Stratigraphical and Sedimentological Study of Fat'ha Formation in W&SW of Mosul City, North of Iraq

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Abstract

Fat'ha Formation characterized by it's wide distribution in Iraq, which is mainly consist of gypsum, limestone and Green marl. Sheik Ibrahim and Atshan (Hammam Al-Elil) anticlines W&SW of Mosul city, were selected for study, in which this formation is well exposed and with considerable thickness. One hundred rock samples were collected from the above two areas. The microscopic examination of 90 thin sections from limestone layers revealed the presence of the following genus: (*Ammonia, Elphidium, Quinqueloculina, Triloculina, Pyrgo, Spiroloculina, Austrotrillina, Borlis, Peneroplis, Praerhaphdionina, Discorbis, Nonion, Textularia).* These assemblages are more likely indicating the lagoonal and shallow water depositional environments.

The petrological studies suggest that although Fat'ha Formation in both area deposited in shallow, semi-restrict basin, and most probably developed under an arid climate, but Atshan area (Hammam Al-Elil basin) received more terrigenous clastics than Sheik Ibrahim.

دراسة طباقية ورسوبية لتكوين الفتحة جنوب وجنوب غرب مدينة الموصل– شمال العراق

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الخلاصة

تكوين الفتحة يمتاز بانتشاره الواسع في العراق، يتالف هذا التكوين اساساً من الجبس والحجر الجيري والمارل. مئة نموذج جمعت من جبل ابراهيم وعطشان (حمام العليل) جنوب وجنوب غرب الموصل حيث يتكشف هذا التكوين بسمكات جيدة. الفحص المجهري لتسعون شريحة محضرة من الحجر الجيري اظهرت وجود الاجناس الاتية *Ammonia, Elphidium, Quinqueloculina, Triloculina,*

Pyrgo, Spiroloculina, Austrotrillina, Borlis, Peneroplis, Praerhaphdionina, Discorbis, Nonion, Textularia . هذه المجاميع الحياتية تشير الى سيادة البيئة لبحرية الضحلة واللاغونية، كما اشارت الدراسة الضحلة شبه المختلفة والمناخ القاحل، الا ان منطقة جبل عطشان كانت تستلم مواد فتاتية اكثر من منطقة جبل شيخ ابراهيم.

Introduction

Lower Fars Formation was originally described in Iran by Busk and Mayo (1918) cited in Bellen *et.al* (1959). Later the name Gachsaran Formation was used as an alternative to the earlier name after its type locality chosen in southwest Iran, during the nineteenth of the last century(Jemes and Wynd,1965), Fat'ha was used instead of lower Fars owing to its exposure with large thickness in Fat'ha area northern Iraq (Al-Rawi *et. al*,1993). It comprised rhythmic alternation of green marls, limestone, gypsum or anhydrite and red mud with rock salt in central of the basin. It is also characterized by its cyclic sedimentological regime; based on the large exposure thickness and the completeness of sedimentological cycles, Two surface sections were selected, the first one is from Atshan near Hammam Al-Elil city with total thickness about175 m and the second from Jabal Sheikh Ibrahim with total thickness about (470 m)(Fig.1).

Fat'ha Formation has a wide geographic extent in Iran, Kuwait, Arabia Soudia Syria and Iraq, particularly it represents the most conspicuous formation in Mosul area, northern Iraq. Lithologically, It's characterized by its evaporatic sequence, which is mainly composed of gypsum, limestone and red to green marl, with essential rock salt occurrences at the center of its depositional basin. Al-Naqib, (1959) and Buday (1980) illustrated that Fat'ha Formation was laid down in a semi-closed basin developed under a semi-arid condition. It is disconformably underlain by Euphrates/Jerbi Formations (L.Miocene), and conformably overlain by Injana Formation (U.Miocene) .

Based on the some distinctive invertebrate Fauna like *Ostrea latimarginata*, Fat'ha Formation is considered to be Middle Miocene in age

(Al-Naqib,1959 and Buday,1980) and L.- M. Miocene depending on *Miogypsina* sp. by Al-Omari and Sadik (1972).

Although the stratigraphy and sedimentology of Fat'ha Formation has been well studied, it is still need more detail investigations owing to its wide geographic extent, lateral facies change and the progress growing of economic importance. Therefore, the scope of this study is to subdivide the Fat'ha Formation in both studied area according to their lithology and faunal contents.

The present study aimed to determine the faunal content and the sedimentary environment of Fat'ha Formation.

Geologic setting

The most diagnostic feature of Fat'ha Formation is the repetition or cyclicity of its lithological units. The cyclicity is generally attributed to tectonic, climate and sedimentary control (Mustafa, 1980; Sulyman,1990 and Tucker, 1999). Based on Mustafa (1980), the repetition in the Fat'ha Formation is related to a symmetrical type (i.e.) rhythmic. The ideal complete cycle of Fat'ha sediments consist of green marl, limestone, gypsum and red mud.

The present repetition in lithology reflects the nature of depositional regime of Fat'ha Formation which was governed by alternating period of desiccation and influx of seawater (Bellen *et al.*, 1959). On the other hand, Mustafa (1980) believed that the intermittent tectonic movements seem to be the most favorable mechanism to explain the cyclicity in Fat'ha Formation deposits, since such pattern is associated with unstable depositional area.

Methodology

To conduct the present study, two lithological surface sections were selected from Atshan and Sheik Ibrahim anticlines where Fat'ha Formation exposed with considerable thickness (Fig1). From structural point of view,

the above two anticlines were doubly plunging, with an axes running approximble NW-SE. They are located on the boundary of the folded zone of northern Iraq.

