https://jssr.ui.ac.ir/?lang=en
Journal of Stratigraphy and Sedimentology Researches
E-ISSN: 2423-8007
Vol. 42, Issue 4, No. 105, 2026, 1-32
Received: 30.08.2025 Accepted: 11.01.2026

Research Paper

The Tethyan seaway during Late Miocene-Early Pliocene: with indication of constraints from foraminifera of southern Iran

Fereshteh Mahdipour Haskouei
Department of Geology, Faculty of Sciences, University of Isfahan, Isfahan, Iran
haskouei@gmail.com

Ali Bahrami*
Department of Geology, Faculty of Sciences, University of Isfahan, Iran
a.bahrami@sci.ui.ac.ir

Mehdi Yazdi
Department of Geology, Faculty of Sciences. University of Isfahan, Iran
meh.yazdi@gmail.com

Hossein Vaziri-Moghaddam
Department of Geology, Faculty of Sciences, University of Isfahan, Isfahan, Iran
avaziri7304@gmail.com

Azizollah Taheri
Faculty of Earth Science, Department of Geology, Shahrood University of Technology, Shahrood, Iran
alitaheri@shahroodut.ac.ir

Abstract
A micropaleontological analysis of the Miocene strata in the Qeshm and Minab regions of southern Iran has yielded a diverse foraminiferal assemblage, comprising twenty-five species belonging to fifteen genera. This fauna is predominantly reported for the first time from the studied outcrops. The identified taxa include: *Asterorotalia dentata, A. pulchella, Triloculina tricarinata, T. terquemiana, T. trigonula, Trilobatus (Globigerinoides) trilobus, Globigerina bulloides, Quinqueloculina bogdanowiczi, Textularia agglutinans, Praeorbulina transitoria, Elphidium crispum, E. craticulatum, E. asiaticum, E. advenum limbatum, E. advenum macelliforme, E. advenum maorium, Poroeponides lateralis, Eponides repandus, Eponides isabellanus, Rotalinoides compressiuscula, Challengerella bradyi, Ammonia beccarii,* and *Bolivina spathulata*. Biostratigraphic analysis, based on key index species, provides refined age constraints for the regional stratigraphy. Within the Mishan Formation on Qeshm Island, the presence of *Praeorbulina transitoria* and *Quinqueloculina bogdanowiczi* in the white sandy limestone of the Stars Valley section indicates a Langhian-Serravallian boundary age. The uppermost strata of the Mishan Formation on the island suggest a depositional range extending from the late Serravallian to the Mio-Pliocene boundary, potentially correlating with the interval of global planktonic foraminiferal zones N8-N9 to N19-N20. In the Minab region, the Gushi Marl of the Makran Basin is dated to the latest Miocene (Messinian) to early-middle Pliocene (Zanclean to Piacenzian boundary), corresponding to the time encompassed by biozones N19-N20. The palaeobiogeographic distribution of the fauna is particularly significant. The co-occurrence of these species in the studied areas, coupled with the presence of *Quinqueloculina bogdanowiczi*-a taxon previously documented only from the Central Eastern Paratethys during the Serravallian to Tortonian-suggests the existence of a marine connection during the Late Miocene. This evidence supports a seaway linking the Iranian Gateway and the Iraqi Basin (represented by the Fatha Formation) with the marginal marine environments of the eastern Paratethys (Qom Basin), the Central Paratethys, the Indo-Pacific Ocean, and the proto-Mediterranean.
Keywords: Tethyan Seaway, Late Miocene-Early Pliocene, Palaeoecology, Qeshm Island, Minab region, Iran.

*Corresponding author
Mahdipour Haskouei F. Bahrami A. Yazdi M. Vaziri-Moghaddam H. and Taheri A. (2026). The Tethyan Seaway during Late Miocene-Early Pliocene: with indication of constraints from foraminifera of the Southern Iran. Journal of Stratigraphy and Sedimentology Researches, 42(4): 1-32 https://doi.org/10.22108/jssr.2026.146509.1319

https://doi.org/10.22108/jssr.2026.146509.1319

Introduction

The Miocene epoch (23.03–5.33 Ma) was a time interval of global warmth, and also, continental configurations and mountain topography transitioned toward modern conditions; many faunae and florae evolved into the same taxa that exist today (Steinthorsdottir et al. 2021). During the Miocene, the Terminal Tethyan Event, and subsequently the closure of the Tethyan Seaway, which connected the proto-Mediterranean Sea with the Indian and Atlantic Oceans, blocked thermohaline exchanges between them and possibly caused a major climate change in the Middle Miocene Climatic Transition (Sun et al. 2021). Although the Tethyan Seaway was closed due to the collision of the African/Arabian and Iranian/Eurasian plates, Dabaghi Sadr (2017) mentioned that climate deterioration had been related to major palaeogeographic changes, including the separation of Antarctica and the closure of the Tethyan Ocean, resulting in the reorganization of ocean circulation and heat transport. In other words, the closure was related to both tectonic and climatic changes (Dabaghi Sadr 2017).

However, to date, the exact timing and the involved forcing mechanism of the final closure of the Tethyan Seaway are still debated. Sun et al. (2021) suggested that this seaway experienced stepwise evolutionary processes changing from a partially opened seaway, restricted marine connection, intermittent connections, to permanent closure in its northwestern segment during the early and middle Miocene.

Reuter et al. (2009) mentioned the Tethyan seaway as Iranian gateways, and suggested that continuous shallowing and restriction of the seaway generated an increasingly hostile hypersaline environment and a biogeographic barrier for marine biota, during the end of the Burdigalian, by comparing Atlantic-Mediterranean and Indo-Pacific bioprovinces with the environmental conditions of the Zagros Basin.

Studied strata belong to the Zagros Basin and Makran Basin, and it is formally suggested that they are separated from each other by the Minab Fault, but the boundary is not accurate. The Minab Fault marks a sharp structural and stratigraphic divide between the Zagros Basin and the Iranian Makran (Gansser 1955; Falcon 1969).

Tectonically, Shearman et al. (1976) divided Makran and Zagros folded zone and mentioned that the deep structural simplicity below the plains suggests a long period of gentle subsidence in pre-Miocene times, perhaps going back to Early Mesozoic times, allowing several kilometers of sediment to be deposited, in Minab Anticline, where the deep crustal fracture below the Zendan Fault line (i.e., the Oman Line) could have been active in a north-south direction, during all the pre-Miocene time and did not disturb this area, which was, however, compressed by the westerly Mio-Pliocene movements that are still going on (Falcon 1969).

In sum, there is almost no research and investigation about the Mio-Pliocene strata in Qeshm Island, Zagros Basin (Fig. 1a). Also, in the Makran Basin, this study only sampled from one section (Gushi Marl), from the Makran Unit (see Tab. 1), where the accurate ages of strata were never studied, and all formations and geological units are informal.

The Mio-Pliocene strata of Qeshm Island have been suggested as Mishan/Aghajari formations (see fig. 1a; Huber 1977; Hassani et al. 2014), and Gushi Marl strata from the Makran Unit have been mentioned as the Late Miocene strata, while none of the studied outcrops have been studied before. This study aims to reveal the age and palaeoenvironmental conditions of the Gushi Marl and the Mishan Formation by using isolated foraminifera samples, and also to investigate the timing possibilities of closure of the Iranian Gateway.

https://doi.org/10.22108/jssr.2026.146509.1319

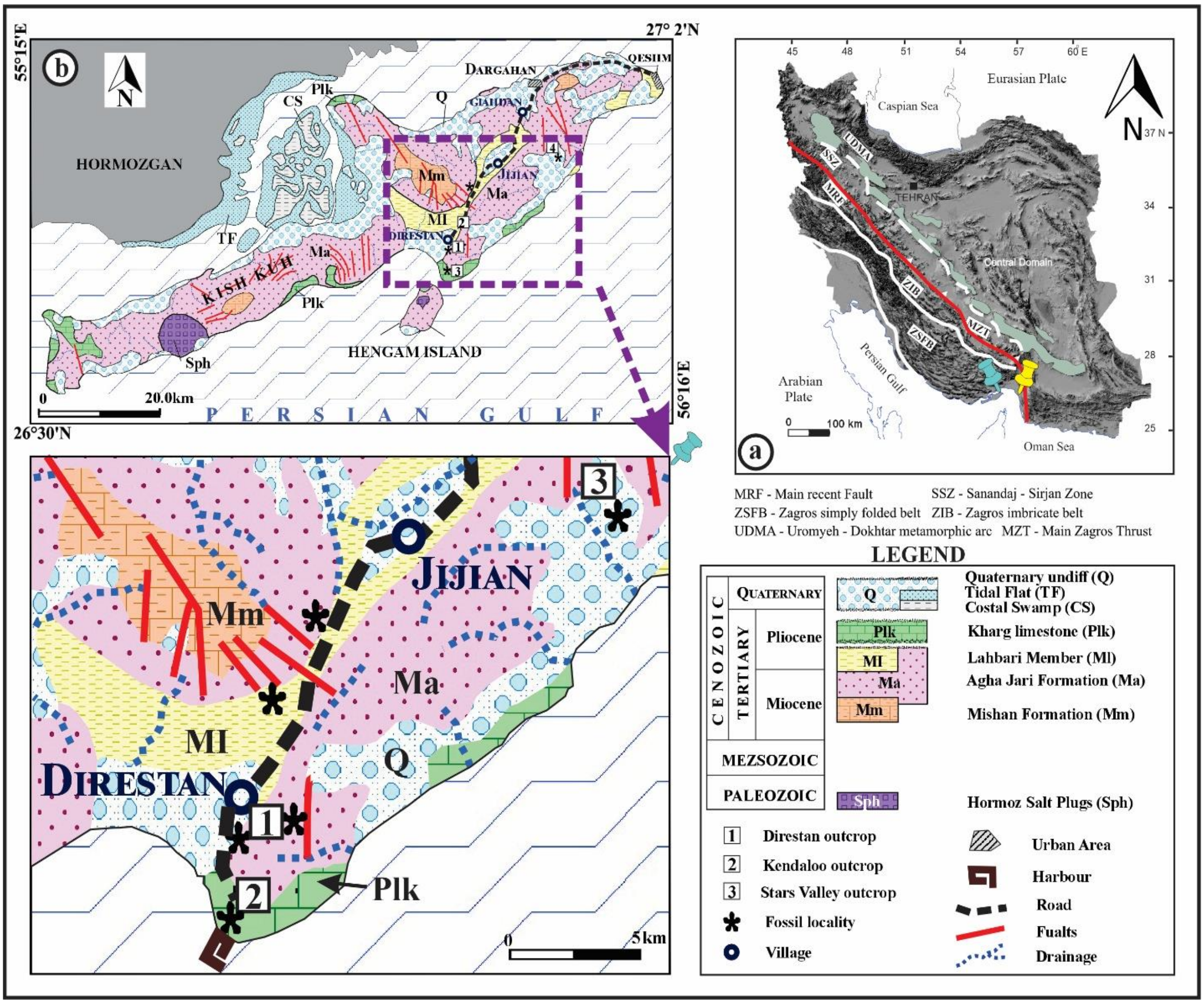


Fig 1a- Geological map of the investigated areas; A. Terrain map of Iran; B. Geological map of Qeshm Island, Persian Gulf (after Huber 1977)**, with three sampled localities: 1) Direstan outcrop near the village; 2) Kendaloo outcrop in NE of the Kendaloo harbor; 3) Stars Valley outcrop.**

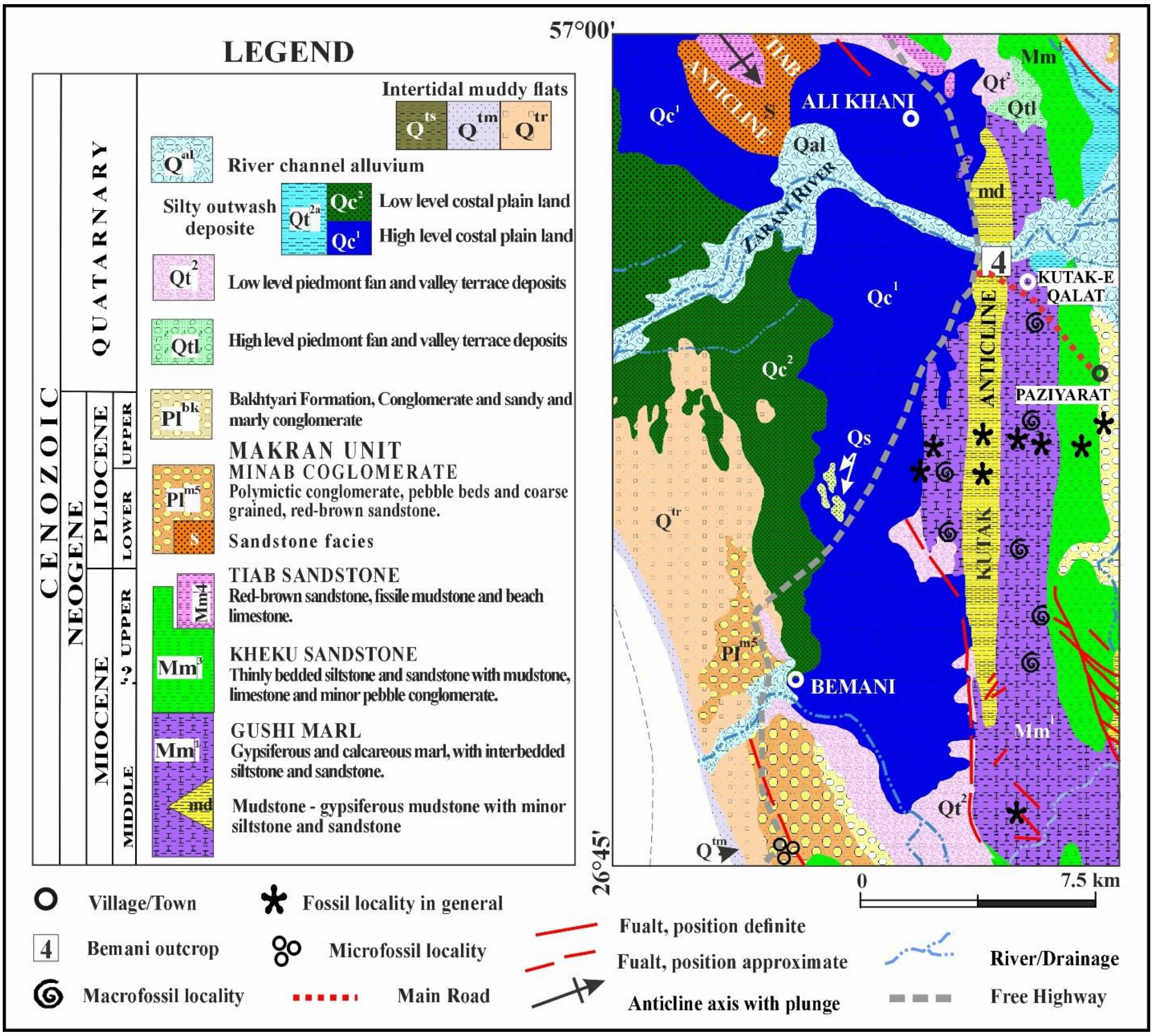


Fig 1b- Geological map of Minab region (after Peterson and Rudzinskas 1982), **4) Bemani outcrop.**

https://doi.org/10.22108/jssr.2026.146509.1319

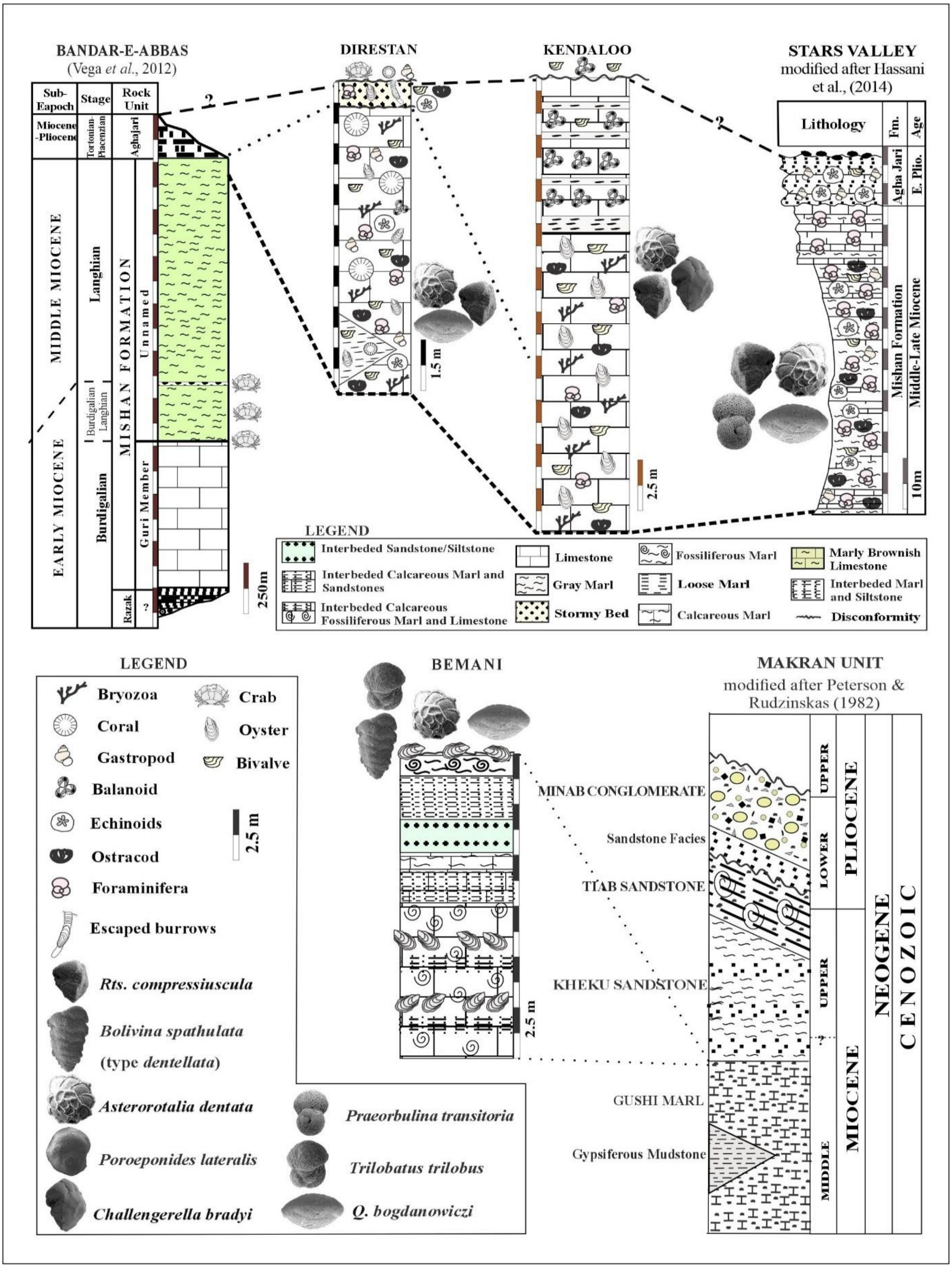


Fig 2- **Some index foraminifera of the studied sections. Including Direstan outcrop (Qeshm Island, Zagros Basin), Kendaloo outcrop (Qeshm Island, Zagros Basin), and Bemani outcrop (Minab Province, Makran Basin).**

https://doi.org/10.22108/jssr.2026.146509.1319

Geological Settings

The Zagros Basin is one of the most universal oil and gas basins, located in the west to south of Iran and in the north of the Arabian Plate (Alsharhan and Nairn 1997; Daneshian et al. 2016).

The geological structure of Qeshm Island consists of four main anticlines, including Souza-Zirang, Holor, Salakh, and Goveie, with axis in strike of north-east to south-west and Gavarzin with axis in strike of north-west to south-east, and the main rock formations of the island are the salt dome of Hormoz, marl of Mishan Formation, marl and sandstone of Aghajari Formation, and the Plio-Pleistocene rocks and the Quaternary calcareous traces (Gerivani et al. 2011).

The Mishan Formation (age: Early to middle Miocene) consists of low-weathering gray marl and ridge-forming ribs of shelly limestone with abundant microfauna, in the type section (Fars Province; Rahmani and Vaziri-Moghaddam 2010)

The top of the highest grey, marine marl of the Mishan Formation is defined as the basal contact of the Aghajari Formation, which transitionally overlies the Mishan Formation (James and Wynd, 1965). The marly member conformably overlies the top of the Guri Member in Bandar Abbas (Gholamalian et al. 2023), in the northern lands of the Strait of Hormoz.

In Qeshm Island and at the Direstan outcrop, sandy fossiliferous limestone, which was assumed to be the uppermost part of the Mishan Formation, includes almost all organisms that have been reported from the Mishan Formation in other parts of the Zagros Basin (e.g., Vega et al. 2012; Fanati Rashidi et al. 2014; Daneshian et al. 2016). In Kendaloo, sandy fossiliferous limestone is very similar to Direstan's sandy fossiliferous limestone, lithologically. The uppermost strata of the Mishan Formation on Qeshm Island consist of sandy, fossiliferous limestone. These deposits are characterized by a diverse and exceptionally well-preserved microfauna, including foraminifers, ostracods, fish teeth, early-stage bivalves, and echinoid needles (Haskouei et al. 2024b).

Palaeobiological studies of the Mishan Formation (Direstan outcrop) and Gushi marls (Makran Basin) have reported ostracods and pectinid bivalves. The ostracod fauna of the studied outcrops shows significant similarity to that of the Fatha Formation in Northern Iraq, supporting its interpretation as an intermediate bioprovince between the Mediterranean and Indo-Pacific realms.

