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БЕНТИЧЕСКИЕ ФОРАМИНИФЕРЫ КАК ИНДИКАЦИОННОЙ ИНСТРУМЕНТ БИОСТРАТИГРАФИИ И ПАЛЕОЭКОЛОГИИ ПАЧКИ ГУРИ (ФОРМАЦИЯ МИШАН), БАНДАР-АББАС, ЮЖНЫЙ ИРАН

BENTHIC FORAMINIFERA AS A TOOL FOR INDICATION OF BIOSTRATIGRAPHY, AND PALEOECOLOGY OF THE GURI MEMBER (MISHAN FORMATION), BANDAR ABBAS, SOUTH IRAN

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Аннотация. Это исследование сосредоточено на биостратиграфии и палеоэкологии фораминифер пачки Гури (формация Мишан) к северо-западу от Бендер-Аббаса, к югу от Ирана и в бассейне Загрос (восточная провинция Тетиса). Пачка Гури в основном состоит из средне- и толстослоистых известняков, среднеслоистых мергелистых известняков и зеленого мергеля с прослоями средних коричневых известняков. В этом исследовании было установлено пять биозон бентосных фораминифер, включающих 21 вид бентосных фораминифер из 17 родов. Сравнение выявленных бентосных фораминиферовых биозон пачки Гури с таковыми в других частях мира обнаруживает близкое сходство с областью Тетис. Фораминиферы подтверждают ранний-средний миоцен пачки Гури. Семь морских высокоизвестковых видов остракод встречались только в мергелевых отложениях, но не в известняках. Биотические ассоциации, выявленные в этом исследовании, позволяют предположить, что карбонатная седиментация мишанской свиты от нижней части к верхней части процветала в условиях от субтропических до тропических, отражала мезотрофные и олиготрофные палео условия, где отлагала мягкие до твердых отложений на глубине воды от 20 до 80 м и откладывались в условиях нормальной солености воды, которая колеблется от 34 до 50 ‰.

Ключевые слова: биостратиграфия; палеоэкология; миоцен; Бассейн Загрос; мишанская свита; группа Гури; Фораминифера, Остракода, Бандар Аббас.

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Annotation. This study is focused on the foraminiferal biostratigraphy and paleoecology of the Guri Member (Mishan Formation) northwest of Bandar Abbas, south of Iran, and in the Zagros Basin (eastern Tethyan province). The Guri Member mainly consists of medium- to thick-bedded limestone, medium-bedded marly limestone, and green marl with intercalated medium, brown limestones. In this study, five benthic foraminiferal biozones were established, including 21 benthic foraminiferal species from 17 genera. A comparison of the identified benthic foraminiferal biozones of the Guri Member with those in other parts of the world reveals close similarity to the Tethyan realm. Foraminifera confirms the Early to middle Miocene for the Guri Member. Seven marine high calcareous rare Ostracoda species were found in marl sediments only, not in Limestone layers. The biotic associations identified in this study suggest that the carbonate sedimentation of the Mishan Formation from the lower part to the upper part thrived in subtropical to tropical environments, reflected mesotrophic to oligotrophic conditions, deposited soft to hard sediments at water depths that ranged from 20–80 m, and deposited in a normal water salinity environment that ranges from 34 to 50 ‰.

Keywords: biostratigraphy; Geology; Paleoecology; Miocene; Zagros Basin; Foraminifera, Ostracoda, Mishan Formation; Guri Member; Bandar Abbas, Iran.

1 INTRODUCTION

The Mishan Formation has previously been called the Middle Fars, its usage is also extended into Fars province, thus replacing the names argillaceous group and Anguru Marl. The type of section was measured at the southwestern Gachsaran Oil Field at approximately 710 m thickness of marl and limestone. (James and Wynd, 1956), the sharp basal contact with gypsum of the Gachsaran Formation is accompanied by a minor amount of ferruginous staining. The thickness of the formation is being reduced gradually from east to west so that in Hormozgan province it is more than 3 000 m in thickness, which is reduced gradually to 100 m in Khuzestan province, and then disappears northward in Lorestan province. The Mishan Formation is the middle unit of the Fars Group that begins with Gachsaran Formation sediments or its clastic equivalents (i.e., Razak Formation) and continues with Mishan Formation sediments, finally forming Aghajari with red clastic sediments (Motiei, 1993). The type of section of the Guri member was measured in the northwestern Lar area (Fars Province), where it consists of 112.5 m thickness, hard, massive, cream, and fossiliferous limestone with interbedded thin layers of marl (Aghanabati, 2004). To trace the geological responses in detail of the Iranian geological record, a Baghestan outcrop section is selected at Zagros basin from the Baz anticline, northwest of the Bandar Abbas Hinterland, south Iran. (Fig. 1)

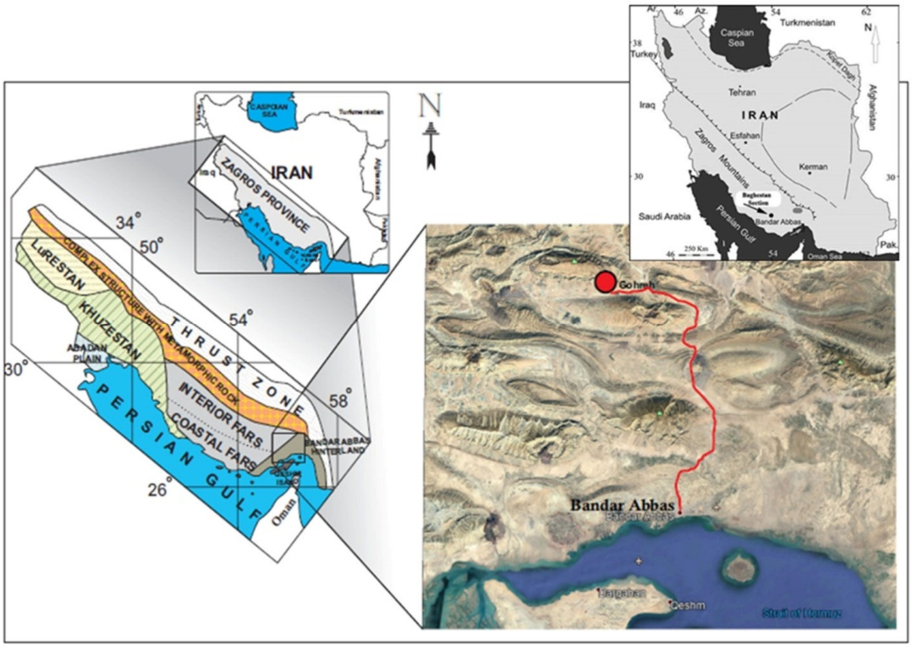

Fig. 1. Location map of the studied area

The studied area consists of 420 m of the Guri Member and 76 m of the Marly Member. The upper boundary of the Mishan Formation, covered by recent alluvial deposits in the region and underlain by the Razak Formation (Fig. 2 and 3) and its fossil content, is as follows: *Miogypsina* sp*., Schlumbergerina* sp., *Quinqueloculina* sp., *Discorbis* sp., *Neorotalia viennoti, Ammonia beccarii, Ammonia stachi, Elphidium* sp. 14*, Triloculina trigonula, Amphistegina lessoni, Discocyclina* sp*., Nephrolepidina* sp., *Borelis melocurdica, Borelis haueri, Peneroplis* cf*. evolutus, Meandropsina iranica, Archaias hensoni, Dendrnitina rangi, Archaias kirkuknesis, Operculina complanata, Amphistegina lesson, Lithothamnium* sp., *Lithophyllum* sp*., Tubucellaria* sp*., Onychocella* sp., *Subterraniphyllum thomasi, and Memberanipora* sp. Several researchers studied the stratigraphy, biostratigraphy, and paleoecology of the Mishan Formation (James and Wynd, 1965; Adams et al., 1983; Stöcklin and Setudehnia, 1991;

Fig. 2. Image showing: (a) the gradual boundary between Mishan and Razak formations at the Baghestan section, showing that the weathering creates the heteromorph destruction. b) the upper boundary of the Mishan Formation and alluvial cover in the region

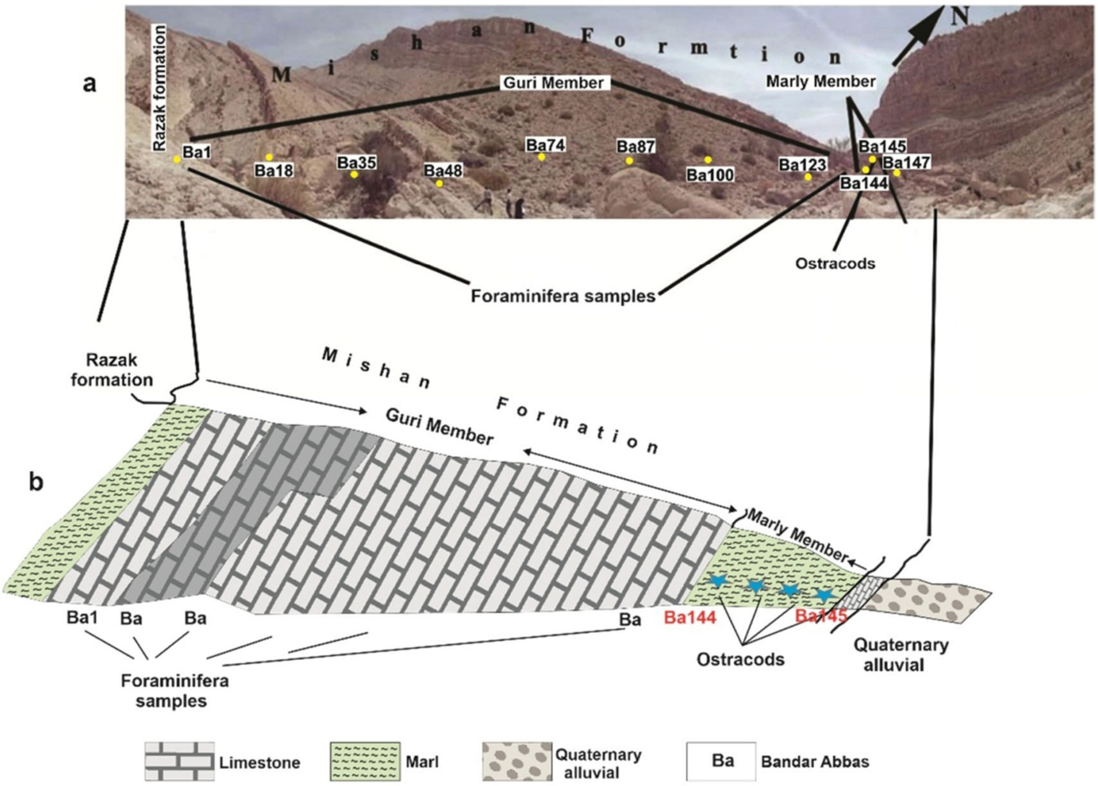

Fig. 3. Baghestan section, northwest of the Bandar Abbas Hinterland, south Iran is sampled the letter Ba1-Ba147 are the locations of the samples: a – field sampling; b – cross-section

Motiei, 1993; Goof et al., 1994; Homaiun-Zadeh, 2002; Alsouki et al., 2008). The Mishan Formation is equivalent to the Jerebi and Fatha formations in Iraq (Ghafor, 2004, 2010, 2011, 2014, 2015, 2022a; Ghafor and Ahmad, 2019, 2021; Ghafor and Muhammad, 2005, 2007, 2011; Ghafor and Najaflo, 2022; Ghafor et al. 2014; Ghafor et al. 2023; Muhammad and Ghafor, 2008). The main goal of the present study is to examine the biostratigraphy and paleoecology of the Mishan Formation in the studied section and correlate bio-events in the Tethyan realms.

