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Benthic Foraminifera and *Bithynia* sp. Opercula as Indicators of Depositional Environment of Late Holocene in Eastern Hammar Marsh, Southern Iraq.

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Abstract

37 samples were collected from three sites in southern Iraq (north of Basrah Governorate), east of Hammar Marsh, in order to determine depositional environments in the Late Holocene. The study was based on the distribution of foraminifera species in sediments, which is an excellent tool in reconstructing the ancient environments of sediments and thus revealing the depositional environments prevailing at that time. In addition to the presence of Gastropoda opercula represented by the species *Bithynia sp.*, which contributed to revealing the effect of river water in the study area. Through tracking the distribution of foraminifera species existing in the deposits of the three sites that which consist of sandy silt, silt and mud deposits, four zones were identified: zonereflects the river flow in the study area due to the widely spread of Bithynia *sp.* opercula. While zone II shows a brackish marsh environment after the reintroduction of river influence to the area. Zone III register a marine influence, zone provide evidence of a brackish marsh environment, this followed by the recent marine influence in the study area.

1. Introduction:

Southern Iraq is located at the bottom of the Lower Mesopotamian Plane, with its south covered by fresh or saltwater lakes and surrounded by extensive marshes [1]. Attention was paid to the formation and extension of these marshes as an evolving feature that increased over time [2]. More than (18,000) years ago, the sea water level was lower than its current level by more than (100) meters, meaning that the marsh area was generally dry, and the appropriate conditions were not available for the formation of these marshes. Then sea level began to rise about 14,000 years ago until 4000 BC [3]. Sedimentation resulting from the Tigris and Euphrates rivers led to the formation of a wide delta with a coastal line that progress until it reached its current location. In the past 4000 years, the intervention of sea level fluctuations, differential sedimentation, and neotectonic activities as an additional factor helped develop the southern marshes, especially in the lower Mesopotamia [4]. The study of macrofauna and microfauna has contributed greatly to revealing the environments in marshes during all the events they went through during their development until they reached their current form. Study of Gastropods and Lamellibranchs of near-surface sediments in different locations in Basrah Governorate demonstrated the presence of a marine and recent environment [5].

In addition, [6] studied the marine or brackish water conditions in the marshes sediments of southern Iraq by studying Mollusca, Foraminifera and Ostracoda. Perhaps one of the most important types of microfauna that are excellently used to indicate environments is foraminifera, due to its presence in all aquatic environments, including marine, brackish and fresh water, as it is distributed in all latitudes [7].

Benthic foraminifera are considered more important in studies of detecting different environments, as they are available in large numbers compared to macrofauna, which makes it traditionally used as an environmental monitor. They also respond to changes in environmental conditions faster [8]. The importance of Gastropods opercula is also no less of their environmental significance and identifying the Gastropods species that existing in that environment, even if their shells are not available, especially the Gastropods opercula are harder than their shells, therefore their numbers are greater than their shells numbers [9].The importance of this was demonstrated in the study of [10] when he used Gastropods opercula to determine the facies type in one section of Maymouna Formation of the Quaternary period.

The current study aims to identify the ancient depositional environments in southern Iraq, which date back to the Late Holocene, using benthic foraminifera and gastropods opercula to detect them.

2. Materials and Method:

2.1 The Study Area:

The study area is located to the east of Hammar Marsh, within the north of Basra Governorate, that located in southern Iraq, as shown in Figure 1. The sources of sediments supply for the study area vary between wind and river sediments [4], in addition to the study area being affected by sea water during the sea level rise through the Holocene period [1]. The sediment samples were collected from three sites whose depths ranged from 0.15 to 2.77 meters during August 2018.

2.2 Sampling:

The three sites were excavated using a Poclain excavator machine, and the surface layer of sediments at each depth was removed before taking samples from the three sites in which mixing of sediments may have occurred during the excavation process. Samples were taken from each site at different depths, depending on the apparent changes in the color and nature of the sediments at each depth.

2.3 Laboratory Proceeding:

Sediment samples were first wet sieved through a 63 μm mesh sieve and dried at room temperature. For the finer fraction analysis, a Malvern Mastersizer 2000 was used at the Department of Geology, College of Science, University of Basrah. Grain size distribution was carried out and the percentage of each group (i.e. sand, silt, and clay fraction) was plotted on a Folk ternary diagram [11] to determine the sediment distribution at the three sites.

For microfossils analyses, the 63 μm fraction that resulted from the wet sieving of each sample was chosen and the studied microfauna assemblages were picked up and classified under a binocular streoscopic microscope. The species were photographed using a scanning electron microscope (Field Emission Scanning Electron Microscopy (FE-SEM) Nova Nano SEM 450(. The identification of foraminiferal taxa was based on [12], [13], [14]. While in the classification of gastropods operculum, [15] and [16] were depended.

3. Results:

3.1 Sediments:

The results of the grain size analysis [11] for the samples of the studied sites show the presence of three types of sediments: sandy silt, silt and mud, listed in Table1. The mud was the most abundant sediment in the studied area, constituting 49% of the total studied samples, followed by silt with 32%, and then the least abundant sediment, sandy silt with 19%.

Sandy silt was present in the surface sediments up to the depth of 0.55 m. As for the silt sediments, the depths reached 2.70 m, while the greater depths were dominated by mud sediments. In general, the proportion of silt grains and then clay in the sediments is the most dominant in the sediments of the area compared to sand grains. From the nature of the existing sediments, it is clear that the deposition of these sediments was during a low-energy sedimentation environment [17].

3.2 Foraminifera and Gastropods Opercula:

Foraminifera shells are the dominant and common microfaunal content in all sites of the study area and in all depths, and all species of foraminifera are from benthic calcareous taxa, as demonstrated in Figures 2 and 3, and the foraminifera species are; *Quinqueloculina parvula* (Schlumberger, 1894), *Buccella frigida* (Cushman, 1922), *Ammonia aomoriensis* (Asano, 1951), *Ammonia beccarii* (Linnaeus, 1758), *Ammonia tepida* (Cushman ,1926), *Elphidium excavatum* (Terquem) forma *galvestonensis* (Kornfeld, 1931), *Elphidium excavatum* (Terquem) forma *gunteri* (Cole, 1931), *Elphidium incertum* (Williamson, 1858), *Elphidium poeyanum* (d'Orbigny, 1839).