(Hawramy and Khalaf 2013), and were mentioned as an intermediate bioprovincial zone between Mediterranean and Indo-Pacific (Haskouei et al. 2025a). Overall, in Qeshm Island, studied strata that have been assumed as uppermost parts of Mishan Formation (e.g. Parast et al. 2020; Haskouei 2025) include organisms as bryozoans, echinoids, corals, gastropods, pectinid and oyster bivalves, crustaceans such as crabs and balanoids, and their shell fragments, while Gushi marls only bear ostreids (oyster bars) and balanoids, as macrofossils (Haskouei et al. 2025a; see fig 2).

McCall (2002) suggested Gushi Marl as the Late Miocene strata of Makran accretionary prism (Tab. 1), which is dominated by grey, gypsiferous marl, mudstone and shale, with subordinate brown interbeds of friable sandstone (poorly sorted lithic arenite) and siltstone, and also, has been mentioned that the Gushi Marl crops out in the western part of the Minab and Taherui quadrangles (fig. 1b), where has an estimated thickness of 2250 m. The Kheku Sandstone overlies the Gushi Marl conformably, in the Taherui quadrangles (Peterson and Rudzinskas 1982; McCall 2002).

Overall, in compare to Qeshm Island, the among of the Miocene strata of Makran Basin are a very huge among of accumulation, which convinced us to show a detailed list of Miocene strata of Makran Basin (see Tab. 1). Also, it is necessary to mention that Gushi Marl is a very thickened strata and the samples in this study have been collected from the uppermost part of the Gushi Marl strata.

Table 1- Mio-Pliocene Stratigraphic units of the Makran accretionary prism, listed with their age ranges (modified after McCall 2002)

Stratigraphic unit	Age range
Flysch turbidite units	
Hichan Unit	Late Early Miocene
Ab-e Shahr Unit	Early Miocene
Shahr Pum Unit	Early Miocene
Dehirdan Unit	Early Miocene
Makran Unit	
Minab Conglomerate	Early Pliocene
Kheku Sandstone-Tiab Sandstone	Late Miocene-Early Pliocene
Gushi Marl	Late Miocene
Jaghin Unit	Mid-Late Miocene
Dar Pahn Unit	Mid-Late Miocene
Roksha Unit	Early-Mid-Miocene (?Late)
Jarut Unit	Early -Mid-Miocene
Darkhunish Shale	
Band-e Chaker Unit	
Ghasr Ghand Unit	
Sahan Tang Unit	
Sabz Unit	
Pishin Unit	Early Miocene
Harzburgite Conglomerate	Early Miocene (Burdigalian)
Vaziri Unit (reefal limestone)	

https://doi.org/10.22108/jssr.2026.146509.1319

Material and Methods

Sediment samples were collected from three locations in Qeshm Island (SE of Zagros Basin) and one location in the Minab region (SW of Makran Basin), see Fig. 1b. The studied sections from Qeshm Island are Stars Valley (26°52'9.99"N; 56°7'20.42"E), Direstan (26°44'14"N; 55°56'07"E), and Kendaloo (26°41'45.84"N; 55°55'25.67"E). The access roads to all three sections are available due to the first and the last are tourist attraction places, and Direstan is a Village near the road to Qeshm Island airport. Likely, the only section of Makran Basin, is named Bemani (26°55'42"N; 57°07'25"E) is accessible cause of being close to the main road of Minab County (fig. 1b). This paper examines the taxonomic description of 67 samples of foraminifera in total, 48 benthic foraminifera samples, which show identified 10 genera and 18 species, and also, 10 planktonic foraminifera samples, which show identified 6 genera and 5 species, illustrated by SEM images. All specimens are housed in the Department of Geology, Faculty of Science, University of Isfahan, Iran, under the acronym IUMC.

Systematic Paleontology

Multiple references have been used for the systematic description of foraminifera (Luczkowska 1974; van der Zwaan 1982; Papp and Schmid 1985; Loeblich and Tappan 1988; Szczechura and Abd-Elshafy 1988; van de Poel 1992; Hauser and Grunig1993; Debenay 2012; Poole and Wade 2019; Tabita and Nathan 2019).

Abbreviations: St_ Stars Valley outcrop, K_ Kendaloo outcrop, D_ Direstan outcrop, BM_ Bemani outcrop, BF_ Benthic Foraminifera, P_ Planktonic, ML_ Miliolid.

Class GLOBOTHALAMEA Pawlowski, Holzmann, Tyszka, 2013
Order ROTALIIDA Delage and Hérouard, 1896
Superfamily ROTALIOIDEA Ehrenberg, 1839
Family AMMONIIDAE Saidova 1981
Subfamily AMMONIINAE Saidova 1981
Genus ASTEROROTALIA Hofker 1950
Asterorotalia dentata (Parker and Jones 1865)
Fig. 4A-I

1865 *Rotalia beccarii* (Linnaeus) *var. dentata* (Parker and Jones), pp. 387-388, 422, Pl. 19, Fig. 18a-c.

2006 *Asterorotalia dentata* (Parker and Jones); Sohrabi et al. P. 18, Pl. 1, Fig. 1.

2012 *Asterorotalia dentata* (Parker and Jones); Mossadegh et al. P. 358, Figs. 3(at–av).

2014 *Asterorotalia dentata* (Parker and Jones); Panchang and Nigam, Pl. 36, Fig. 12a-b.

2017 *Asterorotalia dentata* (Parker and Jones); Bhaumik et al. P. 440, Pl. 1, Fig. m.

2019 *Asterorotalia dentata* (Parker and Jones); Tabita and Nathan, P. 15, Figs. 4.13-14.

Material: Altogether, nine specimens were collected and studied: one specimen from the Mishan Formation of the Direstan outcrop, two from the Kendaloo outcrop, two from the Stars Valley outcrop, Qeshm Island, and four specimens collected from the Gushi Marl, the Bemani outcrop, Minab County, southern Iran.

Diagnosis and Description: see Loeblich and Tappan (1988) and also Tabita and Nathan (2019).

Occurrence and Distribution: Miocene (Serravallian to Tortonian), Limestone Bed of Baripada, Mayurbhanj District, Odisha, India (Bhaumik et al. 2017). Middle Pliocene, southeastern of Zagros Basin, Iran (Hassani and Hosseinipour 2017). Late Pleistocene, Kish Island, Persian Gulf, Iran (Mossadegh et al. 2012). Middle Holocene, core T2S3, Strait of Hormoz, Southern Iran (Hamzeh et al. 2021).

Remark: In the Zagros Basin (Iran), Hassani and Hosseinipour (2017) suggested that the species is a member of biozone Z7 (*Globorotalia acostaensis* abundance zone), which illustrates the Piacenzian-Zanclean boundary, mentioned by Bolli (1966) and Postuma (1971), and also correlated with the global biozone N20 (Hassani and Hosseinipour 2017; also check figure 3 by Spezzaferri et al. 2002).

Environment: Bhaumik et al. (2017) reported the species from a shallow marine oxic environment, and also, Mossadegh et al. (2012) reported it from raised coral reef sequences.

Asterorotalia pulchella (d'Orbigny 1839a)
Fig. 4J

1839a *Rotalia (Calcarina) pulchella* d'Orbigny, P. 80, Pl. 5, Figs. 16-18.

1930 *Rotalia pulchella* (d'Orbigny); Hofker, P. 37, Pl. 16, Figs. 7-10.

1951 *Asterorotalia pulchella* (d'Orbigny); Hofker, P. 505-508, Figs. 343-344.

1968 *Asterorotalia pulchella* (d'Orbigny); Hofker, P. 27, Pl. 8, Figs. 8-10; Pl. 9, Figs. 1-7.

2001 *Asterorotalia pulchella* (d'Orbigny); Szarek, P. 147, Pl. 27, Figs. 11-12.

2015 *Asterorotalia pulchella* (d'Orbigny); Hanagata and Nobuhara, P. 119, Figs. 35.9-10.

2019 *Asterorotalia pulchella* (d'Orbigny); Tabita and Nathan, P. 12, Figs 3.17-18.

Material: Only one specimen was collected and studied from Gushi Marl, Bemani outcrop, Mina County, southern Iran.

Diagnosis and Description: see Hofker (1951; 1971), Loeblich and Tappan, (1988) and also, Tabita and Nathan (2019).

Occurrence and Distribution: Pliocene to Holocene of Cuba, Indonesia, Java, Persian Gulf as *Rotalia pulchella* (Loeblich and Tappan 1988, d'Orbigny 1839a). Quaternary, Pleistocene to Holocene of Kutei Basin, Indonesia (Loeblich and Tappan 1988). Recent, Bay of Jakarta, Java (Hofker 1968).

Remark: Despite mechanical abrasion, the species is identifiable, and characteristic features are still distinct.

Environment: This species was found at a depth of 18 m, always in a muddy environment (Hofker 1978), and also prefers the silty mud environment with badly aerated water (Hofker 1968).

Genus **CHALLENGERELLA** Billman, Hottinger, and Oesterle 1980
Challengerella bradyi (Billman et al. 1980)
Fig. 4K-M

1980 *Challengerella bradyi*, Billrnan, Hottinger, and Oesterle, P. 81.

1988 *Challengerella bradyi* (Billrnan et al.); Loeblich and Tappan, Pl. 770, Figs. 1-8.

2017 *Challengerella bradyi* (Billrnan et al.); Bhaumik et al. P. 440, Pl. 1, Figs. q-s.

2019 *Challengerella* sp., (Billrnan et al.); Amao et al. P. 940, Figs. 4(g-i).

2023 *Challengerella bradyi* (Billrnan et al.); Shareef et al. P. 196, Pl. 4, Fig. 2.

Material: Only three specimens were collected and studied, from the Mishan Formation, Zagros Basin, Iran. One from Direstan, one Kendaloo and one Stars Valley outcrops, Qeshm Island.

Diagnosis and Description: see Loeblich and Tappan (1988).

Occurrence and Distribution: Langhian-Serravallian, Fatha Formation, Southern Iraq (Shareef et al. 2023). Serravallian to Tortonian, Limestone Bed of Baripada, Mayurbhanj District, Odisha, India (Bhaumik et al. 2017). Middle Holocene, core T2S3, Strait of Hormoz, Southern Iran (Hamzeh et al. 2021). Late Pleistocene, Kish Island, Persian Gulf, Iran (Mossadegh et al. 2012). Holocene, Gulf of Elat, Red Sea (Loeblich and Tappan 1988). Recent, the Persian Gulf, southern Iran (Saidova 2010).

Remark: In Zagros Basin (Iran), Hassani and Hosseinipour (2017) suggested that the species is a member of biozone Z1 (= *Globigerinoides trilobus* zone of Postuma 1971), which shows timing Aquitanian before the boundary of early Burdigalian, coincides with the beginning of global biozone N5 (Hassani and Hosseinipour 2017; also check figure 3 by Spezzaferri et al. 2002).

Environment: Bhaumik et al. (2017) mentioned the species from a shallow marine oxic environment. Moreover, the species were described from depths of 20–80 m, in the modern Persian Gulf (Saidova 2010), and also from raised coral reef sequences (Mossadegh et al. 2012).

Genus **ROTALINOIDES** Saidova 1975

Rotalinoides compressiuscula (Brady 1884)

Fig. 4N-P

1884 *Rotalia papillosa var. compressiuscula* Brady, P. 708, Pl. 107, Fig. 1.

2015 *Rotalinoides compressiuscula* (Brady); Hanagata and Nobuhara, P. 119, Fig. 35.11-12.

2019 *Rotalinoides compressiuscula* (Brady), Tabita and Nathan, P. 15, Figs. 4.19-2.

Material: Overall, three specimens were collected and studied from Direstan, Kendaloo, and Stars Valley outcrops, Qeshm Island, Zagros Basin, Iran.

Diagnosis and Description: See Tabita and Nathan (2019).

Occurrence and Distribution: Mio–Pliocene, Mishan Formation, south of Iran (Hassani and Hosseinipour 2017). Recent Coast of India (Tabita and Nathan 2019).

Remark: In Zagros Basin (Iran), Hassani and Hosseinipour (2017) mentioned that the species is a member of biozone Z6 (*Globorotalia crassaformis* range zone), which shows the Mio–Pliocene boundary, suggested by (Bolli 1966; Postuma 1971), and also illustrates a coincidence with the beginning of global biozone N19 (Hassani and Hosseinipour 2017; also check Fig. 3 by Spezzaferri et al. 2002).

Environment: The species mentioned from the 38 to 83 m water depth of a slightly muddy sand to muddy sand environment of the modern shelf (Anbuselvan and Nathan 2017).

Genus **AMMONIA** Brünnich 1772

Ammonia beccarii (Linnaeus 1758)

Fig. 5A-C

1758 *Nautilus beccarii* Linnaeus, P. 710, Pl. 1, Fig. 1.

2001 *Ammonia beccarii* (Linnaeus); Szarek, P. 148, Pl. 26, Figs. 13-15.

2003 *Ammonia beccarii* (Linnaeus); Javaux and Scott, P. 10, Fig. 2.2-3.

2005 *Ammonia beccarii* (Linnaeus); Debenay, Millet and Angelidis, P. 334, Pl. 2, Fig. 17.

2012 *Ammonia beccarii* (Linnaeus), Milker and Schmiedl, P. 117, Fig. 27.1-2.

2019 *Ammonia beccarii* (Linnaeus), Tabita and Nathan, P. 15, Figs. 4.7-8.

Material: Only three specimens were collected and studied from the Mishan Formation, Zagros Basin, Iran. All are from the Direstan outcrop, Qeshm Island. Although two other outcrops on the Island bear the species, because of broken shells and lack of distinct characteristic features, we decided not to collect them.

Diagnosis and Description: See Tabita and Nathan (2019).

Occurrence and Distribution: Early to Middle Miocene (Aquitanian to Langhian), the Mishan Formation, the southeastern end of the Zagros Folded Zone, Iran (Fanati Rashidi et al. 2014). Recent (Hayward et al. 2021). Late Aquitanian to early Burdigalian, Asmari Formation, SW Zagros Basin, Iran (Roozpeykar and Moghaddam 2015).

Remark: In the present study, the species has been observed from the uppermost parts of the equal strata of the Mishan Formation, a fossiliferous limestone, associated with coral patches. Also, the species were found in limestone, marly limestone, and calcareous marl in many parts of the Khorgu section, Mishan Formation, the southeastern end of the Zagros Folded Zone (Fanati Rashidi et al. 2014).

Environment: The outer shelf environment (Fanati Rashidi et al. 2014). Modern inner shelf environment (depth 0-50 m), for *A. beccarii*, and as genus *Ammonia*, one of the two most common globally shallow-marine and estuarine foraminiferal genera (Hayward et al. 2021). Overall, *A. beccarii* is a euryhaline species, extensively distributed in the littoral and neritic environment (Debenay et al. 1998; Anbuselvan and Nathan 2017).

Superfamily **EPONIDACEA** Hofker 1951

Family **EPONIDIDAE** Hofker 1951

Subfamily **EPONIDINAE** Hofker 1951

Genus **EPONIDES** de Montfort 1808

Eponides repandus (Fichtel and Moll 1798)

Fig. 5E-I

1798 *Nautilus repandus* Fichtel and Moll, P. 35, Pl. 3, Figs. a-d.

1971 *Eponides repandus* (Fichtel and Moll); Murray: 173, Pl. 72, Figs. 1- 4.

1974 *Eponides repandus* (Fichtel and Moll); Andreieff et al. Pl. 7, Fig 12.

1982 *Eponides repandus* (Fichtel and Moll); Szczechura, Pl. 14, Figs. 3-4.

1988 *Eponides repandus* (Fichtel and Moll); Szczechura and Abd-Elshafy, Pl. 11, Fig. 1

1992 *Eponides repandus* (Fichtel and Moll); Hansen and Revets, P. 168, Pl. 1, Figs. 7-9.

1993 *Eponides repandus* (Fichtel and Moll); Hauser and Grunig, Pl. 4, Figs. 4-7.

2001 *Eponides repandus* (Fichtel and Moll); Szarek, P. 133, Pl. 19, Figs. 9-11.

2003 *Eponides repandus* (Fichtel and Moll); Javaux and Scott, P. 14, Fig. 3.1-2.

2012 *Eponides repandus* (Fichtel and Moll); Debenay, P. 196.

2014 *Eponides repandus* (Fichtel and Moll); Panchang and Nigam, Pl. 29, Fig. 12a-c.

2019 *Eponides repandus* (Fichtel and Moll); Tabita and Nathan, Figs 8.18-19.

Material: Altogether five specimens were collected and

https://doi.org/10.22108/jssr.2026.146509.1319

studied, from Zagros Basin, Iran, two from Direstan, two from Kendaloo, and one from the Stars Valley outcrop, Qeshm Island.

Diagnosis and Description: See Szczechura and Abd-Elshafy (1988) and also Loeblich and Tappan (1988).

Occurrence and Distribution: Middle Miocene, the Gulf of Suez, Egypt (Szczechura and Abd-Elshafy 1988). Late Oligocene to early Miocene of Qom Formation, Central Iran (Nouradini et al. 2017). Holocene, Gulf of Naples, Italy (Loeblich and Tappan 1988). Recent, the Gulf of Aqaba, Egypt (Hauser and Grunig 1993).

Environment: The species mentioned from the 38 to 83 m water depth of a slightly muddy sand to muddy sand environment of the shelf (Anbuselvan and Nathan 2017). Also, the species has been mentioned from the modern shallow-water (depth = 85 m), and an almost high-temperature environment, 22°C (Hofker 1978).

Eponides isabellanus (d'Orbigny 1846)
Fig. 5D
1839 *Rosalina isabelleana* d'Orbigny, P. 43, Pl. 6, Figs. 10-12.
1971 *Eponides isabellanus* (d'Orbigny); Herb, P. 267, Pl. 1, Figs. 1 and 18.
1980 *Discorbis isabelleanus* (d'Orbigny); Boltovskoy et al. P. 80, Pl. 11, Figs. 8-12.
1993 *Eponides isabellanus* (d'Orbigny); Hauser and Grunig, Pl. 5, Figs. 1-7.

Material: only one specimen was collected and studied, from the Mishan Formation, Direstan outcrop (Qeshm Island), Zagros Basin, Iran.

Diagnosis and Description: See Hauser and Grunig (1993) and also Boltovskoy et al. (1980).

Occurrence and Distribution: Recent, Drake Passage, Antarctica (Hauser and Grunig 1993). Recent, Islas Malvinas (Boltovskoy et al. 1980).

Remark: Hauser and Grunig (1993) suggested that numerous species assigned to *Eponides* by their authors are placed in different genera now, or several species assigned to *Eponides* today originally belonged to other genera. Based on this, *Eponides isabellanus* is an illustration of the species in the family that are different from others by the great variation in coiling and ornamentation (Hauser and Grunig 1993).

Environment: Cold water, open sea environment, Antarctica (Hauser and Grunig 1993). Inner shelf, depth 42 m (Herb 1971).

Genus **POROEPONIDES** Cushman 1944
Poroeponides lateralis (Terquem 1878)
Fig. 5J-M
1878 *Rosalina lateralis* Terquem, P. 25, Pl. 2, Fig.11.
1964 *Poroeponides lateralis* (Terquem); Shchedrina in Rauzer-Tchernousova, P. 98, Fig. 5(1-2).
1980 *Poroeponides lateralis* (Terquem); Boltovskoy et al. P. 109, Pl. 25, Figs. 4-7.
1994 *Poroeponides lateralis* (Terquem); Jones, Pl. 106, Figs. 2 (a-c).
2007 *Poroeponides lateralis* (Terquem); Talib and Farroqui, P. 25, Pl. 1, Fig. 18.
2012 *Poroeponides lateralis* (Terquem); Debenay, P. 210.
2019 *Poroeponides lateralis* (Terquem); Tabita and Nathan, P. 31, Figs. 9(1-2).

Material: Four specimens were collected and studied from the Zagros Basin, Iran, one from Kendaloo, one from Direstan, and two from the Stars Valley outcrop, Qeshm Island.

Diagnosis and Description: See Boltovskoy et al. (1980), Loeblich and Tappan (1988), and Jones (1994).

Occurrence and Distribution: Cosmopolitan, Pliocene to Holocene, Holocene of the West Atlantic, off Rhode Island, USA (Loeblich and Tappan 1988). Late Pliocene of the Isle of Rhodes, Antarctica (Boltovskoy et al. 1980). Recent, the Gulf of Aden (Shchedrina 1964).

Remark: Lunatic-like chambers in the species of Stars Valley (Fig. 5M) are longer and narrower than the specimens from two other outcrops, Direstan and Kendaloo (such as the Recent species studied by Shchedrina 1964).

Environment: Baccaert (1987) suggested that *Poroeponides lateralis* is a shallow-water species of the Peri-reefal Area of the Great Barrier Reef, in normal salinity and the depth between almost 10 to 32 m. Also, it occurs in the mixohaline waters of Lagoa dos Patos (Boltovskoy et al. 1980).