2 GEOLOGICAL SETTING

According to Bahroudi, A., and Koyi Hemin, (2004), the Zagros Basin is defined by a 7–14 km thick succession of deposits over a region along the north–northeastern edge of the Arabian plate. This basin was part of the stable Gondwana supercontinent in the Paleozoic Era, a passive margin in the Mesozoic, and became a site of convergent orogeny in the Cenozoic. Sadeghi et al., (2009) clarified that the Zagros Fold-and-Thrust Belt of Iran is the result of Alpine orogenic events, which occurred in the Alp–Himalayan Mountain range. It extends in an NW–SE direction from eastern Turkey to the Strait of Hormoz in southern Iran. The tectonic activity of this area was entirely due to the convergence of the Arabian and Eurasian continents. Amirshahkarami et al. (2006), clarified that the Arabian and Iranian plates were part of the Eurasian plate and collided during the Mesozoic and Cenozoic periods, creating the Zagros folding belt. The Zagros Basin is a part of the middle section of the Tethyan realm and covers an area of nearly 500 km, with an NW-SE length of about 2300 km and a NE-SW width of 100–300 km. It mainly includes SW Iran, NE Iraq, NE Syria, and SE Turkey. This basin extends from SE Turkey to SW Iran and contains the provinces of Lorestan, Khuzestan, and Fars of the Zagros Basin (Motiei, 1995; Aghanabati, 2006)**.** The Mishan Formation is exposed and present in most parts of the Zagros basin (Motiei 1993), but it's well developed in Hormozgan Province and the Bandar Abbas Hinterland. Bandar-Abbas Hinterland is in the southeastern part of the Zagros Mountains, and it has a different orientation than other parts of the sedimentary basin (Haynes and McQuilan, 1974). This hinterland is bounded by the Minab Fault on the east, the Zagros fold belt, which crosses the Persian Gulf on the south, and the Razak Fault on the north (Barzgar, 1981). Most of the structures are anticlines exposing Fars Group successions, which are thicker than the Fars Zone in the study area, and the eastern border is limited to the Minab fault in the southern border of the rest of Zagros simple fold zone (Aghanabati, 2004). Stöcklin, 1968, subdivided the Iranian Plateau into eight continental parts. (i.e., Zagros, Sanandaj Syrjan, Urmiah-Dokhtar, Central Iran, Alborz, Kopeh-Dagh, Lut, and Makran), based on the sedimentary sequence, structural setting, intensity of deformation, magmatism, and metamorphism, but (Aghanabati, 2004) subdivide the Zagros Zone into two subzones (i.e., Thrust Subzone and Folded Zagros) based on geology characteristics. Folded Zagros Subzone has been subdivided into seven parts, including Lurestan, Khuzestan, Abadan Plain, Fars (external and interior), Bandar Abbas Hinterland, and a complex structure with metamorphic rock (Fig. 4). based on lateral facies variations, the Iranian Zagros fold-thrust belt is divided into different tectonostratigraphic domains that, from SE to NW, are the Fars Province (Eastern Zagros), the Khuzestan Province (Central Zagros), and the Lurestan Province (Western Zagros), respectively (Motiei, 1993). Hormozgan Province is in southern Iran and is part of the Zagros Folded Belt. This region is accompanied by NW-SE, W-E, and N-S trending simple anticlines and synclines with the very great thickness of Fars Group deposits (Gachsaran, Mishan, Aghajari, and Bakhtiari formations) and the presence of 118 salt plugs. So, for these specific features, Motiei, (1993) called this area the «Bandar Abbas Hinterland.»

The Zagros Fold-and-Thrust Belt of Iran is a result of the Alpine orogenic events in the Alpine–Himalayan Mountain range (Sadeghi et al., 2009). This basin was part of the stable Gondwana supercontinent in the Paleozoic Era, a passive margin in the Mesozoic Era, and a site of convergent orogeny in the Cenozoic Era (Bahroudi and Koyi, 2004). It extends in an NW–SE direction from eastern Turkey to the Strait of Hormoz in southern Iran. The tectonic activity of this area was entirely due to the convergence of the Arabian and Eurasian continents. (Aghanabati, 2004).

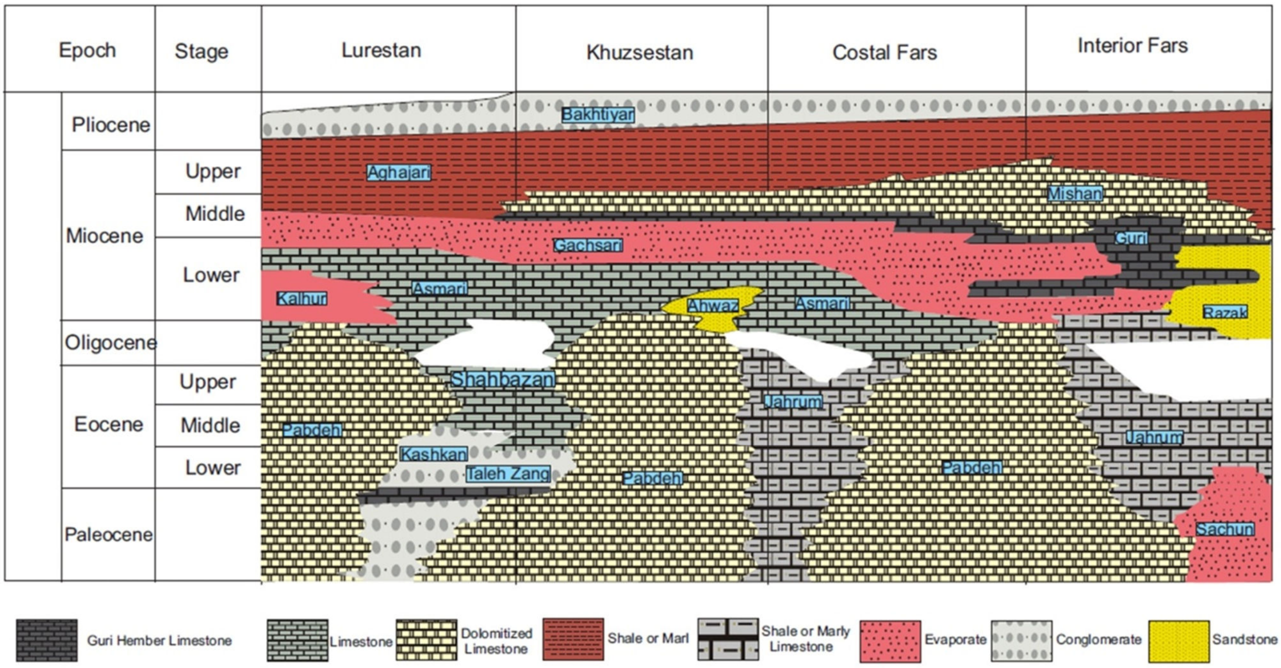

Fig. 4. Lithostratigraphic units of the Cenozoic of Zagros Fold-Thrust (modified from Gulf Petrolink, 1998)

3 MATERIALS AND METHODS

147 samples were collected at 0.5–3 m intervals from the Baghestan section of the Mishan Formation (496 m thick). 200 thin sections were prepared in the laboratory, and the thin sections were examined by using a polarized microscope. Foraminiferal identification and biostratigraphy were done by the foraminiferal classifications (Bakhtiar and Taheri 2010; Sirel et al., 2013; Serra-Kiel et al., 2016; Boudagher-Fadel 2018; Joudaki and Baghbani 2018; Moghaddam et al., 2019), and the studies of (Burchette and Wright, 1992; BouDagher-Fade,l 2008) are applied for palaeoecological interpretation. Seven marine high calcareous Ostracoda species found in marl sediments of Bandar-Abbas were prepared for SEM photography.

4 RESULTS AND DISCUSSION

4.1 Biostratigraphy

The biostratigraphy framework of the Mishan Formation was reported by Wynd, (1965) and developed by Adams et al., (1967). The studied section is characterized by shallow-benthic zones (SBZ) of the Early-Middle Miocene foraminifera related to these families: *Sortidae, Peneroplidae, Miliolidae, Rotalidae, Amphestedae, Hauerinidae, Alveolinidae, Meandrospinidae, Elephinidae, Miogypsinidae, Miogypsinidae*, and A total of 21 species from 17 genera of LBF and 7 species of non- Foraminifera were identified, including algae (*Subterraniphyllum thomasi*, *Lithophyllum* sp., *Lithothamnium* sp.), bryozoans (*Tubucellaria* sp., *Onycocella* sp., *Memberanipora* sp.), molluscan macrofossils (bivalves and gastro From base to top, five biozones were recognized (Plates 1–3, Fig. 5 and 6). The presence of limited marine Miocene Ostracoda species confirms the biostratigraphy of foraminifera fauna collected from field outcrop samples. (Plate 4)

