Iraqi Geological Journal 53 (2C), 2020:105-120
Http://igj-iraq.org ISSN 2414 - 6064

MINERALOGY AND PALEONTOLOGY OF THE QUATERNARY SEDIMENTS IN KARMAT ALI AT BASRAH, SOUTHERN IRAQ

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Received: 18 May 2020; accepted: 16 July 2020

ABSTRACT

The study was carried out on one borehole in Basrah city to describe their texture, mineralogy and fauna contents. The boundary between fluvial recent sediments and the Hammar Formation is hard to determine because both sediments are terrigenous; the present study tries to detect the transitional phase between fluvial and marine environments. The vertical variations in mineralogy and texture of sediments provide an indicator of environmental conversion in the Quaternary period. Quartz is dominated at shallow depth intervals. Thereafter, its abruptly decreases in their abundance after 20 m depth; while the opposite was the case for calcite content, where it increases with the decrease of quartz. halite and gypsum are absent at 3 to 13 m, but they appear at 17 m. Clayey silt exists at 1 to 21 m, and silty sand at 23 to 35 m. Paleontology is enhanced the sedimentological evidence and marked that the Hammar marine transgression started at depths 35 and 30 m with typical sediments at 30 to 27 m; marine regression is restricted at 27-17 m, whereas the fluvial Holocene period is marked at 17 m depth.
Keywords: Hammar Formation; Holocene sediments; Quaternary; Mineralogy; Paleontology

INTRODUCTION

The Quaternary sediments in southern Iraq contain sands, silts, and clays (Awadh et al., 2011; Al-Jumaily, 1994; Al-Jabberi, 2010). Jassim and Goff (2006) demonstrated that fluviatile, lacustrine, deltaic, and aeolian sediments have mostly existed in the Mesopotamian Plain. Quaternary sediments are divided into fluvial recent sediments and marine facies (Al-Jaberi, 2017); the Quaternary freshwater sediments of the Lower Mesopotamian plain include a thin transgressive marine unit that prolongs inland some 250 km from the present coastline (the Hammar Formation) (Plaziat and Younis, 2005). The Hammar Formation is described by Hudson et al. (1957) from well No. 13 as recent marine deposits reaching the thickness of 6.5 m and consisting of sand and silt in the lower part and clay in the upper part. This formation could be considered to represent the last of the marine transgression of the Quaternary, which recorded the world widely during the middle Holocene (Karim et al., 1994).

Much of what has been written and published about the Quaternary sediments in southern Iraq, such as Dance and Eames (1966), MacFadyen and Vita-Finze (1978), Raji and Salman (1983), Shareef and Mahdi (2015), and Al-Jaberi (2017), which concluded the mineralogy of the Quaternary sediments shows significant variability in the depth distribution and size fractions. Besides, they emphasized that kaolinite and chlorite increased in the clayey silt texture, whereas vermiculite and montmorillonite were an increase in the silty sand texture. Also, studies of Khan et al. (1992) and Salman and Al-Mussawy (1994) referenced the texture of the Quaternary sediments is clay and silt where extended from the surface sediments to 18m depth, while the sand fraction was dominant after 18 m depth. Plaziat and Younis (2005) showed the fluvial recent sediments in the Quaternary period comprises bivalve and gastropods genera. The present study aims to recognize the mineral distribution of the Quaternary sediments, in addition to fauna assemblages' study for achievement as an important discipline in identifying between the environments of marine Hammar Formation and fluvial recent sediments (fluvial Holocene) at Basrah city, southern Iraq.

MATERIALS AND M/ETHODS

The study area is located in the Karmat Ali area within Basrah, southern Iraq (Fig. 1); the studied well is one of the wells drilled in the area as a part of the engineering construction project in the region. The present study included depths between 1 to 35 meters. Studied samples were selected according to variation in the color of beds and textures. Texture analyses were achieved by the master sizer instrument in the laboratory of the Department of Geology in the University of Basrah. Sediment texture was classified according to Picard (1971); afterward, the specimens were soaked for one night and then washed under pressurized tap water in standardized sieves these were 105 and 75 mm, for extraction the fauna, and they were stored in micropaleontological slide, four groups were identified for this study, these are foraminifera, ostracod, mollusca, and radiolarian. Two classes were identified (mollusca, pelecypoda) and gastropoda they identified by Ahmed (1975).

Three selected of radiolarian species were chosen to examine for scanning electronic microscope (SEM-EDAX), the type of SEM is Gemini-Zeiss (Supra 55VA) at the laboratories of the Pharmacy College - University of Basrah, to determine the chemical composition of the radiolarian wall. Mineralogy of the bulk samples was detected by X-Ray Diffraction (XRD) measurement in the Department of Physics, University of Basrah. X-ray diffraction patterns were obtained by means of D-5000 x-ray diffractometer, using Cukα source in wavelength, v= 1.54056A° at 40 kV and 30 mA between 5-40°2Θ.