The fieldwork comprises the description of various lithological units including; thickness, color, grain size, sedimentary structures and faunal contents. Furthermore 100 samples were collected from the carbonate rocks for the sedimentological and paleontological investigations. To achieve the microfacies study, 90 thin sections were prepared, for examination with aid of polarized microscope.

A- Stratigraphy

1. Lithostratigraphy

Many stratigraphic subdivisions were proposed for Fat'ha Formation In Iraq.

Fat'ha Formation has been divided according to presence or absence of red sediment into two member, Lower member and Upper member by many workers as Abdul Karim(1976),Al-Mubark & Youkhana(1977), Mohi Al-dine *et al.*(1977), they also divided it into five limestone marker beds; the marker beds (1,2)represented lower member and marker beds (3,4,5) represented the upper member of the Formation(Maa'la *et al.*,1988), in the present study these division was adopted.

Fat'ha Formation was exposed for most of foot hill zone, with the maximum thickness reaches 700m in central deposition of Sinjar basin and decreasing toward the edges of the basin (Fig 2)

Owing to the absence of any complete section in Hammam Al-Elil section, due to the accumulation of slope sediments and scree, which hidden part of Fat'ha Formation, we are forced to use composite sections (Fig 1). The sediment of this formation is composed of cyclic alternation of marl, limestone and gypsum, which generally characterize by cyclicity. The cycles are either complete or incomplete, the incomplete cycles usually lacking one of its lithologic units.

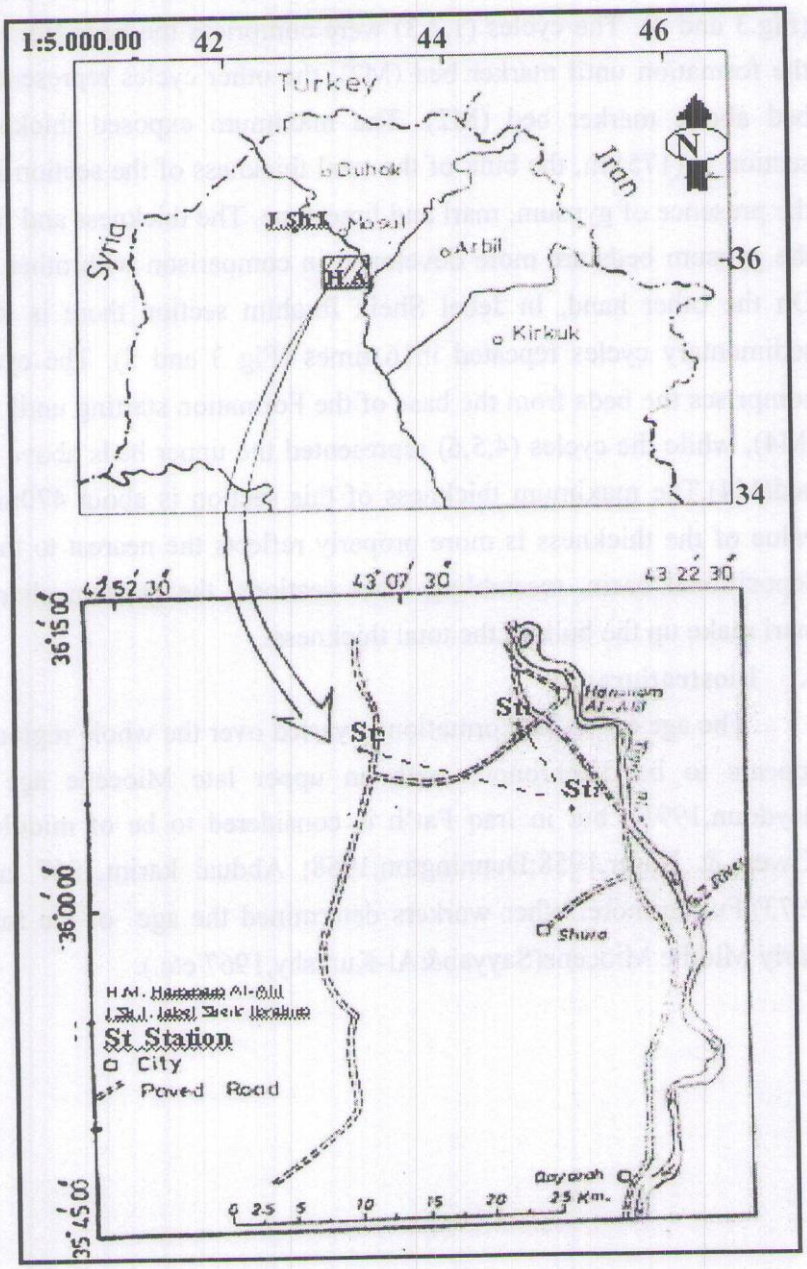


Fig.(1)study area (after Maa'la *et al.*,1988)

In Hamam Al-Elil section, (12) sedimentary cycles were observed (Fig.3 and 4). The cycles (1,2,3) were comprises the beds from the base of the formation until marker bed (M2), the other cycles represents the upper bed above marker bed (M2). The maximum exposed thickness of this section is (175) m, the bulk of the total thickness of the section is shared by the presence of gypsum, marl and limestone. The thickness and frequency of the gypsum beds are more developed in comparison with other lithologies. On the other hand, In Jebel Sheik Ibrahim section there is six types of sedimentary cycles repeated in16 times (Fig 3 and 5). The cycles (1,2,3) comprises the beds from the base of the Formation starting until marker bed (M4), while the cycles (4,5,6) represented the upper beds above the marker bed(M4).The maximum thickness of this section is about 470m. The high value of the thickness is more properly reflects the nearest to the center of depositional basin, resembling other sections, the gypsum alternated with marl make up the bulk of the total thickness.