Family **ELPHIDIIDAE** Galloway 1933
Subfamily **ELPHIDIINAE** Galloway 1933
Genus **ELPHIDIUM** de Montfort 1808
Elphidium fichtellianum (d'Orbigny 1846)
Fig. 6A-B
1846 *Polystomella fichtelliana* d'Orbigny, P.125, Pi. 6, Figs. 7, 8.
1951 *Elphidium fichtellianum* (d'Orbigny); Marks, P. 52, Pl. 6, Figs. 12a, b.
1976 *Elphidium fichtellianum* (d'Orbigny); Berggren, P. 112, Pl. VI, Figs. 7-8.
1982 *Elphidium fichtellianum* (d'Orbigny); van der Zwaan, P. 189, Pl. 9, Fig. 8.
1985 *Elphidium fichtellianum* (d'Orbigny); Papp and Schmid, P. 187, Pl. 40, Figs. 2-5.
1992 *Elphidium fichtellianum* (d'Orbigny); van de Poel, P. 9, Pl. 1, Fig. 4.
2000 *Elphidium fichtellianum* (d'Orbigny); Baggley, P. 1087, Pl. 2, Fig. 5.
2013 *Elphidium chtellianum/complanatum* (d'Orbigny); Jones, P. 283, Pl. 72, Figs. 5-8.
2019 *Elphidium fichtellianum* (d'Orbigny); Amao et al. P. 940, Figs. 4(d-e).

Material: 2 specimens were collected and studied from Kendaloo and Direstan, Qeshm Island, Zagros Basin, Iran.

Diagnosis and Description: Shell coiled spirally, planispiral, hyaline, with crescentic-form chambers. Sutures are depressed, curved, and ponticuli. Shell ornamentation includes hispid, pustulose, costate, and keeled on two sides of the shell. Also, see Papp and Schmid (1985).

Occurrence and Distribution: Late Burdigalian to Langhian, Asmari Formation in the NW of the Zagros basin (Roozpeykar et al. 2019). Tortonian, Kasaba Formation, Turkey (Hayward et al. 1996). Late Miocene (Messinian) of the Andalusian stratotype, western Guadalquivir Basin, SW Spain (Berggren 1976). The latest Tortonian to earliest Messinian, Carboneras-Nijar Basin, SE Spain (van de Poel 1992), and also, the Mediterranean Late Miocene strata (the lowermost of Messinian), Abad Member, Turre Formation, SE Spain (Baggley 2000). Recent, the Iranian coast of the Persian Gulf (Amao et al. 2019).

Remark: Despite mechanical abrasion, the species is identifiable, and characteristic features are still distinct.

Environment: Shallow water, estimated at ~30 m water depth, sandy marls environment (Berggren 1976). The

Mediterranean species, indicating warm-temperate conditions, is warmer than the same species obtaining at present (Jones 2013). Benthic species characteristic of deep open marine (van de Poel 1992), and also, common in pre-concentration basins of natural salt works of the Mediterranean coastal modern environments (Zaninetti 1982; van de Poel 1992)

Elphidium crispum (Linnaeus 1758)

Fig. 6C-E

1758 *Nautilus crispus* Linnaeus, P. 709, Pl. 19, Fig.1d.

1964 *Elphidium crispum* (Linnaeus); Voloshinova and Kuznetsova in Rauzer-Tchernousova, P. 151, Pl. I, Figs. 1(a-b).

1985 *Elphidium crispum* (Linnaeus); Papp and Schmid, P. 187, Pl. 40, Figs. 6-10.

2000 *Elphidium crispum* (Linnaeus); Baggley, P. 1087, Pl. 2, Fig. 4.

2001 *Elphidium crispum* (Linnaeus); Szarek, P.150, Pl. 28, Fig. 3.

2006 *Elphidium crispum* (Linnaeus); Oflaz, P. 235, Pl. 11, Fig. 11.

2007 *Elphidium crispum* (Linnaeus); Talib and Farroqui, P. 21, Pl.1, Fig. 25a-B.

2012 *Elphidium crispum* (Linnaeus); Debenay, P. 216.

2012 *Elphidium crispum* (Linnaeus); Milker and Schmiedl, P. 120, Fig. 27.13-14.

2013 *Elphidium crispum* (Linnaeus); Jones, P. 283, Pl. 72, Figs. 1-2.

2013 *Elphidium crispum* (Linnaeus); Hewaidy et al. P. 43, Pl. 11, Figs. 12(a-b).

2019 *Elphidium crispum* (Linnaeus); Tabita and Nathan, P. 21, Fig. 6.14

Material: Overall, three specimens were collected and studied, from the Mishan Formation, Zagros Basin, Iran, each of them are from Direstan, Kendaloo, and Stars Valley outcrops, Qeshm Island.

Diagnosis and Description: See Hayward et al. (1997), and also, Papp and Schmid (1985).

Occurrence and Distribution: Cosmopolitan, Burdigalian to Langhian of the Asmari Formation in the NW of the Zagros basin (Roozpeykar et al. 2019). Tortonian of Kasaba Formation, Turkey (Hayward et al. 1996). The topmost part of the Miocene succession of the Rosetta Formation, Nile Delta area, Egypt (Hewaidy et al. 2013). The Mediterranean Late Miocene strata (the lowermost of Messinian), Abad Member, Turre Formation, SE Spain (Baggley 2000). Miocene to Recent (Jones 1994).

Remark: The species has been mentioned as an indicator of cool-temperate aspect (slight cooling), Slindon formation, Boxgrove, Britain (Jones 2013). Also, Boltovskoy et al. (1980) suggested that *Elphidium crispum* is one of the species of higher latitudes, which are significantly affected by temperature changes.

Environment: According to Jones (1994), neritic to middle bathyal (to 355 fathoms), and Farooqui (1990) mentioned it as a widely recorded and commonly occurring species in shallow turbulent water of different parts of the modern environments, which can tolerate a wide range of salinity and temperature fluctuation. Also, the species have been mentioned from shallow backreef modern environments with intertidal to subtidal conditions, at depth shallower than 10 m, with eventual salinity fluctuations or normal salinity, also from the barrier reef system (intertidal to slightly subtidal), and from the peri-reefal area of the Great Barrier Reef, in normal salinity and at depth between 10 to 32 m (Boltovskoy et al. 1980).

Elphidium craticulatum (Fichtel and Moll 1798)

Fig. 6F-G

1798 *Nautilus craticulatus* Fichtel and Moll, P. 51, Pl. 5, Figs. h-k.

1987 *Elphidium craticulatum* (Fichtel and Moll); Baccaert, P. 252; Pl. 102, Fig. 8; Pl. 103, Figs 1a, b.

1994 *Cellanthus craticulatum* (Fichtel and Moll); Loeblich and Tappan, P. 167; Pl. 380, Figs 1, 2, 7-10.

1997 *Elphidium craticulatum* (Fichtel and Moll); Hayward et al. P. 73; Pl. 7, Figs 5-12.

2007 *Elphidium craticulatum* (Fichtel and Moll); Talib and Farroqui, P. 21, Pl. 1, Fig. 24 a-b.

2010 *Elphidium craticulatum* (Fichtel and Moll); Sohrabi-Mollayousefi and Sahba, P. 965, Pl. 1, Fig. 5.

2012 *Elphidium craticulatum* (Fichtel and Moll); Debenay, P. 219.

2014 *Elphidium craticulatum* (Fichtel and Moll); Panchang and Nigam, Pl. 38, Fig. 5a-b.

2019 *Elphidium craticulatum* (Fichtel and Moll); Tabita and Nathan, P. 21, Fig. 6(13).

2023 *Elphidium craticulatum* (Fichtel and Moll); Shareef et al. P. 196, Pl. 4, Figs. 10 and 10A.

Material: Two specimens were collected and studied from the Mishan Formation, in Stars Valley and Direstan outcrops, Qeshm Island.

Diagnosis and Description: See Debenay (2012), and also, Tabita and Nathan (2019).

Occurrence and Distribution: Langhian-Serravallian, Fatha Formation, Southern Iraq (Shareef et al. 2023). Holocene of Indonesia (Loeblich and Tappan 1988). Recent, the Great Barrier Reef of Australia (Baccaert 1987), and New Caledonia, Southwestern Pacific (Debenay 2012), also, Persian Gulf (Sohrabi-Mollayousefi and Sahba 2010).

Remark: This has been reported from the Persian Gulf as among some species, which indicate abnormal tests and are capable of tolerating elevated levels of nutrients; the average temperature of the Persian Gulf is 23.5 °C (Sohrabi-Mollayousefi and Sahba 2010).

Environment: A shallow-water species of the peri-reefal area of Great Barrier Reef, in normal salinity and the depth between almost 10 to 32 m (Baccaert 1987), typically associated with coral reefs and hardgrounds (Sen Gupta 1999; Haunold et al. 1997; Parker 2009; Parker and Gischler 2015). Also, it has been mentioned as a limited value environmental parameter, which belongs to the highly complex modern environments, with an enormous variety of ecological niches and of environmental parameters that are acting in this wide carbonate lagoon with reefs, deep depressions, and various continental inputs; depth from 1 to 30 m (Debenay 2012). Modern carbonate ramp (Parker and Gischler 2015).

Elphidium asiaticum (Polski 1959)

Fig. 6H

1959 *Elphidium discoidale* (d'Orbigny) var. *asiaticum*; Polski, P. 585, Pl. 78, Fig. 2a-b.

2000 *Elphidium asiaticum* (Polski,); Kim and Kucera, P. 1073, Fig. 4(a-b).

2015 *Cibrononion asiaticum* (Polski); Lei et al. P. 250, Pl. 1, Fig. 4a-e.

2019 *Elphidium asiaticum* (Polski,); Tabita and Nathan, P. 21, Fig. 6(8).

https://doi.org/10.22108/jssr.2026.146509.1319

Material: Only one specimen was collected and studied from Gushi Marl, Bemani outcrop, Minab Province, southern Iran.

Diagnosis and Description: See Tabita and Nathan (2019).

Occurrence and Distribution: Recent, East Coast of India (Tabita and Nathan 2019). Middle Holocene (Wu et al. 2022). Latest Quaternary, Core DH1-4, the Yellow Sea, central Korea (Kim and Kucera 2000).

Remark: Despite abrasion, the identity of the species based on characteristic features is admissible.

Environment: Liu et al. (2018) suggested the species as shallow marine species strata, which are typical of inner- to middle-shelf environments (Wang et al. 1985; Zhou et al. 1996). Also, it has been mentioned from the tidal flats (Kim and Kucera 2000), and from stormy intertidal (Wu et al. 2022), shallow water, and medium-depth water (Li et al. 2015).

Elphidium advenum macelliforme (McCulloch 1981)

Fig. 6I–J

1981 *Elphidium macelliforme* McCulloch, P. 119, P1.40, Fig. 1.

1993 *Elphidium macelliforme* (McCulloch); Albani and Yassini, P. 28, Figs. 65,66.

1997 *Elphidium advenum macelliforme* (McCulloch); Hayward et al. P. 130, Pl. 5, Figs 6-12

Material: Only two specimens were collected and studied from Gushi Marl, Bemani outcrop, Minab Province, and from Direstan outcrop, Qeshm Island, Persian Gulf, southern Iran.

Diagnosis and Description: See Hayward et al. (1997).

Occurrence and Distribution: Early Oligocene to Pliocene (Hayward et al. 1997).

Environment: See Hayward et al. (1997).

Elphidium advenum maorium (Hayward et al. 1997)

Fig. 6K-M

1952 *Elphidium advenum* (Cushman); Finlay in Marples, P.61 And P. 62.

1974 *Elphidium advenum* (Cushman); Collins, P. 4l.

1979 *Elphidium advenum* (Cushman); Hayward and Buzas, P.52, P1.12, Fig. 157.

1990b *Elphidium advenum* var. *depressulum* (Cushma); Hayward, P.96.

1984 *Elphidium advenum* var. *depressulum* (Cushma); Hayward et al. P.162.

1945 *Elphidium* sp. cf. *simplex* (Cushman); Parr, P. 216, Pl. 11, Fig.8.

1966a *Elphidium charlollense* (Vella); Kenneti, P. 61, P1.8, Figs. 123, 124.

1966b *Elphidium charlollense* (Vella); Kenneti, P. 206-207.

1997 *Elphidium advenum maorium* Hayward n.ssp., Pl. 1, Fig. 7; Pl. 4, Figs. 11-16; Pl. 5, Figs. 1-5.

Material: three specimens were collected and studied, from Stars Valley, Kendaloo, Qeshm Island, and also from Gushi Marl, Bemani outcrop, Minab Province, southern Iran.

Diagnosis and Description: See Hayward et al. (1997).

Occurrence and Distribution: Late Eocene to Recent (for more, see Hayward et al. 1997).

Environment: See Hayward et al. (1997).

Elphidium advenum limbatum (Chapman 1907)

Fig. 6N–Q

1907 *Polystomella macellum* var. *limbatum* Chapman, P.142, Pl. 10, Figs.9a-b.

1922 *Polystomella striatopunctata* (Fichtel and Moll); Heron-Allen and Earland, P. 229.

1933 *Elphidium advenum* (Cushman) var. *depressulum* Cushman, P. 51, Fig. 4 a,b.

1939 *Elphidium macellum* var. *limbatum* (Chapman); Cushman, P.52, Pl. L4, Fig.5.

1958 *Elphidium limbatum* (Chapman); Collins, P. 421.

1961 *Elphidium* cf. *advenum* (Cushman); Hornibrook, P. 129.

1965 *Elphidium* aff. *advenum*? (Cushman); Kustanowich, P. 53,61.

1990b *Elphidium advenum* (Cushman); Hayward, P. 96.

1996 *Elphidium advenum* (Cushman); Hayward et al. Pl. 2, Figs. 6-7.

Material: Four specimens were collected and studied, two from the Mishan Formation in Direstan and Stars Valley outcrops, and two from the Kendaloo outcrop, Qeshm Island, southern Iran.

Diagnosis and Description: See Hayward et al. (1997).

Occurrence and Distribution: Late Eocene to Recent (Hayward et al. 1997).

Environment: See Hayward et al. (1997).

Superfamily **NONIONOIDEA** Schultze 1854

Family **NONIONIDAE** Schultze 1854

Subfamily **NONIONINAE** Schultze 1854

Genus **NONION** de Montfort 1808

Nonion fabum (Fichtel and Moll 1798)

Fig. 6R-S

1798 *Nautilus faba* Fichtel and Moll, P. 103, Pl. 19, Figs. a-c.

2010 *Nonion fabum* (Fichtel and Moll); Margreth, P. 123, Pl. 36, Fig. 2a-c.

2012 *Nonion fabum* (Fichtel and Moll); Milker and Schmiedl, P. 112, Fig. 25.22-24.

2014 *Nonion fabum* (Fichtel and Moll); Panchang and Nigam, Pl. 33, Fig. 11a-b.

2019 *Nonion fabum* (Fichtel and Moll); Tabita and Nathan, P. 21, Fig. 6(20).

2023 *Nonion fabum* (Fichtel and Moll); Shareef et al. P. 198, Pl. 5, Fig. 8.

Material: Only two specimens were collected and studied, from Stars Valley and Direstan, Qeshm Island, Persian Gulf, southern Iran.

Diagnosis and Description: See Loeblich and Tappan (1988) and Tabita and Nathan (2019).

Occurrence and Distribution: Burdigalian to Langhian, Asmari Formation, Zagros Basin, West of Iran (Roozpeykar et al. 2019). Serravallian-Langhian, Fatha Formation, Iraq (Shareef et al. 2023). Recent, the Persian Gulf (Maghsoudlou et al. 2021).

Environment: In a relatively deep basin, consistent with the outer shelf-slope environment (Murray 1991; Schmiedl et al. 2003; Roozpeykar et al. 2019).

Superfamily **BOLIVINITOIDEA** Cushman 1927

Family **BOLIVINITIDAE** Cushman 1927

Subfamily **BOLIVINITINAE** Cushman 1927

Genus **BOLIVINA** d'Orbigny 1839

Bolivina spathulata (Williamson 1858) ***dentellata*** type

Fig. 7A

1858 *Textularia variabilis* (Williamson) *var. spathulata* Williamson; P. 76, Pl. 6, Figs. 164-165.

1979 *Brizalina spathulata* (Williamson); Hageman, P. 89, Pl. 2, Figs. 5a, b.

1955 *Bolivina dentellata* (Williamson); Tavani, P. 144, Pl.

https://doi.org/10.22108/jssr.2026.146509.1319

1, Figs. 1-3.

1982 *Bolivina spathulata* (Williamson); van der Zwaan, Pl. 2, Figs. 1-5; Text-Fig. 59

1992 *Bolivina dentellata* (Williamson); Tavani, P. 11, Pl. 2, Fig. 10.

2014 *Brizalina spathulata* (Williamson); Nabavi et al. P. 25, Pl. 2, Fig. d.

Material: Only one specimen was collected and studied, from Gushi Marl, Bemani outcrop, Minab Province, southern Iran.

Diagnosis and Description: See van der Zwaan (1982).

Occurrence and Distribution: Cosmopolitan, the late early Messinian (van de Poel 1992). Burdigalian to Langhian, Asmari Formation, Lurestan province, NW Zagros Basin, Iran (Roozpeykar et al. 2019). Langhian to Serravallian, carbonate strata, Siwa Oasis, Egypt (Abdel-Fattah et al. 2013). Middle Holocene, core T2S3, Strait of Hormoz, Southern Iran (Hamzeh et al. 2021). Recent, Britain (Williamson 1858).

Environment: The abundance patterns of *B. spathulata* suggest that it was probably a mud-dweller with a wide environmental range; it was tolerant to high salinities and to oxygen deficiency. Possibly, it preferred a high-nutrient environment. It is a low-oxygen marine species, characteristic of the shelf edge and upper slope (Murray 1973; Pujos 1976; Jorissen 1988; van de Poel 1992), and has alsobeen reported from warm waters of the tropical to subtropical zone in carbonate platform (Roozpeykar et al. 2019). In modern environments, from different depths between ~120 and ~250 or 20-40 m (Debenay 2012). Furthermore, it has been described as a deep infaunal and dysoxic species occurring in high organic flux environments (Bernhard and Gupta 1999; Das et al. 2017), with more salinity conditions (Eris et al. 2011; Suokhrie et al. 2021).

Suborder **GLOBIGERININA** Delage and Hérouard 1896

Superfamily **GLOBIGERINOIDEA** Carpenter 1862

Family **GLOBIGERINIDAE** Carpenter, Parker and Jones 1862

Subfamily **GLOBIGERININAE** Carpenter, Parker and Jones 1862

Genus **GLOBIGERINA** d'Orbigny 1826

Globigerina bulloides (d'Orbigny 1826)

Figs. 7B

1826 *Globigerina bulloides* d'Orbigny, p. 277, no.1.

1982 *Globigerina bulloides* (d'Orbigny); Brasier, P. 155, Fig. 5.14 (a-c).

1983 *Globigerina bulloides* (d'Orbigny); Kennet and Srinivasan, P. 36, Pl. 6, Figs. 4-6.

1985 *Globigerina bulloides* (d'Orbigny); Papp and Schmid, P. 215, Pl. 54, Figs. 1-6.

2003 *Globigerina bulloides* (d'Orbigny); Hanagata, P. 322, Pl. 9, Fig. 3.

2005 *Globigerina bulloides* (d'Orbigny); Narayan et al. P. 151, Pl. 6, Figs. 6-8.

2010 *Globigerina bulloides* (d'Orbigny); Ovechkina, Bylinskaya and Uken, P. 239, Fig. 5G-5I.

2019 *Globigerina bulloides* (d'Orbigny); Tabita and Nathan, P. 47, Figs. 13(4-5).

Material: two samples were collected and studied from Kendaloo and Stars Valley, southern Iran.

Diagnosis and Description: See Tabita and Nathan (2019), and also Narayan et al. (2005).

Occurrence and Distribution: Early to Middle Miocene (Aquitanian to Langhian), Mishan Formation in the Khorgu and Khamir anticlines, Bandar Abbas, southern Iran (Fanati Rashidi et al. 2014). Late Burdigalian to Langhian of the Asmari Formation in the NW of the Zagros basin (Roozpeykar et al. 2019). Middle Miocene to Holocene, NW Pacific and Canadian Arctic (Narayan et al. 2005). Late Pliocene, East Antarctica Quilty (2010).

Remark: Steinthorsdottir et al. (2021) mentioned that strengthening of the South Asian monsoon at ~8 Ma was interpreted from an increase in the foraminifer *Globigerina bulloides*, which thrives on upwelling of deep nutrient-rich waters caused today by summer monsoon winds driving surface waters offshore (Kroon et al. 1991; Prell et al. 1992), but in Kendaloo and Stars Valley outcrops, only two *G. bulloides* and *G.* cf. *bulloides* were found.

Environment: According to evidence presented by Be and Hutson (1977), *G. bulloides* has an optimum temperature range of 13.4°±7.8°C, and also, it lives in depths of less than 50 m (Chaproniere 1992).

Genus **TRILOBATUS** Spezzaferri et al. 2015

Trilobatus (Globigerinoides) trilobus (Reuss 1850)

Fig. 7D

1850 *Globigerina triloba* Reuss, 374, Pl. 47, Fig. 11a–e.

1957 *Globigerinoides triloba triloba* (Reuss); Bolli, P. 112, Pl. 25, Fig. 2a–c.

1960 *Globigerinoides triloba triloba* (Reuss); Jenkins, P. 353, Pl. 2, Fig. 5a–c.

1966 *Globigerinoides trilobus trilobus* (Reuss); Jenkins, P. 9, Pl. 2, Fig. 8a–c.

1967 *Globigerinoides quadrilobatus trilobus* (Reuss); Closs, P. 340, Pl. 1, Fig. 22.

1975 *Globigerinoides quadrilobatus trilobus* (Reuss); Srinivasan, P. 139, Pl. 2, Fig. 7.

1983 *Globigerinoides triloba* (Reuss); Kennett and Srinivasan, P. 62, Pl. 13, Figs 1–3.