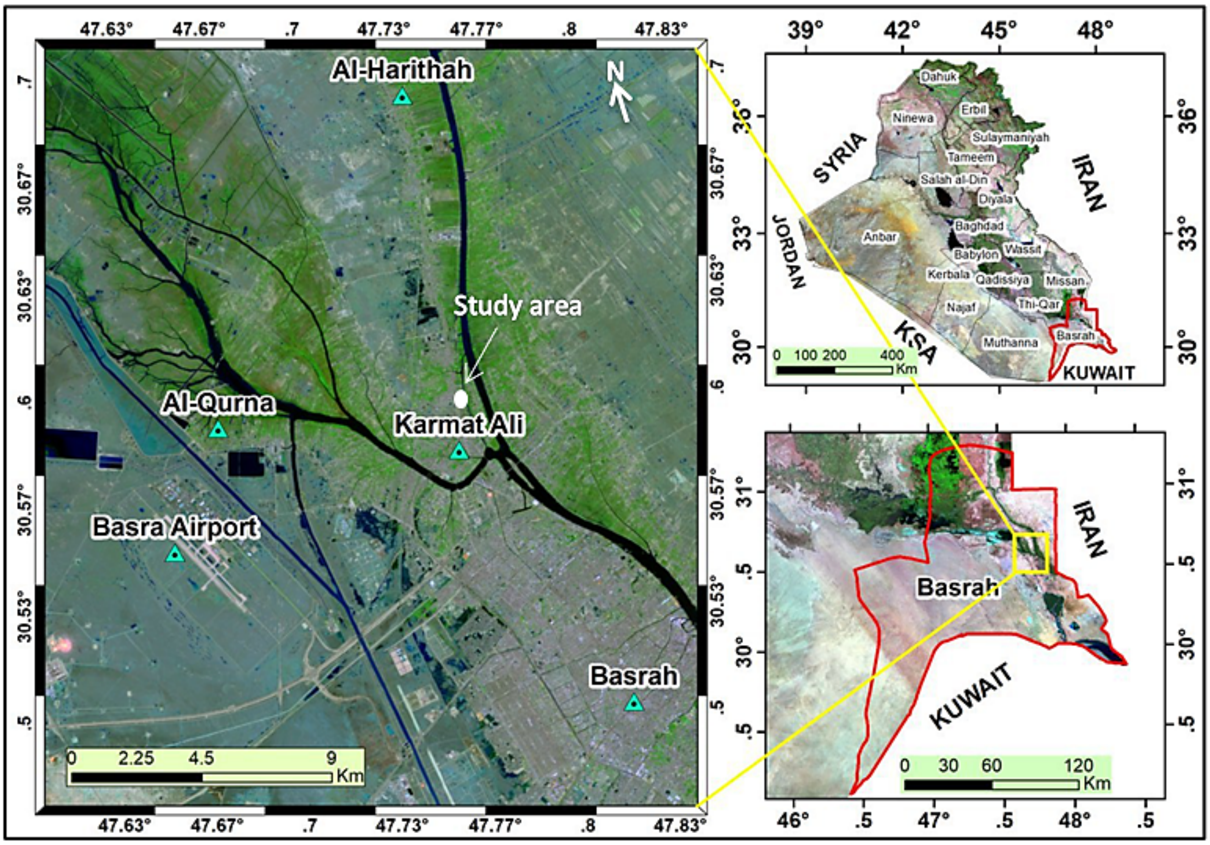

Fig. 1. Map of study area, Basrah city, Iraq

RESULTS

Texture and Mineralogy

The mineral and chemical composition of sediments from the Tigris River are defined granitic rocks, basic igneous rocks, and metamorphic rocks as a provenance in the Taurus Mountain southern Turkey and northern Iraq as well as sediments derived from the river bed like gypsum of the Fat'ha Formation (Awadh et al., 2011). The texture results are summarized in Table 1 and Fig. 2, they show that clayey silt and silty sand are the dominant texture of the studied samples. Quartz, calcite, feldspar (anorthite), and dolomite are the most common of minerals in the studied samples (Table 2).

Faunal Distribution

Foraminifera

The Foraminifera is important groups that identified in the study area; it has a wide environmental range, from continental regions to bottom of sea (Boltovskoy and Wright, 1976). Many species were recorded in this study depending on the classification of Loeblich and Tappan (1964). More than 30 species of foraminifera were identified, belong to 13 genus, as illustrated in Table 3 and Fig. 3. these species are: *Ammonia beccarii*, *A. tepida*, *A. parkinsoniana*, *A. hozanensis*, *A. nipponica*, *Elphidium incertum*, *E. gunteri, E. poeyanum*, *E. advanum*, *E. lesson*, *E. excavatum* , *Bolivina* sp., *Discorps todda*, *Asterorotalia* sp., *Lagena* sp., *Buccella frigida*, *Nonionella* caspia, *Miliammina fusca*, *Quinqueloculina seminula*, *Q. elongate, Q. laevigata*, *Q. lamarkiana*, *Q. buchiana, Q. stalkeri*, *Q. ovula*, *Triloculina oblonga*, *T. rotunda*, *Spiroloculina laevigata*, *S. exima*, *Pyrgo* sp. The recent species like *Ammonia beccarii, Elphidium incertum* , *Elphidium excavatum* , *Triloculina rotunda* have been lived in depth 1-20 m in shallow space as lagoon or near shore (Murray, 1969).

Table 1. Grain size analysis and textures of cutting sediments

Depth m	Clay %	Silt %	Sand %	Texture
1- 1.5	20	80	0	Clayey Silt
3- 3.5	24	76	0	Clayey Silt
5- 5.5	23	74	3	Clayey Silt
7- 7.5	39	54	7	Clayey Silt
10- 10.5	14	79	7	Clayey Silt
13- 13.5	18	78	4	Clayey Silt
16- 16.5	19	75	6	Clayey Silt
20- 20.5	20	72	8	Clayey Silt
21- 21.5	22	69	9	Clayey Silt
23- 23.5	9	34	57	Silty Sand
26- 26.5	9	29	62	Silty Sand
29- 29.5	8	36	56	Silty Sand
31- 31.5	8	31	61	Silty Sand
33- 33.5	7	22	71	Silty Sand
35- 35.5	4	22	74	Silty Sand

Table 2. Minerals variation with depth in studied borehole

Minerals %	Depth										Range	Mean
	3m	9m	13m	17m	20m	23m	27m	28m	30m	35m		
Quartz	40	35	30	37	37	29	25	30	20	33	20-40%	31.6%
Calcite	25	22	28	35	36	38	40	41	35	30	12-41%	33%
Feldspar	13	18	22	9	9	13	11	11	9	11	8-22%	12.6%
Dolomite	9	18	10	10	10	10	11	9	17	11	9-18%	11.5%
Gypsum	ND	ND	ND	ND	5	2	8	9	6	4	2-8%	3.4%
Halite	ND	ND	ND	4	3	3	5	ND	6	5	3-6%	2.6%
Kaolinite	8	5	10	5	ND	5	ND	ND	7	6	5-10%	4.6%
Palygoreskite	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3%
Montmorillonite	2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4%