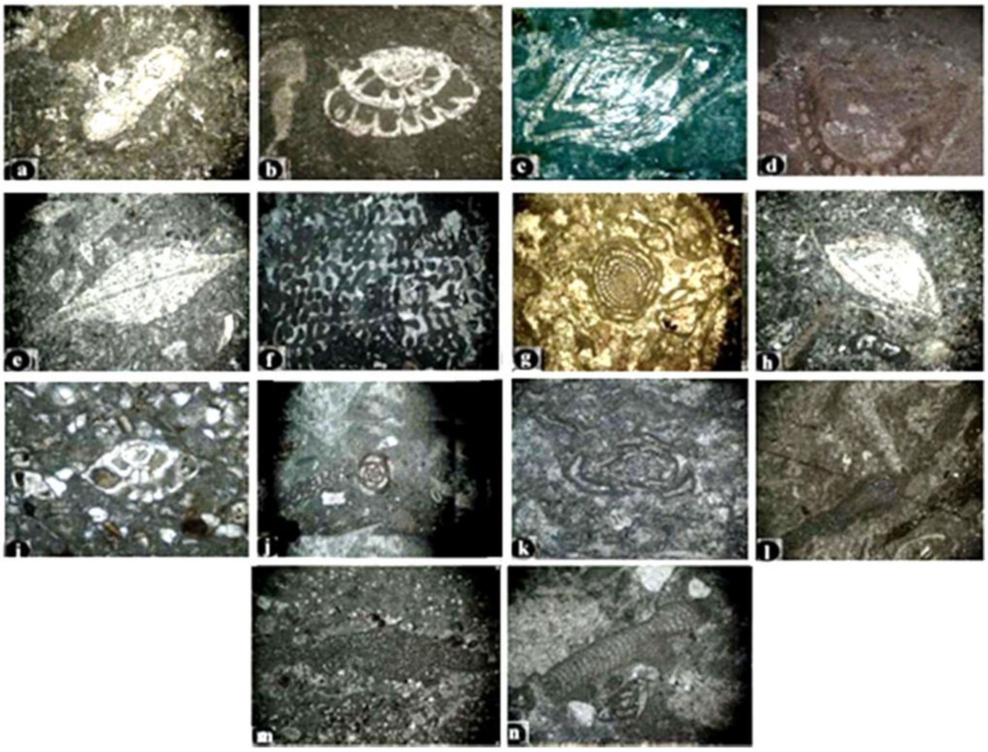

Plate-1. a. *Discorbis sp.* (10 X) sample no. 8; b. *Ammonia beccari* (Line, 1758), (10 X) sample no. 33; c *Amphistegina lessoni* d'Orbigny in Guérin-Méneville, 1832, (10 X) sample no: 12.; d. *Memberanipora sp.* (4X) Sample no: 80; e. *Discocyclina sp.* (4X) sample no. 7; f. coral,), sample no. p.; g. *Borelis haueri* Azmi, 2010 (4X) sample no: 85; h. *Amphistegina radiat* (Fichtel & Moll, 1798) (10X) sample no. 132; i. *Ammonia stachi* d' Orbigny, 1826 (10X) sample no. 2; *Quinquloculina sp.* (4X) sample no. 101. k. *Schlumbergerina sp.* (10 X) sample no: 10; l. *Archaias hensoni* Smout and Eames, 1958 (4X) Sample no. 36; m. *Archias kirkukensis* Henson, 1950 (4X) sample no. 17; n. *Subterraniphyllum thomasi* Elliott (4X) Sample no.10

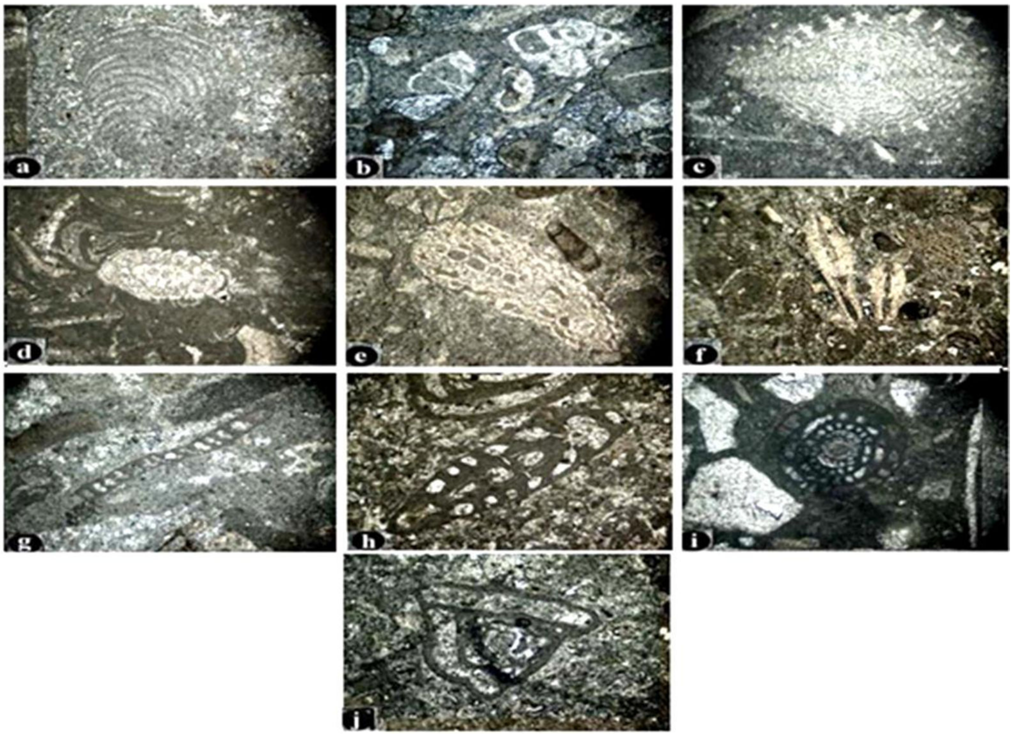

Plate-2. a. *Peneroplis evalutus* (4X) sample no. 9; b *Neorotalia viennotti* (Greig, 1935), (10X) sample no. 138; c. *Nephrolepidina sp.* (4 X) sample no. 8; d *Elphidium* sp 14 (10 X) sample no. 34; e. *Miogypsina sp.* (4 X) sample no. 9; f. *Operculina complanate* (Defrance in de Blainville, 1822) (4X) sample no. 65; g. *Meandropsina iranica* Henson, 1950 (4X) sample no. 10; h. *Dendretina rangi* d'Orbigny emend. Fornasini, 1904 (4 X) sample no. 39; i. *Borelis melo curdica* (Reichel) (4X) sample no. 7; j.*Triloculina trigonula* Lamarck, 1804 (10X) sample no: 30

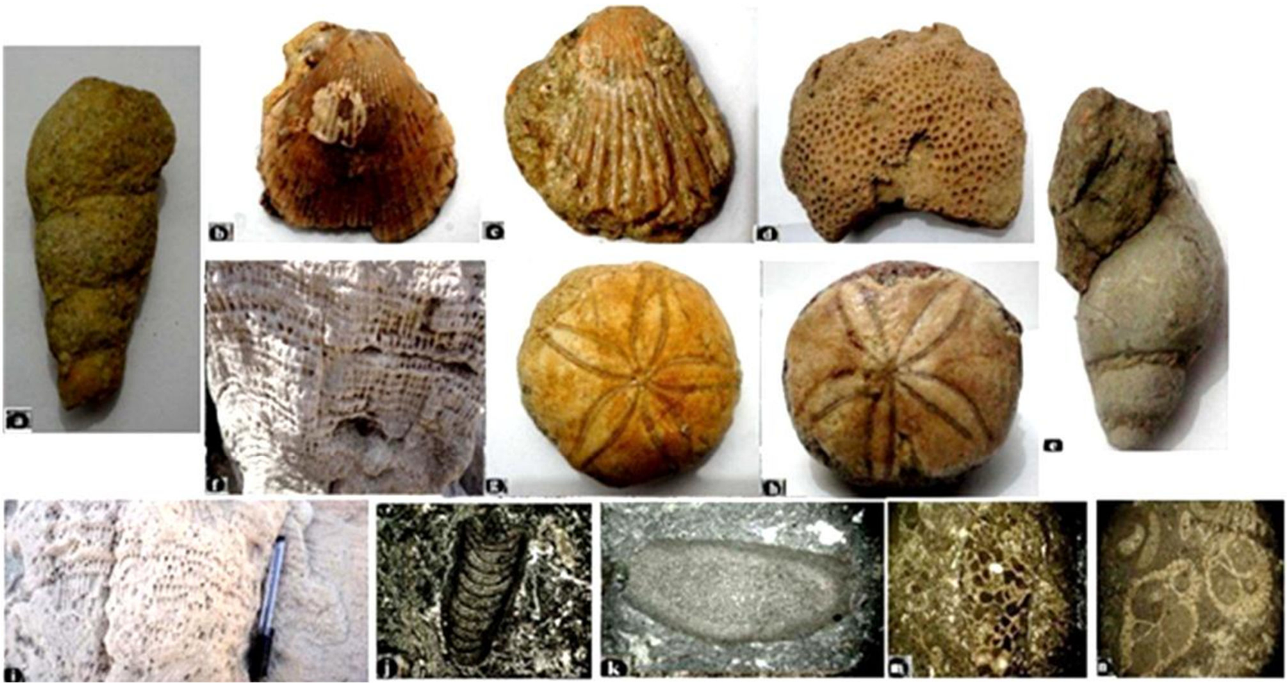

Plate-3. a. *(Gastropods) Ficus papayratium* sample No. 123 b. (Pelecypods). *Leptopectencf. L.ecnomius* Woodring, 1982; c. *(Pelecypods) Pectinidae*, sp.; d. Coral, sample no137 e. *Gastropods,* sample 121. f. Coral, sample No. 146; g. *(Echinoemata) Trachypatagus tuberculatus* Langhian-Serravallian, sample 143; h. *(Echinoermata). Echinolampas cfr. vilanovae* COTTEAU. Burdigalian, *Echinolampas (Macrolampas) discus* Desor. Aquitanian, sample No. 143; i. Coral, sample no146 j. *Lithothamnium* sp. (4X) sample no: 110, (4X); k. *Lithophyllum* sp. (4X) sample no: 75; l. *Onychocella* sp. (4X) sample no: 18. m. *Tubucellaria* sp. (10 X) sample no: 108