Species were classified into indicative groups to define the environments in the study area according to their distinctive species assemblage at the identified depths. Recording the occurrence of species; Quinqueloculina parvula (Schlumberger, 1894), *Ammonia aomoriensis* (Asano, 1951), *Elphidium excavatum* (Terquem) forma *galvestonensis* (Kornfeld, 1931), *Elphidium excavatum* (Terquem) forma *gunteri* (Cole, 1931),

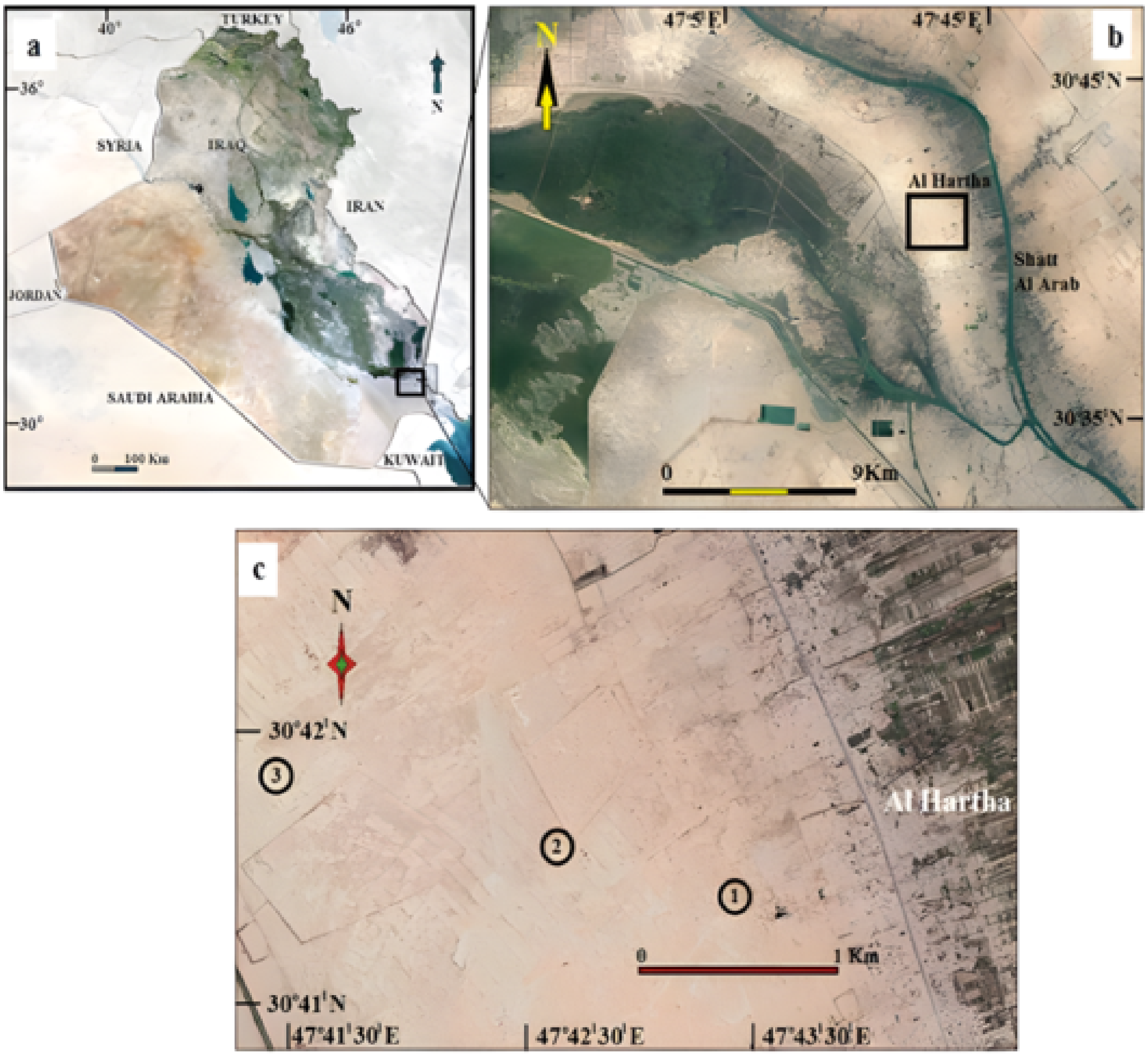

Figure 1. (a) Map of Iraq. (b)The study area. (c) The sampling locations.

Table 1. Grain size distribution and the sediments texture of the three studied sites.

Sediment type	Site 1				Site 2				Site 3			
	Depth m	Sand %	Silt %	Clay %	Depth m	Sand %	Silt %	Clay %	Depth m	Sand %	Silt %	Clay %
Sandy silt	0.25	27	60	13	0.15	27	60	13	0.30	26	62	12
	0.45	21	69	10	0.30	20	75	5	0.45	17	70	13
	0.55	26	65	9	-	-	-	-	-	-	-	-
Silt	0.60	9	84	7	0.35	5	85	10	0.50	2	86	12
	0.75	7	85	8	0.41	6	82	12	0.61	5	85	10
	0.83	9	81	10	0.70	8	80	12	0.80	4	82	14
	0.90	3	88	9	-	-	-	-	-	-	-	-
	2.00	1	84	15	-	-	-	-	-	-	-	-
	2.70	3	86	11	-	-	-	-	-	-	-	-
Mud	0.96	2	56	42	0.80	4	52	44	0.85	9	49	42
	1.35	4	59	37	1.00	4	59	37	1.10	6	56	38
	1.75	5	57	38	1.40	1	57	41	1.70	6	59	36
	1.80	2	62	36	1.45	8	56	36	1.75	7	52	41
	1.95	1	63	36	1.90	2	61	37	2.00	4	49	46
	2.77	1	60	39	2.35	3	60	37	2.40	3	60	37

is the first in Iraq generally and in its south particularly.