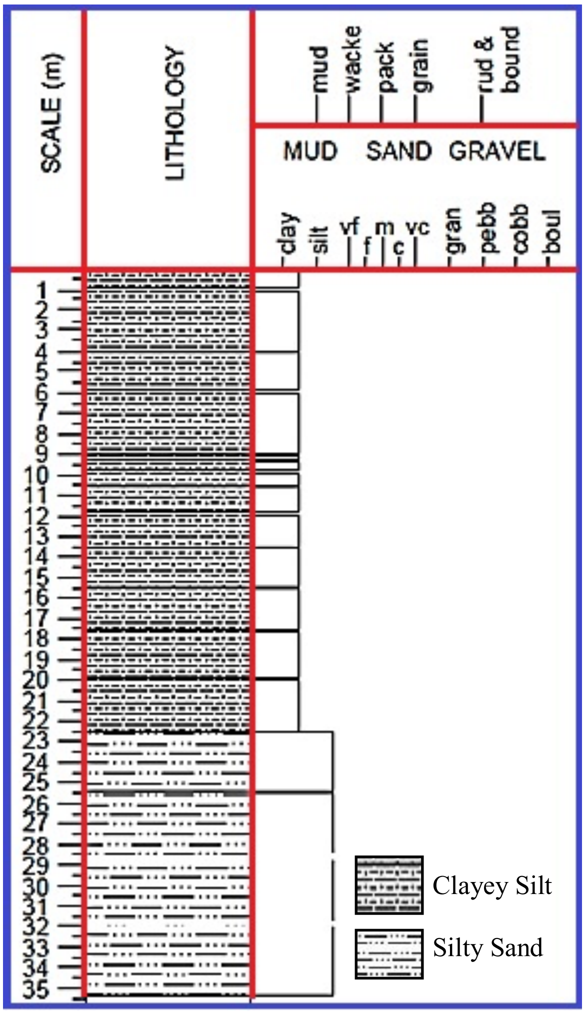

Fig. 2. Sedimentary log of sediments in the studied borehole

In addition, a few well-known euryhaline calcareous species, such as Ammonia beccarii and A. parkinsoniana, are commonly present low marsh: Elphidium williamsoni, Miliammina fusca, Ammonia beccarii (or A. parkinsoniana). An exception is seen in the mangrove Foraminifera of northern New Zealand; Miliammina fusca and two widespread calcareous species of marginal marine waters (Ammonia beccarii and Elphidium excavatum) are the dominant species. Species common in this thanatotope, besides A. beccarii and E. excavatum, are Planulina exorna, Planorbulina mediterranensis, Asterigerina carinata, and Quinqueloculina lamarckiana (Gupta, 1999). Ammonia beccarii, Elphidium gunteri, Nonionella atlantica, and Hanzawaia concentrica (among others) are dominant on the inner continental shelf of Nigeria (0–35 m) on the inner shelf of Senegal (depths < 25 m). The assemblages of fauna reflect the wide range of salinity, the high carbonate ion concentrations of hypersaline waters, where salinities are in excess of 40‰, appear to favor the porcelaneous

Miliolina (especially the Nubecularidae and Miliolidae, e.g. Quinqueloculina, Triloculina). Almost certainly, these assemblages belong to the Hammar Formation. As well as, there are rare species of planktonic foraminifera were occurred in the deep depths, (Fig. 3(26 and27)).

Ostracoda

Ostracods represent the second group in the studied area from side abundance, the diagnosed of Ostracoda species is depending on Al-Jumaily (1994). 25 species were identify (Table 4 and Fig. 4), these species are: *Cyprideis torosa*, *C. torosa var torosa*, *Illyocypris monstrifica*, *Illyocypris gibba*, *Illyocypris bradyi*, *Cyprintous scholiosa*, *Cyprintous salinus*, *Candona neglecta*, *Candona* sp., *Candoniella simpsoni*, *Tyrrhenocythere amnicola*, *Neomonceratina iniqua*, *Carinocythereis indica*, *Alocopocythere reticulata*, *Leguminocythereis papuensis*, *Limnocythere inopenata, Drawinula stevensoni*, *Chrysocythere keiji*, *Hemicytheridea reticulata*, *Loxochoncha* sp., *Kerthe* sp., *Hemicytheridea paiki*, *Cushmanidae guhai*, *Hemikirthe peterseni* and *Haplocythereidae keyseri.* The species *Alocopocythere reticulata*, *Cyprideis torosa*, *Cyprideis* sp., *Haplocythereidae keyseri*, *Kerthe* sp., *Loxochoncha* sp., *Leguminocythereis papuensis, Neomonceratina delicate* were represented a marine taxon in Euhaline zone within range 30-40‰, while the species *Carinocythereis indica, Haplocythereidae keyseri, Hemicytheridea paiki*, *Loxochoncha* sp. lived in brackish water within salinity range 18-30‰. As well as, the species *Candona compressa* , *Candoniella simpsoni*, *Candona neglecta*, *Candona* sp., *Drawinula stevensoni*, *Illyocypris gibba* , *Illyocypris* sp. represented a fresh water (Oligohaline) within salinity range 0.5-5‰ (Al-Jumaily, 1994; Shareef and Mahdi, 2015).

Mollusca

Two classes were identified in the study area (Tables 5 and 6), these are:

A-Gastropoda

Many of genera and species were diagnosed followed to Gastropods these are:

Vitrinella sp., *Cerithium* sp., *Cerithium columna*, *Planorbis* sp., *Odostoma* sp., *Turritella* sp., *Terebra* sp., *Viviparus* sp., *Polinices* sp., *Patella* sp., *Barleeia* sp., *Assiminea* sp., *Margarita* sp., *Ethminolia* sp., *Obtusella intersecta*, *Epitonium scalare*, *Retusa* sp., *Natica* sp., *lymnaea* sp., *Zonitoides* sp., *Gyaulus* sp., *Nucella* sp., *Alvania* sp., *Chrysallida* sp. (Fig. 5).

