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Environmental Significance of the First Appearance of *Porosononion martkobi* in Southern Iraq Sediments

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ABSTRACT

The study aimed to identify a new species that was observed for the first time in Iraq, particularly in the southern region of it, where the recent sediments from the late Holocene period are located in the north of Basrah Governorate. Eighteen samples were collected from nine sites north of Basrah Governorate (Qaryat Nasr). The texture of recent sediments for these samples was determined. As well as the diagnosis of the foraminifera species and the relative abundance of the species in the study area. The results of the grain size analysis of the studied sites' sediments showed that the study area contains five types of sediment texture: clay, sandy silt, sandy clay, mud, and sandy mud. Clay sediment is the most common type in the sediments of the region. As for the species of foraminifera that was identified, it was represented by *Porosononion martkopi*. It is one of the benthic foraminifera species that live in marine environments, so its appearance in the study area was clear environmental evidence of the exposure of southern Iraq to marine influence, which was identified in this study within the sediments of the Late Holocene period. The species *Porosononion martkopi* also showed high relative abundance where the sediments were of fine grain size, that is, the sedimentary ecosystem was quiet, which in turn provided an environment in which the species thrived.

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الأهمية البيئية للظهور الأول لـ *Porosononion martkobi* في رواسب جنوب العراق

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الملخص

هدفت الدراسة إلى التعرف على نوع جديد تم رصده لأول مرة في العراق وخاصة في المنطقة الجنوبية منه حيث تتواجد الرواسب الحديثة من فترة الهولوسين المتأخرة في شمال محافظة البصرة، وقد تم جمع ثمانية عشر عينة من تسعة مواقع شمال محافظة البصرة (قرية نصر)، وتم تحديد نسيج الرواسب الحديثة لهذه العينات، وكذلك تشخيص أنواع المنخربات والوفرة النسبية للأنواع في منطقة الدراسة، وقد أظهرت نتائج تحليل حجم الحبيبات لرواسب المواقع المدروسة أن منطقة الدراسة تحتوي على خمسة أنواع من نسيج الرواسب وهي الطين ، والغرين الرملي والطين الرملي والوحل والوحل الرملي، وتعد الرواسب الطينية النوع الأكثر شيوعاً في رواسب المنطقة. أما عن نوع المنخربات الذي تم التعرف عليه فقد تمثل بالنوع *Porosononion martkopi* وهو من أنواع المنخربات القاعية التي تعيش في البيئات البحرية لذا فإن ظهوره في منطقة الدراسة كان دليلاً بيئياً واضحاً على تعرض جنوب العراق للتأثيرات البحرية والذي تم التعرف عليه في هذه الدراسة ضمن رواسب فترة الهولوسين المتأخرة كما أظهر النوع *Porosononion martkopi* وفرة نسبية عالية حيث كانت الرواسب ذات حجم حبيبات دقيقة أي أن النظام البيئي الرسوبي كان هادئاً مما وفر بدوره بيئة ازدهر فيها هذا النوع.

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Introduction

Southern Iraq, commonly known as Lower Mesopotamia, is a region rich in history and cultural importance. This area is recognized as one of the cradles of civilization, where ancient cultures flourished between the Tigris and Euphrates rivers. Notably, the area is distinguished by its marshlands, specifically the Ahwar of Southern Iraq, which encompass numerous archaeological sites. The climate in this region exhibits considerable differences from other areas of Iraq, possessing distinct features that have shaped its environment (Saad, 2024). Complex implications of neotectonic activities, sea-level fluctuations, and differential sedimentation rates, in addition to the climatic changes during the Holocene, have resulted in the formation and preservation of these unique marshlands (Aqrawi, 2001).

One significant environmental alteration impacting southern Iraq was the rise in temperatures that caused the sea level to rise from the end of the Pleistocene era and during the Holocene (Al-Jumaily, 1994). The impact of these climatic and environmental changes appeared in the Quaternary period in southern Iraq through the influence of marine transgression that caused the formation of marine sediments at the beginning of the Holocene period (Al-Jubouri, 1997). Numerous studies have recorded the marine impact in Southern Iraq by studying the remains of faunal shells in sediments. Hudson and colleagues (1957) conducted research on marine ostracods and bivalves in the near of Basrah. Similarly, Dance and Eames (1966) focused their studies on marine bivalves found in the Basrah and Amarah regions. As for MacFadyen and Vita-Finze (1978) examined the foraminifera, ostracoda, and

bivalves found in the subsurface boreholes located in the Amarah and Garmet Ali (in Basrah) regions.

One of the most important pieces of evidence that reflected the effect of seawater on the sediments of southern Iraq is foraminifera species that proved the validity of that (Issa, 2010, 2024), the two studies successfully validated and substantiated the influence of seawater, attributed to sea level changes during the Holocene period, on the sediments found in northern Basrah (Southern Iraq). This analysis was based on the documented presence and abundance of various marine foraminifera species in the area.

Foraminifera are sensitive to environmental conditions and can adapt to a particular environment. Many studies have shown that environmental factors are the main tool that controls the distribution of foraminifera, and therefore, this type of fossil is valuable in the field of reconstructing the ancient environment (Vu, 2020). Thus, paleoenvironmental inference by using foraminifera is an essential factor for any study that intends to explore the environment of any region during a specific period of time, which is what was used in the current study, especially with the recording of the appearance of species for the first time in the sediments of the region. It also reinforces the confirmation of the impact of the paleoenvironmental conditions in the study area.