Among the distinctive remains in the area sediments is Gastropods opercula which appeared in large numbers at appointed depths without the appearance of their shells. After identification all opercula, they were found that belong to one genus, Bithynia sp, as shows in Figures 2. When comparing these opercula with the modern Bithynia species opercula that found in the sediments of southern Iraq, they were not similar to them, while the *Bithynia sp.* opercula found in the study area are ancient and estimated to be from the late Holocene period.

3.3 Benthic Foraminiferal and *Bithynia sp.* Opercula Zones:

After determining the microfauna content in the three sites, as shown in Figure 2 and Figure 3, it appeared that there were similarities in the assemblages of specific species of foraminifera at appointed depths in the three sites, in addition to the presence of *Bithynia sp.* opercula. Accordingly, the biozonation in the three sites was divided into four zones as shown in Figure 4, which are from bottom to top;

1-ZoneIV

This zone was determined by alternating mud and silt deposits at the first site, and mud deposits at the second and third sites with thicknesses reaching 0.97, 0.9 and 0.65 m respectively.

It is characterized by the appearance of the foraminifera species Ammonia *beccarii* and *Ammonia* tepida as dominant species, with the presence of Elphidium incertum, Elphidium poeyanum and Quinqueloculina parvula, where the latter species appears for the first time in Iraq at its south, with the presence of small numbers of Buccella frigida.

What is noteworthy that below this zone in the first site after a depth of 2.77 m and in the third site at a depth greater than 2.40 m, there are reddish brown mud deposits with completely devoid of any type of fossils. Which in turn is evidence that these deposits are riverine [18]. [19] indicated the presence of these deposits in the southern Mesopotamian, and [20] also mentioned the presence of these deposits in southern Iraq, specifically north of Basrah Governorate.

The assemblage of foraminifera species and the variation in their individuals numbers may add evidence to the type of ancient environment of this zone deposits , which is a brackish environment, where saline marine waters overlap slightly with river waters. This is evident from the appearance of Quinqueloculina parvula, Buccella frigida, Elphidium incertum and Elphidium poeyanum, known for their high tolerance to salinity changes, as well as their dispersal in different environments interspersed with marine waters [21] [22] [23]. What confirms the brackish zone is the dominance of the Ammonia beccarii and Ammonia tepida species, which are present in large numbers that exceed the number of other species [24].