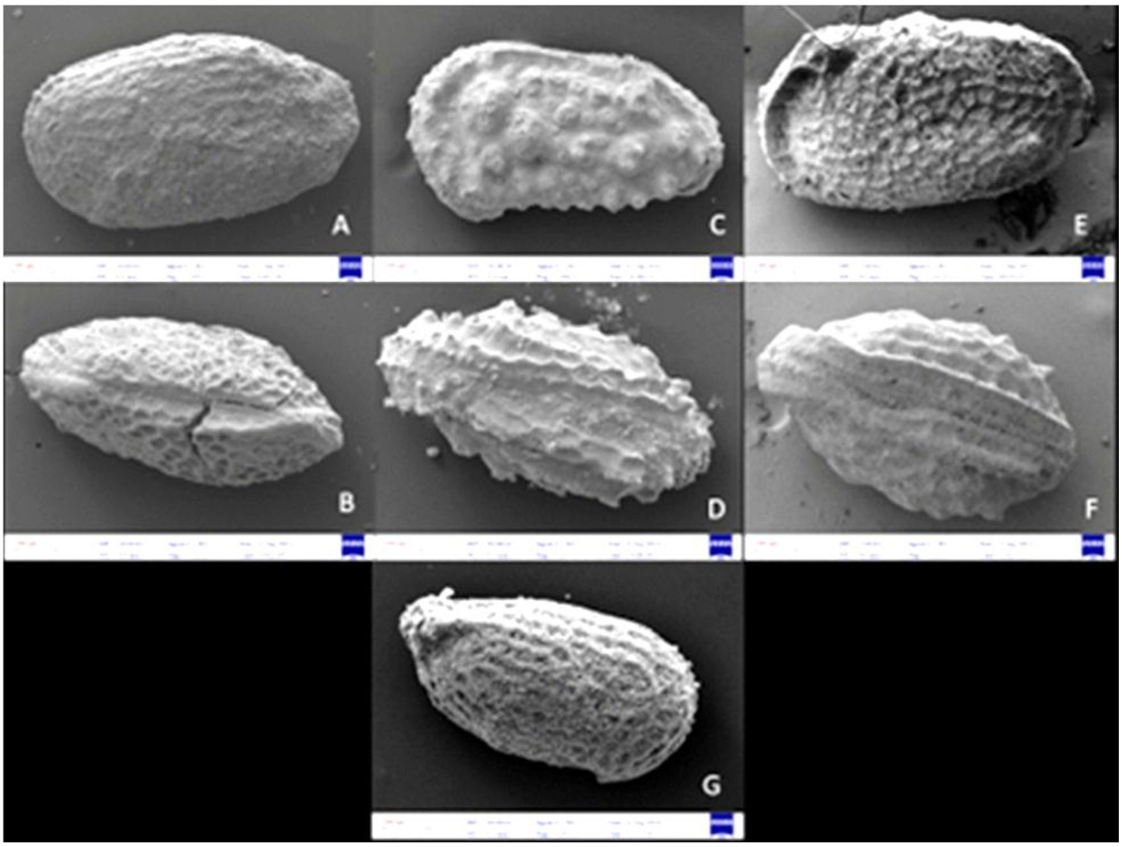

Plate 4. SEM microphotographs of selected ostracods from the Bandar-Abbas outcrop. A – *Cytheretta* sp external view; B – *Cytheretta s*p lateral view; C – *Actinocythereis rosefieldensis* (Howe & Law, 1936) left lateral view; D – *Actinocythereis rosefieldensis* (Howe & Law, 1936) lateral view; E – *Hemicythere* sp external view; F – *Hemicythere* sp lateral view; G – *Cytherura* sp external view

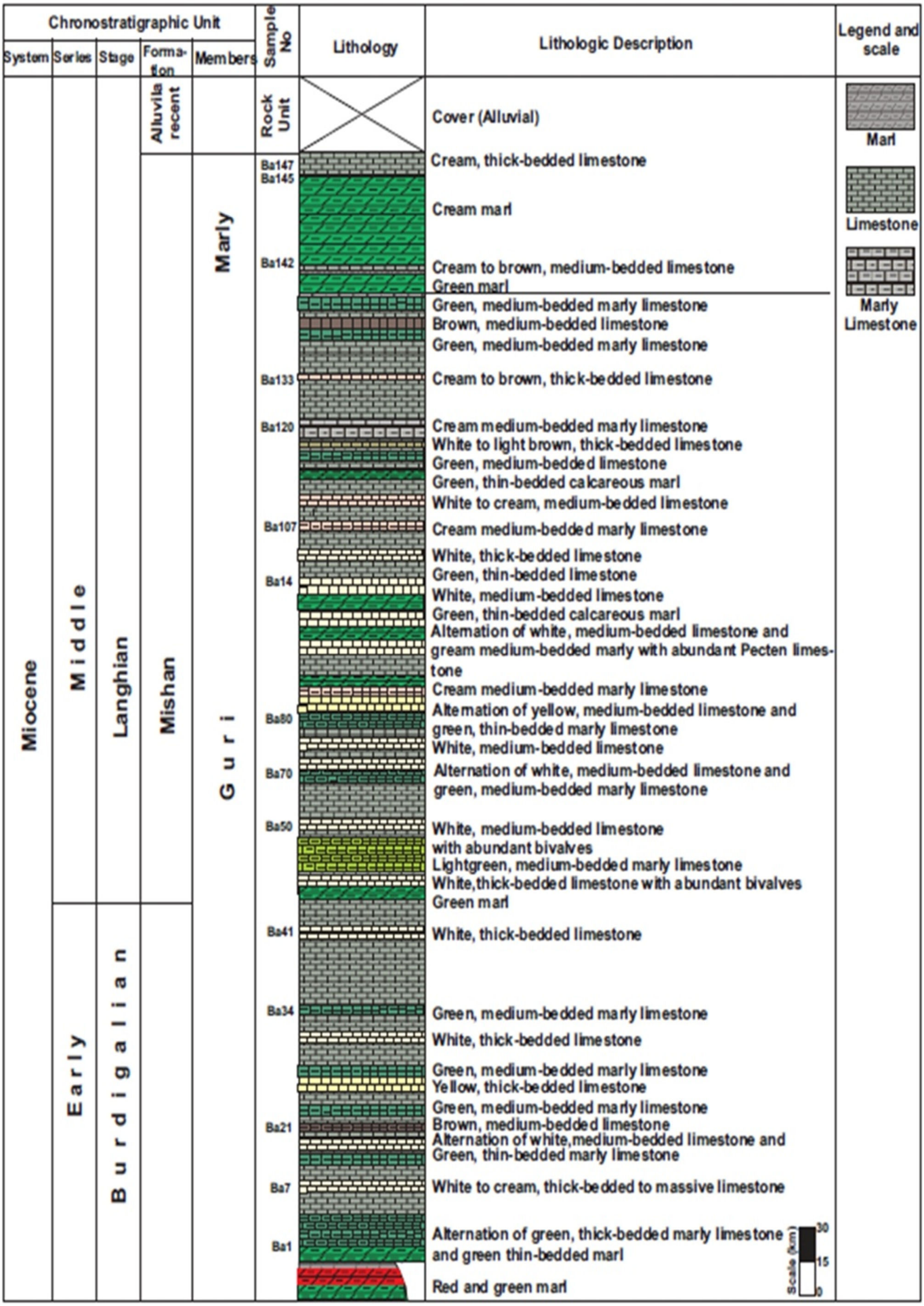

Fig. 5. Lithostratigraphic column of Early-Middle Miocene rock units in the Baghestan section of the studied area

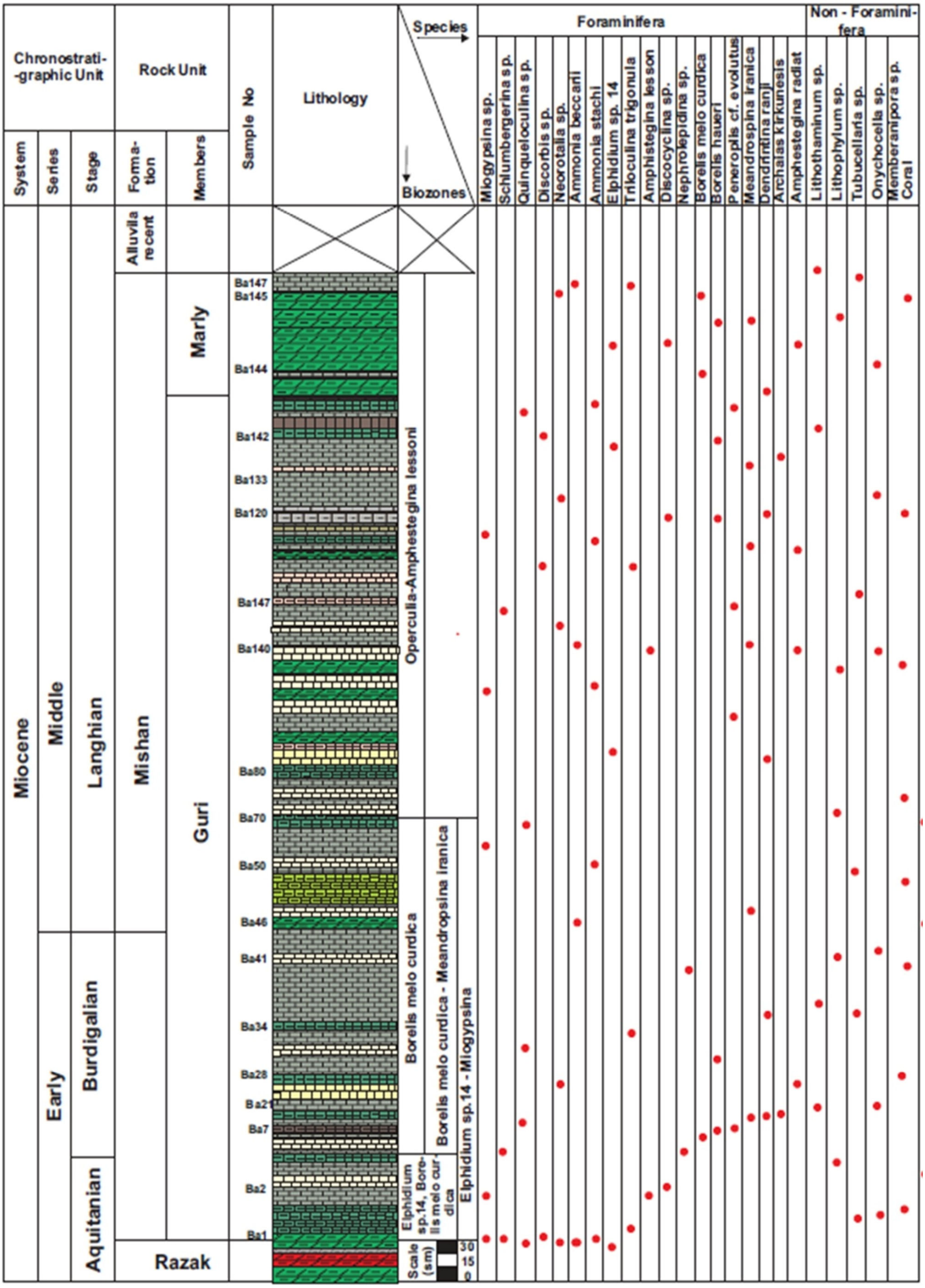

Fig. 6. Biostratigraphic range chart of Larger Benthic Foraminifera (LBF) and non-foraminifera in the Baghestan section of the studied area

4.1.1 *Elphidium* sp.14, *Borelis melo curdica* Interval Zone

Definition: Biostratigraphic interval between the FAD of *Elphidium* sp.14, and FAD of *Borelis melo curdica.*

Boundary zone: This zone is represented by the First Appearance Datum (FAD), and dominance of the large benthic foraminifera is represented by *Elphidium* sp. 14. Thickness: 20 meters, is recorded from the Mishan Formation, samples 1–7.

Association: It is characterized by the appearance and dominance of *Miogypsina* sp., *Schlumbergerina* sp., *Quinqueloculina* sp., *Discorbis* sp., *Neorotalia viennoti*, *Ammonia beccarii*, *Elphidium* sp.14, *Ammonia stachi*, *Triloculina trigonula*, *Amphistegina lesson*, *Amphistegina lesson*, *Nephrolepidina* sp., Borelis *melo curdica*, *Borelis haueri, Subterraniphyllum thomasi, Tubucellaria* sp., and coral.

