspars, show dark grey colour on their outer surfaces (Pl.1.D). The crystals are inequigranular and their outer borders are usually irregular, curved and rarely straight. Rare fragments of shell debris are observed, most of which are derived from molluscs, echinoids, algae and corals. Some fine-grained dolomite rhombs are scattered randomly within the lime-mud. They are inequigranular in fabric and xenotopic to hypidiotopic in texture. Some alabastrine gypsum occurs in fissures and cracks, replacing the lime-mud and dolomite. Few siliceous patches are recorded; they consist of chalcedony and micro-quartz grains. They are mostly replaced the lime-mud.

Interpretation: The massive lime-mudstone lithofacies was probably deposited in shallow subtidal marine environment, where carbonate particles accumulated in quiet water. However, thin laminated lime-mudstone beds accumulated in moderated energy conditions (El-Tabakh and Aroon, 1998). The large proportion of the fine-grained carbonates and the absence of conclusive evidence for the grain-supported features suggest an environment that was relatively quiet, below wave-base and sheltered from current activity (Mossler, 1973). The scattered distribution of fine–grained dolomite within the lime-mud indicates a local post depositional dolomitization process. The Mg ions may be segregated from the lime-mud or its recrystallization may have led to selective dolomitzaton (Khalifa, 1981). In some instances Mg ions released from some clay minerals can gave rise to selective dolomitization (Kahle, 1965)

3.2.2. Wackestone lithofacies:

The wackestone lithofacies is widely distributed in the Um Mahara Formation. It usually overlies the lime-mudstone lithofacies in the emergence cycle (Fig.2). It comprises three lithofacies as follows: -

3.2.2a.Algal wackestone lithofacies :(Al.W)

Algal wackestone is encountered in the lower part of the Um Mahara Formation and is represented by four beds, each of which ranges in thickness from 2.m. to 5.m. This lithofacies usually occurs in the middle part of emergence cycles, overlying the lime mudstone and underlies the packstone lithofacies. The rock is pale grey, with some black spots, fossiliferous with algae and massive.

The rock consists of algae (20 %) as skeletal particles embedded in micrite binding material (Pl.1.E). There are various types of algae that can be observed such as crustose coralline algae and articulate coralline algae which are represented by *Archaeolithothamnium sp. Amphiroa sp. and Corallina sp.* Large unbroken algae up to 2cm in diameter are common. Other types are fragmented (fine sand-sized) and mostly micritized (Pl.1.E). Some of which are obliterated so that no original structures are preserved and they now consist of sparry calcite mosaics enveloped by micrite. Few bioclasts are noticed which were derived from crinoids, bryozoans and molluscs, The binding material between the different types of algae is micrite which has been undergone to microspar due to aggrading neomorphism.

Interpretation: This lithofacies was probably deposited in restricted shallow marine conditions due to the common occurrence of algae. The presence well preserved algae suggests that most of these fossils had not been transported for long distances. The abundance of lime-mud matrix suggests low energy in the site of deposition. The low energy and quiet water is supported by, 1) the high mud content and minor amount of grain-supported sediments;2) the general poor sorting and 3) the unbroken algal tests lying parallel to bedding and with common micrite envelopes on their outer borders (Welch, 1977). The occurrence of micrite envelopes around the particles proves the action of poring algae and fungi that are common in restricted water. The faunal assemblage reflects warm and relatively saline water.

3.2.2b. Molluscan wackestone lithofacies :(M.W)

Molluscan wackestone lithofacies occurs in three beds in the upper part of the Um Mahara Formation. Each of these beds has an average thickness of about 2.5m and usually occurs in the middle part of cycles (Fig.2). Rocks belonging to this lithofacies are yellowish-grey, marly, chalky, with large-sized molluscs (pelecypods), compact and hard. The rock consists mainly of skeletal particles and micrite as matrix. Pelecypods are the main skeletal particles forming about 30 % of the rock. They are elongate, curved and. most of which, if not all, have been recrystallized into microspars and pseudospars due to aggrading neomorphism (Pl.1.F). In some parts, pelecypods show preferred orientation parallel to the bedding planes. Some echinoid plates and stems are recorded, few of which are partially micritized along their margins. Fine-grained bioclasts of different organisms are noticed. The binding material is micritic matrix that was subjected to aggrading neomorphism giving clear patches of microspar and pseudospar.

Inerpretation: The presence of pelecypods indicates open marine environment, with normal marine salinity (Milliman et al., 1972). The high abundance of micrite indicates deep subtidal water depth, below the wave base, with dominant quiet water condition. The presence of numerous skeletal debris in the lime-mud matrix proves that they were fragmented and reworked from nearby source of carbonate banks.

3.2.2c.Foraminiferal wackestone lithofacies :(F.W)

This lithofacies has a wide distribution throughout the Um Mahara Formation, and is recorded at the basal, middle and upper parts of the emergence cycle (Fig.2). The rock is greyish-yellow, marly, porous, fossiliferous, fine grained, compact and hard. The rock consists mainly of skeletal particles represented by foraminifera, ostracods, and algae with dolomite and micrite as matrix. The foraminifera form about 15 % of the rock represented by benthonic and planktonics. The benthonic foraminifera are represented by miliolids (triloculina and quinqueloculina)(Pl.2.A). Many of these particles, if not most are micritized and scattered randomly within the lime mud matrix. The Planktonic foraminifera are very fine sand-sized, represented by globigerinoides. Rare ostracods and algae are recorded. ostracods occur as broken valves and many of which were micritized. Algae are fragmented and micritized. The dolomite rhombs that occur within the matrix range in size from 60um to 80um. Most of them are idiotopic to hypidiotopic in texture, their nature of occurrence in the lime-mud suggest that they selectively replaced certain parts in the matrix.

Interpretation: This lithofacies contains miliolids that are indicative of very shallow water with hypersaline affinity. They are recorded in interdial (backshore and foreshore) in the Quaternary sediments at Sharm El Sheikh (Khalifa, 2003). Moreover, miliolid particles are recorded in the bank interior facies (Lower Eocene Farafra Limestone) at El Quss Abu Said syncline indicating restricted marine condition (Khalifa and Zaghloul, 1990). Algae and ostracods indicate shallow subtidal to restricted lagoonal environments. The dominance of mictitization of most particles suggests the quiet condition and the activation of borer algae and fungai (Bathurst, 1975).The presence of few planktonic foraminifera indicates, some possible blooms coming from deeper

microspar due to aggrading neomorphism.