2. Biostratigraphy

The age of Fat'ha Formation is varied over the whole region, The base appears to be diachronous with an upper late Miocene age in Iran (Beydoun,1991), but in Iraq Fat'h is considered to be of middle Miocene (Owen & Naser,1958;Dunnington,1958; Abdual karim,1967 and Abawi, 1973),Furthermore, other workers determined the age of the formation in Early Middle Miocene(Sayyab&Al-Kureshy,1967 etc.).

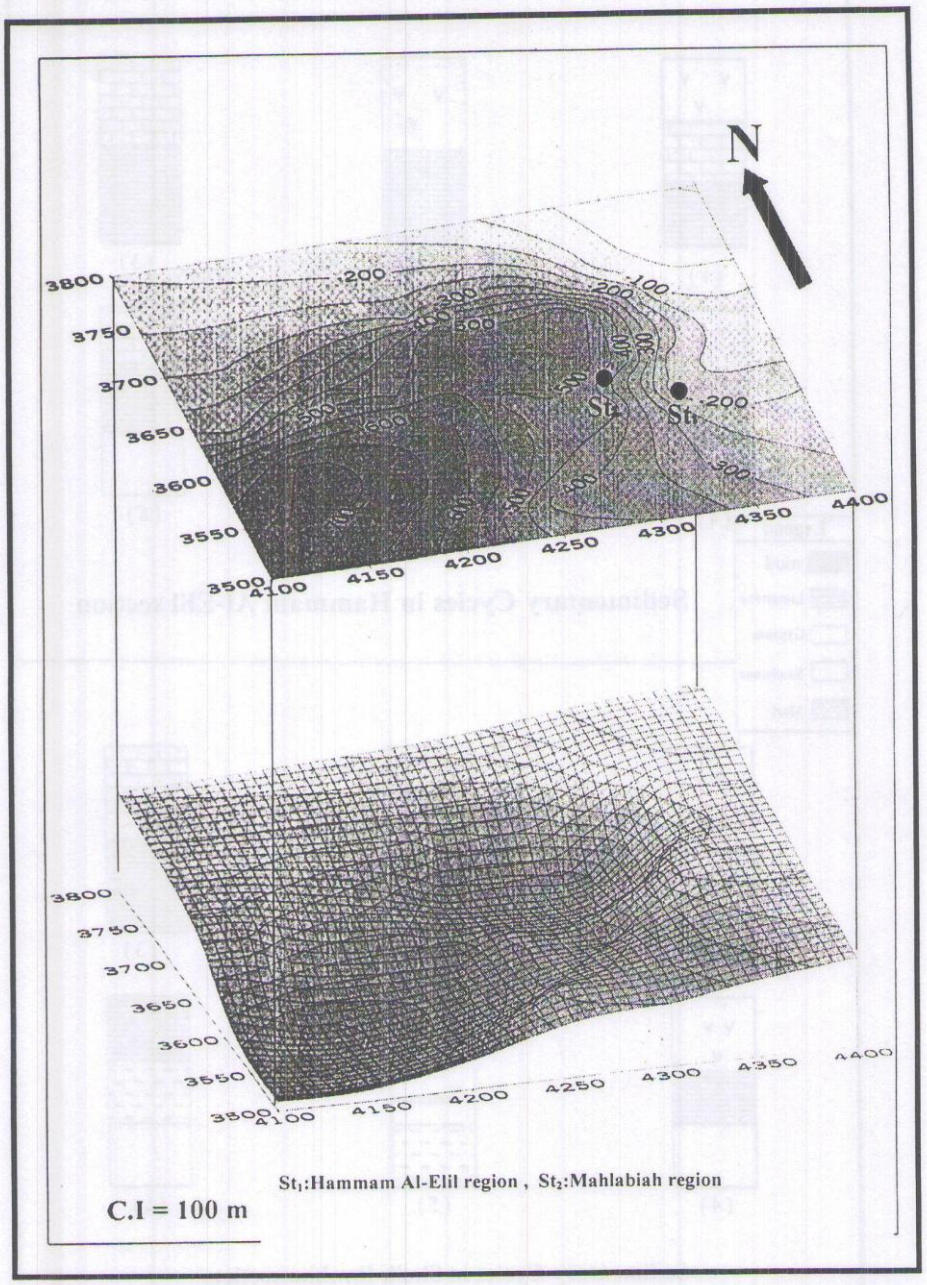


Fig. (2) Isopach map for Fatha Formation in Sinjar Basin depending on data of Mustafa,1980