1994 *Globigerinoides trilobus* (Reuss); Loeblich and Tappan, P. 107, Pl. 206, Figs 1–6.

2012 *Globigerinoides trilobus* (Reuss); Rögl, P. 181, Pl. 1, Figs 1–7.

2018 *Trilobatus trilobus* (Reuss); Spezzaferri, Olsson, and Hemleben, P. 300–302, Pl. 9.14, Figs. 1–21.

2019 *Trilobatus trilobus* (Reuss); Poole and Wade, P. 1998, Figs. 6A–O; P. 2014, Fig. 16E; P. 2015, Figs. 17A, E.

Material: Only one sample was collected and studied from Gushi marl, Minab Province, Makran Basin, southern Iran.

Diagnosis and Description: See Poole and Wade (2019).

Occurrence and Distribution: Late Burdigalian, Zagros Basin (Roozpeykar et al. 2019). Middle Miocene (early Langhian to early Badenian), between 15.2 and 14.8 Myr. of Vienna Basin, Austria (Harzhauser et al. 2020). The middle Miocene to lowermost Pliocene Mishan Formation, Bandar Abbas (Hassani and Hosseinipour 2017). Langhian to Serravallian, in the lower part of the marly member, Mishan Formation, southern Iran (Gholamalian et al. 2015; 2020).

Remark: In the Zagros Basin (Iran), Hassani and Hosseinipour (2017) suggested that the species is a member of biozone Z1 (= *Globigerinoides trilobus* zone of Postuma 1971), which shows timing Aquitanian before the boundary of early Burdigalian, which coincides with the beginning of global biozone N5 (Hassani and Hosseinipour, 2017; also check Fig. 3 by Spezzaferri et al. 2002).

Environment: Common in subtropical/ tropical assemblages worldwide throughout their long stratigraphical ranges from the latest Oligocene/early Miocene to Recent (Poole and Wade 2019), and also have been reported from outer neritic to upper bathyal depositional environments with high nutrient content and connection to the open sea (Harzhauser et al. 2020).

Genus **PRAEORBULINA** Olsson 1964
Praeorbulina transitoria (Blow 1956)
Fig. 7E

1956 *Globigerinoides transitoria* Blow, P.65 text-Figs. 2.12-13.

1971 *Praeorbulina transitoria* (Blow); Postuma, P. 378-379

1985 *Praeorbulina transitoria* (Blow); Iaccarino, P. 298.

1985 *Praeorbulina transitoria* (Blow); Bolli and Saunders, P.200, Figs. 23.6, 7, 9, 12.

1988 *Praeorbulina transitoria* (Blow); Rateb 1988, P.18, Pl.3, Figs. 8(a-b).

2013 *Praeorbulina transitoria* (Blow); Hewaidy et al. P. 41, Pl. 9, Figs. 3(a-b).

Material: Only one sample was collected and studied from Stars Valley, Qeshm Island.

Diagnosis and Description: See Hewaidy et al. (2013).

Occurrence and Distribution: Late Burdigalian to Langhian, Guri Member, Mishan Formation, Zagros Basin, South Iran (Daneshian et al. 2016). Late Burdigalian to Langhian, the lower Miocene Qantara Formation and middle Miocene Sidi Salem Formation, Nile Delta area, Egypt (Hewaidy et al. 2013). Correlated with the boundary of two global biozones N8 to N9, in the Langhian (for more, see chart 6.2 in BouDagher-Fadel 2015).

Environment: Open shelf environments (Rahmani and Vaziri-Moghaddam 2010).

Order **TEXTULARIIDA** Delage and Hérouard 1896
Suborder **TEXTULARIINA** Delage and Hérouard1896
Superfamily **TEXTULARIOIDEA** Ehrenberg 1838
Family **TEXTULARIIDAE** Ehrenberg 1838
Subfamily **TEXTULARIINAE** Ehrenberg 1838
Genus **TEXTULARIA** Defrance 1824
Textularia agglutinans (d'Orbigny 1839b)
Figs. 7F-H

1839b *Textularia agglutinans* d'Orbigny; P. 144, Pl. 1, Figs. 17-18, 32-34.

1935 *Textularia agglutinans* (d'Orbigny); Keijzer, P. 128, 132, Fig. 25 a-g.

2003 *Textularia agglutinans* (d'Orbigny); Javaux and Scott, P. 22, Fig. 5(8-9).

2007 *Textularia agglutinans* (d'Orbigny); Talib and Farroqui, P. 18, Pl. 1, Fig. 1.

2012 Textularia agglutinans (d'Orbigny); Debenay, P. 95.

2012 *Textularia agglutinans* (d'Orbigny); Milker and Schmiedl, P. 38, Fig. 10.15-16.

2015 *Textularia agglutinans* (d'Orbigny); Nouradini et al. P. 69, Figs. 9-11.

2015 *Textularia agglutinans* (d'Orbigny); Hanagata and Nobuhara, P. 18, Figs. 7(3-4).

2017 *Textularia agglutinans* (d'Orbigny); Anbuselvan and Nathan, Fig. 8(3, 3a).

2019 *Textularia agglutinans* (d'Orbigny); Tabita and Nathan, P. 52, Fig. 15(9).

Material: Three specimens were collected and studied, from Mishan Formation, Zagros Basin, Iran, each of the are from Direstan, Kendaloo, and Stars Valley outcrops, Qeshm Island.

Diagnosis and Description: See Tabita and Nathan (2019), Mohan et al. (2018), and also Boltovskoy et al. (1980).

Occurrence and Distribution: Cosmopolitan, it has been reported from numerous locations worldwide (Merkado et al. 2015). In Iran: Lower Miocene, Qom Formation, Central Iran (Nouradini et al. 2015). Recent, the Bay of Bengal, east coast of India (Anbuselvan and Nathan 2017).

Remark: Nouradini et al. (2015, 2017) mentioned the species in oxic, down to 50 m, carbonate sand littoral inner–middle shelf palaeoenvironment of the NE margin of the Tethyan Seaway in the Qom fore arc in Central Iran.

Environment: The widespread species from the Indian to the West Pacific Oceans, including the modern Bay of Jakarta, Java (Hofker 1968). Also, has been mentioned from the modern shallow-water environment (depth: 85 m), and almost high-temperature waters (temperature 22°C) of the North coast of Ambon Island, Indonesia (Hofker 1978), and has been reported from sandy to slightly muddy sand environment, restricted to 30 to 80 m of water depth, in shallower inner shelf (Anbuselvan and Nathan 2017). Baccaert (1987) suggested it as a shallow-water species of the peri-reefal area, in the Great Barrier Reef, in normal salinity, and the depth between 10 to 32 m.

Class **TUBOTHALAMEA** Pawlowski, Holzman and Tyszka 2013
Order **MILIOLIDA** Delage and Hérouard 1896
Suborder **MILIOLINA** Delage and Hérouard 1896
Superfamily **MILIOLOIDEA** Ehrenberg 1839
Family **HAUERINIDAE** Schwager 1876
Subfamily **MILIOLINELLINAE** Vella 1957
Genus **TRILOCULINA** d'Orbigny 1826
Triloculina trigonula (Lamarck 1804)
Figs. 7K-M

1804 *Miliolites trigonula* Lamarck, P. 351, Pl. 17(15), Fig. 4.

1826 *Triloculina trigonula* (Lamarck); d'Orbigny, P. 299, Pl. 16,

1858 *Miliolina trigonula* (Lamarck); Williamson, P. 83, Pl. 7, Figs. 180-182.

1960 *Miliolina trigonula* (Lamarck); Barker, Pl. 3, Figs. 15-16.

1884 *Miliolina trigonula* (Lamarck); Brady, P. 164, Pl. 3, Figs. 15, 16 (not Fig. 14).

1989 *Miliolina trigonula* (Lamarck); Hermelin, P. 39, Pl. 3, Fig. 8.

1994 *Miliolina trigonula* (Lamarck); Jones, P. 20, Pl. 3, Figs. 15-16.

2006 *Triloculina trigonula* (Lamarck); Oflaz, P. 177, Pl. 4, Fig. 4.

2007 *Triloculina trigonula* (Lamarck); Talib and Farroqui, P. 19, Pl. 1, Fig. 16a-b.

2010 *Triloculina trigonula* (Lamarck); Margreth, P. 103, Pl. 11, Fig. 2a-c.

2012 *Triloculina trigonula* (Lamarck); Debenay, P. 138.

2013 *Triloculina trigonula* (Lamarck); Holbourn et al. P. 566, Figs, 1-2.

2014 *Triloculina trigonula* (Lamarck); Panchang and Nigam, Pl. 13, Fig. 7a-b.

2019 *Triloculina trigonula* (Lamarck); Tabita and Nathan, P. 70, Figs. 21(1).

Material: three samples were collected and studied, two from Kendaloo and one from the Direstan outcrop, Qeshm Island, Zagros Basin, southern Iran.

https://doi.org/10.22108/jssr.2026.146509.1319

Diagnosis and Description: See Tabita and Nathan (2019).

Occurrence and Distribution: Worldwide, Early Eocene to Recent (Jones 1994; Holbourn et al. 2013). Late Oligocene (Chattian), Asmari Formation, Qeshm Island, Persian Gulf, southern Iran (Sajadi and Fanati Rashidi 2019). Chattian to Aquitanian, Asmari Formation, SW Zagros Basin, Iran (Roozpeykar and Moghaddam 2015). And also, the Al-Kharrar Lagoon (modern environment), eastern Red Sea coast, Saudi Arabia (Al-Dubai et al. 2017).

Environment: Lower neritic to bathyal (Holbourn et al. 2013). Shoreline to 100 fathoms (Jones 1994). Reported from the lower bathyal zone in the eastern Pacific Ocean (see Hermelin 1989). Also, it has been mentioned that it shows positive relationships with pH, deep muddy substrates enriched in organic matter, and is negatively correlated with high temperature and salinity (Al-Dubai et al. 2017).

Triloculina terquemiana (Brady 1884)

Figs. 7N-O

1884 *Miliolina terquemiana* Brady, P. 166, Pl. 114, Fig. 1a-b.

1999 *Triloculina terquemiana* (Brady); Nigam and Khare, P. 292, Pl. 3, Fig. 7.

2007 *Triloculina terquemiana* (Brady); Talib and Farroqui, P. 18, Pl. 1, Fig. 15a-b.

2012 *Triloculina terquemiana* (Brady); Debenay, P.138.

2012 *Triloculina terquemiana* (Brady); Mossadegh et al. P. 354, Figs. 11(r-t).

2019 *Triloculina terquemiana* (Brady); Tabita and Nathan, P. 67, Figs. 20(16-17).

Material: Two samples were collected and studied, from Direstan and Stars Valley outcrops, Qeshm Island, Zagros Basin, southern Iran.

Diagnosis and Description: See Debenay (2012).

Occurrence and Distribution: Late Oligocene (Chattian), Qom Formation, Central Iran (Nouradini et al. 2017). Late Pleistocene, from raised coral reef sequences, Kish Island, Persian Gulf, Iran (Mossadegh et al. 2012). Recent, Coastal areas of the Indian Ocean (Farooqui 1990), and also, the Southwestern Pacific (Debenay 2012).

Remark: Nouradini et al. (2017) reported the species from the NE margin of the Tethyan Seaway in the Qom fore arc in Central Iran.

Environment: This have been mentioned from oxic, 0–50 m, muddy epifaunal of inner shelf of palaeoenvironment (Nouradini et al. 2017), also, from shore sand (Brady 1884), sandy beaches and coastal modern environments (see Farooqui 1990). In the Ligurian Sea (Italian part of the Mediterranean Sea), the Miliolidae occur in large numbers from 20 to 90 m (Giunta 1955; Luczkowska 1974).

Triloculina tricarinata (d'Orbigny 1826)

Fig. 7P

1826 *Triloculina tricarinata* d'Orbigny, P. 299, Pl. 1, Fig. 8.

2010 *Triloculina trigonula* (Lamarck); Margreth, P. 103, Pl. 11, Fig. 2a-c.

2012 *Triloculina tricarinata* (d'Orbigny); Debenay, P. 138.

2012 *Triloculina tricarinata* (d'Orbigny); Milker and Schmiedl, P. 68, Fig. 17.23-24.

Material: only one sample was collected and studied from the Kendaloo outcrop, Qeshm Island, Zagros Basin, southern Iran.

Diagnosis and Description: See Debenay (2012).

Occurrence and Distribution: Chattian to Aquitanian, Asmari Formation, SW Zagros Basin, Iran (Roozpeykar and Moghaddam 2015). Early to Middle Miocene (Aquitanian to Langhian), Mishan Formation, southern Iran (Fanati Rashidi et al. 2014). Langhian to Serravallian, in the lower part of the marly member, Mishan Formation, southern Iran (Gholamalian et al. 2015; 2020). Recent, the Persian Gulf (Sohrabi-Mollayousefi and Sahba 2010).

Environment: *T. tricarinata* suggests a particular numerous occurrence in down to 20 m (Giunta 1955; Luczkowska 1974). Living in the Persian Gulf under conditions of seasonal temperature and salinity, the average temperature is 23.5 °C, and the average dissolved oxygen exceeded 6.1 mg/lit (Sohrabi-Mollayousefi and Sahba 2010). Also, it has been reported from the low-energy and the shelf lagoon deposition environment of the Mishan Formation (Fanati Rashidi et al. 2014).

Subfamily **HAUERININAE** Schwager 1876

Genus **QUINQUELOCULINA** d'Orbigny 1826

Quinqueloculina bogdanowiczi (Serova 1955)

Figs. 7Q-S

1955 *Miliolina bogdanowiczi* Serova, P. 309, Pl. 4, Figs. 1-3.

1961 *Quinqueloculina bogdanowiczi* (Serova); Didkovsky, P. 22, Pl. 1, Fig. 4.

1961 *Quinqueloculina brevia* (Didkovsky); Ibidem, P. 45, Pl. 9, Fig. 2.

1974 *Quinqueloculina bogdanowiczi* (Serova); Luczkowska, P. 170, Pl. V, Figs. 3(a-c), 4(a-c); P. 44, Text-Fig. 10.

2014 *Quinqueloculina bogdanowiczi* (Serova); Filipescu et al. P. 71, Fig. 5(7).

Material: three samples were collected and studied from Direstan and Stars Valley outcrops, Qeshm Island, and from Gushi marl, Minab Province, Iran.

Diagnosis and Description: See Luczkowska (1974).

Occurrence and Distribution: Serravallian (the early Sarmatian), Pannonian Basin, Romania (Filipescu et al. 2014). Upper Tortonian and also the sea of the lower Sarmatian, Poland, and Lower and Upper Tortonian, the southwestern border of the Russian Platform, and Lower Tortonian, western Ukraine (Luczkowska 1974).

Remark: The reporting of the species from Ukraine, the southwestern border of the Russian Platform, the Pannonian Basin, and the Sarmatian Sea in central Europe suggests that it may be an Eastern-Central Paratethyan species.

Environment: Palaeogeographically, reported from a sandy environment (Luczkowska 1974), and marginal to shallow marine, with fairly high energy and fluctuating salinity (Filipescu et al. 2014).

Evidence of the Connection

The micropaleontological assemblages recovered from Qeshm Island (Zagros Basin) and Bemani (Makran Basin) provide some evidence for evaluating the status of the Iranian Gateway during the Late Miocene–Early Pliocene, including the co-occurrence of taxa such as *Quinqueloculina bogdanowiczi*, previously restricted to the Paratethys (Harzhauser and Piller 2007; Reuter et al. 2009), together with tropical planktonic markers including *Praeorbulina transitoria* and *Globigerinoides trilobus* (Poole and Wade 2019), suggests intermittent marine connections between the Indo-Pacific and the proto-Mediterranean realms. Planktonic foraminifera

https://doi.org/10.22108/jssr.2026.146509.1319

palaeotemperature markers (Spezzaferri et al. 2002; Holcová and Zágoršek 2008), *Globigerina bulloides*, is a marker of cold temperature, and *Globigerinoides* (*Trilobatus*) *trilobus* is a marker of warm temperature (Poole and Wade 2019). In Qeshm Island, the presence of *Globigerina bulloides*, a cold-water indicator (Spezzaferri et al. 2002) and other taxa like *Elphidium crispum* and *Challengerella bradyi*, alongside warm-water taxa including Triloculina group and Eponides group, further supports the interpretation of episodic faunal exchange through narrow seaways (fig. 3), what is conclusionable in Minab region based on the co-occurrence of *Asterorotalia* group and Elphidium *advenum* group with G. *trilobus* and *Bolivina spathulata* (see Table 2). These assemblages correlate with global planktonic biozones N8–N9 and N19–N20 (Boboye and Adeleye 2009), indicating that the Iranian Gateway remained at least partially open until the Messinian–Zanclean interval. Thus, the new data strengthen existing models of episodic marine incursions ("tongues") advancing westward into Mesopotamia (Harzhauser et al. 2007; Piller et al. 2024).

Table 2- The environmental indicator foraminifera in this study are briefly listed below to provide an overview of intermittent marine connections between the Indo-Pacific and the proto-Mediterranean realms.

Location	Species	Environment Indicator	Notes
Qeshm Island	*Poroeponides lateralis*	Warm–temperate shallow	Benthic coastal indicator
	Elphidium crispum	Cold to temperate shallow waters	Found in cooler neritic zones; sensitive to ecological changes
	Triloculina group	Warm, shallow lagoons	Common in tropical shallow carbonate environments
	Quinqueloculina bogdanowiczi	Warm, shallow	Indicator of tropical lagoonal and reefal settings
	Eponides group	Warm–temperate	Indicators of lagoonal and shallow marine settings
	Textularia agglutinans	Variable, stressed environments	Agglutinated species; tolerant of environmental stress and high energy, polluted waters
	Rotalinoides compressiuscula	Temperate	Stable benthic environments
	Challengerella bradyi	Cold, deep waters	Indicator of deeper, colder benthic habitats
Kendaloo and Stars Valley	*G. bulloides*	Cold, nutrient-rich waters	Widely distributed in temperate to subpolar regions; indicator of upwelling and cold-water masses
Minab Region	*T. trilobus*	Warm, tropical waters	Common in tropical, and sub-tropical surface waters and/or warm shallow seas
	Bolivina spathulata	Oxygen minimum zones (OMZ)	Indicator of low-oxygen environments; common in stressed benthic settings
*	*Asterorotalia* group	Warm, shallow	Found in tropical/subtropical coastal zones
	E. asiaticum and E. *advenum* group	Temperate–cold coastal	Indicators of oxygen and salinity fluctuations
Direstan only	*Ammonia beccarii*	Estuarine, variable salinity	Tolerant of brackish and polluted environments; indicator of coastal stress

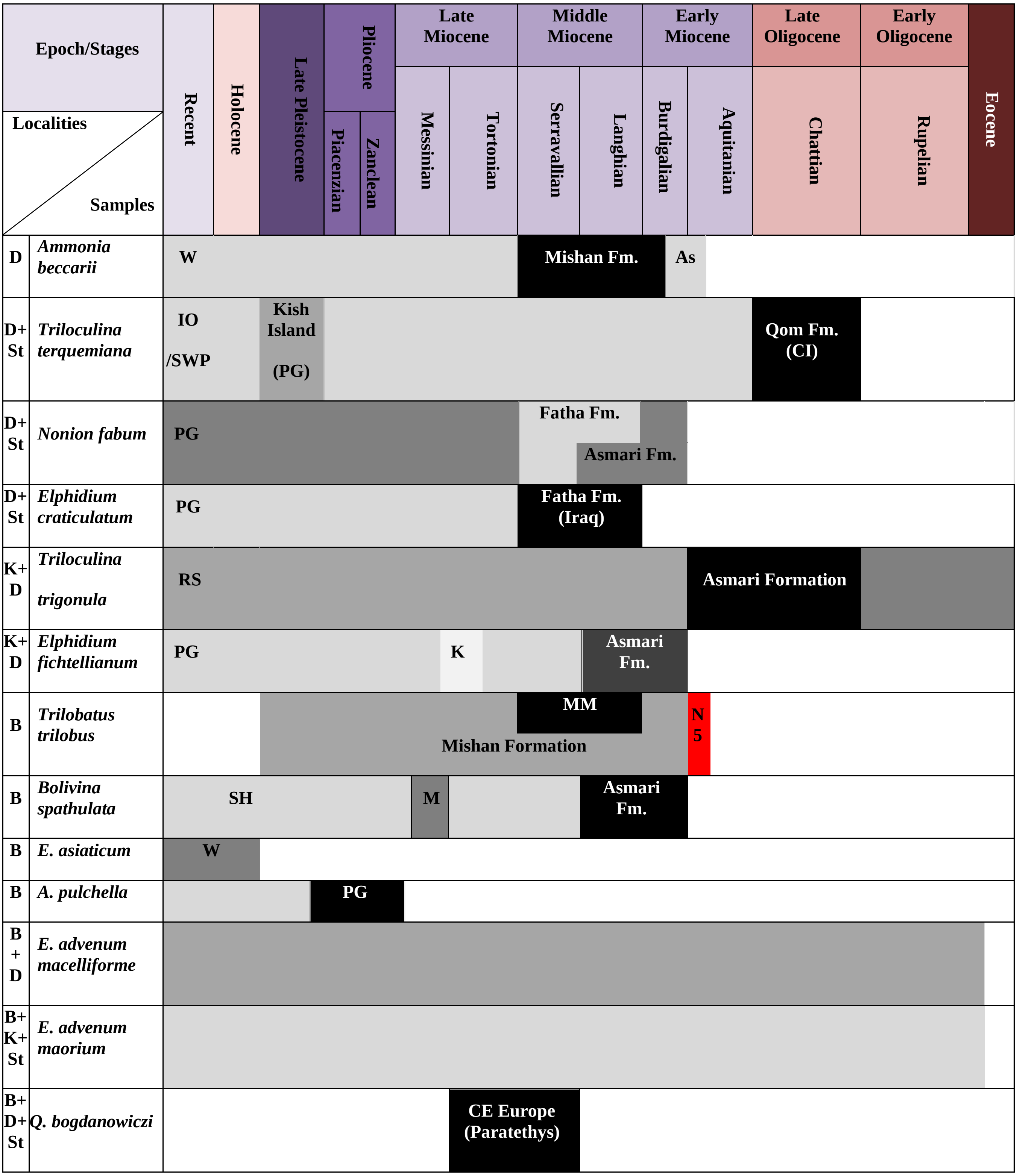
* Collected from Qeshm Island and Minab region, both.