B- Pelecypoda

The important genera followed to Pelecypoda are:

Theora sp., *Ostrea* sp., *Anadara* sp., *Cuna* sp., *Abra* sp., *Corbula* sp., *Arca* sp., *Corbicula* sp., *Pitar* sp., *Barbatia* sp., *Barchidontes* sp., *Tellina* sp., *Protothaca* sp., *Mactra* sp. (Fig. 6).

Fig. 3. Selected foraminifera of the Hammar Formation; (1, 2) *Ammonia tepida*, (3) *A. hozanensis*, (4) *A. nipponica*, (5) *Ammonia beccari*, (6)*Elphidium incertum*, (7) *E. gunteri*, (8)*Buccella frigida*, (9) *Asterorotalia* sp. (10) *Elphidium excavatum*, (11) *Discorps todda*, (12)*Ammonia parkinsoniana*, (13) *Triloculina oblonga*, (14) *Quinqueloculina elongate*, (15)*Milionella oblonga*, (16)*Quinqueloculina lamarkiana*, (17) *Q. buchiana*, (18) *Q. laevigata*, (19) *Q. seminula*, (20) *Triloculina rotunda*, (21)*Spiroculina exima*, (23, 24) *S. laevigata*, *S.* sp., (25) *Pyrgo* sp., planktonic forams, (26) *Globigerina* sp., (27). *Globigerinoides* sp. (scale bar 1-12 =0.5 mm) (scale bar 13-27 =0.5 mm)

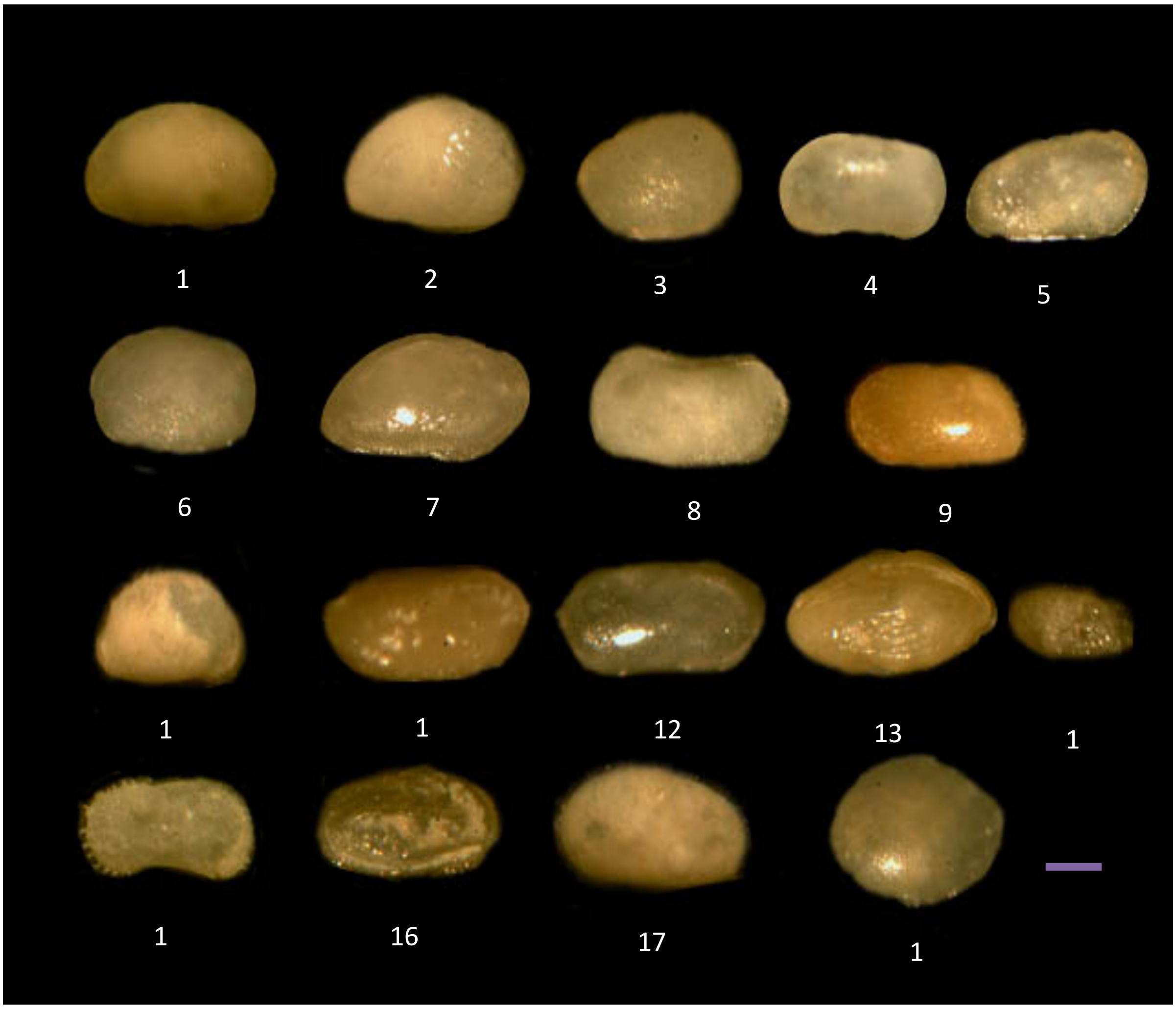

Fig. 4. Selected Ostracodes of the Hammar Formation; (1)*Cyprideis torosa*, (2)*Cyprintous salinus*, (3) *Tyrrhenocythere amnicola*, (4)*Candona neglecta*, (5)*Illyocypris gibba*, (6) *Hemikirthe peterseni*, (7)*Candona* sp., (8) *Liminocythere inopiata*, (9) *Drawinula stevensoni*, (10)*Cyprintous scholiosa*, (11)*Hapocythereidae keyseri*, (12) *Candoniella simpsoni*, (13) *Neomonceratina iniqua*, (14) *Leguminocythereis papuensis*, (15)*Illyocypris monstrifica*, (16) *Carinocythereis indica*, (17) *Cyprideis torosa var torosa*, (18) *Loxochoncha* sp. (scale bar =0.5mm)

Radiolarian

The Radiolaria is protozoa of diameter 0.1–0.2 mm that produce intricate mineral skeletons. The elaborate mineral skeleton is usually made of silica (Smalley, 1963). It is not recorded within freshwater; therefore, the authors concentrate on this group by examined them in SEM. Two species were classified at the Hammar Formation, these are: *Melitosphaera* sp. and *Cenosphaera* sp. The radiolarian species are different sizes, the height is ranging between 191.1 to 250.6 um, with composition of Si element as shown in Figs. 7, 8, and 9. This result give a confident conclusion that these species lived in the marine environment of the Hammar

Formation. Marine Radiolarian species at depth intervals of 30m and 35m is the first detect in the Hammar Formation in Iraq.