Correlation: This zone is equivalent to the Indeterminate Zone of Laursen et al., (2009) and *Miogypsinoides – Archaias*-Valvulinid Zone (*Arhaias asmarius-Archaias hensoni* subzone and *Elphidium* sp.1-*Miogypsina* sp. subzone) of (Adams & Bourgeois, 1967), and to the SBZ 24 (*Austrotrillina howchini-Miogypsina- miogypsinoides deharti*) of Cahuzac and Poignant, (1997), with *Austrotrillina howchini-Peneroplis farsensis* assemblage Zone of Ahmmad (2020)) (Fig. 7). It is corresponding to the *Ammonia beccari-Austritrillina hawchini* zone (Ghafor and Ahmad, 2021).

Age: Early Miocene (Aquitanian).

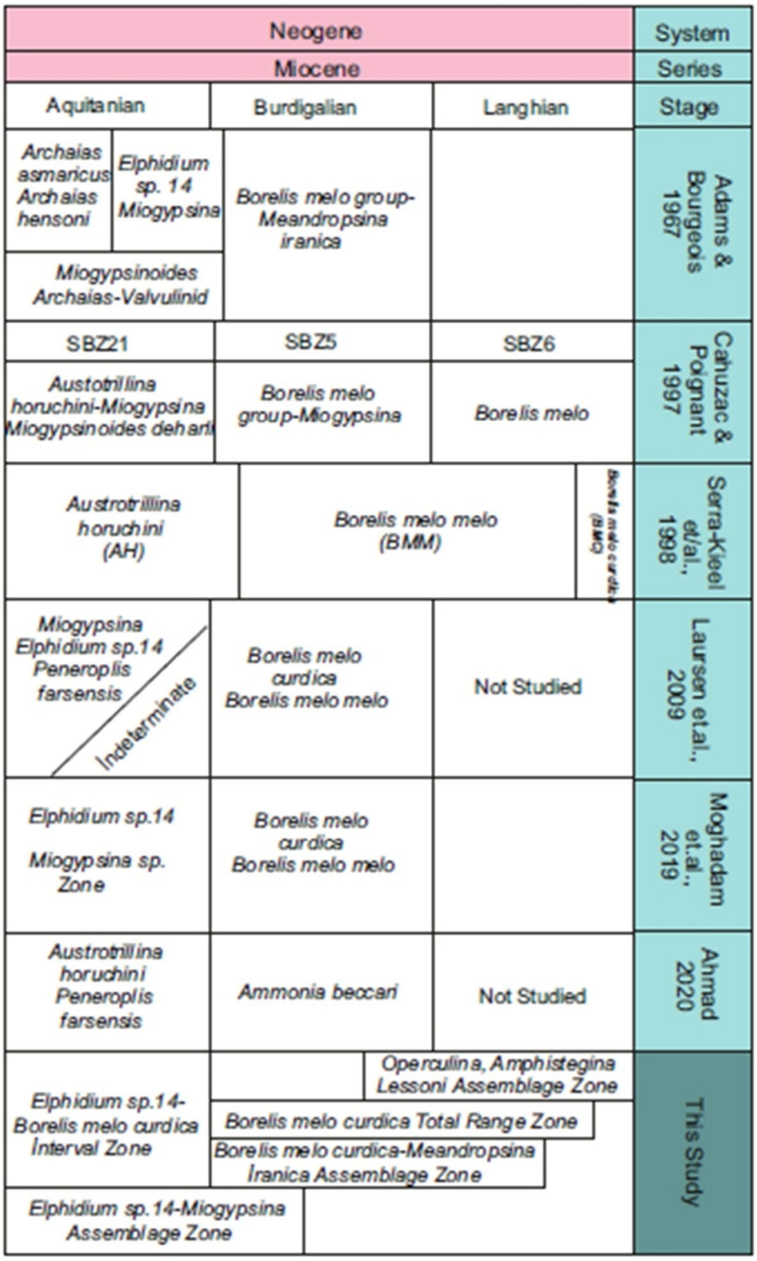

Fig. 7. Correlation chart showing the biostratigraphic zones of this study with the other studies

4.1.1.2 *Elphidium* sp.14, *Miogypsina* Assemblage Zone

Definition: The biostratigraphic interval of this zone is characterized by the association of taxa (*Elphidium* sp. 14 and *Miogypsina*).

Boundary zone: This zone is represented by the First Appearance Datum (FAD), and dominance of the large benthic foraminifera is represented by (*Elphidium* sp. 1 and *Miogypsina*). The Mishan Formation, samples 1–36, has a thickness of 133 meters.

Association: It is characterized by the appearance and dominance of *Schlumbergerina* sp., *Quinqueloculina* sp., *Discorbis* sp., *Neorotalia viennoti*, *Ammonia beccarii*, *Ammonia stachi*, *Triloculina trigonula*, *Amphistegina lesson*, *Amphistegina lesson*, *Nephrolepidina* sp., *Borelis melocurdica*, *Borelis haueri*, *Peneroplis* cf. *evolutus Meandropsina iranica, Dendritina rangi, Archaias kirkukensis, Amphistegina* cf. *radiat Subterraniphyllum thomasi, Lithothamnium* sp.*, Tubucellaria* sp.*, Memberanipora* sp.*, Onychocella* sp., *Memberanipora* sp., and coral

Correlation: This zone is equivalent to the Adams & Bourgeois (1967) *Miogypsinoides-Archaias-Valvulinid* Zone-*Borelis* melo group-*Meandrospiuna irania* Assemblage Zone, Cahuzac and Poignant (1997) SBZ24 and lower part of SBZ25, Laursen et al., (2009) Miogypsina-Elphidium sp. It corresponds to the *Ammonia beccari-Austritrillina hawchini* zone of (Ghafor and Ahmad, 2021).

Age: Early Miocene (Aquitanian–Burdigalian).

4.1.1.3 *Borelis melo curdica – Meandropsina iranica* Assembly Zone

Definition: The biostratigraphic interval of this zone is characterized by the association of taxa (*Borelis melo curdica and Meandropsina iranica*).

Boundary zone: This zone is represented by the First Appearance Datum (FAD) of *Borelis melo curdica,* and the dominance of the large benthic foraminifera is represented by *Meandropsina iranina*. A thickness of 207 meters is recorded in the Mishan Formation; samples number 7–64.

Association: It is characterized by the appearance and dominance of *Schlumbergerina* sp., *Quinqueloculina* sp., *Discorbis* sp., *Neorotalia viennoti*, *Ammonia beccarii*, *Ammonia stachi*, *Triloculina trigonula*, *Amphistegina lesson*, *Amphistegina lesson*, *Nephrolepidina* sp., *Borelis melocurdica*, *Borelis haueri*, *Peneroplis* cf. *evolutus Meandropsina iranica, Dendritina rangi, Archaias kirkukensis, Amphistegina* cf. *radiat Subterraniphyllum thomasi, Lithothamnium* sp.*, Tubucellaria* sp.*, Memberanipora* sp.*, Onychocella* sp., *Memberanipora* sp., and coral

Correlation: This zone is equivalent to the *Borelis melo* group–*Meandrospiuna iranica* Assemblage Zone of Adams and Bourgeois (1967), SBZ25 and the lower part of SBZ26 of Cahuzac and Poignant (1997), the *Borelis melo group–Borelis melo* assemblage Zone of Laursen *et al*. (2009), and the *Borelis melo group–Borelis melo* assemblage Zone of Moghadam et al., (2019). *Ammonia beccari* zone of Ahmmad, (2020) (Fig. 7). It corresponds to the *Ammonia beccari-Austritrillina hawchini* zone of (Ghafor and Ahmad, 2021).

Age: Early Miocene (Burdigalian–Langhian).

4.1.1.4 *Borelis melo curdica* Total Range Zone

Definition*:* Biostratigraphic interval between the First and Last Appearances of *Borelis melo curdica* Zone boundary: This zone is represented by the First Appearance Datum (FAD) of *Borelis melocurdica* and the last occurrence of this species. Thickness: **316** meters, is recorded in the Mishan Formation, samples 7–105.

Association: It is characterized by the appearance and dominance of *Schlumbergerina* sp., *Quinqueloculina* sp., *Discorbis* sp., *Neorotalia viennoti*, *Ammonia beccarii*, *Ammonia stachi*, *Triloculina trigonula*, *Amphistegina lesson*, *Amphistegina lesson*, *Nephrolepidina* sp., *Borelis melocurdica*, *Borelis haueri*, *Peneroplis* cf. *evolutus Meandropsina iranica, Dendritina rangi, Archaias kirkukensis, Amphistegina* cf. *radiat Subterraniphyllum thomasi, Lithothamnium* sp.*, Lithophyllum* sp., *Tubucellaria* sp.*, Memberanipora* sp.*, Onychocella* sp., *Memberanipora* sp., and coral

Correlation: This zone is equivalent to the Borelis melo group Meandropsina iranica of Adams and Bourgeois (1967) and to the *Borelis melo curdica total range* zone of James and Wynd (1965). Van Buchem *et al*. (2010), and to the SBZ 26(*Borelis melo*) of Cahuzac and Poignant, (1997), with *Ammonia beccari Total Range* Zone of Ahmmad, (2020) (Fig. 7). It corresponds to the *Dendrintina ranji-Rotlia vieonti* zone (part) of (Ghafor and Ahmad, 2021).

Age: Early-Middle Miocene (Burdigalian-Langhian).

4.1.1.5. *Operculina-Amphestegina lessoni* Assemblage Zone

Definition: The biostratigraphic interval of this zone is characterized by the association of taxa (*Operculina and Meandropsina iranina*).

Boundary zone: This zone is represented by the First Appearance Datum (FAD) of *Operculina* and the association of the *Amphistegina lessoni.* Thickness: 337 meters, recorded from the Mishan Formation; samples number (40–147)

Association: It is characterized by the appearance and dominance of *Schlumbergerina* sp., *Quinqueloculina* sp., *Discorbis* sp., *Neorotalia viennoti*, *Ammonia beccarii*, *Ammonia stachi*, *Triloculina trigonula*, *Amphistegina lesson*, *Amphistegina lesson*, *Nephrolepidina* sp., *Borelis melocurdica*, *Borelis haueri*, *Pen-*

eroplis cf. *evolutus Meandropsina iranica, Dendritina rangi, Archaias kirkukensis, Amphistegina* cf. *radiat Subterraniphyllum thomasi, Lithothamnium* sp.*, Tubucellaria* sp.*, Memberanipora* sp.*, Onychocella* sp., *Memberanipora* sp., and coral

Correlation: This zone is equivalent to the *Borelis melo* zone (SBZ26) of Cahuzac and Poignant, (1997) and the upper part of the *Borelis melo melo* (BMM) zone–the *Borelis melo curdica* zone of Serra kieel et al., (1998). (Fig. 7). It corresponds to the *Dendrintina ranji-Rotlia vieonnti* zone (part) of (Ghafor and Ahmad, 2021).

Age: Early to Middle Miocene (Burdigalian–Langhian).