https://doi.org/10.22108/jssr.2026.146509.1319

Table 3- **Occurrences of studied foraminifera at the nearest parts of the world to all four outcrops in the present study, and also correlation of three global biozones of N5, N19, and N20 with studied foraminifera (for more see "Distribution and Occurrence" sections of every sample in this manuscript). Note: K= Kendaloo, B= Bemani, St= Stars Valley, D=Direstan, MM= marly member, GM=Guri Member, Q= Qeshm Island (Kendaloo, Direstan, Stars Valley), As = Asmari Formation, K= Kasaba Formation, W=worldwide, Fm.=Formation, E= Egypt, M= Mediterranean, IO= Indian Ocean, SWP= South West of Pacific, NWP= North West of Pacific, EC=Eastern-Central, SH= Strait of Hormoz, PG=Persian Gulf, CI=Central Iran, GA= Gulf of Aden, RS= Red Sea, DK= Drake Passage, Antarctica, (*) = all four outcrops.**

Epoch/Stages					Pliocene		Late Miocene		Middle Miocene		Early Miocene		Late Oligocene	Early Oligocene	
Localities	Samples	Recent	Holocene	Late Pleistocene	Piacenzian	Zanclean	Messinian	Tortonian	Serravallian	Langhian	Burdigalian	Aquitanian	Chattian	Rupelian	Eocene
(*)	*Asterorotalia dentata*					N 20									
Q	*Textularia agglutinans*	W									Qom Fm.				
Q	*Elphidium crispum*	W					M			Asmari Fm.					
Q	*E. advenum limbatum*														
Q	*P. lateralis*	GA				W									
Q	*E. repandus*	E										Qom Formation (CI)			
Q	*R. compressiuscula*						N 19								
Q	*C. bradyi*	PG	SH	Kish (PG)				Mishan Formation	Fatha Fm.			N 5			
K	*Triloculina tricarinata*	PG							Mishan Formation (Southern Iran)	MM		Asmari Formation			
St	*Praeorbulina transitoria*									GM N8-N9					
K+St	*Globigerina bulloides*		NWP							Mishan Fm. As					
D	*Eponides isabellanus*	DK													

https://doi.org/10.22108/jssr.2026.146509.1319



https://doi.org/10.22108/jssr.2026.146509.1319

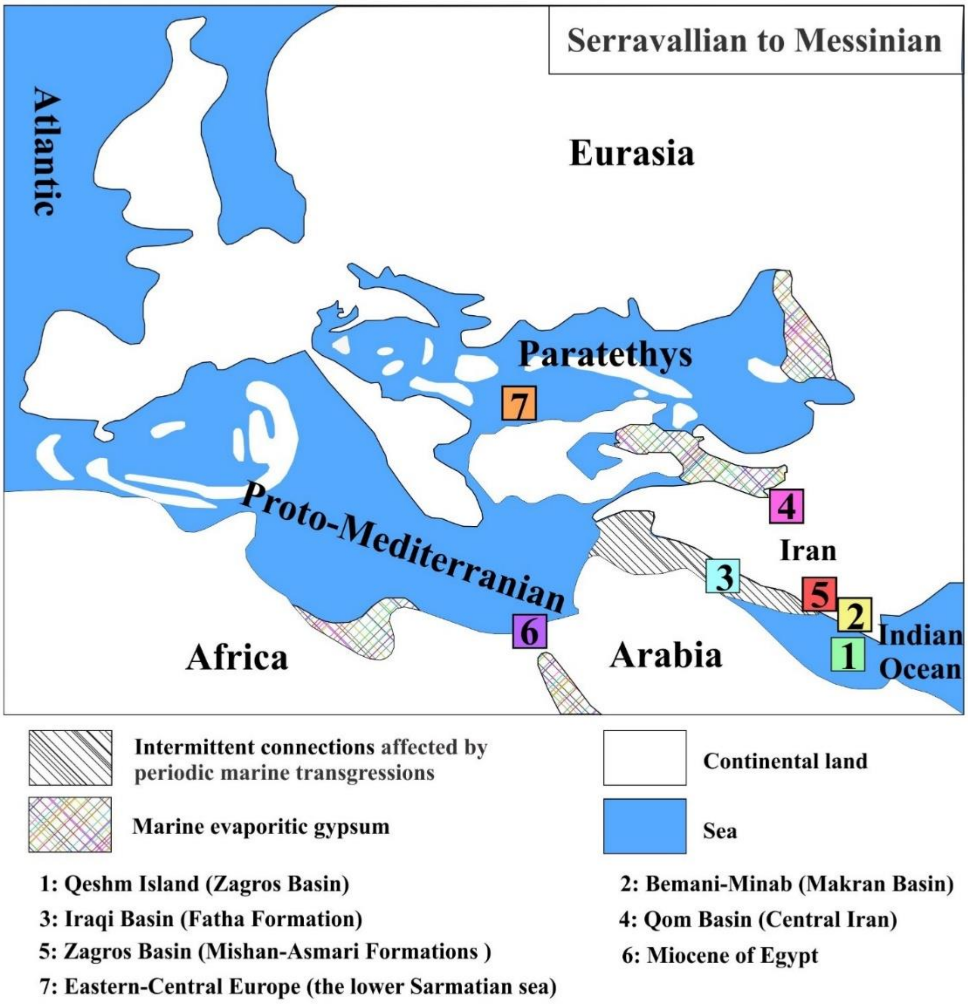


Fig 3- Geographic map of the Paleo-Basins, where the species in the present study have been reported. These Paleo-Basins may show probable connections between numerous parts of Paratethys (from Europe to the Qom Basin), the Mediterranean/Proto-Mediterranean Basin (Egypt, Spain, and Italy), the nearest basins around the studied area (Iraq and other parts of the Zagros Basin), and the studied area itself, all during the Miocene (after Sun et al. 2021)**.**

Discussion

From nearest area of the southern Iran, Shareef et al. (2023) reported some of the same species including *Ammonia beccarii*, *Challengerella bradyi*, *Elphidium advenum*, *E. craticulatum*, *E. crispum*, *Nonion fabum*, from Fatha Formation of Iraq (NW of Persian Gulf and subsequently all studied areas), and they suggested that the taxa probably show presence of a thin seaway connection, which had been remained open (the connection between Mediterranean Sea and Indo-Pacific Oceans), during the time of Middle–Late Miocene, which had been in direct contact with the open sea. In Central Iran (see fig. 3), Nouradini et al. (2014) reported the shallow and warm water environment strata of Qom Formation, at the Burdigalian, including some foraminiferal species such as *Textularia agglutinans*, *Elphidium fichtellianum*, *Triloculina tricarinata*, *Triloculina trigonula*, *Globigerinoides trilobus*, which are palaeobiogeographically located in the marginal seaways (Qom Basin), the connection between the West, Central Paratethys and Indo-Pacific Ocean during the Lower Miocene. Also, the planktonic foraminiferal fauna, including *Praeorbulina transitoria*, has been mentioned as a typical Tethyan indicator of tropical-subtropical climatic conditions (Hani and Abawi 2005). On the other hand, Barbieri and Vaiani (2018) suggested that the species *Elphidium advenum* lives in coastal areas and is recorded in low percentages in the Mediterranean lagoons (Albani and Serandrei Barbero 1990; Hohenegger et al. 1993). Also, Safari et al. (2020), reconstructed the depositional sequences of the Qom Basin and suggested that the basin were influenced primarily by local tectonics, while global sea level changes had a greater impact on the southern Tethyan seaway and Paratethys basins, which may show the depositional basins of the Tethyan seaway (southern Tethyan seaway, Paratethys Basin and Qom Basin) were probably related during the Burdigalian to Langhian and early Serravallian.

Palaeoecologically, the majority of *Elphidium* species indicate lagoonal environments with brackish to marine water (Rao and Rao 1974; Shareef et al. 2023), which occur in the

https://doi.org/10.22108/jssr.2026.146509.1319

Direstan outcrop. On the other hand, of the seven studied *Elphidium* species, six samples are from Direstan.

In case of palaeoenvironmental suggestions corresponding to the morphology of the species, Edwards (1982) reported *Eponides repandus* from very coarse sandy gravels of the eastern Shiant Bank, North Minch Channel, Scotland, and mentioned that the species displays a secondary thickening of shell material on the exterior surface, which serves to strengthen it against damage through current buffeting occurring in the high-energy environment. Not only *Eponides*, but all vagrant benthonic forms reported by Edwards (1982), such as miliolids and *Elphidium* species, are suggested as they occur in association with high-energy environments, where such free-living forms are generally thick-shelled to withstand vigorous current activity. By paying attention to this suggestion, it is necessary to mention that the *Eponides* species samples from Stars Valley have more fragile shells than the samples of Kendaloo and Direstan.

Moreover, Edwards (1982) suggested that open umbilical apertures like *Ammonia* and *Elphidium* are adaptive in littoral habitats of varying salinity but may be less important in some sublittoral and marsh habitats. However, *Ammonia beccarii* is the most euryhaline among living trochospiral Rotaliina and occurs in various forms, some called species, that dwell in different habitats.

From the nearest area to the present studied sections, Nouradini et al. (2015) mentioned some genera like *Elphidium* as an oxic indicator and *Bolivina* as dyoxic indicators of the Qom Basin palaeoenvironment, and suggested that the frequency of bryozoans, brachiopods, echinoids, and bivalves, associated with the presence of widespread euryhaline taxa (e.g., *Elphidium*), indicates a normal marine salinity dominated. Also, low diversity, high abundance, and small test size of foraminifers suggest a stable environment.

Overall, the foraminiferal fauna, including *Triloculina*, *Elphidium*, *Challengerella*, *Bolivina*, *Ammonia*, *Textularia*, *Nonion*, and *Asterorotalia* show the shelf edge to upper slope association characteristics (Saidova 2010; Murray 2006; Hamzeh et al. 2021).

Miliolids-dominated benthic foraminiferal assemblages are a key indicator of restricted lagoonal environments, characterized by decreased circulation and often hyposaline, hypersaline, or low-oxygen conditions. While miliolids can occur in normal-salinity settings like sand shoals, their dominance is widely used as diagnostic evidence for lagoon restriction (Brasier 1975a; 1975b; Brandano et al. 2008; Sajadi and Fanati Rashidi 2019).

Nouradini et al. (2017) suggested that miliolids such as *Triloculina* and *Quinqueloculina* are euryhaline (Murray 1991) and able to adapt to various salinities.

In sum, the ecological distribution of studied foraminifera from Kendaloo, Direstan, Stars Valley, and Bemani outcrops is illustrated based on BouDagher -Fadel (2018) in Fig. 9 a to d.

Conclusion

In all outcrops from Qeshm Island, the planktic foraminifera species show a low diversity, and it may reflect a restricted environment or almost restricted, where connection with the open marine must be limited, topographically, but not because of the high energy of water. Miliolids samples of all four outcrops cannot help us to prove the presence or absence of any kind of barriers and/or connections to the open marine environment, because *Triloculina* and *Quinqueloculina* genera are euryhaline and able to adapt to various salinities. The most dominant foraminiferal species in Bemani (Gushi marl) is *Asterorotalia dentata*, while in Qeshm Island outcrops, a variety of genera and species of benthic foraminifera occurred, which refer to shallow marine oxic environments. In all four outcrops, planktonic foraminifera are rare, and from all studied samples the most common non-planktonic species is *Textularia agglutinans*, which shows the normal salinity conditions, and the depth between almost 10 to 32 m. The foraminiferal fauna in Qeshm Island outcrops represents the stable, oxic environments in normal marine salinity and colder waters than modern environments, with fairly high energy.

The foraminiferal fauna of Gushi marl (Bemani outcrop) indicates oxic, shallow, connected to both open sea and silty mud environments, which may refer to the shelf edge to upper slope, while the temperature is warmer than modern environments of the tropical to subtropical zones in present-day environments.

In Bemani, the presence of *Trilobatus* (*Globigerinoides*) *trilobus*, *Bolivina spathulate* (*dentellata*), *Asterorotalia pulchella*, *Asterorotalia dentata*, shows the probable age range, referring to the latest Miocene (Messinian) to early–middle Pliocene (Piacenzian–Zanclean boundary), for Gushi marl (in Makran Basin), which is possible to correlate with the time between global biozones N19–N20.

The foraminiferal species of Qeshm Island outcrops represent the age of the Langhian–Serravallian boundary for white sandy limestone of Mishan Formation at the Stars Valley outcrop, while uppermost strata of Mishan Formation (sandy fossiliferous limestones Direstan) show the age of late Serravallian to Mio–Pliocene boundary, in Qeshm Island, which is a possibility to indicate a correlation with the time between global biozones of N8–N9 and N19–N20.

The presence of *Quinqueloculina bogdanowiczi* in Qeshm Island outcrops, which have only been reported from Central Eastern Europe (Paratethys) during Serravallian to Tortonian, probably refer to the assumption of presence of a narrow temporarily connection between the Iranian Gateway and the Iraqi Basin (Fatha Formation), to the eastern parts of Indo-Pacific Ocean and western coastal proto-Mediterranean, and also show a connection between the marginal seaways of eastern Paratethys (Qom Basin) and the Iraqi Basin (Fatha Formation) to the Central Paratethys, and proto-Mediterranean Sea. Not only the presence of foraminifera, but also the presence of the rare reported taxa from the basins mentioned above can be more convincing evidence of the assumption. The reported taxa including rare species of Ostreids *Ostrea callifera* (Lamarck) from Miocene of Europe, Qom Formation and Gushi Marl of Makran Basin. Also, the study is focused on the foraminiferal species, including *Asterorotalia dentata*, *A. pulchella*, *Triloculina tricarinata*, *T. terquemiana*, *T. trigonula*, *Trilobatus* (*Globigerinoides*) *trilobus*, *Globigerina bulloides*, *Quinqueloculina bogdanowiczi*, *Textularia agglutinans*, *Elphidium crispum*, *E. craticulatum*, *E. asiaticum*, *E. advenum limbatum*, *E. advenum macelliforme*, *E. advenum maorium*, *Poroeponides lateralis*, *Eponides repandus*, *Eponides isabellanus*, *Rotalinoides compressiuscula*, *Challengerella bradyi*, *Ammonia beccarii*, *Bolivina spathulata*, which almost all of them are reported for the first time from the studied outcrops.

Acknowledgments

Hereby, we acknowledge the Vice Chancellor for Research and Technology of the University of Isfahan. As well, the authors appreciate Department of Geology to the scientific and logistical supports.

References

Abdel-Fattah Z. A. Kora M. A. and Ayyad S. N. 2013. Facies architecture and depositional development of Middle Miocene carbonate strata at Siwa Oasis, Northwestern Egypt. Facies, 59: 505-528. https://doi.org/10.1007/s10347-012-0332-2

Albani A. and Serandrei Barbero R. 1990. I Foraminiferi della Laguna e del Golfo di Venezia, Memorie di Scienze Geologiche, 42: 271–341.

Albani A.D. and Yassini I. 1993. Taxonomy and distribution of the foraminifera of the family Elphidiidae from shallow Australian waters. University of New South Wales Centre for marine science, technical contribution 5, 51 pp.

Al-Dubai T. A. Abu-Zied R. H. and Basaham A. S. 2017. Diversity and distribution of benthic foraminifera in the Al-Kharrar Lagoon, eastern Red Sea coast, Saudi Arabia. Micropaleontology, 63(5): 275-303. DOI:10.47894/mpal.63.5.02

Alsharhan A.S. and Nairn A.E.M. 1997. Sedimentary Basins and Petroleum Geology of the Middle East, Amsterdam: Elsevier, xxxiv + 843 pp.

Amao A. O. Kaminski M. A. Asgharian Rostami M. Gharaie M. H. M. Lak R. and Frontalini F. 2019. Distribution of benthic foraminifera along the Iranian coast. Marine Biodiversity, 49: 933-946. https://doi.org/10.1007/s12526-018-0879-4

Anbuselvan N. and Senthil Nathan D. 2017. Benthic Foraminifera from Shelf Sediments of the Bay of Bengal, Central East Coast, India. Thalassas: An International Journal of Marine Sciences, 34(1): 13-52. https://doi.org/10.1007/s41208-017-0037-y

Baccaert J. 1987. Distribution patterns and taxonomy of benthic foraminifera in the Lizard Island Reef Complex, northern Great Barrier Reef, Australia. Université de Liège—CAPS Laboratoire de Biosédimentologie, 290p.

Baggley K. A. 2000. The Late Tortonian-Early Messinian Foraminiferal Record of The Abad Member (Turre Formation), Sorbas Basin, Almería, South-East Spain. Palaeontology, 43(6): 1069-1112. https://doi.org/10.1111/1475-4983.00162

Barbieri G. and Vaiani S. C. 2018. Benthic foraminifera or ostracoda? Comparing the accuracy of palaeoenvironmental indicators from a Pleistocene lagoon of the Romagna coastal plain (Italy). Journal of Micropalaeontology, 37(1): 203-230. https://doi.org/10.5194/jm-37-203-2018, 2018.

Barker R.W. 1960. Taxonomic notes on the species figured by H.B. Brady in his report on the foraminifera dredged by H.M.S. Challenger during the years 1873-1876. Society of Economic Paleontologists and Mineralogists Special Publication, 9: 1-238.

Be A.W.H. and Hutson W.H. 1977. Ecology of planktonic foraminifera and biogeographic patterns of life and fossil assemblages in the Indian Ocean. Micropaleontology, 23: 369-414. https://doi.org/10.2307/1485406

Berggren W. A. and Haq B. U. 1976. The Andalusian stage (Late Miocene): biostratigraphy, biochronology and paleoecology. Palaeogeography, Palaeoclimatology, Palaeoecology, 20(1-2), 67-129. https://doi.org/10.1016/0031-0182(76)90026-2

Bernhard J. M. and Gupta B. K. S. 1999. Foraminifera of oxygen-depleted environments, in Modern Foraminifera, ed. B. K. S. Gupta (Berlin: Springer), 201–216. doi: 10.1007/0-306-48104-9_12

Berning B. 2020. Fossil des Monats. Die fossile Auster *Ostrea callifera* (LAMARCK, 1819) – Naturkundliches Objekt des Monats - Biologiezentrum Linz, 02: 1.

Bhaumik A. K. Paikray J. Dutta J. Mitra A. Tiwari D. and Patil D. J. 2017. Biostratigraphy and depositional environment of the Miocene limestone bed of Baripada, Mayurbhanj district, Odisha: Foraminiferal, sedimentological and bulk organic geochemical evidences. Journal of the Geological Society of India, 90: 437-446. https://doi.org/10.1007/s12594-017-0737-1

Billman H. Hottinger L. and Oesterle H. 1980. Neogene to Recent rotaliid foraminifera from the Indopacific Ocean; their canal system, their classification and their stratigraphic use. Schweizerische paläontologische Abhandlungen. 101: 71-113.

Blow W. H. 1956. Origin and Evolution of the Foraminiferal Genus Orbulina d'Orbigny. Micropaleontology, 2(1): 57–70.

Boboye O. A. and Adeleye A. M. 2009. High resolution biostratigraphy of early Pliocene–Late Miocene calcareous nannoplankton and foraminiferal, Deep Offshore, Niger Delta, Nigeria. European journal of scientific research, 34(3), 308-325. https://www.researchgate.net/publication/237228024_High_Resolution_Biostratigraphy_of_Early_Pliocene_-_Late_Miocene_Calcareous_Nannoplankton_and_Foraminiferal_Deep_Offshore_Niger_Delta_Nigeria

Bolli H. M. 1966. Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera. Bulletin der Geologisches Institut der Eidg. Technischen Hochschule und der Universität Zürich, 9(1): 1-26.

Boltovskoy E. Giussani G. Watanabe S. and Wright R. C. 1980. Atlas of benthic shelf foraminifera of the southwest Atlantic. The Hague-Boston-London, Springer Netherlands. pp. 1-147.

BouDagher-Fadel K. M. 2015. Biostratigraphic and geological significance of planktonic foraminifera (p. 306). UCL Press.

BouDagher-Fadel, M. K. 2018. Evolution and geological significance of larger benthic foraminifera. UCL press.

Brady H. B. 1884. Report on the foraminifera dredged by H.M.S. Challenger during the years 1873-1876. In Brady, H.B., ed., Report on the Scientific Results of the Voyage of the H.M.S. Challenger during the years 1873– 1876. Zoology, 9: 1-814.