Aim of the study

The study aimed to identify a new species observed in southern Iraq (north of Basrah Governorate) where late Holocene sediments are found, and to confirm its identity as a benthic foraminifera species known as *Porosononion martkobi* and to reveal its environmental significance that led to its appearance in the study area, which in turn contributes to ultimately enhances the understanding of the paleoenvironment associated with late Holocene sediments.

Materials and Methods

The study was implemented in July 2018 in southern Iraq, Basra Governorate, south of Qaryat Nasr (Fig. 1), where sediment samples were collected using a shovel from nine sites with depths ranging between 0.5m and 1.10m according to the variation in the sediment color appearing at each depth.

To identify the type of sediments existing in the study area sites, 100 grams were taken from each sample of the mentioned sites, and a grain size analysis was performed by wet sieving on a 0.0625 mm sieve to isolate the sand from silt and clay, and to conduct the Pipette analysis based on Folk (1980).

As for the study of the foraminifera species, the wet samples were washed through a 0.0625 mm sieve to remove silt and clay, then dried and the species picked up and fixed on slides, to determine the foraminifera species was using a binocular stereoscopic microscope. The species was imaged using a scanning electron microscope (FE-SEM) Nova Nano SEM 450 in the Department of Physics, University of Basrah. The taxonomy of foraminifera was based mainly on Yanko and Troitskaja (1987), with the assistance of Cimerman and Langer (1991), and the classification of higher taxonomic categories was based on the WoRMS (World Register of Marine Species) website.

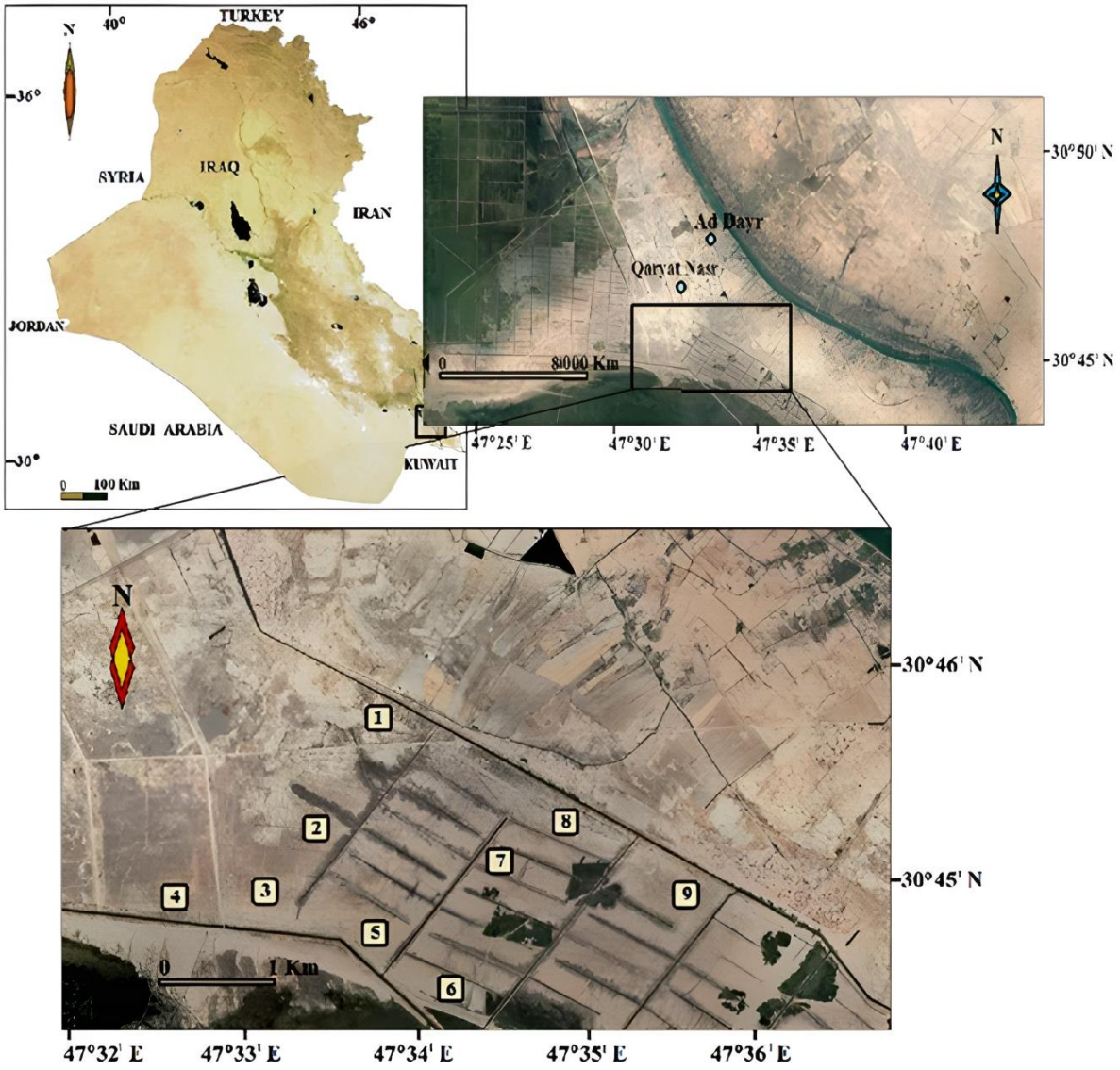

Fig. 1. Satellite image showing the studied area and location of samples

Results

Sediments texture

The results of the grain size analysis according to the classification of Folk (1980), as shown in Figure 2 and Table 1, clay sediment is very high in the study area, which forms about 44%, while sandy silt formed 17%, and also sandy clay 17%. As for the sediments of mud and sandy mud, the percentage of each of them was 11%.