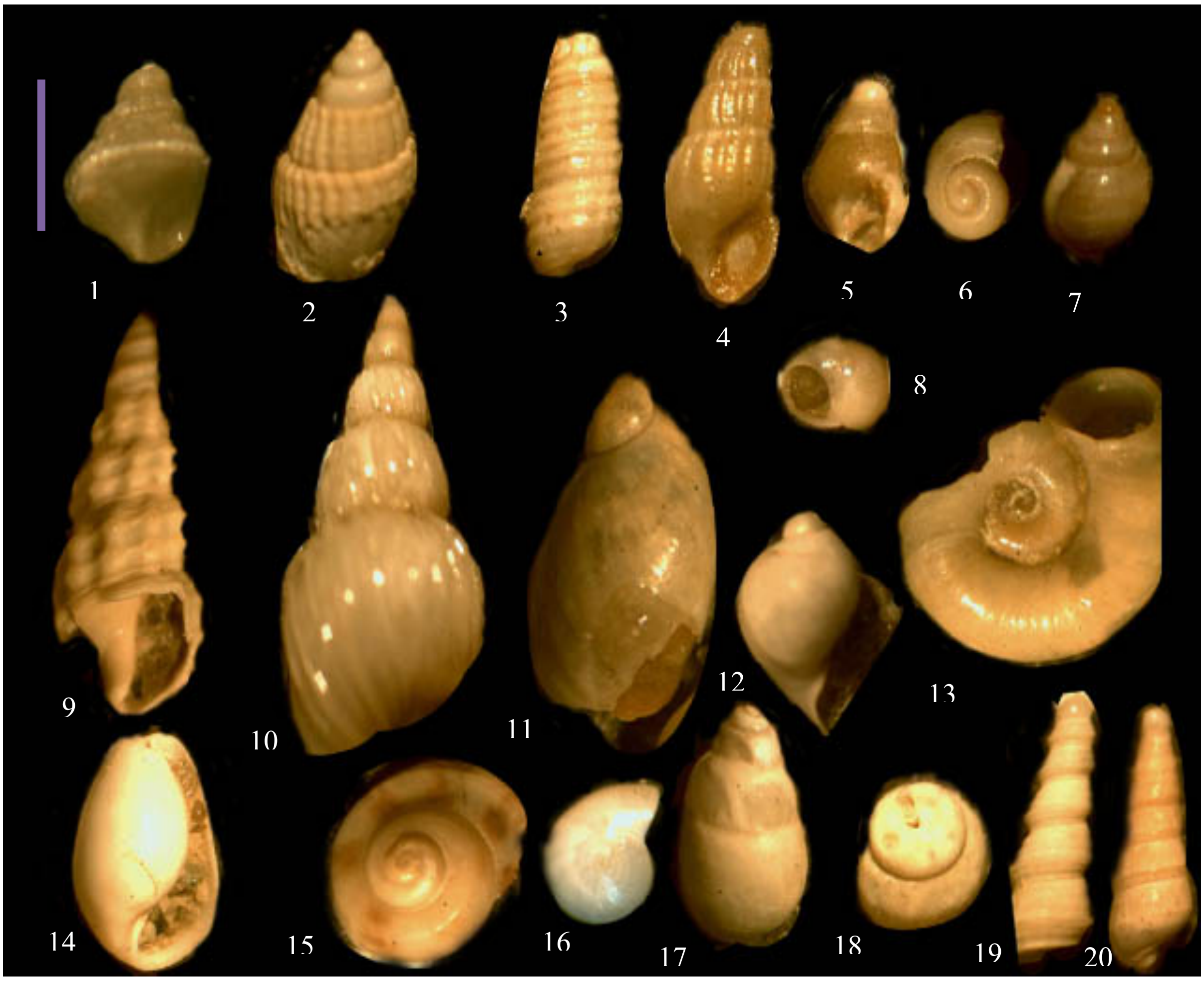

Fig. 5. Selected gastropods of the Hammar Formation; (1) *Nucella* sp., (2) *Alvania* sp., (3) *Cerithium* sp., (4) *Chrysallida* sp., (5) *Odostoma* sp., (6) *Planorbis* sp., (7) *Barleeia* sp., (8) *Margarita* sp., (9) *Cerithium columna*, (10) *Epitonium scalare*, (11) *Polinices* sp., (12) *lymnaea* sp., (13) *Gyaulus* sp., (14) *Retusa* sp., (15) *Ethminolia* sp., (16) *Natica* sp., (17) *Obtusella intersecta*, (18) *Zonitoides* sp., (19) *Terebra* sp., (20) *Turritella* sp. (Scale bar=1mm)