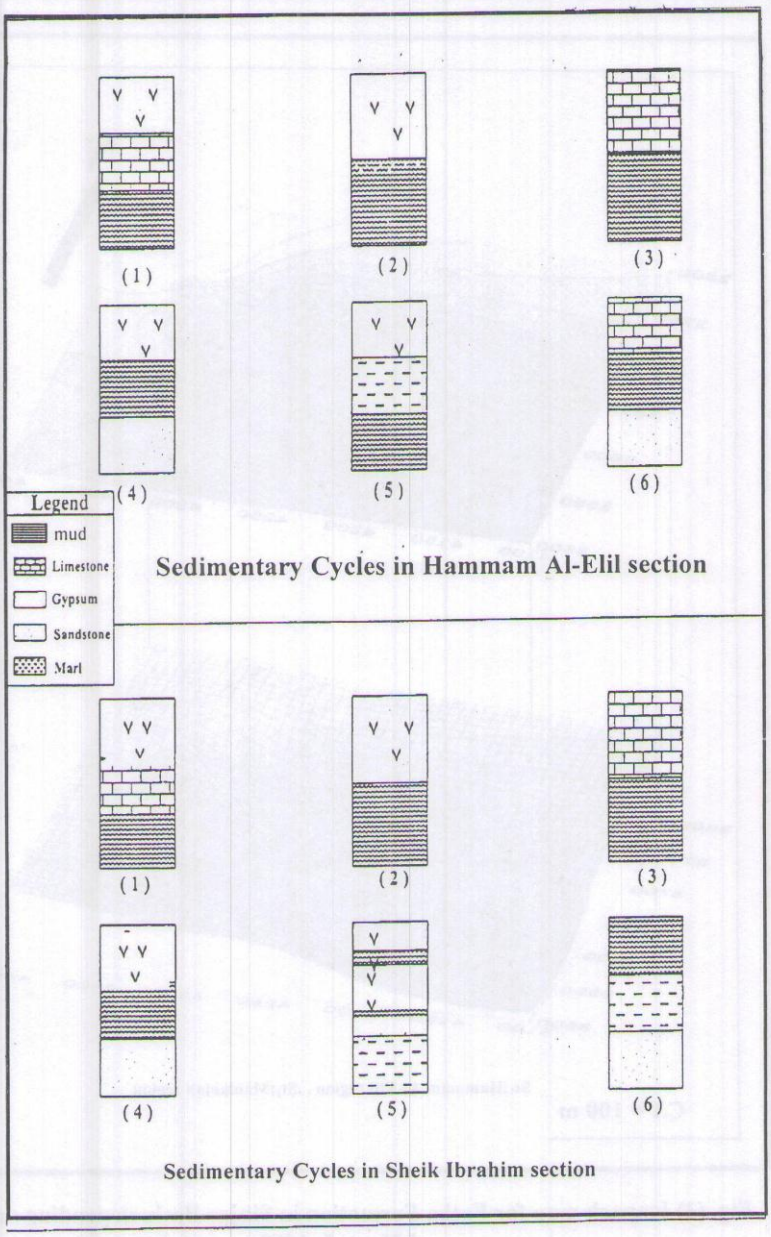


Fig (3)Types of Sedimentary Cycles in study area

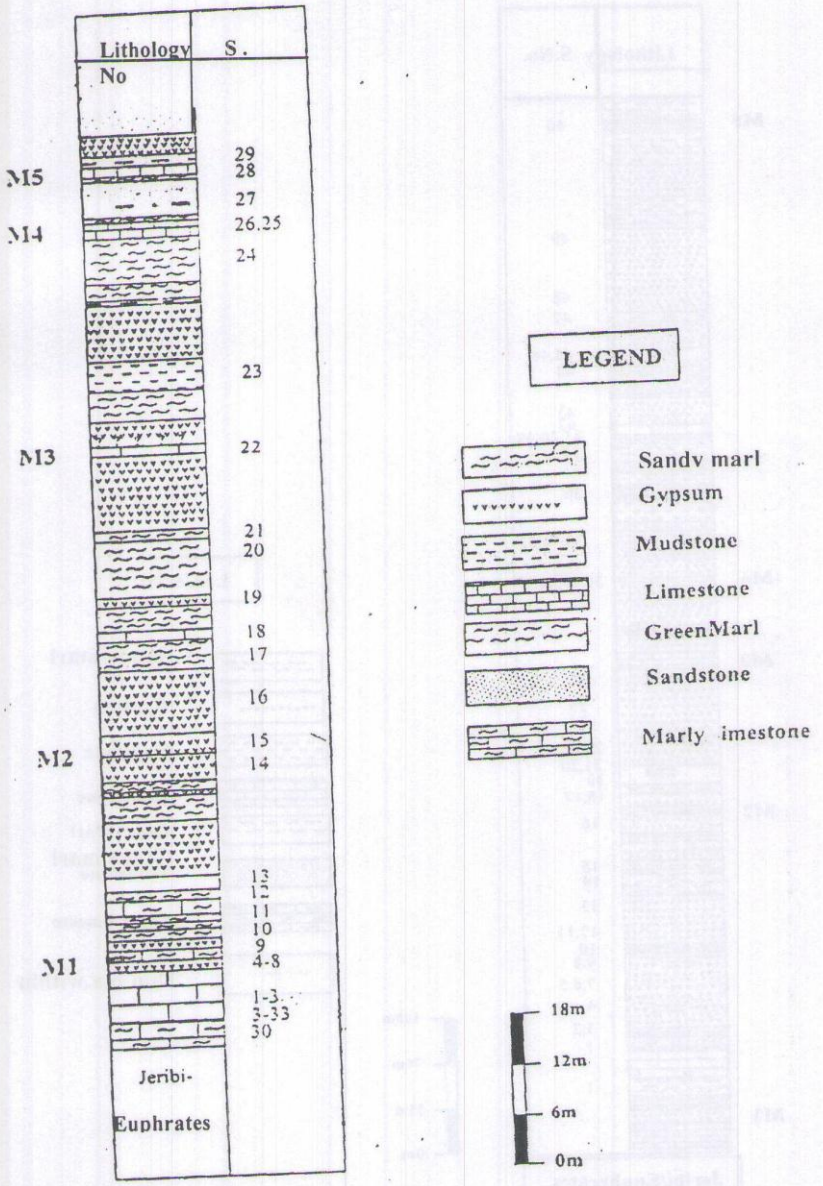


Fig (4) Lithological column of Fat'ha Formation in Hammam Al-Elil Section

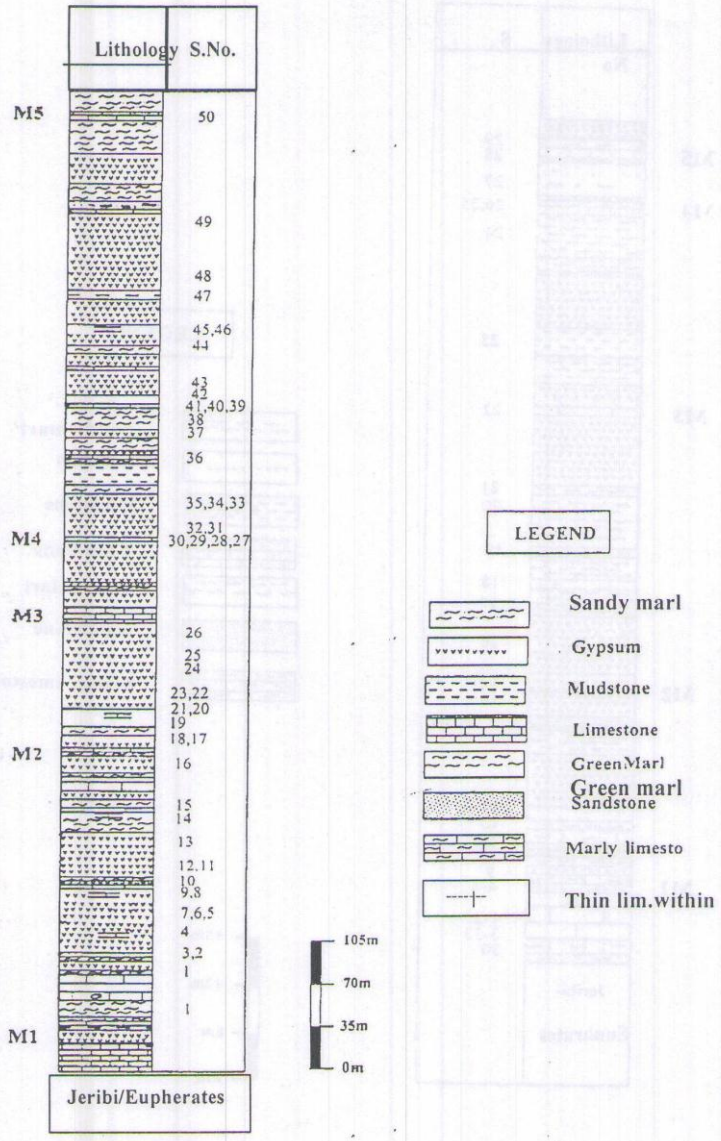


Fig (5) Lithological column of Fat'ha Formation in Sheik Ibrahim Section

Biostratigraphy Zones

Depending on the identified benthonic foraminifera assemblages, two biozones were recognized

I. ***Ammonia beccarri* Assemblage Zone:**

The lower contact determined in the appearance of the species *Ammonia beccarri*, while the upper contact with appearance of the species *Peneroplis farensis* (Fig.6).

Thickness of this zone in Hammam Al-Elil section is 120m, while in sheik Ibrahim section is (240m). In this zone many type of benthonic foraminifera were identified As:

(*Ammonia nipponica, Ammonia sp aff inflata ,Ammonia sikokuensis, Discorbis floridana, Discorbis scops , Elphidium indicum, Elphidium advanum , Elphidium megellanicum, Elphidium sulaimani, Elphidium lessonii, Elphidium cripsum, , Nonion gransus,Triloculina trigonula,Quinqueloculina lamarckiana, Quinqueloculina triloculiniforma, Quinqueloculina oblique, Quinqueloculina elongata ,Quinqueloculina stalkeri, Austrotrillina howchini, Spiroloculina alreata, Pyrgo yabi).*

II. *Peneroplis farensis -Borlis melo* Assemblage Zone

The lower contact determinated in the appearance of species *Peneroplis farensis* and continue to Injana Formation (Fig.6). The thickness of this zone in Hamam Al-Elil section is 24m ,while in Sheick Ibrahim section reach to 135m. Most of the foraminifera species in first zone are found in this zone too, these are: *Borlis melo, Praerhaphdionina delicata, Textularia cuyleri, Triloculina oblonga Triloculina tricarinata ,Quinqueloculina suturata Quinqueloculina tropicalis, Spiroloculina oculina.*

The presence of *Ammonia beccarri* and the other associated fauna in these part of the study sections is more likely reflect brakish to salty environment, while the assemblage is most probably occur in a shallow-marine environment. Comparing these two biostratigraphic biozones with

other local zones elsewhere, the author's conclude that Fat'ha Formation evident to be Middle Miocene in age(Fig.7).