In general, it is noted that the fine fraction, represented by clay, is concentrated at great depths, while the coarse fraction, sand, appears at lower depths. The variation in the distribution of fine and coarse fractions may be due to the nature of study area location, where the drying process that the area was exposed to facilitated the role of erosion on its surface, which in turn assisted in increasing the percentage of aeolian sediments that are active in the area, in addition to the proximity of the study area to river water and swamps. As well as the role of marine sediments during the Holocene period, where sea level rose and its effect on the area (Issa, 2010).

The main goal of grain size analysis is to determine the type of environment and energy associated with the transport mechanism at the time of deposition; thus, gaining a deeper understanding of the paleoenvironmental features and the conditions of deposition (López,

2017). The significance of grain size analysis extends beyond this aspect; it also plays a crucial role in understanding the relationship between the abundance of foraminifera species and particular sediment types. Foraminifera thrive in specific sediment types, with their abundance often correlated with sediment grain size. Finer sediments, such as silt and clay, tend to support higher densities of foraminifera due to better nutrient retention and organic matter availability. In contrast, coarser sediments may lead to instability and lower food quality, negatively affecting foraminiferal populations (Naik et al.,2023; El Bakkali et al., 2024).

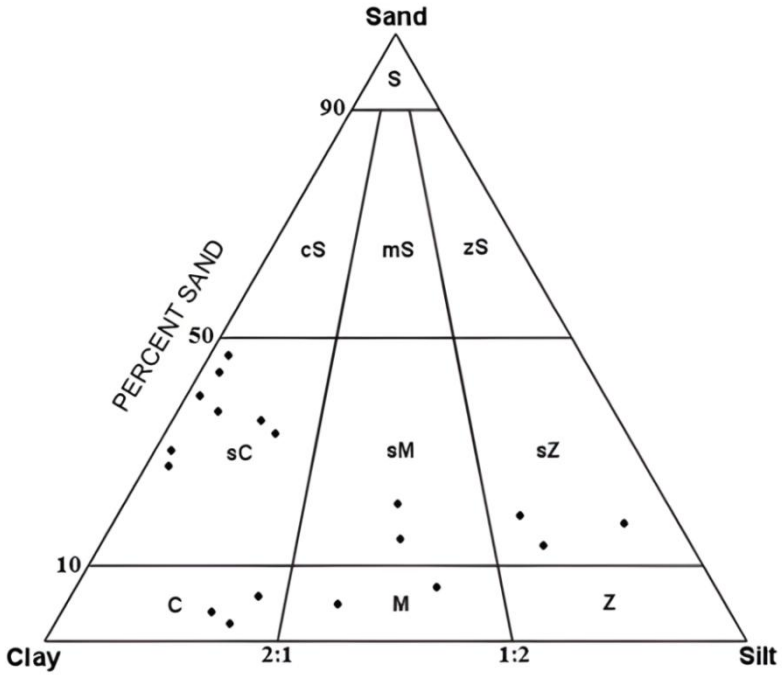

Fig. 2. Sand, silt, and clay percentage ternary diagram of the studied samples

Table 1: Sediment texture and the percentage of sand, silt, and clay in the sediment samples

Site	Sample depth (m)	Sand %	Silt %	Clay %	Sediment texture
1	0.7	14	65	21	Sandy silt
	1.0	7	52	41	Mud
2	0.8	21	40	39	Sandy mud
	0.95	4	39	57	Mud
3	0.77	44	2	54	Sandy clay
	0.96	4	20	76	Clay
4	0.5	38	6	56	Sandy clay
	0.95	40	3	57	Clay
5	0.75	38	10	52	Clay
	1.0	31	3	66	Clay
6	0.8	35	12	53	Clay
	1.05	2	28	70	Clay
7	0.5	20	58	22	Sandy silt
	1.10	47	4	49	Sandy clay
8	0.6	15	43	42	Sandy mud
	1.0	6	66	28	Clay
9	0.7	17	73	10	Sandy silt
	0.95	3	27	70	Clay

Foraminiferal species

The species *Porosononion martkobi* identity was determined as shown in Figure 3, which was prominently observed in the study area, exhibiting a dominant presence over the other remaining few foraminifera species, which were four species of benthic foraminifera (Fig. 4). Table 2 shows the relative abundance and dominance of the species *Porosononion martkobi* in the study area sites compared to the remaining foraminifera species.