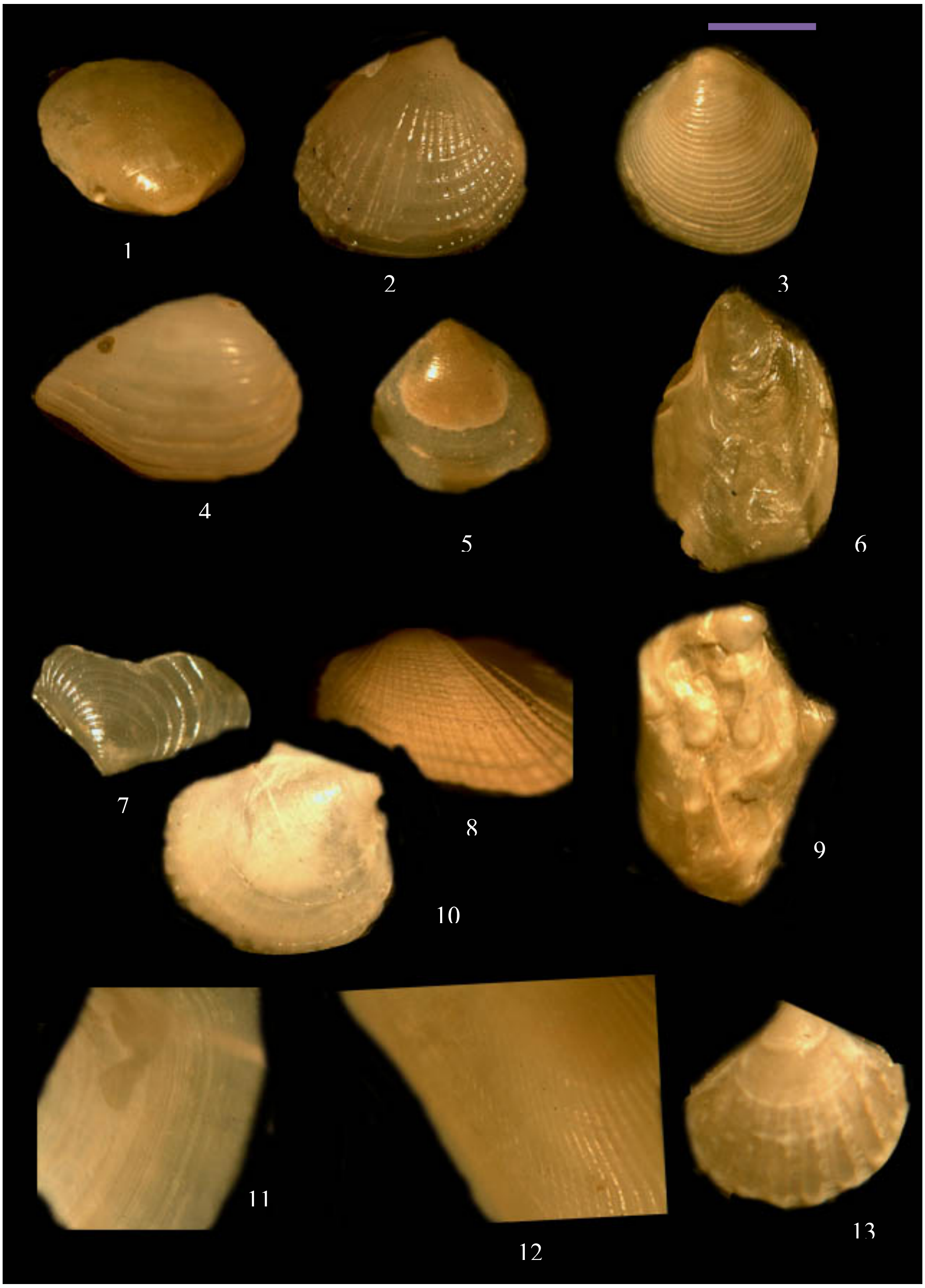

Fig. 6. Selected pelecypods; (1) *Abra* sp., (2) *Protothaca* sp., (3) *Pitar* sp., (4) *Corbula* sp., (5) *Mactra* sp., (6 and 9) *Ostrea* sp., (7) *Theora* sp., (8) *Barbatia* sp., (10) *Tellina* sp., (11) *Theora* sp., (12) *Barchidontes* sp., (13) *Cuna* sp. (Scale bar=1mm)

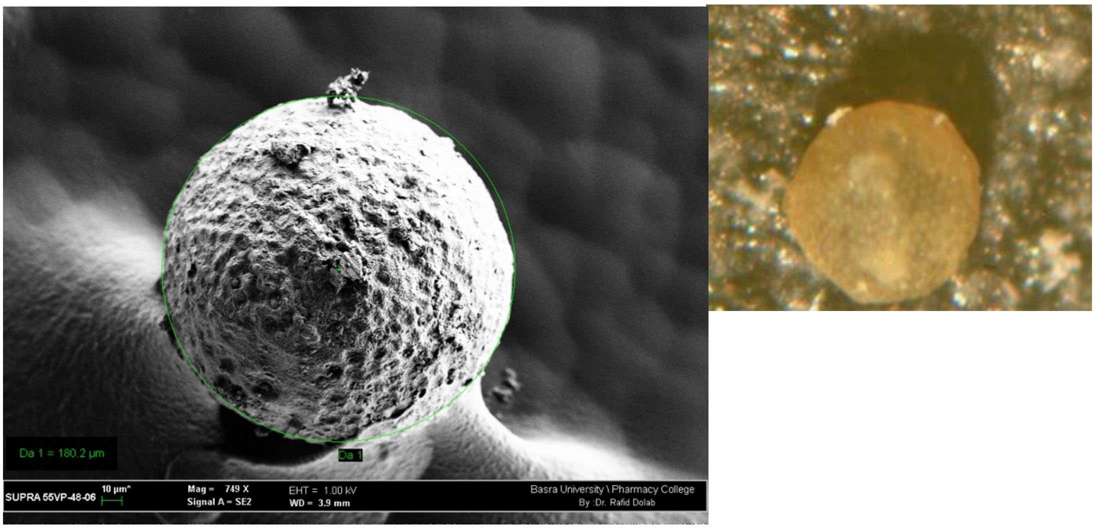

Fig. 7. SEM of radiolarian species, *Melitosphaera* sp. with normal microscopic view