5 PALAEOECOLOGICAL INTERPRETATION

Foraminifera and non-foraminifera were used in the paleoecology of Paleogene-Neogene carbonate platforms (Hottinger, 1997; Pedley, 1998; Geel, 2000; Pomar, 2001; Romero et al., 2002; Cosovic et al., 2004; Pomar and Hallock, 2008; Ghafor and Ahmad, 2021; Ghafor et al., 2023; Ghafor et al., 2023). BouDagher-Fadel, 2008), clarified that the shapes and sizes of the foraminiferal species are significant and occur in many different environments, from near-shore to the deep-sea environment. The recorded biozones were calibrated with the previously studied Miocene planktonic foraminiferal biozones on the same samples and correlated with the Miocene redeposited ostracods regardless of their limited presence in the studied outcrop. These ostracods are also found in the neighbouring countries in Miocene deposits. The calcareous red algae are also used in palaeoecological studies. Many parameters and variables influence foraminiferal distribution in aquatic life: temperature, water depth, hydrostatic pressure, light intensity, sediment type, current systems, salinity, nutrients, and oxygen (Table 1).

Table 1 – Vertical distribution of faunal composition, palaeoecological elements (Temperature, light, depth, hydrodynamic energy, substrate, salinity, nutrient, and oxygen estimation) of the Guri Member (Mishan Formation) in the studied section

Age	Early-Middle Miocene
Fossil Content Families	*Sortidae, Peneroplidae, Miliolidae, Rotalidae, Amphestedae, Hauerinidae, Alveolinidae, Meandrospinidae, Elephinidae, Miogypsinidae, Miogypsinidae.* Non-Foraminifera, algae bryozoans' molluscan macrofossils -bivalves and gastropods.
Temperature	Subtropical to tropical
Light	Mesophothic to euphotic
Depth	Open marine environments to shallower water depths
Hydrodynamic energy	Large shells with thin walls in open marine foraminifera and smaller and thicker shell in shallow and restricted environments.
Substrate	Soft sediments to hard sediments
Salinity	Normal to higher salinity environments ranges from 34 to 50 ‰.
Nutrients and oxygen	Mesotrophic to oligotrophic

5.1 Temperature: Temperature acts as a barrier to the dispersal of marine animals. (Brasier, 2004; Wilson and Vecsei, 2005) shows that larger benthic foraminifera live in tropical and subtropical water environments and restrict to temperatures of about 14 to 25 ºC. According to Hattinger, (1997), most of the perforate foraminifera such as *Nummulites, Miogypsina*, *Operculina*, and *Amphistegina* are abundant in subtropical to tropical environments, while some imperforate foraminifera such as *Archaias, Borelis, Peneroplis*, and miliolids are restricted to tropical environments (BouDagher-Fadel and Wilson, 2000; Brandano et al., 2009); and (Fügel, 2010; Brandano et al., 2010) show that red algae such as *Lithoporella*, *Lithium*, and *Lithotaminium* are restricted in subtropical to tropical environments. Therefore, the presence of perforate large benthic foraminifera such as *Operaculina* and *Amphistegina* in the middle to the upper part of the Mishan Formation in the studied section reflects subtropical to tropical environments, and the presence of imperforate large benthic foraminifera such as *Archaias, Dendritina, Peneroplis*, and miliolids in the lower to the middle part of the Mishan Formation at the studied section shows a tropical environment.

5.2 Light: While light penetration in the oceans (the photic zone) is attractive to foraminifera (Brasier 2004), the larger benthic foraminifera such as *Amphistegina, Heterostegina*, and *Operculina* reflect mesophotic to oligophotic conditions (Pomar, 2001; Hohenegger 2004; Beavington-Penney and Racey 2004; BouDagher-Fadel, 2008). The change in the test shape reflects decreased light levels at greater depths (BouDagher-Fadel, 2008). It is known that larger foraminifera living in fairly turbulent waters become relatively large, with a thickness-to-diameter ratio of 0.6–0.7 (Cosovic et al., 2004). Associations of larger foraminifera and symbiont red algae are well-dependent on the photic zone (Barattolo et al., 2007). The abundance of larger benthic foraminifera such as *Borelis*, *Peneroplis*, *Dendritina*, *Archaias, and* zooxanthellate corals in the studied section of the Mishan Formation indicate a mesophothic to euphotic condition (Halfar *et al.*, 2004; Pomar and Hallock, 2008; Brandano *et al.,* 2009b; Mazzucchi and Tomassetti, 2011; Tomassetti and Brandano, 2013). Larger perforate foraminifera is represented by *Operculina, Elphidium,* and *Miogypsina in* the Guri Member of the Mishan Formation, and comparison with analogs in the modern platform led to the interpretation of these sediments as being photic zone deposits (Hottinger, 1980; Hottinger, 1983; Leutenegger, 1984; Reiss, and Hottinger, 1984; Hohenegger, 1996; Hallock, 1999).

5.3 Depth: According to Brassier (2004), foraminifera is found from sea level to more than 10,000 meters. Changes in water depth could affect environmental changes such as sedimentation rate, turbulence, light intensity, organic change, hydrodynamic energy, and dissolved oxygen (Leckie and Olsen, 2003). Large Benthic Foraminifera (LBF) was previously used to determine water depth due to its sensitivity to it. Some larger benthic foraminifera, such as *Amphistegina* and *Nummulites,* become flatter with thinner outer walls with increasing water depth and decreasing light intensity. This reveals the dependence of morphology on the depth gradient (Pecheux 1995). Some imperforate benthic foraminifera such as *Archaias, Peneroplis*, and *Borelis* are indicators of shallow waters below 30 m (Romero et al., 2002; Murray, 2006). Most of the perforate foraminifera, such as *Nummulites, Miogypsina*, *Operculina*, and *Amphistegina, are* distributed in a water depth of about 40–70 m (Hottinger, 1997); according to Flügel (2010; Brandano et al. (2010), red algae, such as *Lithoporella*, *Lithophyllum*, and *Lithotaminium,* are restricted to a depth of 20–80 m. (Bou-Dagher-Fadel and Wilson, 2000; Brandano et al., 2009); and (Flügel, 2010; Brandano et al. 2010). *Operculina, Elphidium,* and *Miogypsina* in the Guri Member of the Mishan Formation are the most important indicators for warm, shallow marine environments (Geel, 2000; Sajadimet et al., 2014). At the lower part of the Mishan Formation, perforate foraminifera are common and reflect an open marine environment, while in the lower and middle part of the studied section, imperforate foraminifera such as *Peneroplis* and miliolids are abundant and generally found in shallower water (20–80 m)

5.4 Hydrodynamic energy: Depending on hydrodynamic water energy, some foraminifera develop thick lamellar crust shells, while others tend to develop a hard, conical shell shape with abundant secondary cells (Rasser et al., 2005). *Operculina* and *Heterostegina* have inhabited environments ranging from high-energy, shallow-water fore reef facies (BouDagher-Fadel 2008) to quiet waters near the base of the photic zone (Chaproniere, 1975). In the studied area, open marine foraminifera such as *Operculina, Nerhrolepidina, Discocyclina,* and *Amphistegina* have large shells with thin walls, while those with smaller and thicker shell walls live in shallow and restricted environments.

5.5 Substrate: Foraminifera from coarser substrates tend to be thick-shelled, heavily ornamented forms of lenticular or globular shape. Low-energy habitat with fine-grained substrates is attractive to many faunal species with thin, delicate, and elongated shells (Brasier 2004). Conical and thick-shelled forms of foraminifera prefer to live on coarse-grained substrates, while flattened forms prefer soft substrates (Brasier, 1975). *Operculina* is inhabited on soft sediment, while *Borelis* and *Archaias* live in relatively unstable substrates in shallow environments (Geel, 2000). *Archaias* and *Operculina* can live in environments with about 40 % clastic influx but increases in clastic influx led to a reduction in their numbers (Kumar and Saraswati, 1997). So, the Mishan Formation of the studied section has deposited soft to hard sediments.

5.6 Salinity: A miliolid-dominant environment in a benthic foraminifer assemblage reflects decreased circulation and reduced oxygen content, or euryhaline conditions. Miliolids are found in a variety of very shallow, hyposaline to hypersaline environments and are also common in sand shoal environments of normal salinity (Brasier, 1975a). They are generally evidence of a restricted lagoon environment (Wilson, 1975). Perforate-wall foraminifera such as *Nummulites, Operculina,* and *Amphistegina* wall refer to normal seawater conditions with salinity ranges from 34 to 40 (Geel 2000; Mossadegh et al., 2009). The association of imperforate foraminifera such as *Archaias and Peneroplis* with coral and red algae reflects a salinity of 40 to 50 (Mossadegh et al., 2009). As a result, the middle to the upper part of the Mishan Formation in the studied section has deposited in a normal water salinity environment (with salinity ranges from 34 to 40), while the lower to the middle part of the studied section experienced intermittent normal and higher salinity environments (with salinity ranges from 40 to 50).

5.7 Nutrients and oxygen: If the food supply is low, as in the deep sea, foraminiferal densities tend to be low, but diversity can be high. However, if the food supply is high, foraminiferal diversity tends to be low. (Brasier, 2004). The imperforate foraminifera, such as *Archaias* and miliolids, indicate low levels of nutrients (Geel, 2000; Samankassou, 2002; Romero et al., 2002). Also, coral reefs develop in submarine environments with the lowest levels of nutrients (Schlager 2005). Increasing amounts of nutrients lead to thriving red algae, and decreasing amounts of nutrients cause coral growth and development (James et al.,1999). Nutrient conditions have a negative relationship with temperature (Samankassou, 2002). The presence of larger benthic foraminifera indicates mesotrophic to oligotrophic conditions (Geel, 2000; Romero et al., 2002). The occurrence and abundance of large benthos foraminifera such as *Amphistegina, Peneroplis, Operculina*, and *Archaias*, along with coral and red algae in the

6 DISCUSSIONS

All the previous biostratigraphy and palaeoecological studies of the Mishan Formation did not explain it in detail (Wynd, 1965; Adams et al., 1967; Rashidi et al., 2015; Amirshahkarami and Taheri, 2009; Joudaki and Baghbani, 2018), but the present interpretation in the studied section shows that more than 30 species of foraminifera and non-foraminifera have been identified and subdivided into five biozones that the Earl - Middle Miocene age was recorded of the Guri Member (Mishan Formation), and the interpretation of the palaeoecological results, gives us the following results, the Member was deposited from subtropical to tropical environments, mesotrophic to oligotrophic conditions, soft sediments to hard sediments, open marine to shallower water depths, and of a normal water salinity environment ranging from 34 to 50 ‰. Ostracods presented in the lower and upper parts of the studied section indicated an inner neritic marine environment of moderate energy of currents and rapid sedimentation, while the assemblages in the middle part showed deeper (outer neritic) environments with low energy of currents and low rate of sedimentation. In general, ostracodal biostratigraphy is not as detailed as those based on foraminifera, due to their great sensitivity to ecological factors that control their distribution.