The remaining species (Fig. 4) were not well defined, with some exhibiting morphological changes and others suffering from inadequate preservation, resulting in their classification as relatively minor compared to the previously mentioned species. The taxonomic system for Porosononion martkobi is outlined as follows:

Kingdom: Chromista CAVALIER-SMITH, 1981

Subkingdom: Harosa CAVALIER-SMITH, 2010

Infrakingdom: Rhizaria CAVALIER-SMITH, 2002

Phylum: Foraminifera d'ORBIGNY, 1826

Class: Globothalamea PAWLOWSKI, HOLZMANN, and Tyszka, 2013

Subclass: Rotaliana MIKHALEVICH, 1980.

Order: Rotaliida DELAGE and HEROUAD, 2013

Superfamily: Rotalioidea EHRENBERG, 1839

Family: Elphidiidae GALLOWAY, 1933

Subfamily: Elphidiinae GALLOWAY, 1933

Genus *Porosononion* PUTRYA IN VOLOSHINOVA, 1958

Porosononion martkobi BOGDANOVICH,1947

(Fig. 3)

1947*Nonion martcobi* Bogdanowicz; p. 30, pl. 1v, figs. 4a-c.

1987 *Porosononion martcobi* Bogdanowicz; Yanko and Troitskaya, p.52, pl.18, figs 1-4.

1991 *Porosononion* sp.1; Cimerman and Langer, p. 81, pl. 84, figs 9-12.

2002 *Porosononion martkobi* Bogdanowicz; Kaminski et al., p. 178, pl. V, figs. 9a, b.

2020 *Porosononion martkobi* Bogdanowicz; Grizelj et al., p. 162, pl. 7, fig 17.

2024 *Porosononion martkobi* Bogdanowicz; Peryt et al., p. 5, pl. 3, fig. G.

Morphological characteristics: The shell exhibits a rounded to oval shape on its sides, characterized by a weakly lobed outline and a narrowly oval form on the aperture side. The peripheral margin is rounded, and the shell typically contains 7 to 8 chambers, with 7 being the most common. The chambers are slightly convex, except the last two, with bluntly rounded umbilical ends that do not close in the umbilical region. The sutures are deepened, superficial on the peripheral margin and expanding towards the umbilical region, which gives the latter the appearance of an irregular star with short rays. The umbilical region is wide, flattened, and covered with granules of various sizes and shapes. Granulation extends into the deepened parts of the sutures and onto the lower part of the broadly oval septal surface. The aperture is sieve-shaped, covered with granulation, and the foramen is in the form of large openings on the septum and in the form of a slit at its base. The wall is coarse-pored, radially radiant.

Distribution: The species *Porosononion martkobi* is documented in various formations and deposits from many parts of the world and during geological periods Miocene to Modern (Table 3).

Ecology: The studies have documented a general trend of decreasing salinity in sediment profiles where *Porosononion martkobi* is found (Koubová and Hudáčková,2010; Filipescu et al., 2011), indicating that the study of Yanko and Troitskaja (1987) indicated that

Porosononion martkobi is of narrowly euryhaline warm-water species, where it was recorded in the Black Sea at salinity from 11‰ in estuaries to 18-21‰ on the western shelf of it.

As the species *Porosononion martkobi* is associated with shallow marine environments where salinity levels fluctuated significantly. The coexistence of *Porosononion martkobi* with other foraminifera species in conditions ranging from hypersaline to marine is evidence of its adaptation to different salinity levels (Peryt and Peryt, 2009). The ecological implications of these findings suggest that *Porosononion martkobi* thrived in environments where salinity was influenced by factors such as evaporation and water depth fluctuations, characteristic of marginal seas or lagoons (Koubová and Hudáčková, 2010; Filipescu et al., 2011). Overall, the ecological context indicates that *Porosononion martkobi* is adapted to a range of salinity levels typical of the sedimentary environments.

In the current study, it was observed that the species *Porosononion martkobi* emerged as the predominant species among the limited benthic foraminifera identified in the study area, which comprised a total of four species. Most of these species were found to exhibit poorly preserved shells, characterized by significant alterations in their morphology, alongside the occurrence of shell fragments. While none of these signs were seen on *Porosononion martkobi*, individuals of this species appeared in their normal forms without any morphological changes and with similar sizes.

The aforementioned factors, particularly the reduction in both species diversity and abundance, alongside the prevalence of opportunistic species such as *Porosononion martkobi* within the assemblage, serve as significant indicators of paleoecological stress in the study area, which results from the transitions between different environmental states. (Gustiantini et al., 2016; Dayong and Nagarajan, 2023).

It has been noted that the abundance of the species *Porosononion martkobi* is found in sites characterized by a high percentage of fine sediments, specifically silt and clay, as this species is prevalent in regions abundant in fine sediments, which provide a significant supply of nutrients (Temelkov, 2008; Lo Giudice Cappelli et al., 2019; Yanko, 2020).