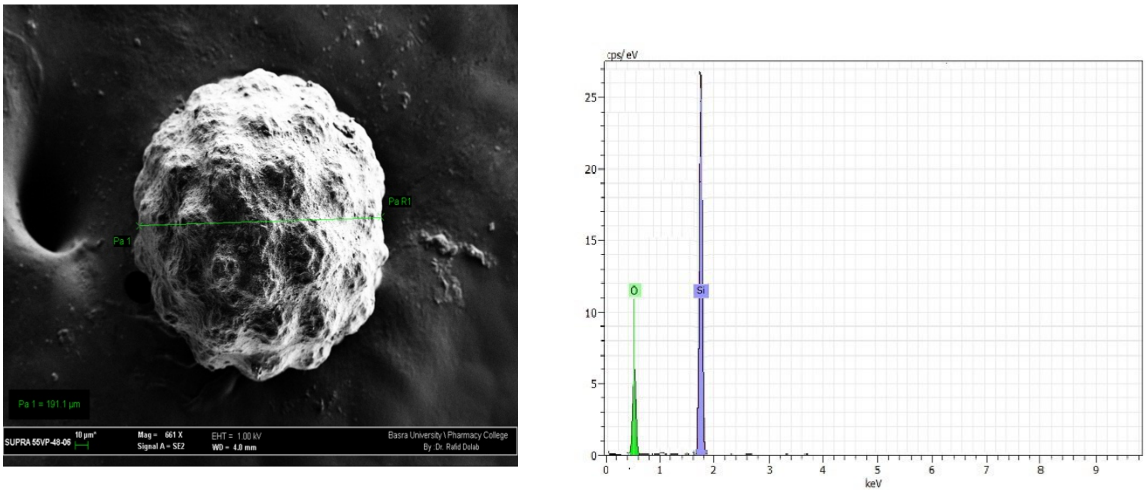

Fig. 8. Radiolarian species, *Cenosphaera* sp. and its spectrum under SEM-EDAX

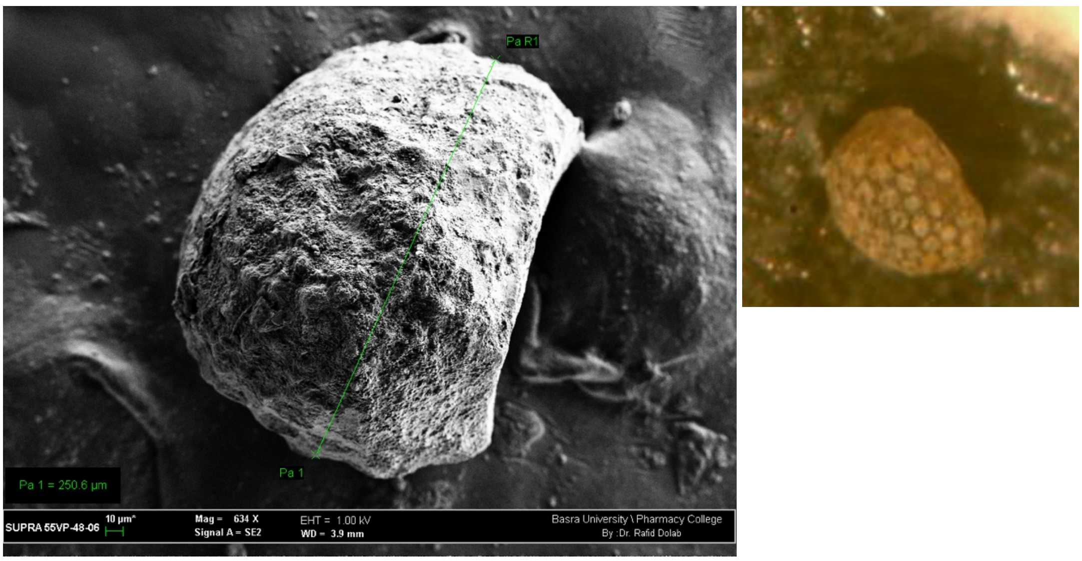

Fig. 9. SEM of *Cenosphaera* sp. with normal microscopic view

DISCUSSION

At the end of the glacial period (Wurm Glaciation), the land was higher than at the present day, the swamps covered large parts; a period of submergence followed that of swamp growth resulting in low lying tract deposits of marine and estuarine silts and clays. The present study aims to recognize the mineral distribution and fauna assemblages during the Holocene sedimentation in Basrah city. Grain size analyses showed that clay and silt fractions were predominant at depths between 1m to 23m with clayey silt texture, while sand fraction started to increase from 57% at a depth interval of 23 m to 74 % at 35m, with silty sand texture (Table 1 and Figure 2). XRD analyses revealed that quartz, calcite, feldspar (anorthite), dolomite, and clay minerals (represented by kaolinite, montmorillonite, and palygoreskite) present in most samples. Quartz, calcite, anorthite, and dolomite where dominant mineral phases whereas kaolinite, palygorskite, and montmorillonite were minor ones.

Table 3. Distribution of Foraminifera species on the studied borehole (the empty square is valid from fauna)

Depth (m)	*Ammonia becarii*	*A. tepida*	*A. parkinsoniana*	*A. hozanensis*	*A. nipponica*	*Elphidium gunteri*	*E. incerturn*	*E. advanum*	*E. lessoni*	*E. poeyanum*	*E. excavatum*	*Quinqueloculina.*	*Q. elongate*	*Q. Leavigata*	*Q. Lamarkina*	*Q. bushiana*	*Q. stalkeri*	*Q. Ovula*	*Triloculina rotonda*	*T. oblonga*	*Spiroloculina laevigata*	*Asterorotalia sp*	*Bolivina* sp.	*Buccella frigida*	*Nonionella caspia*	*Lagena* sp	*Discorps todda*
15																											
16																											
17																											
18																											
19	X													X													
20	X							X																			
21	X	X										X															
22	X				X																						
24	X							X									X					X					
25	X										X																
26	X	X	X	X	X	X																					
27	X					X	X	X	X	X	X	X	X	X	X	X						X					
28	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
29	X											X															
30	X											X										X		X	X	X	
31		X					X					X										X		X		X	
32	X		X																								
35																											
36																											
37	X	X						X	X			X	X							X							

Table 4. Distribution of Ostracoda species on the studied borehole (the empty square is valid from fauna)