Brandano M. Frezza V. Tomassetti L. Cuffaro M. Heterozoan 2008. Carbonates in oligotrophic tropical waters: The Attard member of the lower coralline limestone formation (Upper Oligocene, Malta). Palaeogeography Palaeoclimatology Palaeoecology.274: 54-63. https://doi.org/10.1016/j.palaeo.2008.12.018

Brasier M. D. 1982. Architecture and evolution of the foraminiferid test - a theoretical approach. In: F.T., Banner and A.R., Lord Aspects of Micropalaeontology, (eds), London, Allen and Unwin. pp. 1-41.

Brasier M. D. 1975a. The ecology and distribution of recent foraminifera from the reefs and shoals around Barbuda, West Indies. Journal of Foraminiferal Research, 5: 42-46.

Brasier M. D. 1975b. The ecology and distribution of recent foraminifera from the reefs and shoals around Barbuda, West Indies. Journal of Foraminiferal Research, 5: 193-210 https://doi.org/10.2113/gsjfr.5.3.193

Chapman F. 1907. Recent Foraminifera of Victoria: some littoral gatherings. Journal of the Quekett Microscopical Club, 2(10): 117–146.

Chaproniere G.C.H. 1992. The distribution and development of Late Oligocene and Early Miocene reticulate globigerines in Australia. Mar. Micropaleontol, 18: 279-305. 10.1016/0377-8398(92)90044-K

Cushman J. A. 1944. Foraminifera from the shallow water of the New England coast. Special Publ. No. 12, Cushman Lab. Foram. Res., 1-37.

Dabaghi Sadr F. 2017. Evolution of the Tethyan Seaway during the Oligocene and Miocene: Constraints from foraminiferal faunas of the Qom Formation, Iran [Doctoral dissertation, Universität Hamburg]. https://ediss.sub.uni hamburg.de/handle/ediss/7601

Daneshian J. Moallemi S. A. and Derakhshani M. 2016. Refinement of stratigraphy according to the first finds of planktonic species of Orbulina and Praeorbulina from the Guri Limestone of the Mishan Formation in northwest of Bandar Abbas, South Iran. Stratigraphy and Geological Correlation, 24: 267-275. https://doi.org/10.1134/S0869593816030023

Das S. K. Konwar M. Chakravarty K. and Deshpande S. M. 2017. Raindrop size distribution of different cloud types over the Western Ghats using simultaneous measurements from Micro-Rain Radar and disdrometer. Atmospheric Research, 186: 72-82.

Debenay J-P. Bénéteau E. Zhang J. Stouff V. Geslin E. Redois F. and Fernandez-Gonzalez M. 1998. *Ammonia beccarii* and *Ammonia tepida* (foraminifera): morphofunctional arguments for their distinction. Mar Micropaleontol 34:235–244. 10.1016/S0377-8398(98)00010-3

Debenay J. P. 2012. A guide to 1,000 foraminifera from Southwestern Pacific: New Caledonia. IRD Editions. 1-385 pp.

d'Orbigny A. 1826. Tableau méthodique de la classe des Céphalopodes. Annales des Sciences Naturelles, 7: 245-314.

d'Orbigny A. D. 1839a. Foraminifères, in de la Sagra R., Histoire physique, politique et naturelle de l'ile de Cuba. A. Bertrand. 1-224.

d'Orbigny, A. D. 1839b. Foraminifères. In R. de la Sagra (Ed.), Histoire physique, politique et naturelle de l'île de Cuba (pp. 1–224). Paris: Arthus Bertrand.

d'Orbigny A. D. 1846. Foraminifères fossiles du bassin tertiaire de Vienne (Autriche). Gide et Comp., Paris. xxxvii + 312 pp., 21 pl.

Edwards P.G. 1982. Ecology and distribution of selected foraminiferal species in the North Minch Channel, northwestern Scotland, 111-141 pp. *In Aspects of micropalaeontology, Dordrecht: Springer Netherlands.*

Eri S. K. K. Çaˇgatay M. N. Akçer S. Gasperini L. and Mart Y. 2011. Late glacial to Holocene sea-level changes in the sea of Marmara: new evidence from high-resolution seismics and core studies. Geo Mar. Lett. 31: 1–18. doi:10.1007/s00367-010-0211-1

Falcon N.L. 1969. Problem of the relationship between surface structures and deep displacements illustrated by the Zagros range: time and place in orogeny. Geological Society of London Special Publication. 3(1): 9-21.

Fanati Rashidi R. Vaziri S. H. Keyvan Khaksar Gholamalian H. 2014. Microfacies and sedimentary environment of the Early-Middle Miocene deposits (Mishan Formation) in South of Iran. Adv. Environ. Biol., 8(10): 1031-1039. https://www.researchgate.net/publication/264557995_Microfacies_and_sedimentary_environment_of_the_Early-Middle_Miocene_deposits_Mishan_Formation_in_South_of_Iran

Farooqui M.Y. 1990. Taxonomy and Distribution of Recent foraminifera from Dwarka Beach, Saurashtra Coast, Gujarat. Doctoral dissertation, Aligarh Muslim University, Aligarh, India.

Fichtel L. von and Moll J. P. C. von. 1798. Testacea microscopica aliaque minuta ex generibus Argonauta et Nautilus ad naturam delineata et descripta. Cum 24 tabulis aeri incisis. Wien: Camesina. [1-12], 1-123, 24 pl.

Filipescu S. Miclea A. Gross M. Harzhauser M. Zagorsek K. and Jipa C. 2014. Early Sarmatian paleoenvironments in the easternmost Pannonian Basin (Borod Depression, Romania) revealed by the micropaleontological data. Geologica Carpathica, 65(1): 67.

Fuchs T. 1879. Über die von Dr. Tietze aus Persien mitgebrachten Tertiärversteinerungen. Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch–Naturwissenschaftliche Classe. 41(2): 99–108, pls. 1–6.

Galloway J. J. 1933. A Manual of Foraminifera. Bloomington, Ind.: Principia Press. xii, 483 pp.

Gansser A. 1955. June. 2. New aspects of the geology in central Iran (Iran). In World Petroleum Congress (pp. WPC-6018). WPC.

Gerivani H. Haghshenas E. Safaeian R. and Shafiee A. 2011. Regional site effect zonation of Qeshm Island (Iran). In Proc. 6th Int. Conf. of Seismology and Earthquake Engineering (Tehran, Iran, 16–18 May), 52-60.

Giunta M. 1955. Studio delle microfaune contenute in cinque saggi di fondo prelevati presso S. Margherita Ligure e Chiavari (Genova). - Arch. Ocean. Limn., 10(1-2): 67-108. [In Italian].

Gholamalian H. Fanati-Rashidi R. and Sajadi S.H. 2015. Miocene (Mishan Formation) Echinoidea from Gohreh section, North of Bandar Abbas, Hormozgan Province. Geosciences, 25: 73–82. [In Persian, with English abstract] 10.22071/gsj.2016.41163

Gholamalian H. Hassani M. J. and Hosseinipour F. 2020. Miocene Argonautidae (Octopoda) from the Persian Gulf area and their palaeogeographic distribution. Acta Geologica Polonica, 70(1): 135-145. DOI: 10.24425/agp.2019.126455

Gholamalian H. Rameshgar R. Lotfi Sharif-Abad F. and Azizi M. 2023. Microbiostratigraphy of miocene Guri member of the Mishan formation in the Bandar Abbas area, SE Zagros, Iran. Carbonates and Evaporites, 38(1): 17.

Hamzeh M. A. Khosravi M. Carton X. Yarahmadi D. and Safarkhani E. 2021. Paleoceanography of the Strait of Hormoz and its link to paleoclimate changes since the mid-Holocene. Continental Shelf Research, 226: 104507. https://doi.org/10.1016/j.csr.2021.104507

Hanagata S. 2003. Miocene-Pliocene foraminifera from the Niigata oil-fields region, northeastern Japan. Micropaleontology, 49(4): 293-340. https://doi.org/10.2113/49.4.293

Hanagata S. and Nobuhara T. 2015. Illustrated guide to Pliocene foraminifera from Miyakojima, Ryukyu Island Arc, with comments on biostratigraphy. Palaeontologia

Electronica, 18.1.3A, 1-140. DOI:10.26879/444
Hani H. D. and Abawi T. S. 2005. Paleoecology of the Lower Miocene sequence in Jambur well No. 18 Northern Iraq. Rafidain journal of science, *16*(6), 41-49. https://doi.org/10.33899/rjs.2005.41820
Hansen H. J. and Revets S. 1992. A revision and reclassification of the Discorbidae, Rosalinidae, and Rotaliidae. The Journal of Foraminiferal Research, 22(2), 166-180. https://doi.org/10.2113/gsjfr.22.2.166
Haskouei F. M. Bahrami A. Yazdi M. and Vega F. J. 2025a. Review of Mio-Pliocene pectinids and ostracods from Minab region and Qeshm Island, Persian Gulf, southern Iran. Boletín de la Sociedad Geológica Mexicana, 77(1). https://doi.org/10.18268/bsgm2025v77n1a251224
Haskouei F. M. Zágoršek K. Bahrami A. and Yazdi M. 2025b. First report of Miocene Bryozoan fauna of the Mishan Formation from the Qeshm Island and Minab Province, southern Iran. Bulletin of Geosciences 100(2): 187–211.
Harzhauser M. and Piller W.E. 2007. Benchmark data of a changing seaway: palaeogeography, palaeobiogeography and events in the Central Paratethys during the Miocene. Palaeogeography, Palaeoclimatology, Palaeoecology, 253(1–2), 8–31. https://doi.org/10.1016/j.palaeo.2007.03.031
Harzhauser M. Piller W.E. Reuter M. and Kroh A. 2007. An integrated palaeogeographic model for the Central Paratethys during the Miocene. Geologica Carpathica, 58(6): 379–390.
Herb R. 1971. Distribution of recent benthonic foraminifera in the Drake Passage: Antarctic Research Series, 17: 251-300.
Hermelin J.O.R. 1989. Pliocene benthic foraminifera from the Ontong - Java Plateau (Western Equatorial Pacific Ocean): faunal response to changing paleoenvironment. Special Publication of the Cushman Foundation for Foraminiferal Research, 26: 1-143.
Harzhauser M. Kranner M. Mandic O. Strauss P. Siedl W. and Piller W. E. 2020. Miocene lithostratigraphy of the northern and central Vienna Basin (Austria). Austrian Journal of Earth Sciences, 113(2): 169-192. https://doi.org/10.17738/ajes.2020.0011
Haskouei F. M. Bahrami A. Yazdi M. Vaziri-Moghaddam H. Bitner A. and Vega F. 2024b. First report of the bivalve Placuna placenta (Linnaeus 1758) from the Late Miocene–Early Pliocene strata of the Minab region and Qeshm Island, Persian Gulf, Southern Iran: Palaeoecology, systematic and taphonomy. Journal of Stratigraphy and Sedimentology Researches, 40 (4), 41-62. 10.22108/JSSR.2024.142783.1297
Haskouei F. M. 2025. Paleoenvironment, paleoecology and taphonomy of the latest Miocene fossiliferous levels of south Iran, in Direstan (Qeshm Island) and northeast Sirik (Minab) sectioned based on Bivalvia and Bryozoans fossils, P. 219. PhD Thesis, University of Isfahan. [In Persian]
Haskouei F. M. Bahrami and A. Yazdi M. 2024a. Mio-Pliocene strata in Qeshm Island (Zagros Basin) and Minab Region (Makran Basin): Paleoecology and Taphonomy. Iranian Journal of Petroleum Geology, 14(27): 55-75. [In Persian] file:///C:/Users/taheri/Downloads/14031220065714483402.pdf
Haskouei F. M. Bahrami A. Yazdi M. and Vega F. J. 2025a. Review of Mio-Pliocene pectinids and ostracods from Minab region and Qeshm Island, Persian Gulf, southern Iran. Boletín de la Sociedad Geológica Mexicana, 77(1). https://doi.org/10.18268/bsgm2025v77n1a251224
Hassani M. J. and Hosseinipour F. 2017. Lithostratigraphy and microbiostratigraphy of the Neogene deposits (the Mishan and Aghajari formations) in the northern Bandar Abbas. Paleo 4: 141–154. [In Persian]
Hassani M.J. Hosseinipour F. and Derisi M. 2014. Stratigraphy, paleontology and paleoecology characteristics of Stars Valley deposits in Qeshm Island. Paleontology, 2: 19–34. https://www.researchgate.net/publication/281165810_Stratigraphy_paleontology_and_paleoecology_characteristics_of_Stars_Valley_deposits_in_Qeshm_Island
Haunold T.G. Baal C. and Piller W.E. 1997. Benthic foraminiferal associations in the northern Bay of Safaga, Red Sea, Egypt. Mar Micropaleont, 29: 185–210. 10.1016/S0377-8398(96)00031-X
Hauser E. H. and Grunig A. K. 1993. Eponides and some related genera (Cretaceous to Recent); a taxonomic revision. The Journal of Foraminiferal Research, 23(4): 238-253. https://doi.org/10.2113/gsjfr.23.4.238
Hayward B. W. Hollis C. J. and Grenfell H. R. 1997. Recent Elphidiidae (Foraminiferida) of the south-west Pacific and fossil Elphidiidae of New Zealand. Institute of Geological and Nuclear Sciences, Monograph, 16: 166 p.
Hayward B. W. Holzmann M. Pawlowski J. Parker J. H. Kaushik T. Toyofuku M. S. and Tsuchiya M. 2021. Molecular and morphological taxonomy of living Ammonia and related taxa (Foraminifera) and their biogeography. Micropaleontology, 67(2-3): 109-274. 10.47894/mpal.67.3.01
Hawramy O.A. and Khalaf S.K. 2013. Ostracoda of Fatha Formation (Middle Miocene) from (Darbandikhan and Aghjalar) sections, Sulaimani-Kurdistan Region/Northeastern Iraq. Journal of Zankoy Sulaimani Part A, 15: 49–76. DOI:10.17656/jzs.10259
Hayward A.B. Robertson A.H.F. and Scoffin T. 1996. Miocene patch reefs from a Mediterranean marginal terrigenous setting in southwest Turkey. In: Franseen E.K. Esteban M. Ward W.C. Rouchy J.-P. (Eds.), Models for Carbonate Stratigraphy from Miocene Reef Complexes of Mediterranean Regions, Society of Economic Mineralogists and Paleontologists: Concepts in Sedimentology and Paleontology, pp. 317–332.
Hewaidy A. G. A. Sallam M. M. and Khalifa M. F. 2013. Miocene calcareous foraminifera of the Nile delta area, Egypt. Egypt J Paleontol, 13: 121-171. https://www.researchgate.net/publication/272511246_MIOCENE_CALCAREOUS_FORAMINIFERA_OF_THE_NILE_DELTA_AREA_EGYPT
Hofker J. 1951. Foraminifera of the Siboga Exped. Foraminifera dentata. Siboga Exped. Mon., 4a (3): 1-513.
Hofker J. 1968. Foraminifera from the Bay of Jakarta, Java Bijdragen tot de dierkunde, 37(1): 11- 35.
Hofker J. 1971. Studies of Foraminifera. pt. 3. Sytematic problems. Publ. Natuurhist. Genootschap, Limburg, 21: 1-202.
Hofker J. 1978. Biological results of the Snellius Expedition XXX: the foraminifera collected in 1929 and 1930 in the eastern part of the Indonesian Archipelago. Zoologische Verhandelingen, 161(1): 3-69. https://repository.naturalis.nl/pub/323936
Holcová K. and Zágoršek K. 2008. Bryozoa, foraminifera and

calcareous nannoplankton as environmental proxies of the "bryozoan event" in the Middle Miocene of the Central Paratethys (Czech Republic): Palaeogeography, Palaeoclimatology, Palaeoecology, 267(3), 216–234. https://doi.org/10.1016/j.palaeo.2008.06.019
Holbourn A. Henderson A. S. and MacLeod N. 2013. Atlas of benthic foraminifera. John Wiley and Sons, 1-656pp.
Hohenegger J. Piller W. E. and Baal C. 1993. Horizontal and vertical spatial microdistribution of foraminifers in the shallow subtidal Gulf of Trieste, Northern Adriatic Sea, J. Foramin. Res., 23: 79–101.
Huber H. 1977. Geological map of Iran sheet No.5 South-Central Iran, 1:1000000 scale. National Iranian Oil Company, Tehran, Iran.
James G. A. and Wynd J. G. 1965. Stratigraphic Nomenclature of Iranian Oil Consortium Agreement area. Bulletin of the American Association of Petroleum Geologists. 49 (12): 2182-2245. https://doi.org/10.1306/A663388A-16C0-11D7-8645000102C1865D
Jones R. W. 1994. The Challenger Foraminifera. Oxford University Press, (p. 149) Oxford.
Jones R. W. 2013. Foraminifera and their applications. Cambridge University Press.
Jorissen F.J. 1988. Benthic foraminifera from the Adriatic Sea; principles of phenotypic variation. Utrecht Micropal. Bull. 37: 1-174.
Kim J. M. and Kucera M. 2000. Benthic foraminifer record of environmental changes in the Yellow Sea (Hwanghae) during the last 15,000 years. Quaternary Science Reviews, 19(11): 1067–1085.
Kroon D. Steens T. and Troelstra S. R. 1991. Onset of Monsoonal related upwelling in the western Arabian Sea as revealed by planktonic foraminifers. In W. Prell, and N. Niitsuma (Eds.), Proceedings of the ocean drilling program, scientific results. (pp. 257–263). College Station, TX: Ocean Drilling Program.
Lamarck J.B. 1804. Suite des memoires sur les fossiles des environs de Paris. Annales Muséum National d'Histoire Naturelle, 5: 349-357.
Lei Y.L. Li T.G. Bi H. Cui W.L. Song W.P. Li J.Y. and Li C.C. 2015. Responses of benthic foraminifera to the 2011 oil spill in the Bohai Sea, PR China. Marine Pollution Bulletin, 96: 245-260.
Li T. Xiang R. and Li T. 2015. Application of a self-organizing map and canonical correspondence analysis in modern benthic foraminiferal communities: A case study from the Pearl River estuary, China. The Journal of Foraminiferal Research, 45(3): 305-318.
Linnaeus C. 1758. Systema Naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. [The system of nature through the three kingdoms of nature, according to classes, orders, genera, species, with characters, differences, synonyms, places.]. Impensis Direct. Laurentii Salvii. Holmiae [Stockholm]. 1(10): iii + 824.
Liu J. Zhang X. Mei X. Zhao Q. Guo X. Zhao W. … Chu H. 2018. The sedimentary succession of the last ~ 3.50 Myr in the western South Yellow Sea: Paleoenvironmental and tectonic implications. Marine Geology, 399: 47–65. doi:10.1016/j.margeo.2017.11.005
Loeblich A.R. and Tappan H. 1988. Foraminiferal Genera and their Classification (2 vols). xi + 970 pp.; ix + 213 pp. + 847 plates. New York: Van Nostrant Reinhold; London: Chapman and Hall. Price £169.00. ISBN 0 442 25937 9.
Luczkowska E. 1974. Miliolidae (Foraminiferida) from the Miocene of Poland Part II. Biostratigraphy, palaeoecology and systematics. Acta Palaeontologica Polonica, 19(1): 3-176.
Maghsoudlou A. Olad Azimi N. Ghavam Mostafavi P. Moghaddasi B. and Mashinchian Moradi A. 2021. Study of coral reef benthic foraminiferal assemblages in Qeshm Island, Persian Gulf. Iranian Journal of Fisheries Sciences, 20(2): 558-571.
Merkado G. Titelboim D. Hyams-Kaphzan O. Holzmann M. Pawlowski J. Almogi-Labin A. Abdu U. Herut B. and Abramovich S. 2015. Molecular Phylogeny and Ecology of Textularia agglutinans d'Orbigny from the Mediterranean Coast of Israel: A Case of a Successful New Incumbent. *PLOS ONE*, 10(11): e0142263. https://doi.org/10.1371/journal.pone.0142263
McCall G. J. 2002. A summary of the geology of the Iranian Makran. Geological Society, London, Special Publications, 195(1): 147-204.
McCulloch I. 1981. Qualitative observations on Recent foraminiferal tests. Part IV with emphasis on the Allan Hancock Atlantic Expedition Collections. University of Southern California, Los Angeles. 362 p., 72 pls.
And Milker Y. and Schiemdi G. 2012. A taxonomic guide to modern benthic shelf foraminifera of the western Mediterranean Sea. Palaeontologia Electronica, 15.2.16A: 1-134. DOI:10.26879/271
Mohan P.M. Murugantham M. Sachithanandam V. Srinivasalu S. and Kasilingam K. 2018. Foraminifera, pp. 15-44, In: Chandra K. Raghunathan C. Chandra K. and Raghunathan C. (Eds.), Faunal Diversity of Biogeographic Zones: Islands of India: An Overview. Faunal Diversity of Biogeographic Zones: Islands of India, 1-8.
Montfort P. [Denys de]. 1808-1810. Conchyliologie systématique et classification méthodique des coquilles. Paris: Schoell. Vol. 1: pp. lxxxvii + 409 [1808]. Vol. 2: pp. 676 + 16 [1810].
Mossadegh Z. K. Parker J. and Gischler E. 2012. Biodiversity and community structure of Late Pleistocene foraminifera from Kish Island, Persian Gulf (Iran). Facies, 58(3): 339-365.
Murray J.W. 1971. Living foraminiferids of tidal marshes; a review. The Journal of Foraminiferal Research, 1(4): 153-161.
Murray J.W. 1973. Distribution and ecology of living benthic foraminiferids. Heinemann Educational Books, London: 1-274.
Murray J.W. 1991. Ecology and Paleoecology of Benthic Foraminifera. Longman Scientific and Technical, New York, 397p.
Murray J. W. 2006. Ecology and applications of benthic foraminifera. Cambridge University Press 426p.
Nouradini M. Ashouri A. R. Yazdi M. and Rahiminejad A. H. 2019. Palaeoecology and distribution of upper Oligocene–lower Miocene foraminifera in the Qom Formation, the Bagher-Abad section, NE Isfahan, Central Iran. Carbonates and Evaporites, 34: 563-579.
Nabavi S. M. B. Moosapanah S. G. R. Rajab Zadeh Ghatrami E. Ghayyem Ashrafi M. and Nabavi S. N. 2014. Distribution, diversity and abundance of benthic foraminifera of the Northwstern Persian Gulf. Journal of the Persian Gulf (Marine Science), 5(16): 15-26.
Narayan Y. R. Barnes C. R. and Johns M. J. 2005. Taxonomy and biostratigraphy of Cenozoic foraminifers from Shell