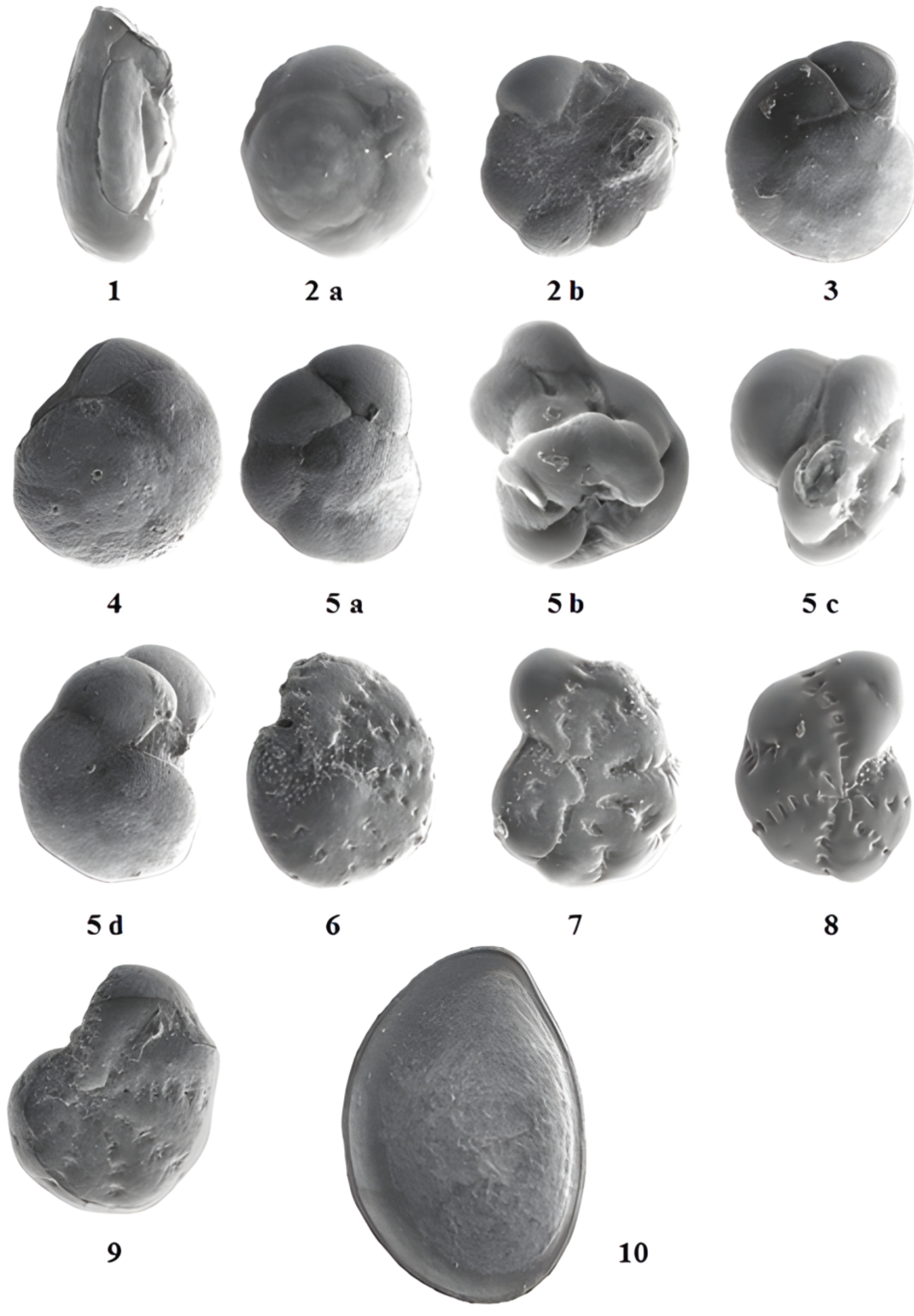

Figure 2. Scanning electron micrographs (SEM) of the identified Benthic foraminifera in this study. 1. Quinqueloculina parvula (Schlumberger, 1894), Four chamber side. 2a-2b. Buccella frigida (Cushman, 1922), a. Spiral view. b. Chamber deformation, Umbilical view. 3. Ammonia aomoriensis (Asano, 1951), Spiral view. 4. Ammonia beccarii (Linnaeus, 1758), Spiral view. 5a-5d. Ammonia *tepida* (Cushman ,1926), a. Spiral view, b. Twin forms, Umbilical view. c. Additional chamber, Spiral view. d. Additional chamber, Spiral view. 6. Elphidium excavatum (Terquem) forma galvestonensis (Kornfeld, 1931). 7. Elphidium excavatum (Terquem) forma gunteri (Cole, 1931). 8. Elphidium incertum (Williamson, 1858), Spiral view. 9. Elphidium poeyanum (d'Orbigny, 1839), Spiral view. 10. Bithynia sp. operculum, Interior surface. The scale bar is 100 μm.

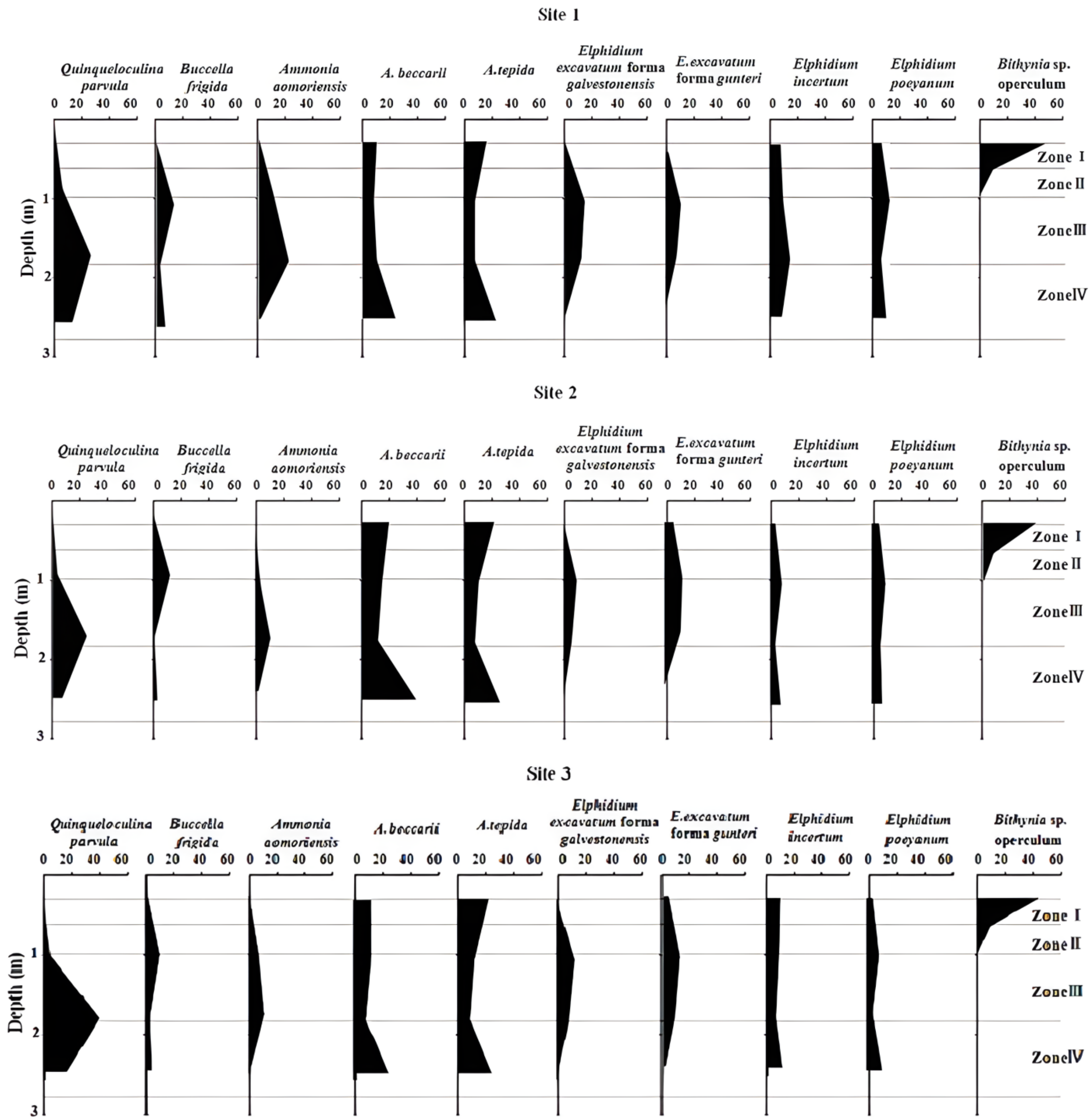

Figure 3. Relative abundance of the identified foraminiferal species and *Bithynia sp.* opercula (%) within zones I - IV.

2-Zone III

This zone is composed by mud deposits in most of the three sites except the first site where it is shared with silt deposits (Figure 4). The thicknesses of the zone is varied as 0.79 m in site 1, and 0.6 m in site 2, while the highest thickness of the zone is 0.85 m in site 3.

Quinqueloculina parvula dominated the other foraminifera species of *Ammonia aomoriensis*, *Ammonia beccarii* and *Ammonia tepida.* Ammonia aomoriensis recorded for the first time in southern Iraq, as are the two other species *Elphidium excavatum* (Terquem) forma *galvestonensis* and *Elphidium excavatum* (Terquem) forma *gunteri*, but their individuals numbers are lower compared to the foraminifera assemblage mentioned previously. There were also fewer occurrences of *Buccella frigida*, *Elphidium incertum* and *Elphidium poeyanum*, but their numbers were higher than in the previous zone.