B - Lithology

Comprises two subfacies;Clastic facies and nonclastic facies:

I-Clastic facies

A-marl:

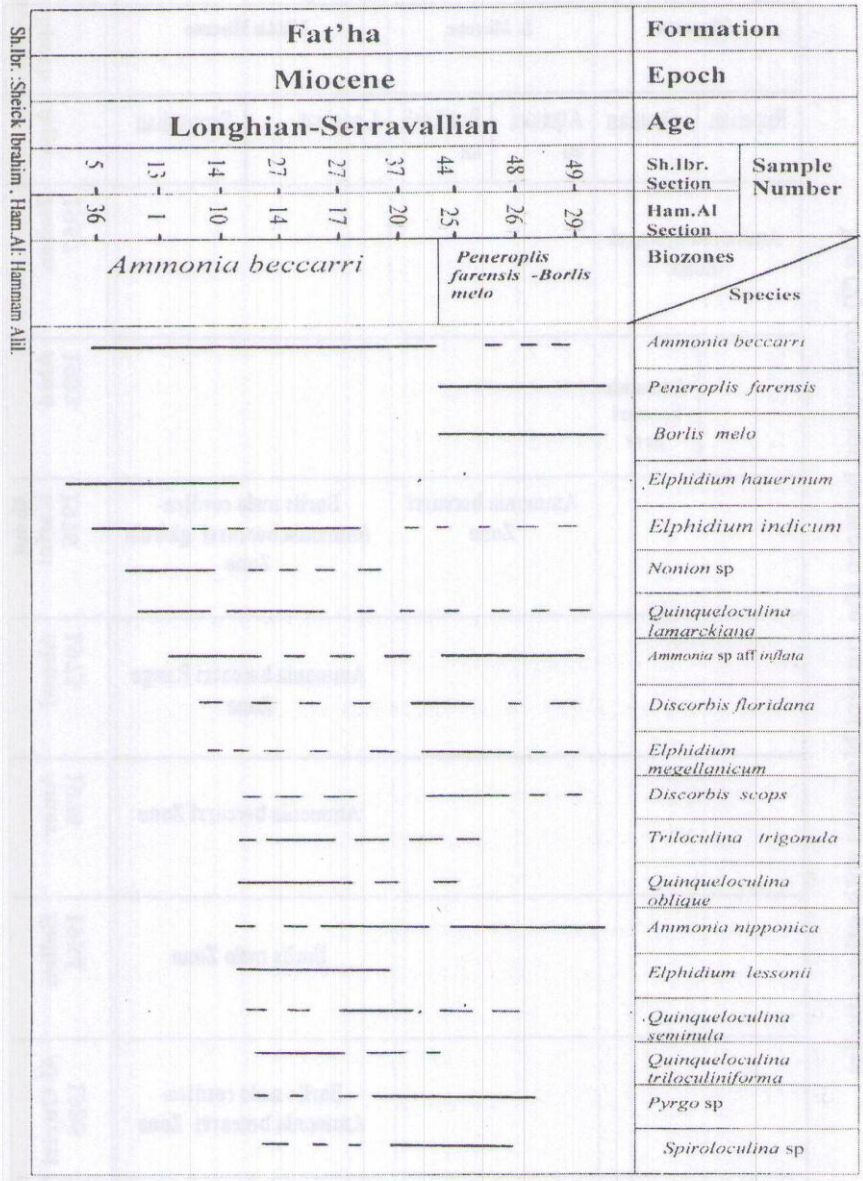
The thickness in both section, ranges between 0.1 to 16m, the color is varied from grey molted (red and green) to yellow from place to another.The thickness of marl facies increasing in upper parts of Fat'ha Formation, most of marls are barren and devoid diagnostic sedimentary structures, such type of sediments is more likely deposited in marine or quasi-marine environment (Tucker, 1999).

B-Sandstone:

The total thickness of these sediments in Hammam Al-Elil section is greater then that of Jebel Sheik Ibrahim section, which may reflect the long period opening of the depositional basin, It's located above the marker bed (M2), the sandstone vary from fine to coarse grained with green color, fining and thickening upward.

Many workers suggested the existence of two sedimentary cycles with coarsening upward return to delta, prodelta, distibutary channels, Delta front and natural levee environments(Al-Naqib&Aghwan,1993; Al-Jubouri,1999 and Al-Jubouri *et al.*,2001).

Occurrence of sandstone facies in Jebel Sheik Ibrahim section is very limited. One medium grain size sandstone layer has been observed with 2.5 m in thickness with, green color, according to Mustafa(1980), this sandstone bed was deposited in continental environments.



Fig(6)Biostratigraphic Zones in study area

Epoch	Oligocene		L. Miocene		Middle Miocene		
Age	Rupelian	Chattian	Aquitani an	Burdigali an	Longhian	Serravalian	
Bellen 1957	Ammonia beccarri Zone						
Abid 1983		Ammonia beccarri Zone					
Abdul Karim 1976			Ammonia beccarri Zone		Borlis melo cordica-Ammonia beccarri globula Zone		
Abawi 1973					Ammonia beccarri Range Zone		
Amer 1976					Ammonia beccarri Zone		
Bellen 1954					Borlis melo Zone		
Al-Guriri 1985					Borlis melo cordica-Ammonia beccarri Zone		
Current study					Ammonia beccarri Range Zone	Peneroplis farensis-Borlis melo Assemblage Zone	

Fig (9) comparison between the current biozones with other studies

Π-Nonclastic Facies

A-Limestone (Carbonate Facies):

The thickness of limestone beds is more developed from the marker bed M1 to M4 , the thickness of the marker bed ranges between few cm to 10.5 m.