Canada wells, Tofino Basin, offshore Vancouver Island, British Columbia. Micropaleontology, 51(2): 101-168.
Nouradini M. Ashouri A. R. Yazdi M. and Rahiminejad A. H. 2017. Palaeoecology and distribution of upper Oligocene–lower Miocene foraminifera in the Qom Formation, the Bagher-Abad section, NE Isfahan, Central Iran. Carbonates and Evaporites, 34: 563-579.
Nouradini M. Azami S. H. Hamad M. Yazdi M. and Ashouri A. R. 2015. Foraminiferal paleoecology and paleoenvironmental reconstructions of the lower Miocene deposits of the Qom Formation in Northeastern Isfahan, Central Iran. Boletín de la Sociedad Geológica Mexicana, 67(1): 59-73. https://www.scielo.org.mx/scielo.php?pid=S1405-33222015000100005&script=sci_abstract&tlng=en
Nouradini M. Yazdi M. and Ashouri A. 2014. Systematic notes on Burdigalian echinoids from the Qom Formation in the Bagher Abad area, Central Iran. Geopersia, 4(2): 155-167. https://doi.org/10.22059/jgeope.2014.52716
Papp A. and Schmid M. E. 1985. The fossil foraminifera of the Tertiary basin of Vienna. Die fossilen foraminiferen des Tertiaren Bekens von Wien. Abh. Geologisch. Bundesanst, 37: 1-311.
Parast A. Yazdi M. and Bahrami A. 2020. First report on Late Miocene regressive sequence (Mishan Formation to Aghajari) in Direstan area, Qeshem Island based on the presence of invertebrate macrofossil. Journals of Palaeontological Society of Iran, 13:1-7. [In Persian]
Parker J.H. 2009. Taxonomy of Foraminifera from Ningaloo Reef, Western Australia. Mem Assoc Austral Palaeont, 36:1–812.
Parker J. H. and Gischler E. 2015. Modern and relict foraminiferal biofacies from a carbonate ramp, offshore Kuwait, northwest Persian Gulf. Facies, 61(3): 10. https://doi.org/10.1007/s10347-015-0437-5
Parker W. K. and Jones T. R. 1865. VI. On some foraminifera from the North Atlantic and Arctic Oceans, including Davis Straits and Baffin's Bay. Philosophical transactions of the Royal Society of London, (155): 325-441.
Peterson L.W. and Rudzinskas K.K. 1982. Cartography: explanatory text of the Taherui quadrangle map 1:250000: Geological Survey of Iran, Tehran, 1 map.
Polski W. 1959. Foraminifera from the Upper Pleistocene of the South Yellow Sea. Micropaleontology, 5(4): 585-595.
Poole C. R. and Wade B. S. 2019. Systematic taxonomy of the *Trilobatus sacculifer plexus* and *descendant Globigerinoidesella fistulosa* (planktonic foraminifera). Journal of Systematic Palaeontology, 17(23): 1989-2030. https://doi.org/10.1080/14772019.2019.1578831
Postuma J. 1971. Manual of Planktonic Foraminifera. Elsevier Publishing Company, Amsterdam, 420 p.
Prell W. L. Murray D. W. Clemens S. C. and Anderson D. M. 1992. Evolution and variability of the Indian Ocean summer monsoon: Evidence from the western Arabian Sea drilling program. In: R. A. Duncan D. K. Rea R. B. Kidd U. Von Rad and J. K. Weissel (Eds.), Synthesis of results from scientific drilling in the Indian Ocean. American Geophysical Union, Geophysical Monographs https://doi.org/10.1029/GM070p0447
Piller W.E. Harzhauser M. Kranner M. Mandic O. Mohtat T. & Daneshian J. 2024. The Tethyan Seaway during the early to middle Miocene – New data and a review. Gondwana Research, 135: 57-74. https://doi.org/10.1016/j.gr.2024.08.004
Pujos M. 1976. Ecologie des foraminifères benthiques et des thécamoebiens de la Gironde et du plateau continental Sud-Gascogne. Application à la connaissance du Quaternaire Terminal de la région Ouest-Gironde. — Doctor's Thesis Univ. Bordeaux: 1-274.
Quilty P.G. 2010. Foraminifera from late Pliocene sediments of Heidemann Valley, Vestfold Hills, East Antarctica. The Journal of Foraminiferal Research, 40(2): 193-205. DOI:10.2113/gsjfr.40.2.193
Rahmani Z. and Vaziri-Moghaddam H. 2010. Facies distribution and palaeoecology of the Guri Member of the Mishan Formation, in Lar area, Fars Province, SW Iran. Iranian Journal of Science, 34(3): 257-266. 10.22099/IJSTS.2010.2193
Rao R.U. and Rao G.V. 1974. Results of some geothermal studies in Singhbhum Thrust Belt, India. Geothermics, 3(4): 153–161. 10.1016/0375-6505(74)90014-5
Reuss A. E. 1850. Neue Foraminiferen aus den Schichten des österreichischen Tertiärbeckens. Denkschriften der Kaiserlichen Akademie der Wissenschaften, 1: 365–390.
Reuter M. Piller WE. Harzhauser M. Mandic O. Berning B. Rögl F. Kroh A. Aubry MP. Wielandt-Schuster U. and Hamedani A. 2009. The Oligo-/Miocene Qom Formation (Iran): evidence for an early Burdigalian restriction of the Tethyan Seaway and closure of its Iranian gateways. International Journal of Earth Sciences, 98: 627-650. DOI: 10.1007/s00531-007-0269-9
Roozpeykar A. and Moghaddam I. M. 2015. Benthic foraminifera as biostratigraphical and paleoecological indicators: an example from Oligo-Miocene deposits in the SW of Zagros basin, Iran, Geoscience Frontiers. DOI: 10.1016/j.gsf.2015.03.005.
Roozpeykar A. Maghfouri-Moghaddam I. Yazdi M. and Yousefi-Yegane B. 2019. Paleontology and paleoecology of coralline algal assemblages from the Early–Middle Miocene deposits in NW of the Zagros basin, Iran. Carbonates and Evaporites, 34: 1595-1618. https://doi.org/10.1007/s13146-019-00509-z
Safari A. Ghanbarloo H. Mansoury P. and Esfahani M. M. 2020. Reconstruction of the depositional sedimentary environment of Oligocene deposits (Qom Formation) in the Qom Basin (northern Tethyan seaway), Iran. Geologos, 26(2): 93-111. DOI:10.2478/logos-2020-0010
Saidova K. M. 2010. Benthic foraminifer communities of the Persian Gulf. Oceanology, 50: 61-66. https://doi.org/10.1134/S0001437010010078
Sajadi S. H. and Fanati Rashidi R. 2019. Paleoecology and Sedimentary Environments of the Oligo-Miocene Deposits of the Asmari Formation (Qeshm Island, SE Persian Gulf). In New Insights into the Stratigraphic Setting of Paleozoic to Miocene Deposits-Case Studies from the Persian Gulf, Peninsular Malaysia and South-Eastern Pyrenees. (pp. 15-29). IntechOpen
Schmiedl G. Mitschele A. Beck S. Weldeab S. Schulz H. Hemleben C. Sperling M. R. and Emeis K.-C. (2003). Benthic foraminiferal number, diversity, and species abundance of size fraction 63-125µm across sapropel S6 in core M40/4_KL51 from the lower bathyal of the western Levantine Basin [Dataset]. PANGAEA. https://doi.org/10.1594/PANGAEA.115688
Schwager C. 1876. Saggio di una classificazione dei foraminiferi avuto riguardo alle loro famiglie naturali. Bolletino R. Comitato Geologico d'Italia, 7: 475–485.
Sen Gupta B.K. 1999. Modern Foraminifera. Kluwer

Academic Press, Dordrecht, 371 p.
Serova M. Y. (1955). Стратиграфия и фауна фораминифер миоценовых отложений Предкарпатья-Stratigraphy and Miocene foraminiferal fauna from Precarpathian sediments. Материалы по биостратиграфии западных областей Украинской ССР - Materials for the biostratigraphy of the western regions of the Ukrainian SSR. 261-451.
Shareef N. F. Mahdi M. M. and Mohamed A. H. 2023. Combined ostracoda and foraminiferal biozonation with environment of Fatha Formation (Middle Miocene) in different oilfields, southern Iraq. The Iraqi Geological Journal, 56:188-211. https://www.semanticscholar.org/reader/fc01d8f36cd7c524155911b1f44f8376a12b61c8
Shearman D. J. Walker G. P. L. Booth B. and Falcon N. L. 1976. The Geological evolution of southern Iran: The Report of the Iranian Makran Expedition. The Geographical Journal, 142(3): 393. doi:10.2307/1795293
Shchedrina G. 1964. On some changes in the system of the order Rotalida (Foraminifera), pp.91-118, In: Rauzer-Tchernousova D. M. (Ed.), Questions of micropaleontology. Issue 8. Morphology, taxonomy and state of knowledge of foraminifera and ostracods, Voprosy mikropaleontologii, pp. 233. (In Russian)
Sohrabi M. Khosrou T.K.H. and Moumeni I. 2006. Study of benthic foraminifera in mangrove ecosystem of Qeshm Island (Persian Gulf). Journal of Sciences (Islamic Azad University), 16:61, 10-19.
Singh R. K. Gupta A. K. and Bhaumik A. K. 2017. Holocene strengthening of the oxygen minimum zone in the northwestern Arabian Sea linked to changes in intermediate water circulation or Indian monsoon intensity? Palaeogeogr. Palaeoclimatol. Palaeoecol. 483: 125–135. doi: 10.1016/j.palaeo.2016.10.035
Sohrabi-Mollayousefi M. and Sahba M. 2010. Environmental response of benthic foraminifera in Asalooye coastline sediments (Persian Gulf). The 1st International Applied Geological Congress, Department of Geology, Islamic Azad University-Mashhad Branch.
Spezzaferri S. Kucera M. Pearson P. N. Wade B. S. Rappo S. Poole C. R. Morard R. and Stalder C. 2015. Fossil and genetic evidence for the polyphyletic nature of the planktonic Foraminifera 'Globigerinoides', and description of the new genus Trilobatus. PLoS ONE, 10, e0128108. https://doi.org/10.1371/journal.pone.0128108
Spezzaferri S. McKenzie J. A. and Isern A. 2002. Linking the oxygen isotope record of late Neogene eustasy to sequence stratigraphic patterns along the Bahamas margin: results from a paleoceanographic study of ODP Leg 166, Site 1006 sediments. Marine Geology, 185(1-2), 95-120. https://doi.org/10.1016/S0025-3227(01)00292-4
Steinthorsdottir M. Coxall H. K. De Boer A. M. Huber M. Barbolini N. Bradshaw C. D. ... and Strömberg C. A. E. 2021. The Miocene: The future of the past. Paleoceanography and Paleoclimatology, 36(4): e2020PA004037. https://doi.org/10.1029/2020PA004037
Sun J. Sheykh M. Ahmadi N. Cao M. Zhang Z. Tian S. … Talebian M. 2021. Permanent closure of the Tethyan Seaway in the northwestern Iranian Plateau driven by cyclic sea-level fluctuations in the late Middle Miocene. Palaeogeography, Palaeoclimatology, Palaeoecology, 564: 110172. https://doi.org/10.1016/j.palaeo.2020.110172
Suokhrie T. Saraswat R. and Nigam R. 2021. Multiple ecological parameters affect living benthic foraminifera in the river-influenced west-central Bay of Bengal. Frontiers in Marine Science, 8: 656757. https://doi.org/10.3389/fmars.2021.656757
Szczechura J. and Abd-Elshafy E. 1988. Ostracodes and foraminifera from the? Middle Miocene of the western coast of the Gulf of Suez, Egypt. Acta Palaeontologica Polonica, 33(4): 273-342. https://www.app.pan.pl/archive/published/app33/app33-273.pdf
Tabita S. K. and Nathan D. S. 2019. Taxonomic notes on recent foraminifera from the continental shelf-slope region of southwestern Bay of Bengal, east coast of India. Palaeontologia Electronica 22.3.55A 1-89. https://doi.org/10.26879/811
Terquem O. 1878. Les Foraminifères et les Entomostracés-Ostracodes du Pliocène supérieur de l'île de Rhodes. Mémoires de la Société géologique de France, 1-135.
van de Poel H.M. 1992. Foraminiferal biostratigraphy and palaeoenvironments of the Miocene-Pliocene Carboneras-Nijar Basin (SE Spain). Scripta Geol, 102: 1-32.
van der Zwaan G. J. 1982. Paleoecology of late Miocene Mediterranean foraminifera. Utrecht Micropaleontological Bulletins 25: 300.
Vega F. J. Gholamalian H. Hassani M. J. Sajadi S. H. and Schaaf P. 2012. Miocene crustacea from northern Bandar Abbas, south Iran; Neues Jahrbuch fur Geologie und Palaontologie-Abhandlungen, 265(3): 221-234. DOI: 10.1127/0077-7749/2012/0247
Voloshinova N.A. and Kuznetsova V.N. 1964. New data on morphology and evolution of some representatives of the family Elphidiidae, Voprosy mikropaleontologii, 8: 138–153, In: Rauzer-Tchernousova D. M. (Ed.), Questions of micropaleontology. Issue 8. Morphology, taxonomy and state of knowledge of foraminifera and ostracods, Voprosy mikropaleontologii, pp. 233. [In Russian]
Wang P. (Ed.). 1985. Marine Micropaleontology of China. Beijing: China Ocean Press; Berlin: Springer-Verlag. x, 370 pp.
Williamson W.C. 1858. On the recent Foraminifera of Great Britain. The Ray Society, London. 1-107.
Wu Y. Huang X. Zheng X. Meadows M. E. and Wang Z. 2022. Sedimentary records of mid-Holocene extreme storm events on the north bank of Hangzhou Bay, East China. Marine Geology, 451: 106891. https://doi.org/10.1016/j.margeo.2022.106891
Zaninetti L. Altiner D. Çatal E. and Decrouez D. 1982. Shanita bronnimanni, n. sp., (Hemigordiopsidae, Foraminiferida), dans le Permien supérieur du Taurus Oriental, Turquie: un exemple d'adaptation structurale à l'évolution régressive de la cavité loculaire chez les grands foraminifères porcelanés du Paléozoïque. Revue de Paléobiologie, 1(1): 29-33.
Zhou J. P. and Yang X. N. 1996. Zellia (Fusulinid) from Guangxi and Guizhou. Acta Palaeontologica Sinica, 35, 600–606.

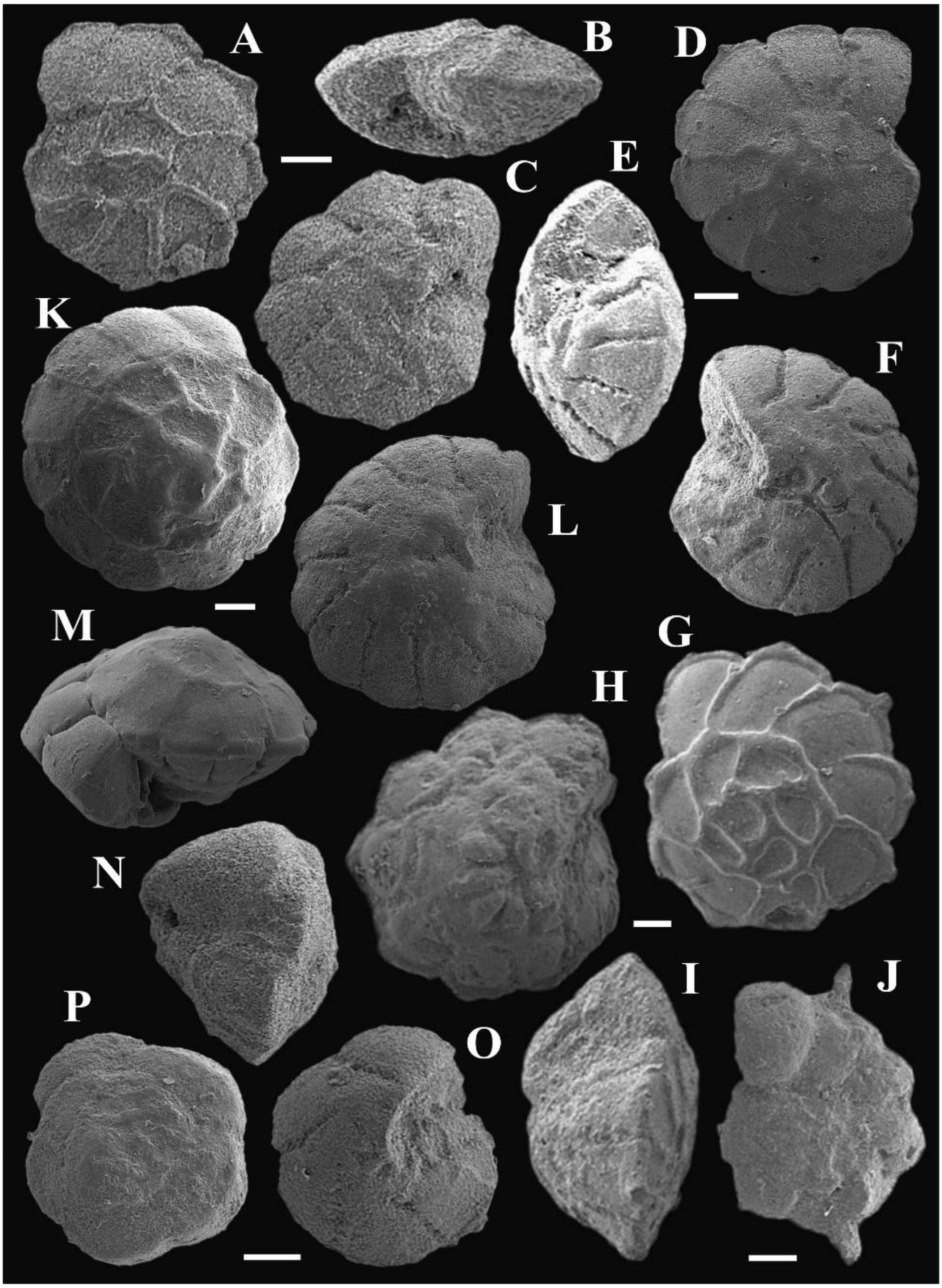


Fig 4- A-C. *Asterorotalia dentata* (Parker and Jones); A: spiral view (K1-BF), B: lateral view (St1-BF), C: umbilical view (D1-BF); D-F. *Asterorotalia dentata* (Parker and Jones); D: spiral view (K2-BF), E: lateral view (BMF-1), F: umbilical view (D2-BF); G-I. *Asterorotalia dentata* (Parker and Jones); G: spiral view (BMF-4), H: umbilical view (BMF-2), I: lateral view (BMF-3). J. *Asterorotalia pulchella* (d'Orbigny), in dorsal view (BMF-7). K-M. *Challengerella bradyi* (Billman *et al*); K: spiral view (D16-BF), L: umbilical view (St2-BF), M: lateral view (K4-BF). N-P. *Rotalinoides compressiuscula* (Brady); N: lateral view (St6-BF), O: umbilical view (D7-BF), P: spiral view (K8-BF). Scale bar =100 μm

https://doi.org/10.22108/jssr.2026.146509.1319

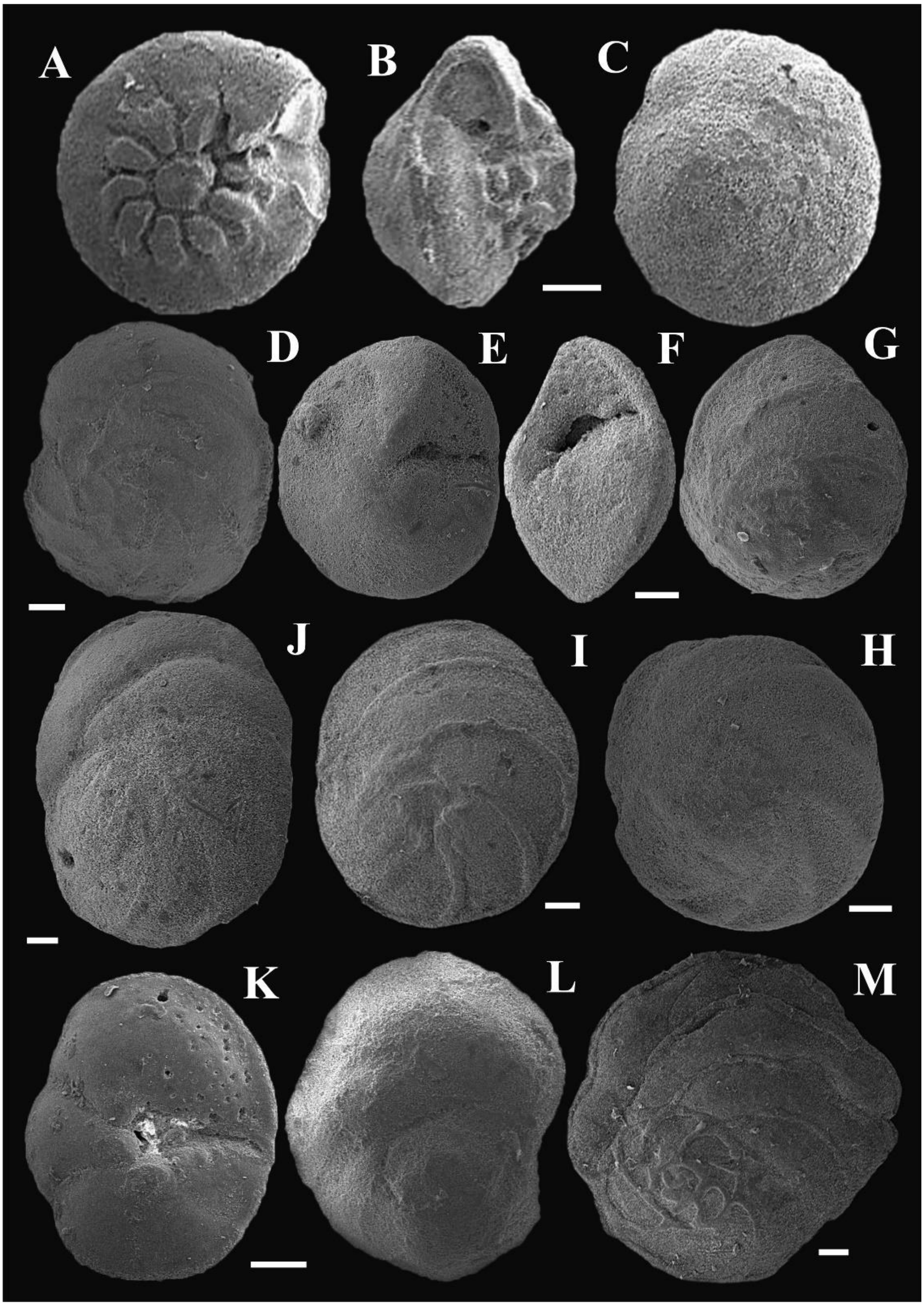


Fig 5- **A-C. *Ammonia beccarii* (Linnaeus); A: umbilical view (D11-BF), B: apertural view (D9-BF), C: spiral view (D10-BF). D. *Eponides isabellanus* (d'Orbigny); spiral view (D4-BF). E-G. *Eponides repandus* (Fichtel and Moll); E: umbilical view (K6-BF), F: lateral view (St5-BF), G: spiral view (D6-BF). H-I. *Eponides repandus* (Fichtel and Moll); H: spiral views (D3-BF), I: spiral view (K5-BF). J-M. *Poroeponides lateralis* (Terquem); J: spiral view (K7-BF), K: umbilical view (St4-BF), L: spiral view (D5-BF), M: spiral view (St3-BF). Scale bar =100 µm**