It was noted in this range that there were abnormalities in shape of the two species Buccella *frigida* and Ammonia *tepida*, but in a small proportion compared to the proportion of individuals of the two species with the normal form Known for these species.

This zone may reflect the shallow marine environment due to the dominance of the species *Quinqueloculina parvula* [23], and the presence of the Ammonia aomoriensis [25]. The same applies to the rest of the species, the appearance of which indicates a dominant marine influence in the study area in these depths [21] [26].The abnormalities of Buccella frigida and Ammonia tepida are considered evidence of environmental stress [27]. Based on the abnormality of the two species and the presence of these forms, which does not exceed 1% compared to the normal forms, the cause of the environmental change can be attributed to the occurrence of salinity fluctuations represented by an increase in the salinity level, but under normal marine salinity conditions estimated at (37%) [28].

3-Zone II

This zone is distinguished at site 1 with silt deposits with 0.3 m thick, and at sites 2 and 3 where mud deposits are 0.35 and 0.3 m thick, respectively (Figure 4). The individuals numbers of the combined species of *foraminifera* are close in terms of presence, namely; *Buccella frigida*, *Ammonia beccarii*, *Ammonia tepida*, *Elphidium excavatum* (Terquem) *forma gunteri*, *Elphidium incertum* and *Elphidium poeyanum*. While the two species *Quinqueloculina parvula* and *Ammonia aomoriensis* showed less existence.

Although this zone is devoid of gastropods shells, only opercula without shells have been recorded. These opercula are registered for the first time in this study, they belong to the species *Bithynia sp.* and have few numbers as well as varying in size.

This zone represents the reintroduction of the river water'sinfluence on the marine environment, transforming it into a brackish setting, this change is reflected in the species of foraminifera, especially the presence of Ammonia beccarii, Ammonia tepida, and Elphidium excavatum (Terquem) forma gunteri [29].

The opercula also played a role in the environmental indication of the return of the river water effect, especially since it belongs to the freshwater gastropoda known as *Bithynia sp* [30]. The occurrence of *Bithynia sp.* opercula is evidence of the shells presence of this species in the southern Iraq sediments, even if the shells did not appear, because the opercula of this species in particular is characterized by being calcareous compared to their shells composed of aragonite, and therefore the opercula appears more abundant than their shells due to the possibility of their preservation [9].

4-Zone I

The largest thickness of the zone appeared at site 1, where it reached 0.3 m of sandy silt deposits, and the thickness of the zone was equal at sites 2 and 3, where it reached 0.15m of silt and sandy silt deposits as shown in Figure 4.

As for foraminifera species, *Ammonia tepida* predominates, with the presence of a number of *Ammonia beccarii* individuals and the rare existence of *Elphidium excavatum* (Terquem) *forma gunteri*, *Elphidium incertum*, and *Elphidium poeyanum*.

The predominance of *Bithynia sp* opercula in the area sediments is an obvious indication of a riverine environment where freshwater influence is dominant [30], this is because the species Bithynia is common in all types of freshwater bodies [31], [32] and the opercula sizes variation with their dense existence, in turn, is evidence of the coexistence species in the study area. The same applies to the occurrence of *Ammonia beccarii* and *Ammonia tepida* in somewhat good numbers, indicating a high river influence in the area [24], [33], [34].

4. Discussion:

The sediments of the four zones occupied depths ranging between (2.35–2.77 m) and their sediments were accumulated over ancient river sediments which are probably sediments of the banks of the ancient Shatt al-Arab [20] [35]. The quality of the shells and the nature of their preservation suggested that these deposits represent the Late Holocene, approximately 3000-2000 years ago. This is consistent with what [20] stated that approximately 2 meters below the surface of the deposits north of Basra are from the Late Holocene period. Foraminifera played a major role in revealing the depositional environments of these zones, especially since foraminifera can be used to reconstruct the paleoenvironment of past environments [36].