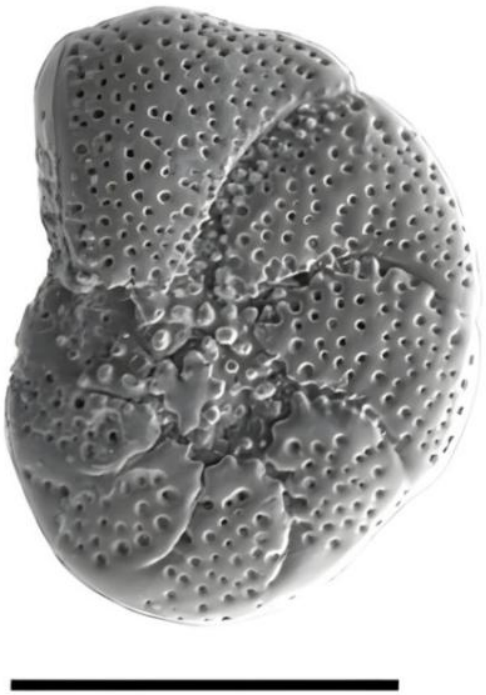

Fig. 3. Scanning electron micrographs (SEM) of the identified *Porosononion martkobi* in this study. The scale bar is 100 µm

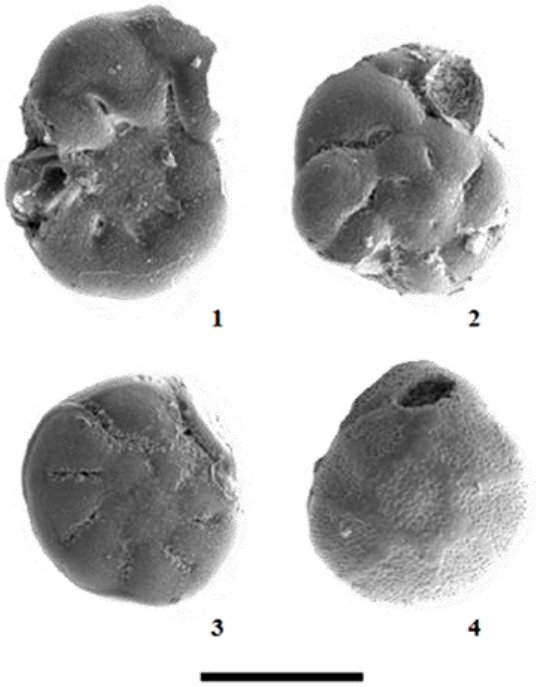

Fig. 4. Scanning electron micrographs (SEM) images of unidentified foraminifera species 1-4. Scale bar=100 µm

Table 2: Relative abundance of *Porosononion martkobi* and unidentified foraminifera species in the study area sites.

Site	Sample depth (m)	*Porosononion martkobi* %	Unidentified foraminifera species %
1	0.7	70	30
	1.0	88	12
2	0.8	80	20
	0.95	84	16
3	0.77	65	35
	0.96	71	29
4	0.5	65	35
	0.95	74	26
5	0.75	66	34
	1.0	71	29
6	0.8	64	36
	1.05	76	24
7	0.5	78	22
	1.10	79	21
8	0.6	64	36
	1.0	71	29
9	0.7	66	34
	0.95	77	23

Table 3: Distribution of *Porosononion martkobi* in the regions and geological periods.

Formation or Sediment	Region	Period	Source
Underwater sediments	Southern Romanian	Modern	Yanko-Hombach et al.,2014
Underwater sediments	Black Sea	Modern	Yanko (1990)
Azov Sea	Between Russia and Ukraine	Modern	Yanko and Troitskaja(1987)
Northwestern shelf sediments	Black Sea	Holocene	Yanko and Troitskaja(1987)
Azov Sea	Between Russia and Ukraine	Holocene	Yanko and Troitskaja(1987)
The Bosphorus Strait-exit delta	Marmara Sea	Holocene	Kaminski et al. (2002)
Cape Tuzla area	Romanian coast	Late Pleistocene	Yanko and Troitskaja(1987)
Taman Peninsula sediments	Krasnodar Krai, Russia.	Late Pleistocene	Yanko and Troitskaja(1987)
Sarmatian deposits	Georgia	Late Miocene	Shatilova et al. (2020)
Transylvanian Basin	Romania	Miocene	Silye(2015)
The middle and lower Sarmatian deposits	Crimean-Caucasia	Miocene	Bogdanovich (1947)

Discussion

Porosononion martkobi was first described by Bogdanovich in 1947 as *Nonion martkobi* (Bogdanovich,1947). This species is primarily identified from Neogene Miocene deposits in the Transylvanian Basin, particularly around areas like Jimbor and Sibiel (Silye, 2015). It is considered a typical species of both the Konkian and Sarmatian basins; it assisted in stratigraphic correlation (Koiava et al., 2017). Often, the biozones established for Sarmatian sediments face challenges due to the diverse facies' conditions, but the presence of *Porosononion martkobi*, along with other foraminiferal species, provides insights into the micropaleontological content of these sediments that the assemblages can vary significantly, reflecting changes in environmental conditions over time (Filipescu, 2005; Maissuradze et al., 2006).

Outside the boundaries of the Black Sea and Mediterranean areas, *Porosononion martkobi* was recognized in the northern Adriatic Sea as part of foraminiferal communities located within an intertidal pool (Koubová and Hudáčková, 2010). Additionally, in the Middle Miocene sediments of the Central Paratethys, which includes regions that are now Austria, Hungary, and Slovakia, *Porosononion martkobi* has been recorded in association with a variety of other benthic foraminiferal species (Peryt et al., 2024). The appearance of the species in these studies, in association with other benthic foraminifera species, together indicated the fluctuation in salinity and tolerance of euryhaline conditions (Koubová and Hudáčková, 2010; Peryt et al., 2024).