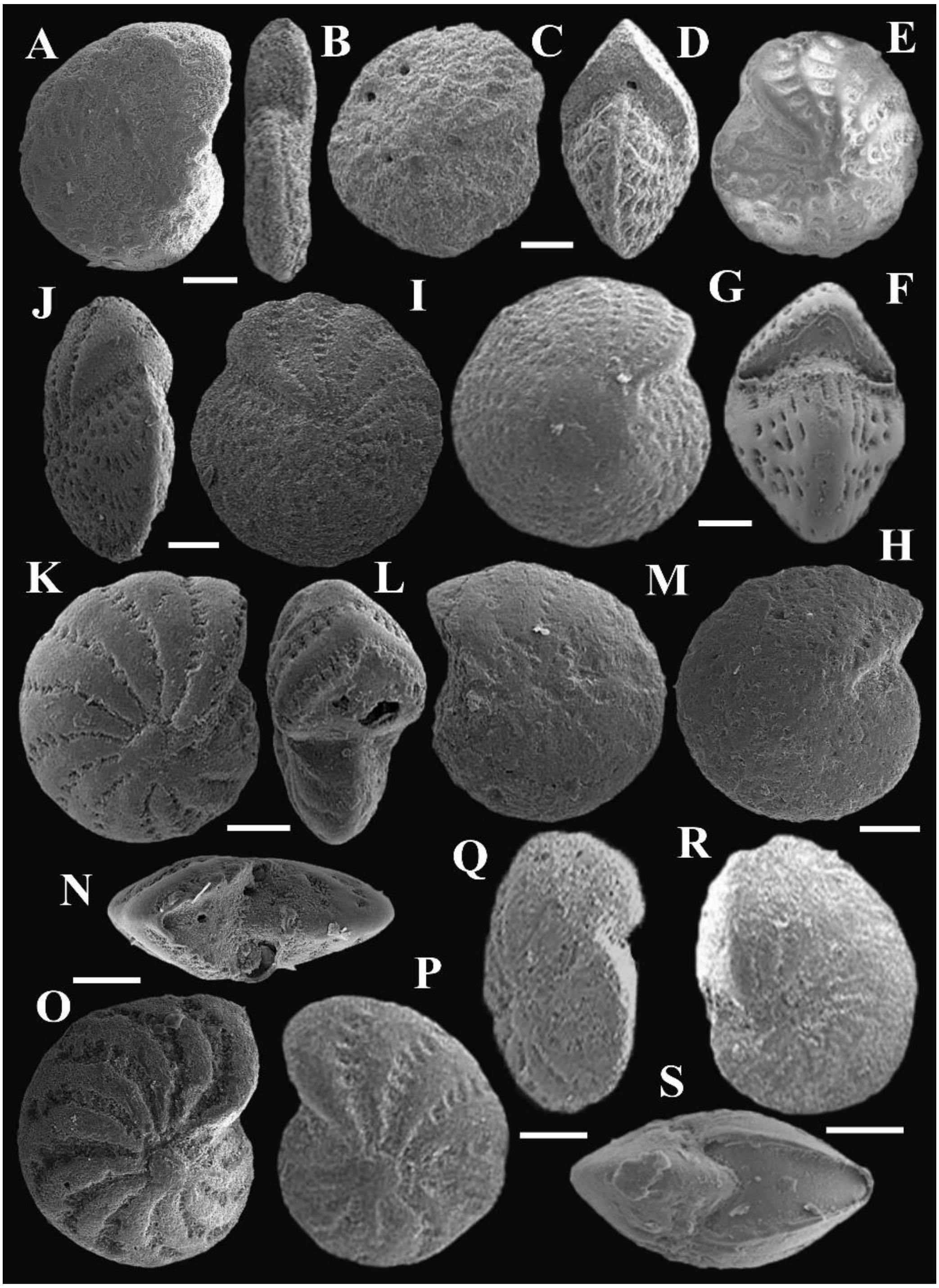


Fig 6- **A-B. *Elphidium fichtellianum* (d'Orbigny); A: spiral view (D8-BF), B: apertural view (K9-BF). C-E. *Elphidium crispum* (Linnaeus), C: an eroded shell in dorsal view (D13-BF), D: in apertural view (K3-BF), E: a well-preserved shell in dorsal view (St8-BF). F-G. *Elphidium craticulatum* (Fichtel and Moll); F: in apertural view (St9-BF), G: in dorsal view (D12-BF). H. *Elphidium asiaticum* (Polski), in dorsal view (BMF-5). I-J: *Elphidium advenum macelliforme* (McCulloch); I: in dorsal view (BMF-6), J: in apertural view (D14-BF). K-M. *Elphidium advenum maorium* (Hayward); K: a well-preserved shell in dorsal view (K11-BF), L: in apertural view (St11-BF), M: an eroded shell in dorsal view (BMF-8). N-Q. *Elphidium advenum limbatum* (Chapman), N: in apertural view (St10-BF), O: in dorsal view (K10-BF), P: in dorsal view (D15-BF), Q: in apertural view (K12-BF). R-S. *Nonion fabum* (Fichtel and Moll); R: lateral view (D17-BF), S: apertural view (St7-BF). Scale bar =100 µm**

https://doi.org/10.22108/jssr.2026.146509.1319

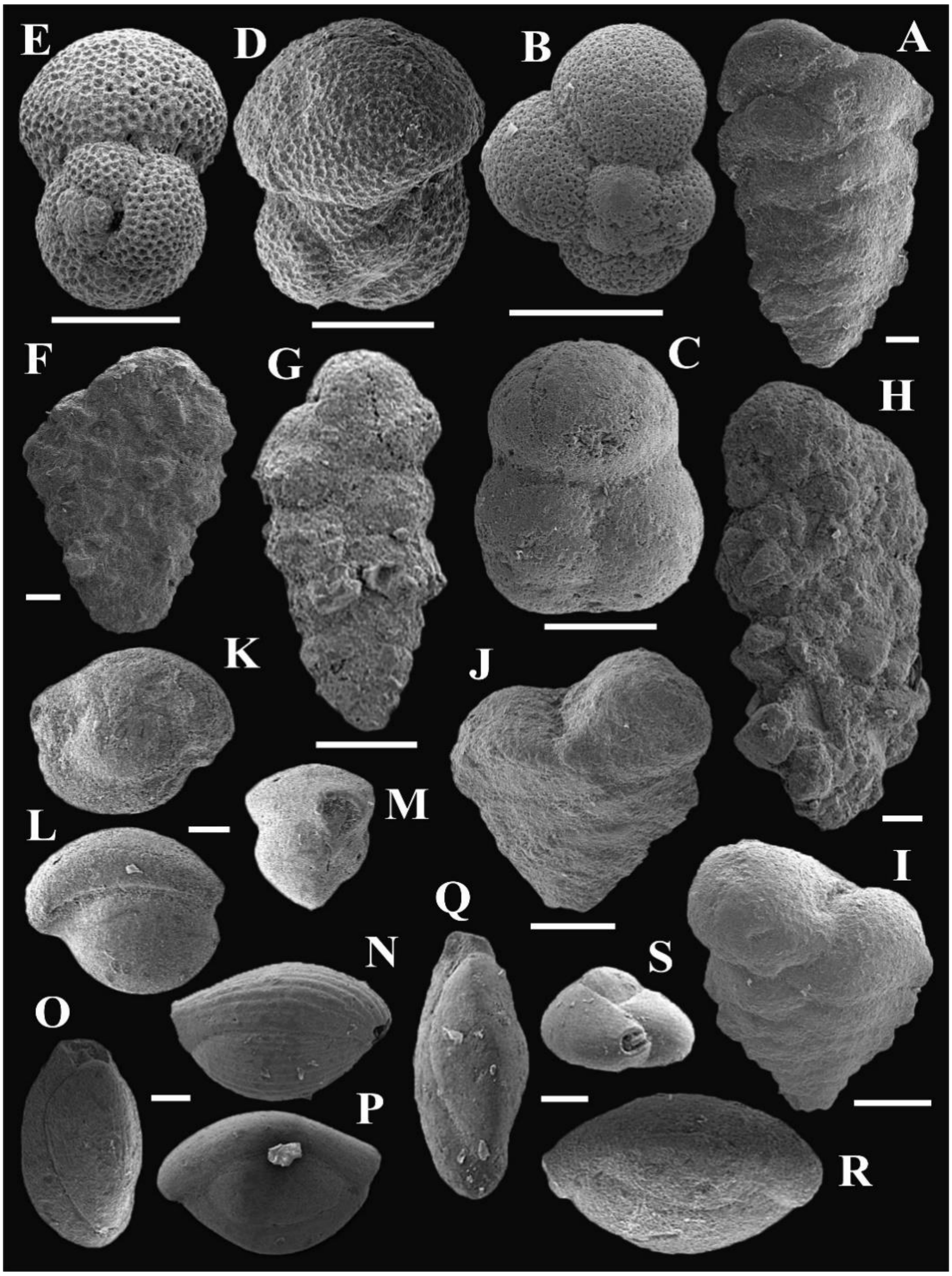
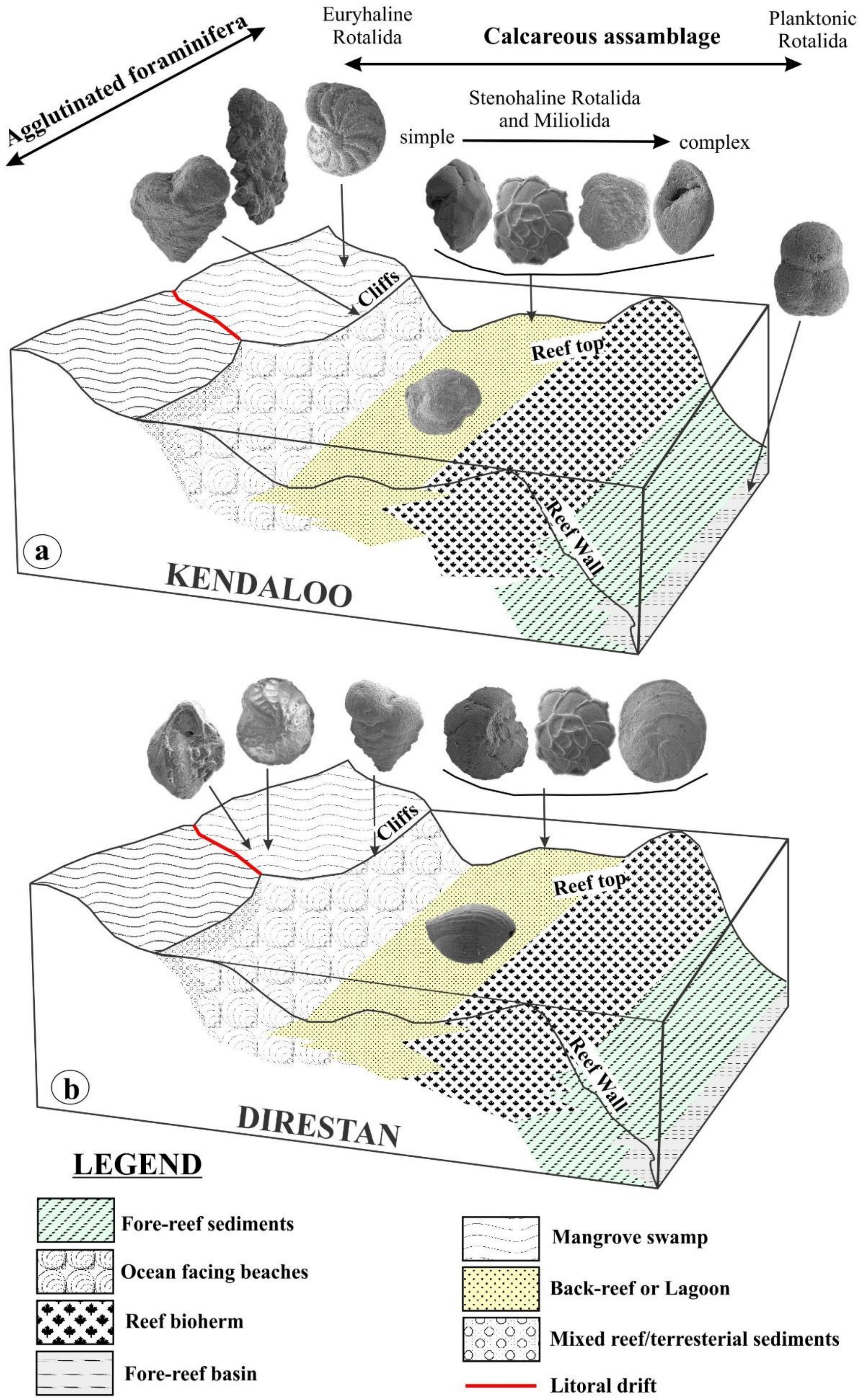


Fig 7- **A. *Bolivina spathulata* (Williamson), *dentellata* type (van der Zwaan, 1982); in dorsal view (BM-PF-1). B. *Globigerina bulloides* (d'Orbigny); in dorsal views (St-PF-2). C. *Globigerina* cf. *bulloides* (d'Orbigny); tattily eroded specimen in dorsal views (KPF-3). D. *Trilobatus* (*Globigerinoides*) *trilobus* (Reuss, 1850); in dorsal views (BM-PF-2). E. *Praeorbulina transitoria* (Blow); in dorsal views (St-PF-3). F-H. *Textularia agglutinans* (d'Orbigny); F: the sample is in dorsal view (DPF-1), but obviously more plain in corresponding to the other samples of the species, G: in dorsal view (St-PF-1); H: in dorsal view and obviously much bigger than others (KPF-1). I. *Textulariopsis* sp., in dorsal view (DPF-2). J. *Textularia* sp., F: in dorsal view with a more eroded shell (KPF-2). K-M. *Triloculina trigonula* (Lamarck); K: in dorsal view (K3-ML), L: in ventral view (D3-ML), M: in apertural view (K2-ML). N-O. *Triloculina terquemiana* (Brady); N: in ventral view (D2-ML); O: in lateral view (St2-ML). P. *Triloculina tricarinata* (d'Orbigny); in dorsal view (K1-ML). Q-S. *Quinqueloculina bogdanowiczi* (Serova); Q: in lateral view (D1-ML); R: in dorsal view (St1-ML); S: in apertural view (B1-ML). Scale bar =100 µm**

https://doi.org/10.22108/jssr.2026.146509.1319



https://doi.org/10.22108/jssr.2026.146509.1319

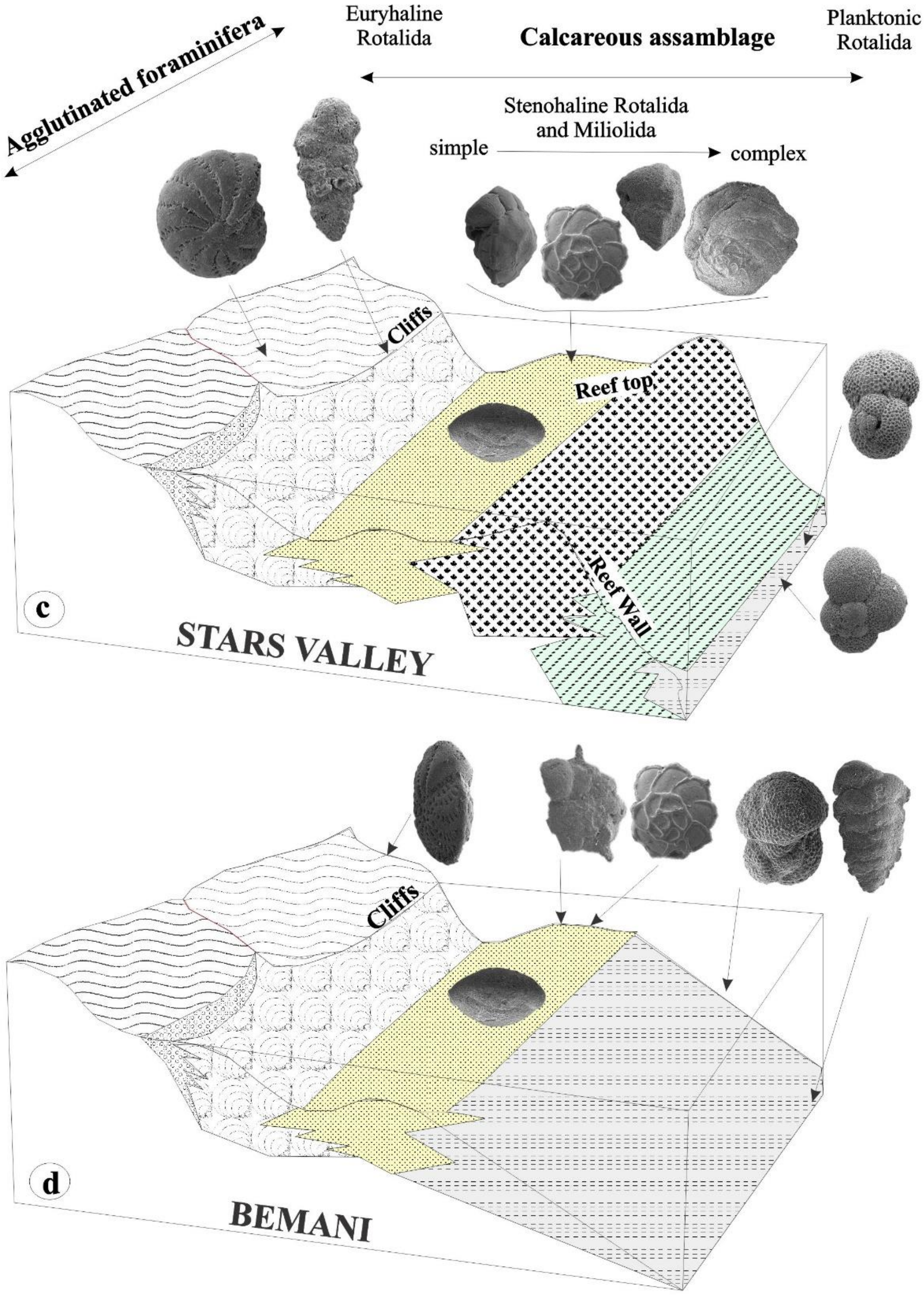


Fig 8- The ecological distribution of studied foraminifera (modified after BouDagher-Fadel 2018)**, from (a) Kendaloo, (b) Direstan, (c) Stars Valley and (d) Bemani outcrops, southern Iran** (Haskouei, 2025). **(Note: for more see Figs. 4 to 7).**

https://doi.org/10.22108/jssr.2026.146509.1319

https://doi.org/10.22108/jssr.2026.146509.1319