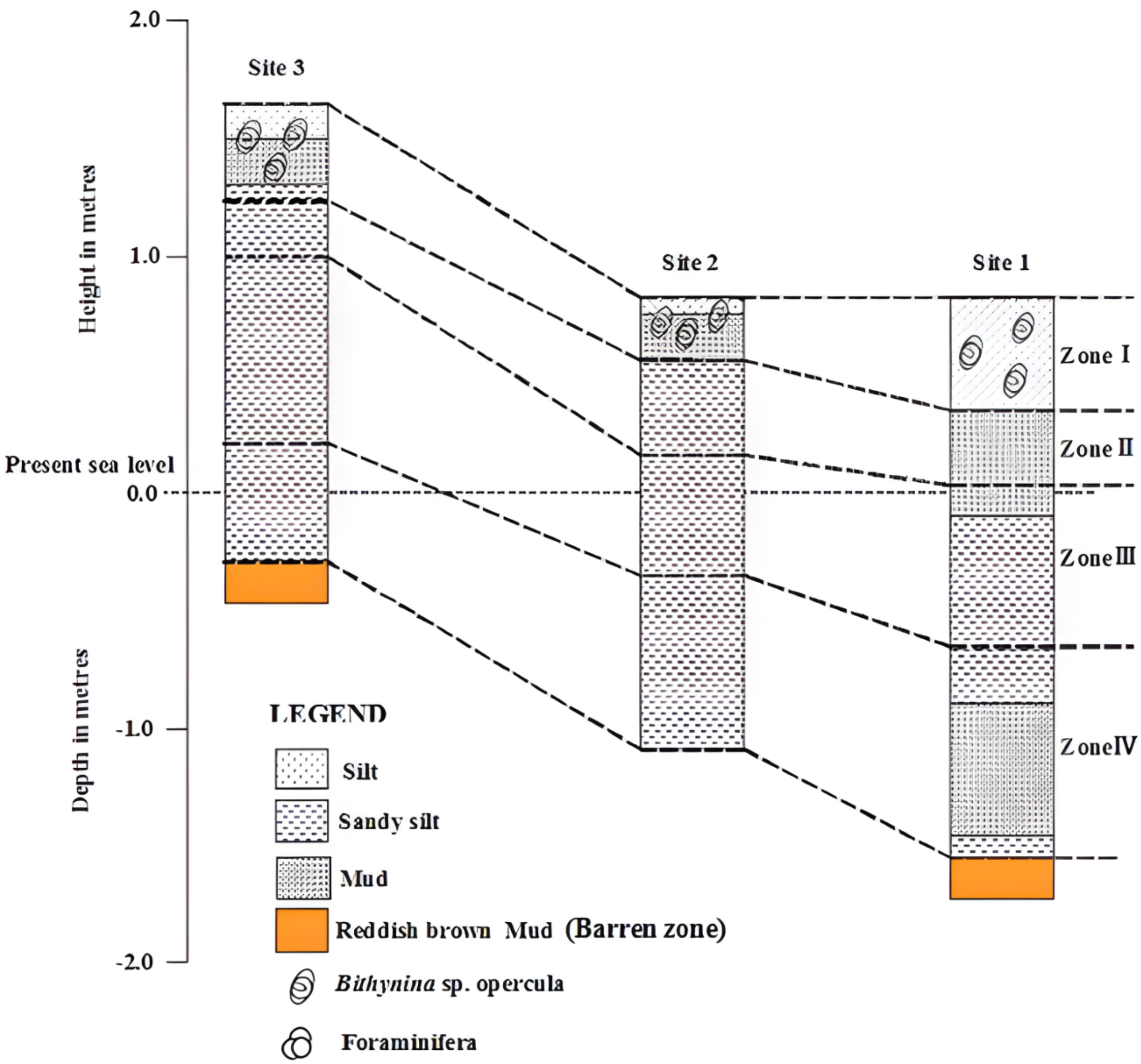

Figure 4. Distribution of the identified zones,II, III and IV in the study.

The high presence of *Ammonia beccarii* and *Ammonia tepida* in zone IV is an indication of the influence of river water in the area [37] and this was also evident in the sediments of the zone, which varied from mud at the bottom to silt. However, the occurrence of *Quinqueloculina parvula*, *Elphidium incertum* and *Elphidium poeyanum* supported the idea of a transition in this zone to a Brackish environment [38]. The depositional environment of this zone is Brackish marsh, where *Elphidium incertum* and *Elphidium poeyanum* assemble [36] [39].

Zone III reflected increased marine water flow, with the dominance of *Quinqueloculina parvula* and the appearance of *Ammonia aomoriensis*, *Elphidium excavatum* (Terquem) forma *galvestonensis* and *Elphidium excavatum* (Terquem) forma *gunteri*, and the decline of *Ammonia beccarii* individuals number, indicating a shallow marine environment with normal salinity [40], [41]. Sea level rise during the Late Holocene was minor, as the marine environment was shallow and limited to the presence of only benthic foraminifera species [20].

Zone II showed the marine influence decreased while the effect of river water flow into the area became apparent through the increase of Ammonia beccarii individuals and the presence of Ammonia tepida. However, the occurrence of Elphidium excavatum (Terquem) forma gunteri gave the opportunity for the marsh environment [42] to be of the Brackish type, especially with the existence of Elphidium incertum and Elphidium poeyanum.

As zone II approached its end, *Bithynia sp* opercula began to appear (missing their shells) without shells. This is due to the calcareous character of this species opercula, which enabled their preservation in the sediments during geological time periods. Also, their shells were not found anywhere close to the study area. *Bithynia sp* opercula increased in zone I sediments and dominated over the foraminifera species, thus concluding the zone sediments with the predominance of river water condition in the area.

When reviewing the sediment type in each zone, it is noted that the increase or decrease of any individuals species of foraminifera was not related to the type of sediments, which are generally fine sediments, as much as they were related to the quality of the water penetrating the sediments. The study area in general showed the effect of sea level fluctuations on it in the Late Holocene, which was represented by a rise in sea level during the past 3000-2000 years. This is apparent from the foraminifera species those presence in the zones. The current study agreed with the study of [20] and [43] that the southern Iraq region was exposed to a slight marine transgression in the Late Holocene.

5. Conclusions:

1. The foraminifera assemblages in the sediments of the three sites revealed of four biozones: zone IV, where the marsh environment is brackish, zone III, which showed the influence of the normal marine environment, zone II, which reflected the return of the brackish environment with the decline of the marine influence and was represented the brackish marsh environment, and close to the surface, zone showed the riverine environment through the large contribution of Gastropoda opercula of a freshwater type known as *Bithynia sp*, which is widely spread in this zone.
2. The identified foraminifera species (*Quinqueloculina parvula* (Schlumberger, 1894), *Buccella frigida* (Cushman, 1922), *Ammonia aomoriensis* (Asano, 1951), *Ammonia beccarii* (Linnaeus, 1758), *Ammonia tepida* (Cushman ,1926), *Elphidium excavatum* (Terquem) forma *galvestonensis* (Kornfeld, 1931), *Elphidium excavatum* (Terquem) forma *gunteri* (Cole, 1931), *Elphidium incertum* (Williamson, 1858), *Elphidium poeyanum* (d'Orbigny, 1839)) showed that they were affected by the degree of water salinity in their distribution, and their assemblage did not show any relationship with the type of sediments in the study area, which was represented by sandy silt, silt and mud.
3. This study recorded for the first time in Iraq, and especially in the south of it, the appearance of new species, which are; *Quinqueloculina parvula* (Schlumberger, 1894), *Ammonia aomoriensis* (Asano, 1951), *Elphidium excavatum* (Terquem) forma *galvestonensis* (Kornfeld, 1931), *Elphidium excavatum* (Terquem) forma *gunteri* (Cole, 1931).

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Data Availability Statement: All of the data supporting the findings of the presented study are available from corresponding author on request.

Declarations:
Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: The manuscript has not been published or submitted to another journal, nor is it under review.

References

[1] A. Aqrawi. The nature and preservation of organic matter in holocene lacustrine/deltaic sediments of lower

mesopotamia, SE Iraq. *Journal of Petroleum Geology*, 20: 69–90, 1997, doi:10.1111/j.1747-5457.1997.tb00756.x.