The significance of *Porosononion martkobi* studying has increased more than with time, particularly during the Holocene period, which has been identified in Holocene sediments, especially in marine environments such as the Marmara Sea and the Black Sea (Yank et al., 1999; Kaminsk et al., 2002). *Porosononion martkobi* holds significant importance in the study of Holocene sediments due to its role as a bioindicator of past environmental conditions. As a benthic foraminifer, this species is sensitive to changes in environmental conditions such as salinity, temperature, and organic matter availability. Thus, its presence in sediment can indicate historical marine environments and shifts in ecological conditions during the Holocene (Geslin et al., 2000).

The species has contributed through its distribution can assist in tracing historical connections between marine bodies, such as the Black Sea and the Mediterranean Sea. The presence of *Porosononion martkobi* in sediments has been linked to periods of marine transgression and the establishment of estuarine conditions, which are crucial for understanding past hydrological changes and biotic interactions in these regions (Kaminski et al.,2002; Khameiss and Zubi, 2024).

The presence of *Porosononion martkobi* in a given region serves as an indicator that the area has been influenced by marine conditions (Koubová and Hudáčková, 2010l; Filipescu et al., 2011; Peryt et al., 2024), suggesting that seawater once inundated the region, thereby facilitating the species' stabilization within its sediments. This observation leads to the inference that the study area experienced marine transgression during the Holocene, particularly in the late Holocene period (Aqrawi, 2001). Furthermore, Issa (2010) corroborated this by stating that the southern region of Iraq, where the current study area is situated, underwent fluctuations in sea level in the Late Holocene (3000-2000 years ago). Additionally, Issa (2016) reported that the boundaries of the range corresponding to this period are situated approximately less than two meters from the surface of the study area.

What contributed to confirming the marine water impact in the study area was that revealed by the sediment grain size analysis revealed a reduction in the proportion of coarse grains, with fine grains being the most prevalent in the sediment samples. This shift in grain size distribution is likely associated with the lack of riverine influence (Sadough et al., 2013).

Furthermore, the increased presence of the species *Porosononion martkobi* in depths characterized by fine sediments reinforces the notion that marine water conditions are the dominant environment in these sediments.

The species is not only important as an environmental indicator but also provides insights into sedimentary processes and paleoenvironmental reconstructions. It was observed that *Porosononion martkobi* is often dominant in the fine-grain sediments like silt-sand and silt (Temelkov, 2008; Yanko, 2020), where this species is found more commonly in environments characterized by calm depositional settings, such as areas with low energy, where the accumulation of organic-rich sediments, which are essential for the sustenance of foraminiferal populations (Lo Giudice Cappelli et al.,2019; Binczewska et al., 2023).

The present study findings are consistent with previous results, that the relative abundance of the *species Porosononion martkobi* exhibited an increase in regions with finer sediment sizes. This observation was made by comparing the proportion of species (Table 2) against the sediment type at each site within the study area in Table 1.

Conclusion

- Identified five sediment types within the study area are clay, sandy silt, sandy clay, mud, and sandy mud. Where clay sediment was the most common type.
- The micropaleontological study depended on one species that was dominant in the study area, which is *Porosononion martkobi*.
- The initial appearance of *Porosononion martkopi* was documented in southern Iraq during the Late Holocene period.
- This study is the first in identifying the species *Porosononion martkopi* in Iraq.
- The importance of the species *Porosononion martkobi* is evident in revealing the paleoenvironment and thus interpreting the environmental events at that time in the studied area.
- The paleoenvironmental indication for the presence of the species *Porosononion martkopi* showed that the study area has been influenced by marine conditions, especially marine transgression in the late Holocene period.
- The current study showed that the relative abundance of the species *Porosononion martkopi* increases with the fineness of the grain size of the sediments of the study area.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this manuscript.

References

Al-Jubouri, B.S., 1997. Palynological evidence of the climatic and environmental changes during the Quaternary period in the Mesopotamian plain, southern Iraq, unpublished master's thesis, Baghdad University, 79 P. (In Arabic)

Al-Jumaily, W.A.,1994. Quaternary Ostracodes in Southern Iraq, PhD Thesis (unpublished), Baghdad University, 117 P.

Aqrawi, A.A., 2001. Stratigraphic signatures of climatic change during the Holocene evolution of the Tigris–Euphrates delta, lower Mesopotamia, Global and Planetary Change, 28(1-4): pp. 267-283. DOI:10.1016/S0921-8181(00)00078-3

Bogdanovich, A.K., 1947. Results of the study of the Miocene foraminifera from the Crimean-Caucasian region. Microfauna of the oil deposits of Caucasus, Emba**,** and Central Asia. ВНИГРИ - Oil Research Geological Institute (VNIGRI), Leningrad, pp. 5-34. **(**in Russian**).** http://marbef.org/data/aphia.php?p=sourcedetails&id=300376

Cimerman, F. and Langer, M.R.,1991. Mediterranean Foraminifera, Slovenska Akademija Znanosti in Umetnosti, Akademia Scientiarum et Artium Slovenica, Ljubljana, 118 P. https://www.researchgate.net/profile/Martin-Langer-3/publication/46958692

Dance, S.P. and Eames, F.E., 1966. New Molluscs from Recent Hammar Formation of South-East Iraq. Proc. Malac. Soc. London, 37, pp. 35-43. DOI:10.1093/oxfordjournals.mollus.a064973