Two types of limestone were recognized, Laminated limestone and massive limestone, most of limestone are fossilferous (Pelecypod and Oyster shell), thinly to thickly bedded, yellowish red to grey color.

Based on Flugel (1982) eight Carbonate microfacies have been recognized in both sections, Plate(1 and 2) these microfacies are:

1 . **mudstone microfacies** (pl. 1.1) :This facies consist mainly of calcareous mud , this facies indicated quiet depositional energy (Dunham,1962), and deposited in isolated lagoonal environment. In the selected section show an irregular distribution (Hammam Al- Elil) mainly between the M1 to M2 marker beds . On the other hand, lime mudstone facies seldom occurs in sheik Ibrahim section .Based on Wilson (1975) this facies is equivalent to standard microfacies SMF 23 which present in the Facies zone FZ 8,9 deposited in hypersaline tidal pond .

2. Wackestone contains Algal microfacies (pl.1.2) **:**This facies consists of calcareous mud which contain a 10- 40% of Foraminifera, algal, Oyster shells and pelletal fragments, this facies occurs between M1 and M2 marker beds in Shiek Ibrahim and in marker 1 bed in the Hammam Al-Elil section. This facies equivalent to SMF 8,9 which present in the Facies zone FZ 7 which deposited with lagoon (Wilson ,1975).

3. Packstone contains Pellets microfacies (pl.1.3):The fragments essential composed of various size pellets, it's percent reach 90% .This facies appears between M1 and M4 marker beds within the studied section .Owing to Wilson (1975) this facies equivalent to SMF 16 which occur within the FZ 8,9 which refers to the depositional in warm ,shallow basin of fair energy.

4. Packstone contains Dolomite. microfacies(pl.1.4) **:**This facies characterized by skeletal and non skeletal grains content mainly of algal, Foraminifera and Mollusca shells in addition to fear percents of sparite and disseminated fine euhedral dolomite crystals .This facies have been found in

very closely similar percent within the studied sections in the beds bounded Between M1 and M2 marker beds .This facies equivalents to SMF 12 which occurs in the FZ 6 common in the slope and shelf edges.

5. Grainstone contains Foraminifera microfacies(pl.2.7):This facies mainly consist of faunal assemblages e.g mollusca, benthonic foraminifera, Oyster and Bryozoa. It is typically represented in M1, M2 and M4 markers beds mainly concentrated in the upper part of Sheik Ibrahim section with irregular occurrence within the rest studied section ,according to Wilson (1975)the present facies equivalent to SMF 18 which occurs within the FZ 8,7 deposited in the lagoon and tidal bars.

6. Grainstone contains Oolites microfacies(pl.2.5) **:**This facies essentially consist of oolites beside few algal fragments . Its observed mainly in Sheik Ibrahim section restricted to M3 and M4 marker beds. In the Hammam Al-Elil section, this facies found in the upper part of M4 marker bed. This facies equivalent to SMF 15 which present in the Facies zone FZ 6 that indicates high energy shoal or tidal bars environments shown by Wilson (1975).

7. Grainstone contains Peloids microfacies (pl.2.6) **:**This facies consist mainly of peloidal grainstone of various size and origin. This facies exhibit clear fluctuation in occurrence between M1 and M2 marker beds, it is equivalent to SMF 17 which occurs within the FZ 8, 7 refers to the tidal flat depositional environment (Wilson, 1975).

8. Crystalline Limestone microfacies(pl.2.8) **:**This facies characterized by its pale color which considered of the final product of many diagenetic processes (e.g. neomorphism) .this facies is only restricted at Hammam Al-Elil section mainly in the M3 marker bed.

B-Gypsum

Gypsum represents the major exposed lithology of Fat'ha Formation. Its thickness ranges between 1.5 and 35m. The following variates of gypsum were recognized (pl. 2(9,10));

- Nodular gypsum as mosaic gypsum and wispy gypsum.
- Bedded gypsum (massive thinly bedded).
- Secondary gypsum (selenite gypsum and Fibrous or satin spar gypsum).

The white or milky color was recognized as dominant color, however the greenish white color of nodular gypsum also observed. This color is attributed to green marl material which enveloped the nodules. Moreover some other nodules coated wholly or partially with calcareous sediments. The absence of rock salt deposits, and the occurrence of gypsum with high thickness in both sections under study, suggested the monomineralic evaporitic deposits, which accumulated, followed the reflex mechanism presented by Kings (1947) cited in Mustafa (1980).

Many authors such as Al-Kufashi and Al-Marsumi(1988) and Sa'aed(1988) were agreed that the evaporitic sequence of Fat'ha Formation were depositional in semi – closed lagoon developed under arid climate for long time.

Conclusions

After this study , it could conclude that:

1- The stratigraphic study throughout these two sections reveals numerous sedimentary cycles. The typical cycles of Fat'ha Formation is comprised of marl ,limestone, gypsum and red mud. The number of cycles in Hammam Al-Elil section reach to 12 cycles, while in Sheik Ibrahim section is 16 cycles, the evaporites are the main part form of the section.

2- The study of the Benthonic Foraminifera is an aid in the subdivision of the sections into two biozones that's:

a-*Ammonia beccarri* Assemblage Zone

b- *Peneroplis farensis -Borlis melo* Assemblage Zone.