[2] C. Baeteman, L. Dupin, and V–M Heyvaert. The persian gulf shorelines and the karkheh, karun, and jarrahi rivers: A geo-archaeological approach. *Geo-Environmental Investigation*, 2: 5–12, 2005.

[3] P. Sanlaville. The deltaic complex of the lower mesopotamian plain and its evolution through millennia, 2002.

[4] A. Aqrawi and G. Evans. Sedimentation in lakes and marshes (ahwar) of the tigris-euphrates delta, southern mesopotamia. *Journal of Sedimentology*, 41: 755–776, 1994, doi:10.1111/j.1365-3091.1994.tb01422.x.

[5] R.G.S. Hudson, F.E. Eames, and G.L. Wilkins. The fauna of some recent marine deposits near basrah. *Iraqi Geological Magazine*, 94(5): 393–401, 1957.

[6] W.A. Macfadyen and C. Vita-Finzi. Mesopotamia: the tigris-euphrates delta and its holocene hammar fauna. *Geological Magazine*, 115(4): 287–300, 1978.

[7] B. Moghaddasi, S. Nabavi, G. Vosoughi, S.M.R Fatemi, and S. Jamili. Abundance and distribution of benthic foraminifera in the northern oman sea (iranian side) continental shelf sediments. *Research Journal of Environmental Sciences, Academic Journals Inc.*, 2: 210–217, 2009.

[8] V.M.P. Bouchet, E. Alve, B. Rygg, and J. Richard. Benthic foraminifera provide a promising tool for ecological quality assessment of marine waters. *Telford Ecological Indicators*, 23: 66–75, 2012, doi:10.1016/j.ecolind.2012.03.011.

[9] H. Scholz and M. Glaubrecht. Shell and operculum taphonomy of the bithyniid gastropod gabbiella in the pleistocene turkana basin, north kenya. *Journal of Paleontology*, 87(1): 84–90, 2013.

[10] S. Al Sheikhly. Maymouna formation: A new fresh-brackish water formation of quaternary age in southern iraq. *Iraqi Journal of Science*, 42C(4): 120–127, 2001.

[11] R.L. Folk. *Petrology of Sedimentary Rocks*. Hemphill Publishing Company, Austin, 4^{th} edition, 1980.

[12] A.R. Loeblich and H. Tappan. *Foraminiferal Genera and Their Classification*. Van Nostrand Reinhold Company, New Yourk, 1^{st} edition, 1988.

[13] F. Sgarrella and M. Moncharmont Zei. Benthic foraminifera in the gulf of naples (italy): systematics and autoecology. *Bollettino della Societá Paleontologica Italiana*, 32(2): 145–264, 1993.

[14] Y. Lei and T. Li. Ammonia aomoriensis (asano, 1951) and ammonia beccarii (linnaeus, 1758) (foraminifera): Comparisons on their taxonomy and ecological distributions correlated to temperature, salinity and depth. *Acta Micropalaeontologica Sinica*, 32(1): 1–19, 2015.

[15] A.G. Checa and A.P. Jiménez-Jiménez. Constructional morphology, origin, and evolution of the gastropod operculum. *Paleobiology*, 24: 109–132, 1998.

[16] F.W. Welter-Schultes. *European Non-Marine Molluscs, a Guide for Species Identification*. Planet Poster Editions, Göttingen, Germany, 1^{st} edition, 2012.

[17] R. Bhattacharya, N. Das Chatterjee, and G. Dolui. Grain size characterization of instream sand deposition in controlled environment in river kangsabati, west bengal. *Modeling Earth Systems and Environment*, 2(118): 1–14, 2016, doi:10.1007/s40808-016-0173-z.

[18] H.F.L Williams. *Sea-Level Change and delta growth: Fraser Delta, British Columbia*. PhD thesis, Simon Fraser University, Burnaby, British Columbia, 1988.

[19] A. Aqrawi. Stratigraphic signatures of climatic change during the holocene evolution of tigris-euphrates delta, lower mesopotamia. *Journal of Global and Planetary Change*, 28: 267–283, 2001, doi:10.1016/S0921-8181(00)00078-3.

[20] B.M Issa. Depositional environment and biofacies of selected sediments north basra. *Journal of Basrah Research*, 32(5): 1–13, 2010.

[21] G. Bartlett. *Distribution and abundance of foraminifera and thecamoebina in Miramichi River and Bay*. Canada, Bedford Institute of Oceanography, Dartmouth, 1966.

[22] S. Yasufy, K. Watanabe, Y. Kamoi, and I. Kobayashi. Holocene foraminiferal fauna and sedimentary environment in the shirone area, echigo plain, central japan. *Science reports of Niigata University, Series E, (Geology)*, 15: 67–89, 2000.

[23] B.W. Hayward, F. Le Coze, D. Vachard, and O. Gross. *World Foraminifera Database. Quinqueloculina parvula Schlumberger, 1894*. 2021.

[24] A. Goineau, C. Fontanier, M. Mojtahid, A-S. Fanget, M-A. Bassetti, S. Berne, and F. Jorissen. Live–dead comparison of benthic foraminiferal faunas from the rhône prodelta (gulf of lions, nw mediterranean): Development of a proxy for palaeoenvironmental reconstructions. *Marine Micropaleontology*, 119: 17–33, 2015, doi:10.1016/j.marmicro.2015.07.002.

[25] Y. Lei and T. Li. *Atlas of benthic foraminifera from China Seasthe Bohai Sea and the Yellow Sea*. Berlin, Germany, Springer, 1st edition, 2016.

[26] B. Satyanarayana, M-L Husain, R. Ibrahim, S. Ibrahim, and F. Dahdouh-Guebas. Foraminiferal distribution and association patterns in the mangrove sediments of kapar and matang, west peninsular malaysia. *Journal of Sustainable Science and Management*, 9: 32–48, 2014.

[27] Y.L. Lei, T.G. Li, H. Bi, W.L. Cui, W.P. Song, J.Y. Li, and C.C. Li. Responses of benthic foraminifera to the 2011 oil spill in the bohai sea, pr china. *Marine Pollution Bulletin*, 96(1–2): 245–260, 2015.