Dayong, V. and Nagarajan, R., 2023. Interpretation of paleoenvironment using benthic foraminifera from Tertiary rocks, northern Sarawak. In MATEC Web of Conferences, 377 P., EDP Sciences. DOI:10.1051/matecconf/202337701002

Filipescu, S., Silye, L. and Krézsek, C., 2005. Sarmatian micropaleontological assemblages and sedimentary paleoenvironments in the southern Transylvanian Basin, Acta Palaeontologica Romaniae, 5: pp. 173-179. https://adatbank.ro/vendeg/htmlk/pdf7672.pdf

Filipescu, S., Wanek, F., Miclea, A., DeLeeuw, A. and Vasiliev, I., 2011. Micropaleontological response to the changing paleoenvironment across the Sarmatian-Pannonian boundary in the Transylvanian Basin (Miocene, Oarba de Mures section, Romania), Geologica Carpathica, 62(1): pp. 91-102. DOI:10.2478/v10096-011-0008-9

Folk, R.L., 1980. Petrology of Sedimentary Rocks, Hemphill, Texas, 184 **P**. https://repositories.lib.utexas.edu/bitstreams/4537855d-d386-4794-bfbc-0f24715e64dc/download

Geslin, E., Stouff, V., Debenay, J.P. and Lesourd, M., 2000. Environmental variation and foraminiferal test abnormalities, In Environmental micropaleontology: the application of microfossils to environmental geology, Boston, MA: Springer, USA, pp. 191-215. DOI:10.1007/978-1-4615-4167-7_10

Grizelj, A., Milošević, M., Bakrač, K., Galović, I., Kurečić, T., Hajek-Tadesse, V., Avanić, R., Miknić, M., Horvat, M., Čaić Janković, A. and Matošević, M., 2020. Paleoecological and sedimentological characterisation of Middle Miocene sediments from the Hrvatska Kostajnica area (Croatia), Geologia Croatica, 73(3): pp. 153-175. DOI:10.4154/gc.2020.15

Gustiantini, L., Dewi, K.T., Muller, A. and Praptisih, P., 2016. Paleoenvironmental Reconstruction from Benthic Foraminiferal Assemblages of Early Holocene, Shallow Marine Deposits in Gombong, Central Java, Bulletin of the Marine Geology, 22(1): pp. 16-27. DOI: 10.32693/bomg.v22i1.2

Hudson, R.G.S., Eames, F.E. and Wilkins, G.L., 1957. The fauna of some Recent marine deposits near Basrah, Iraq, Geol. Mag., 94, pp. 393-401. DOI: 10.1017/S0016756800069429

Issa, B.M., 2010. Depositional environments and biofacies of selected sediments, north Basrah, Journal of Basrah Research (Sciences), 36(5) A: pp. 1-14. https://www.iasj.net/iasj/download/08dad357ddb0c657

Issa, B.M., 2016. Ostracoda and Charophyte as indicators of environmental varity in the marshland area of Southern Iraq. Journal of Basrah Researches (Sciences), 42(2)A: pp. 148-159. https://www.academia.edu/download/51709979/14.pdf

Isaa, B.M., 2024. Benthic Foraminifera and *Bithynia* sp. Opercula as Indicators of Depositional Environment of Late Holocene in Eastern Hammar Marsh, Southern Iraq, Kirkuk Journal of Science, 19(3): pp. 36-47. DOI: 10.32894/kujss.2024.152718.1174

Kaminski, M.A., Aksu, A., Box, M., Hiscott, R.N., Filipescu, S. and Al-Salameen, M., 2002. Late Glacial to Holocene benthic foraminifera in the Marmara Sea: implications for Black Sea–Mediterranean Sea connections following the last deglaciation, Marine Geology, 190(1-2): pp. 165-202. DOI:10.1016/S0025-3227(02)00347-X

Khameiss, B. and Zubi, H., 2024. Diversity, Ecology and Environmental Significance of Foraminifera in Al Hamama and Susah Coastal Regions, Northeastern Libya: Insights from Holocene Sediments, Journal of Environmental Protection, 15(01): pp. 13-25. DOI:10.4236/jep.2024.151002

Koiava, K., Kvaliashvili, L., Maissuradze, L., Mauvilly, J. and Mosar, J., 2017. Species of the genus *Porosononion* from Sarmatian deposits of Georgia and their stratigraphic significance, In the 15th Swiss Geoscience Meeting, Davos, Switzerland, pp. 181-182. DOI:10.13140/RG.2.2.13115.11049

Koubová, I. and Hudáčková, N., 2010. Foraminiferal successions in the shallow water Sarmatian sediments from the MZ 93 borehole (Vienna Basin, Slovak part), Acta Geologica Slovaca, 2(1): pp. 47-58. https://www.researchgate.net/profile/Natalia-Hudackova/publication/301956751

Lo Giudice Cappelli, E., Clarke, J.L., Smeaton, C., Davidson, K. and Austin, W.E.N., 2019. Organic-carbon-rich sediments: benthic foraminifera as bio-indicators of depositional environments. Biogeosciences, 16(21): pp. 4183-4199. https://bg.copernicus.org/articles/16/4183/2019/