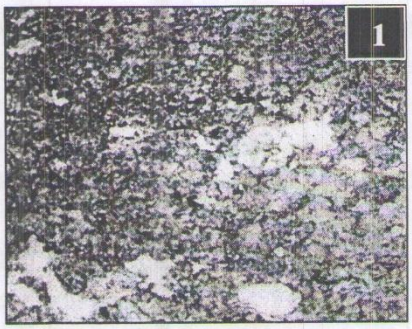
3- Depending on The Benthonic Foraminifera, the age of Fat'ha Formation is Middle Miocene.

4- The thickness differences between the two sections, in sheik Ibrahim section reflects closeness to the center of depositional basin, while in Hammam Al-Elil section is nearer to coastal waters of the depositional basin.

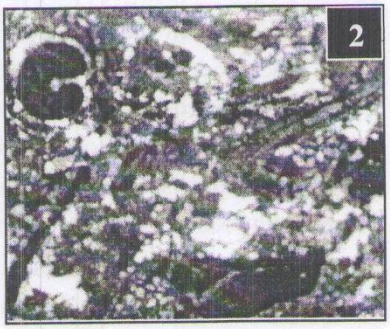
5- Fat'ha Formation was deposited in lagoonal environment as well as temporary environments as flood plain, distbutary channel and Delta.

PLATE 1

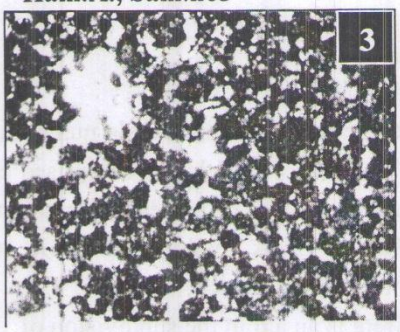
Sh.Ib=Sheik Ibrahim
Ham.A=Hammam Al-Elil



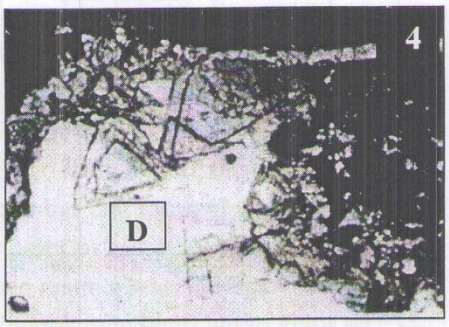
Mudstone microfacies 40x Ham.A., Sam.no3



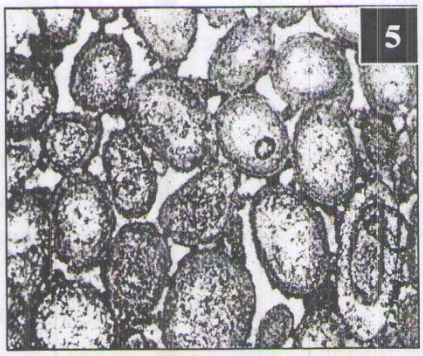
Wackestone contains Algal microacies



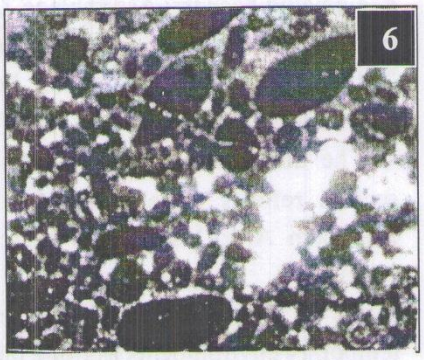
Packstone contains Pellets micr-ofacies 40x Ham.A., Sam.no. 34



Dolomite microfacies 40x Sh.Ib., Sam.no7,D=dolomite



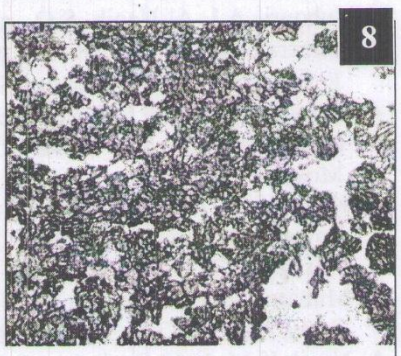
Grainstone contains Oolites microfacies 40x microfacies Ham.A., Sam. no.24



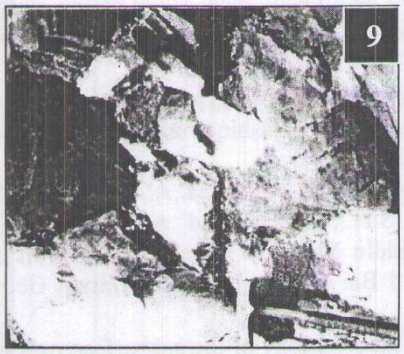
Grainstone contains Peloids 40x Sh.Ib., Sam.no36

PLATE 2

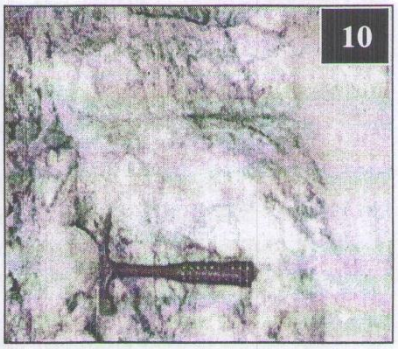
Gr. contains Foraminifera microfacies 40x microfacies Sh.Ib., Sam.no18



Crystalline Limestone 40x 40 x Ham.A., Sam.no22



Secondary Gypsum (Selenite) Sh.Ib.



Nodular Gypsum Sh.Ib.

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