[28] V. Stouff, E. Geslin, J.-P Debenay, and M. Lesourd. Origin of morphological abnormalities in ammonia (foraminifera): studies in laboratory and natural environments. *Journal of Foraminiferal Research*, 29(2): 152–170, 1999.

[29] D.B. Ostrognay and D.W. Haig. Foraminifera from microtidal rivers with large seasonal salinity variation, southwest western australia. *Journal of the Royal Society of Western Australia*, 95(3/4): 137–153, 2012.

[30] P. Glöer, C. Albrecht, and T. Wilke. Enigmatic distribution patterns of the bithyniidae in the balkan region (gastropoda: Rissooidea). *Mollusca*, 25(1): 13–22, 2007.

[31] Y.P. Chitramvong. The bithyniidae (gastropoda: Prosobanchia) of thailand: comparative internal anatomy. *Walkerana Transactions of the POETS Society*, 5(14): 161–206, 1991.

[32] Y.P. Chitramvong. The bithyniidae (gastropoda: Prosobranchia) of thailand:comparative external morphology. *Malacological review*, 25: 21–38, 1992.

[33] I.M. Ghafor and P.M. Ahmad. Stratigraphy of the oligoceneearly miocene successions, sangaw area, kurdistan region, ne-iraq. *Arabian Journal of Geosciences*, 14(6): 1–7, 2021, doi:10.1007/s12517-021-06697-0.

[34] R. F. Rashidi, I.M. Ghafor, and A. Javadova. Benthic foraminifera as a tool for indication of biostratigraphy, and paleoecology of the guri member (mishan formation), bandar abbas, south iran. *Bulatovsky Readings Collection Of Articles –UDC*, 55(1): 37–53, 2023.

[35] A.A.M. Aqrawi. *Recent sediments of the Tigris–Euphrates delta: the southern marshlands Ahwar*. PhD thesis, University of London, UK, 1993.

[36] J.W. Murray. The niche of benthic foraminifera, critical thresholds and proxies. *Marine Micropaleontology*, 41(1-2): 1–7, 2001.

[37] A. Goineau, C. Fontanier, F. J. Jorissen, R. Buscail, P. Kerhervé, C. Cathalot, A. M. Pruski, F. Lantoine, S. Bourgeois, E. Metzger, E. Legrand, and C. Rabouille. Temporal variability of live (stained) benthic foraminiferal faunas in a river dominated shelf: faunal response to rapid changes of the river influence (rhône prodelta, nw mediterranean). *Biogeosciences*, 9: 1367–1388, 2012, doi:10.5194/bgd-8-9033-2011.

[38] Ir. Rifardi. Ecological analysis of living benthic foraminifera in surface sediments from the south yatsushiro kai (sea), southwest kyushu, japan. *Journal of Coastal Development*, 5(3): 117–129, 2002.

[39] F.B. Phleger. Patterns of marsh foraminifera, galveston bay. *Limnology and Oceanography,Texas, USA*, 1965.

[40] L. Gustiantini, K.T. Dewi, A. Muller, and P. Praptisih. Paleoenvironmental reconstruction from benthic foraminiferal assemblages of early holocene, shallow marine deposits in gombong, central java. *Bulletin of the Marine Geology*, 22(1): 16–27, 2016, doi:10.32693/bomg.22.1.2007.2.

[41] S. Tabita. *A study on foraminifera in the shelf sediments off Chennai-Cuddalore, East Coast of India*. PhD thesis, University of Pondicherry, India, 2015.

[42] D. Scott, J. Suter, and E. Kosters. Marsh foraminifera and arcellaceans of the lower mississippi delta: Controls on spatial distributions. *Micropaleontology*, 37(4): 373–392, 1991.

[43] B.M Issa. Ostracoda and charophyte as indicators of environmental varity in the marshland area of southern iraq. *Journal of Basrah Researches: Sciences*, 42(2): 148–159, 2016.

المنخربات القاعية واغطية النوع *Bithynia* كمؤشرات للبيئة الترسيبية للهولوسين المتأخر في شرق هور الحمار، جنوب العراق

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الخلاصة

تم جمع 37 عينة من ثلاثة مواقع في جنوب العراق (شمال محافظة البصرة) شرق هور الحمار، وذلك لتحديد البيئات الترسيبية في العصر الهولوسيني المتأخر.واعتمدت الدراسة على توزيع أنواع المنخربات في الرواسب، وهي أداة ممتازة في إعادة بناء البيئات القديمة للرواسب وبالتالي الكشف عن البيئات الترسيبية السائدة في ذلك الوقت.من خلال تتبع توزيع أنواع المنخربات الموجودة في رواسب المواقع الثلاثة المدروسة والتي تتكون من رواسب الغرين الرملي والغرين والوحل، تم تحديد أربع انطقة هي: النطاق *II* والنطاق *II* و النطاق *III* و النطاق *IV*.وقد ظهر تأثير المياه البحرية في النطاق *III* ، في حين عكس النطاق *I* تدفق مياه النهر بسبب الانتشار الواسع لأغطية النوع *Bithynia* أما بالنسبة للنطاق *II* و النطاق *IV* فقد أظهر كل منهما بيئة مستنقعية مالحة، ولكن النطاق *IV* كان قبل التأثير البحري في منطقة الدراسة، في حين كان النطاق *II* بعد عودة التأثير النهري إلى المنطقة.

الكلمات الدالة: المنخربات؛ النوع *Bithynia* ؛ بطنيات الأرجل؛ شرق هور الحمار؛ الهولوسين المتأخر.

التمويل: لايوجد.

بيان توفر البيانات: جميع البيانات الداعمة لنتائج الدراسة المقدمة يمكن طلبها من المؤلف المسؤول.

اقرارات:

تضارب المصالح: يقر المؤلفون أنه ليس لديهم تضارب في المصالح.

الموافقة الأخلاقية: لم يتم نشر المخطوطة أو تقديمها لمجلة أخرى، كما أنها ليست قيد المراجعة.