7 CONCLUSIONS

The foraminiferal contents for the same rock samples with ostracods and other macrofossils were employed in age determination and correlation. High-resolution biostratigraphy and palaeoecological investigations were carried out on the Guri Member in the Bandar Abbas area of the Zagros Mountains using mainly benthic foraminifera. In this study, 31 diagnostic benthic foraminifera species of the 17 genera, were encountered, and seven non-foraminifera with macrofossils of Mollusca, Echinodermata, bryozoans, seven ostracods, and corals were distributed, which led to five zones, revealing the early-middle Miocene age. The palaeoecological study shows that the Guri Member of the Mishan Formation in the studied section was deposited under subtropical to tropical environments, from mesotrophic to oligotrophic conditions, with soft sediments to hard sediments from open marine environments to shallower water depths, and deposited in normal water salinity environment ranging from 34 to 50 ‰.

Список литературы / List of references:

1. Adams, T.D., Bourgeois F., 1967, Asmari biostratigraphy. Iranian Oil Operating Companies, Geological and Exploration Division, Report 1074 (unpublished) 1–37.
2. Aghanabati, S.A., 2004, Geology of Iran. Geological Survey of Iran; 586.
3. Ahmad, P.M., 2020, Biostratigraphy of Oligocene-Miocene successions, Sangaw area, Kurdistan Region, Northeast Iraq. Dissertation, University Sulaimani. Iraq.
4. Alsouki, M., Riahi, M.A. & Abdollahie-Fard, I., 2008, Analysis of Miocene depositional systems in the offshore area of Hormuz Strait based on 3D-seismic data. Journal of Applied Sciences, 8, 1812–1821.
5. Amirshahkarami, M., Ghabishavi, A. and Rahmani, A., 2010, Biostratigraphy and paleoenvironment of the larger benthic foraminifera in wells sections of the Asmari Formation from the Rag-e-Safid oil field, Zagros Basin, southwest Iran, Stratigraphy and Sedimentology Research, 40, 63–84.
6. Amirshahkarami, M. and Taheri, A., 2009, Biostratigraphy characterization of the Rupelian-Burdigalian carbonate succession at the Chaman-Bolbol area in the Zagros Basin, Stratigraphy and Sedimentology Research, 40, 119–136.
7. Bahroudi, A. and Koyi Hemin, A., 2004, «Tectono-sedimentary framework of the Gachsaran Formation in the Zagros foreland basin», Marine and Petroleum Geology, 21, 1295–1310.
8. Bakhtiar, H.A., & Taheri, M.R., 2010, Microfossils Pictorial Atlas of Zagros Formations in Iran. Iran, Technical manager (geology).
9. Bassi, D., Nebelsick, J.H., 2010, Components, facies, and ramps: Redefining Upper Oligocene shallow water carbonates using coralline red algae and larger foraminifera (Venetian area, northeast Italy): Palaeogeography, Palaeoclimatology, Palaeoecology, 295, 258–280.
10. Brandano, M., Frezza, V., Tomassetti, L., Pedley, M., 2009, Facies analysis and paleoenvironmental interpretation of the Late Oligocene Attard Member (Lower Coralline Limestone Formation), Malta. Sedimentology, 56,1138–1158. doi: 10.1016/j.palaeo.2008.12.018
11. Brandano, M., Morsilli, M., Vannucci, G., Parente M., Bosellini F., Vicens G. (2010), Rhodolith-rich lithofacies of the Porto Badisco Calcarenites (upper Chattian, Salento, southern Italy). J Geosci, 129, 119–131. doi:10.3301/1JG.2009.10
12. Brandano, M., Frezza, V., Tomassetti, L., Cuffaro, M., 2009a, Heterozoan carbonates in oligotrophic tropical waters, The Attard member of the lower coralline limestone formation (Upper Oligocene, Malta): Paleogeography, Palaeoclimatology, Paleoecology, 274, 54–63.
13. Brasier, M.D., 1975, An outline history of seagrass communities. Paleontology 18:681–702.
14. Brasier, M.D., 1975a., Ecology of Recent sediment-dwelling and phytol foraminifera from the lagoons of Barbuda, West Indies. Journal of Foraminifera Research, 5, 42–46.
15. Brasier, M.D., 1984, Armstrong and Brasier, Microfossils, BLACKWELL PUBLISHING, Howard A. Armstrong, and Martin D. Brasier Copyright © 2005 by Blackwell Publishing Ltd.
16. Burchette, T.P., and Wright, V.P., 1992, «Carbonate ramp depositional system», Sedimentary Geology, 79, 3–57.
17. BouDagher-Fadel, M.K., 2008, Evolution and Geological Significance of Larger Benthic Foraminifera. Developments in Paleontology and Stratigraphy, 21, Elsevier, p. 540.

18. Boudagher-Fadel, M.K., 2018, Evolution and geological significance of larger benthic foraminifera, UCL Press.

19. BouDagher-Fadel, M.K., Wilson, M., 2000, A revision of some larger foraminifera of the Miocene of Southeast Kalimantan. Micropaleontology. 46.153–165. doi:10.2113/46.2.153

20. Bozorgnia, F., 1964, Microfacies and Microorganisms of Paleozoic through Tertiary sediments of some part of Iran, NIOC, 22P., CLVIIIPls.

21. Brandano, M., Frezza, V., Tomassett, L. and Cuffaro, M., 2009, Heterozoan carbonates in oligotrophic tropical waters: The Attard member of the lower coralline limestone formation (Upper Oligocene, Malta), Palaeogeography, Palaeoclimatology, Palaeoecology Journal, 274, 54–63.

22. Brandano, M., Frezza, V., Tomassetti, L., Pedley, M., Matteucci, R., 2009b, Facies analysis and palaeoenvironmental interpretation of the Late Oligocene Attard Member (Lower Coralline Limestone Formation), Malta: Sedimentology, 56, 1138–1158.

23. Brandano M., Morsilli M., Vannucci G., Parente M., Bosellini F., Vicens G., 2010, Rhodolith-rich lithofacies of the Porto Badisco Calcarenites (upper Chattian, Salento, southern Italy). J Geosci .129.119–131. doi:10.3301/1JG.2009.10

24. Barzgar, P., 1981, Razak fault. Third Geology of Iran Symposium, Iranian Petroleum Society, Abstract Volume (in Iranian).

25. Chaproniere GCH 1975 Paleoecology of Oligo-Miocene larger foraminifera, Australia. Alcheringa 1:37–58.

26. Cosovic, V., Drobne, K., Moro, A., 2004, Paleoenvironmental model for Eocene foraminiferal limestones of the Adriatic carbonate platform (Istrian Peninsula): Facies, 50, 61–75.

27. Daneshan, J. and Deziani, S., 2004. Study of Foraminifera Biostratigraphy of Qom Formation in Sorkh Deh, Southeast Ashtian, Journal of Sciences Islamic Azad University, 14.

28. Daneshian, J., and Ramezani Dana, L., 2007, Early Miocene benthic foraminifera and biostratigraphy of the Qom Formation, Deh Namak, Central Iran, Journal of Asian Earth Sciences 29, 844–858.

29. Flügel, E., 2010, Microfacies of Carbonate Rocks, Analysis, Interpretation and Application, 2nd Edition: Springer-Verlag, Berlin Hiedelberg, 984 p.

30. Geel, T., 2000, Recognition of stratigraphic sequences in carbonate platform and slope deposits: empirical models based on microfacies analysis of Palaeogene deposits in southeastern Spain: Palaeogeography, Palaeoclimatology, Palaeoecology, 155, 211–238.

31. Ghafor, I.M. (2004). Biometric analysis of *Lepidocylina* (*Nephrolepidina*) and Miogypsinids from Baba and Azkand formations (Oligocene-Miocene) In Kirkuk area, Iraq. Ph. D. Thesis. University of Sulaimani. Iraq. 70 Figs., 16 plates. 159 pages.

32. Ghafor, I.M., (2010). Systematic Description of Larger Foraminifera from Oligocene-Miocene in Different Oil Field, Kirkuk Area, North Iraq, Conference Proceedings, GEO 2010, European Association of Geoscientists & Engineers, GEO 2010, Mar 2010, cp-248-00408. DOI: Doi.org/10.3997/2214-4609-pdb.248.414

33. Ghafor, I.M., 2011, Microfacies and Biostratigraphy of Baba Formation (Late Oligocene) in Bai - Hassan, Oil Well-25. Iraqi Bulletin of Geology and Mining, 7, 25–32.

34. Ghafor, I.M., 2014, Biometric analysis of *Lepidocyclina (Nephrolepidina)* from Baba Formation (Late Oligocene) in Bai-Hassan Well-25, Kirkuk area, Northeast Iraq, Science Research, 2, 111-118, DOI: 10.11648/j.sr.20140205.16

35. Ghafor, I.M., 2015, Evolutionary aspects of *Lepidocyclina* (*Nephrolepidina*) from Baba Formation (Late Oligocene) in Bai-Hassan well-25, Kirkuk area, Northeast Iraq, Arabian Journal of Geosciences 8, 9423–9431. DOI: 10.1007/s12517-015-1865-9

36. Ghafor, I.M., (2022a, Biostratigraphy and microfacies of Azkand Formation in Qarah Chaugh-Dagh Section, Kirkuk Area (Northeastern Iraq). In: Çiner A. et al. (eds) Recent Research on Geomorphology, Sedimentology, Marine Geosciences, and Geochemistry. Book chapter, Springer, 2022, doi.org/10.1007/978-3-030-72547-1_45

37. Ghafor, I. M., (2022b, Systematic, micro biostratigraphy and paleoecology of the Bajwan Formation (Late Oligocene) in the Kirkuk Well-160, northeastern Iraq. Carbonates and evaporates. 37, 1–18. https://doi.org/10.1007/s13146-022-00793-2

38. Ghafor, I., F.Lawa, and.Karim, 2003, «New Discovery of Carnivores Mammalian Skeleton Fossils of Late Miocene-Early Pliocene Age from Chamchamal Area / Kurdistan Region/NE-Iraq». Journal of Zankoy Sulaimani-Part A, 6, 61–73.

39. Ghafor, I.M. and Muhammed, Q.A., 2005, Evolutionary Aspects of *Lepidocyclina* (*Nephrolepidina*) from Baba and Azkand Formations (Oligocene Miocene) in Kirkuk area, Iraq, Iraqi Journal of Earth Science*,* 5, 19–31.

40. Ghafor, I.M. & Muhammed, Q.A., 2007, Evolutionary Aspects of the Miogypsinidae from Azkand Formation (Oligocene-Miocene) in Kirkuk Area, Iraq, Iraqi National Journal of Earth Sciences, 7, 21–36.

41. Ghafor, I.M. & Muhammed, Q.A., 2011, *Lepidocyclina (Nephrolepidina) kirkukensis* n. sp., a new Larger Foraminifera from the Late Oligocene of Kirkuk Area, Northern Iraq, Iraqi National Journal of Earth Sciences, 11, 37–50.

42. Ghafor, I.M. Ahmad, P.M., 2019, Biostratigraphy and paleoecology of Anah Formation in the Pungalla village, Sangaw area, Sulaimaniya, Northeastern Iraq. Iraqi Bulletin of Geology and Mining 15,1–15.