Depth (m)	*Cyprideis torosa*	*C. torosa var torosa*	*Illyocypris monstrifica*	*Illyocypris gibba*	*Cyprintous salinus*	*Candona neglecta*	*Candona* sp.	*Tyrrhenocythere amnicda*	*Illyocypris .Bradi*	*Neomonceratina iniqua*	*Carinocythereis indica*	*Candoniella simpsion*	*Alocopocythere reticulata*	*Leguminocythereis* sp.	*Limnocythere inopenata*	*Drawinula stevensoni*	*Chrysocythe Keijella*	*Hemicytheridea* sp.	*Loxochoncha* sp.	*Krithe* sp.	*Hemicytheridea Paiki*	*Cushmanidae guhai*	*Hemikirthe peterseni*	*Haplocythereidae* sp.	*Canadensis Kingsleyi*
16																									
17																									
18																									
19										X															
20										X														X	
21											X														X
22	X																								
24	X	X									X														
25										X								X							
26																									
27	X					X				X															
28	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
29	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	X																								
31	X										X														
32	X																						X		
35	X	X									X	X	X				X		X	X		X	X		
36	X	X					X			X	X	X	X								X				
37	X	X								X						X						X			

Table 5. Distribution of Pelecypoda species with Bryozoa, Echinoid and Crabs

Depth (m)	**Bryozoa**	**crabs**	**Echinoid**	**Radiolaria**	***Theora* sp.**	***Ostrea* sp.**	***Anadara* sp.**	***Cuna* sp.**	***Abra* sp.**	***Corbula* sp.**	***Arca* sp.**	***Mactra* sp.**	***Corbicula* sp.**	***Tellina* sp.**	***Barchidonte* sp.**
20											X		X		X
21															
22			X												
24					X	X	X								
25															
26	X														
27			X		X			X			X		X	X	X
28		X	X	X			X								
29	X	X	X	X	X	X	X	X	X	X	X		X	X	X
30	X	X	X	X	X			X	X	X					

Table 6. Distribution of Gastropoda species on the studied borehole.

Depth (m)	*Vitrinella* sp.	*Cerithium* sp.	*Cerithium columra*	*Planorbis* sp.	*Odostoma* sp.	*Chrysallida* sp.	*Assiminea* sp.	*Turritella* sp.	*Terebra* sp.	*Vivipara* sp.	*Nucella* sp.	*Polonius* sp.	*Patella* sp.	*Barleeia* sp.	*Margarita* sp.	*Obtusella intersecta*	*Ethminolia* sp.
22			X	X	X	X											
24													X	X			
25																	
26																	
27	X			X			X		X				X		X	X	X
28											X						
29	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30							X				X	X	X				

Quartz is a dominant mineral from depth intervals between 3 to 20 m, after it decreases at their amount from depth intervals 23 to 30m as presented in Table 2. On the other hand, calcite has the highest values at depth intervals of 17, 20, 23, 27, 28, and 30m. The variations in mineralogy and texture studies with depths gave an indicator to environment conversion in the Quaternary period; evaluation of the ionic content and concentration determines in the marine environment caused by precipitation of the main evaporation minerals represented by carbonate, halite, and gypsum (Geisler, 1982). Quartz and feldspar are the main components in detrital sediments. Calcite and evaporate minerals are the main minerals during marine transgression and/or regression. The variation in the chemical and physical properties and relative content of terrigenous and chemical sedimentary rocks can reflect the differences in the sedimentary environment. The relationship between quartz and calcite may give an indicator to the environment transition from terrestrial to the marine environment. The height values of quartz than calcite at top profiles of depth intervals and it decreased gradually from 40% at 3m to 29% at 23m, and increase the calcite content at 23 and 27m respectively, may be attributed to environment conversion from the terrestrial (fluvial) environment to marine. In addition to, evaporate minerals represented by halite and gypsum started to increment from depth intervals 17, 20 m to 35m may be compatible for this result. To enhance this conclusion, the organism's investigation is carried out. Depending on the study of assemblages from identified fossils (Foraminifera, Ostracoda, Mollusca, and Radiolarian), there are four distinguished stages in the study area respectively from the bottomto the top of the studied well (Tables 3, 4, 5 and 6).The first stage started from the depths interval 35 to 30m, the similarity of facies (silty sand) and fauna existence, reflect a union in deposition could belong to the marine environment at the beginning of the coastline towards the land, some of the planktonic assemblages and radiolarian species are a good indicator of marine facies (Fig. 3 (26 and 27)). The second stage presented the depths interval of 30 to 27 m, it was typical facies (silty sand) of the Hammar Formation, the assemblages of fauna have been represented a saline water like Alocopocythere reticulata, Cushmanidae guhai, Hemikirthe petersoni, Carinocythereis indica. etc. It completely matched with typical section of the Hammar Formation (both of stages 1 and 2 are compatible with mineralogy study by present of calcite and evaporate minerals). The third stage extended from depths interval 27 to 17 m, it was represented a slight regression of the sea water and most of the Hammar fauna are disappeared gradually or rarely existence. The fourth stage extended from depths 17 to 0 m, it represents of mixed environments between the freshwater (continental) and brackish water, it is fluvial Holocene period. This result agree with the conclusions that gave by Al-Jaberi (2017), who give data indication that early quaternary marine transgression happened in 35 to 30m, and center of quaternary marine transgression detected in 27 and 28 m, while late marine transgression detected in 17m, and all of these represent by the Hammar Formation.

CONCLUSIONS

1. Quartz and feldspar are present in the clayey silt texture.
2. Calcite and most of the evaporate minerals are dominant in the silty sand texture.
3. Foraminifera, ostracods, mollusca, and radiolarian are most of fossils in the study area.
4. Hammar marine transgression started at depths 35 and 30 m, while marine regression started at 27 and finished at 17m.
5. Fluvial Holocene period started from the depth of 17m to the surface.

ACKNOWLEDGEMENTS

The authors are very grateful to the Editor in Chief Prof. Dr. Salih M. Awadh, the Secretary of Journal Mr. Samir R. Hijab and the Technical Editor Dr. Heba S. Al-Mimar for their great efforts and valuable comments. Also, special thanks to Mr. Ammar A. Jasim for his assistance.

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