López, G.I., 2017. Grain size analysis. Encyclopedia of geoarchaeology, pp. 341-348. DOI:10.1007/978-1-4020-4409-0_18

Macfadyen, W.A. and Vita-Finzi, C., 1978. Mesopotamian: The Tigris – Euphrates Delta and the Holocene Hammar fauna, Geological Magazine, 115: pp. 287-300. DOI:10.5194/bg-16-4183-2019

Maissuradze, L. and Koiava, K., 2006. New Data on Distribution of Sarmatian Foraminifera in the Sediments of Kakheti. Georgian Oil and gas, 19: pp. 50-62. https://www.researchgate.net/publication/259661618

Peryt, D. and Peryt, T., 2009. Environmental changes in the declining Middle Miocene Badenian evaporite basin of the Ukrainian Carpathian Foredeep (Kudryntsi section). Geologica Carpathica, 60(6): pp. 505-517. DOI:10.2478/v10096-009-0037-9

Peryt, D., Gedl, P., Worobiec, E., Worobiec, G. and Peryt, T.M., 2024. Foraminiferal and Palynological Records of an Abrupt Environmental Change at the Badenian/Sarmatian Boundary (Middle Miocene): A Case Study in Northeastern Central Paratethys, Geosciences, 14(3): pp. 1-38. DOI: 10.3390/geosciences14030086

Saad, K.S., 2024. Marshes of Southern Iraq and Some Economic Activities of its inhabitants, Journal of Misan Researches, 19(39): pp. 359 - 381. DOI: 10.52834/jmr.v20i39.236

Sadough, M., Ghane, F., Manouchehri, H., Moghaddasi, B. and Beikaee, H., 2013. Identification and abundance of benthic foraminifera in the sediments from Fereidoonkenar to Babolsar of Southern Caspian Sea. Turkish Journal of Fisheries and Aquatic Sciences, 13(1), pp. 79-86. DOI: 10.4194/1303-2712-v13_1_10

Shatilova, I.I., Maissuradze, L.S., Koiava, K.P., Kokolashvili, I.M., Bukhsianidze, M.G. and Bruch, A.A., 2020. The environmental history of Georgia during the Late Miocene based of foraminifera and pollen, Georgian National Museum: Tbilisi, Georgia, pp.1-84. DOI: 10.5281/zenodo.13680652

Silye, Lóránd, 2015. Sarmatian foraminiferal assemblages from southern Transylvanian Basin and their significance for the reconstruction of depositional environments. Cluj−Napoca: Presa Universitară Clujeană, 2015. 229 P. https://www.researchgate.net/profile/Lorand-Silye/publication/279917900

Temelkov, B.K., 2008. Ecological characteristics of the foraminiferal fauna (Protozoa: Foraminifera) of the Bulgarian South Black Sea area, Acta zoological Bulgarica, Supplementary, 2: pp. 275-282. https://www.researchgate.net/publication/265982612

Trogrlić, A.M., 2018. Sarmatski paleookoliši lokaliteta Vranović (kamenolom Našicecement) na osnovu foraminifera, PhD thesis, Zagreb University, Faculty of Science, Department of Geology, Croatia,.41 P. https://urn.nsk.hr/urn:nbn:hr:217:283928

Vu, A.T., 2020. Foraminiferal assemblages of Cretan beaches (Greece)-proxy for tsunami deposits, PhD thesis, RWTH Aachen University, 196 P. DOI: 10.18154/RWTH-2021-00155

World Register of Marine Species. URL: https://www.marinespecies.org/2019

Yanko, V.V., 1990. Stratigraphy and paleogeography of the marine Pleistocene and Holocene deposits of the southern seas of the USSR, Mem. Soc. Geol. Ital., 44: pp. 167-187. https://www.researchgate.net/profile/ValentinaYanko/publication/281479633_Stratigraphy

Yanko-Hombach, V.V., Kondaryuk, T.O., Likhodedova, O.G., Akindinova, O.V. and Motnenko, I., 2014. Evaluating the influence of river discharge on marine benthic ecosystems using benthic foraminifera and lithology as the main tools. In Proceedings of the Second Plenary Conference. IGCP 610 Second Plenary Conference and Field Trip: "From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary" (A. Gilbert and V. Yanko-Hombach, eds.), Baku, Azerbaijan, pp. 12-20. https://gpimo.nas.gov.ua/sites/default/files/91-117.pdf

Yank, V., Kennett, J., Coral, H. and Cornfield, J., 1999. Stable isotopic evidence from Holocene Sea of Marmara sediments for two-way watermass interchange between the Black Sea and the Mediterranean Sea, South African Journal of Science, 95(4): pp. 201-204. https://www.researchgate.net/profile/Joel-Kronfeld/publication/286415348

Yanko, V.V. and Kondariuk, T.O., 2020. Origin and taxonomy of the Neopleistocene–Holocene Ponto-Caspian benthic foraminifera. Geological magazine, (1): pp. 17-33. DOI: 10.30836/IGS.1025-6814.2020.1.196975

Yanko, V.V. and Troitskaja, T.S., 1987. Late Quaternary Foraminifera of the Black Sea. Trudy Instituta Geologii i Geo¢siki, Akademiya Nauk SSSR, Novosibirsk, 694: 111 P. (in Russian). https://www.marinespecies.org/foraminifera/aphia.php?p=sourcereq&id=261696