43. Ghafor, I.M., Ahmad, P.M., 2021, Stratigraphy of the Oligocene early Miocene successions, Sangaw area, Kurdistan Region, NE-Iraq. Arabian Journal of Geoscience, 14,1–17. DOI. org/10.1007/s12517-021-06697-0

44. Ghafor, I.M., Karim, K.H. & Sissakian, V., 2014, Biostratigraphy of Oligocene succession in the High Folded Zone, Sulaimani, Kurdistan region, Northeastern Iraq, Arabian Journal of Geoscience, 7, 3599–3610. DOI: 10.1007/s12517-013-1067-2

45. Ghafor, I.M. & Najaflo, S., 2022, Biostratigraphy, microfacies, paleoenvironment, and paleoecological study of the Oligocene (Late Rupelian-Early Chattian) Baba Formation, Kirkuk area, Northeastern Iraq. Carbonates and Evaporates 37:7. DOI: org/10.1007/s13146-021-00753-2

46. Ghafor, I.M., Ahmad P.M., & Khafaf A.O., 2023. Biostratigraphy and paleoecology of the Anah Formation in Kurdistan Region, Iraq. Proceedings of the GEOKURDISTAN V – The 5th International Geological Conference of Kurdistan September 20–22 / 2022 Sulaimaniah, Kurdistan Region, IraqIraqi Bulletin of Geology and Mining. 19 (1).

47. Goff, J.C., Jones, R.W. & Horbury, A.D., 1994, Cenozoic basin evolution of the Northern part of the Arabian plate and its control on hydrocarbon habitat. In: M.I. Al-Husseini (Ed.), Middle East Petroleum Geosciences, GEO, 94, 402–412.

48. Gulf Petrolink., 1998, Exploration and production features the United Arab Emirates and Iran. Geo Arabia, 3, 427–455.

49. Hadavandkhani, N., 2010, Biostratigraphy ana Micropaleontological studies on the cutting and core sample of the sirri Farhad well, Department of Geological & Geochemical Studies and Research, Paleontological report: 773.

50. Hallock, P., 1999. Symbiont bearing foraminifera, in Sen Gupta B.K. Modern Foraminifera 123–139.

51. Halfar, J., Godinez-Orta, L., Mutti, M., Valdez- Holguin, J., Borges, J., 2004, Nutrient and temperature controls on modern carbonate production: an example from the Gulf of California, Mexico: Geology, 32, 213–216.

52. Heydari, A., Feldmann, R.M., Moussavi-Harami R., 2012, Miocene decapod crustacean from the Guri Member of the Mishan Formation, Bandar-Abbas, Southern Iran. Bulletin of the Mizunami Fossil Museum, 38: 1–7.

53. Henson, F.R.S.,1950, Middle Eastern Tertiary Peneroplidae (Foraminifera), With Remarks on The Phylogeny and Taxonomy of the Family, pl. 1–10; Text-Figs. i–iii.

54. Hohenegger, J., 2004, Depth coenoclines and environmental considerations of Western Pacific larger foraminifera. Journal of Foraminifera Research 34:9–33. doi: 10.2113/0340009

55. Homaiun-Zadeh, S., 2002, Lithostratigraphy and biostratigraphy of Mishan Formation in the central part of Dezful Embayment. 94 p., M.Sc. Thesis, Tarbiat-Moalem University, Tehran, Iran.

56. Hosseini, S.A., Haeri, H. and Kalantari, M., 2010, Biostratigraphy and Micropaleontological investigations on the surface samples of Kuh-e Gashu, Kuh-e Khamir, Kuh-e Khush and Kuh-e Genau, Bandar-e Abbas Hinterland, Department of Geological & Geochemical Studies and Research, Paleontological report: 751.

57. Hohenegger, J., 1996, Remarks on the distribution of larger foraminifera (Protozoa) from Palau (western Carolines). in Aoyama, The progress report of the 1995 survey of the research project, Man, and the environment in Micronesia. Kagoshima University Research Center for the Pacific Islands. Occasional Papers, 32, 19–45.

58. Hottinger, L., 1980, Repartition compare des grands foraminiferes de la mer Rouge et de l. ceanindien. Ann. Univ, vol. 6, pp. 35–51.

59. Hottinger, L., 1983, Processes determining the distribution of larger foraminifera in space and time.trecht Micropaleontology, 30, 239–253.

60. Hottinger, L., 1997, Shallow benthic foraminiferal assemblages as signals for depth of their deposition and their limitations: Bulletin de la Societé Géologique de France, 168, 491–505.

61. Huang, T., 1964, *Rotalia* group form the upper Cenozoic of Taiwan icropaleont.,10, 49–62. Iranian Oil Operating Cos. Company Geol.

62. Haynes, S.J., and McQuillan, H., 1974, Evolution of the Zagros Suture Zone, Southern Iran. Geological Society of America Bulletin, 85, 739–744.

63. James, N.P., Collins, L.B., Bone, Y., Hallock, P., 1999, Subtropical carbonates in a temperate realm, modern sediment on the southwest Australian shelf. J Sediment Res 69:1297–1321.

64. James, G.A. and Wynd, J.G., 1965, stratigraphic nomenclature of Iranian oil consortium agreement area. American Association of Petroleum Geologists Bulletin, 49, 2182–2245.

65. Joudaki, M., & Baghbani, D., 2018, «Biostratigraphy of Oligocene and Lower Miocene deposits, Anneh Anticline, Folded Zagros, SW of Iran», Carbonates and Evaporites, 33, 509–515.

66. Kalantari, A.,1986, Microfacies of carbonate rocks of Iran, National Iranian Oil Campany, Geological Laboratory Publication, Tehran, 11, 520.

67. Kroh, A., Gholamalian, H., Mandic, O., Ćoric, S., Harzhauser, M., Reuter, M., Piller, W., 2004, Echinoids and pectinid bivalves from the Early Miocene Mishan Formation of Iran. Acta Geologica Polonica, 61, 419–439.
68. Kumar, A., Saraswati, P.K., 1997, Response of larger foraminifera to mixed carbonate-siliciclastic environments: an example from the Oligocene-Miocene sequence of Kutch, India. Palaeogeogr Palaeoclimatol Palaeoecol, 136, 53–65.
69. Laursen, G.V., Monibi, S., Allan, T.L., Pickard, N.A.H., Hosseiney, A., Vincent, B., Hyamon, Y., Van Buchem, F.S.H., Moallemi, A. and Driullion, G., 2009, The Asmari Formation revisited: Changed stratigraphic allocation and new biozonation. First international petroleum conference & exhibition, Shiraz, Iran.
70. Leckie, R.M., Olsen, H.C., 2003, Foraminifera as proxies of sea-level change on siliciclastic margins. In: Olsen HC, Leckie RM (Eds) Micropaleontologic proxies for sea-level change and stratigraphic discontinuities. SEPM Special Publication, 75, 5–9
71. Leutenegger, S., 1984, Symbiosis in benthic foraminifera, specificity, and host adaptations. Journal of Foraminifera Research, 14, 16–35.
72. Mazzucchi, A., Tomassetti, L., 2011, Coral bioconstruction in a Burdigalian mixed siliciclastic-carbonate coastal system (Cala paraguano, Corsica): Mediterranean Earth sciences, 3, 15–23.
73. Movahed B., Petrology, 1995, microfacies, and sedimentary environment of Guri Member from Mishan Formation in North of Bandar-Abba's region. M.Sc. thesis (in Iranian).
74. Moghaddam, I.M., Roozpeykar, A., & Shirmohamadi G., 2019, «Biostratigraphy of early Oligocene-Early Miocene benthic foraminifera in Lorestan Zone, south-west Iran», *Indian Journal of Geo-Marine Sciences* 48(6): 925–935.
75. Muhammed, Q.A. and Ghafor, I.M., 2008. Biometric Analysis of Miogypsinidae and their Taxonomic Significance from Azkand Formation (Oligocene-Miocene) in Kirkuk area, Iraq, Tikrit Journal of Pure Science, Vol. 13, No.1, p. 198–213.
76. Mossadegh, Z.K., Haig, D.W., Allan, T., Adabi, M.H., Sadeghi, A. (2009) Salinity changes during late Oligocene to early Miocene Asmari formation deposition, Zagros mountains, Iran. Palaeogeogr Palaeoclimatol Palaeoecol 272,17–36. doi: 10.1016/j.palaeo.2008.10.021
77. Motiei, H., 1993 treatise on Geology of Iran, the stratigraphy of Zagros. Geological Survey of Iran; 536.
78. Pecheux, M.J.F., 1995, Ecomorphology of a recent large foraminifer, Operculina ammonoides. Geobios 28:529–566. doi:10.1016/S0016-6995(95)80209-6
79. Pedley, M., 1998, A review of sediment distributions and processes in Oligo-Miocene ramps of southern Italy and Malta (Mediterranean divide): Geological Society, London, Special Publications, 149(1), 163–179.
80. Pilarczyk, J.E., Reinhardt, E.G., Boyce, J.I., Schwarcz, H.P. and Donato, S.V., 2011, Assessing surficial foraminiferal distributions as an overwash indicator in Sur Lagoon, Sultanate of Oman, Marine Micropaleontology journal, 80, 62–73.
81. Pomar, L., 2001, Ecological control of sedimentary accommodation: evolution from a carbonate ramp to rimmed shelf, Upper Miocene, Balearic Islands: Palaeogeography, Palaeoclimatology, Palaeoecology, 175, 249–272.
82. Pomar, L., Hallock, P., 2008, Carbonate factories: A conundrum in sedimentary geology: Earth-Science Reviews 87, 134–169.
83. Pomar, L., Bassant, P., Brandano, M., Ruchonnet, C., Janson, X., 2012, Impact of carbonate producing biota on platform architecture: Insights from Miocene examples of the Mediterranean region: Earth-Science Reviews, 113, 186–211.
84. Rahmani, Z., Vaziri-Moghaddam, H. and Taheri, A., 2010, Faciesdiestribution and paleoecology of the Guri member of the Mishan Formation, in Lar area, Fars province, SW Iran. Iranian Journal of Science and Technology, 34, 257–266.
85. Rasser, M.W., Scheibner, C., Mutti, M., 2005, A paleoenvironmental standard section for Early Ilerdian tropical carbonate factories (Corbieres, France; Pyrenees, Spain). Facies, 51,217–232.
86. Rashidi, R.F., Vaziri, S.H., Khaksar, K.K. and Gholamalian, H., 2014, Lithostratigraphy of the Mishan Formation in North, and West of Hormozgan province (South of Iran).
87. Rashidi, R.F., Vaziri, S.H., Keyvan Khaksar, K.K., Hossein Gholamalian, H., 2015, Paleoecology of Early to Middle Miocene Deposits (Guri Member) and Sedimentary Environment, SE Zagros Zone, Roydar, Iran, Fanati Rashidi et al. / Iranian Journal of Earth Sciences, 7, 68–77.
88. Reiss, Z. and Hottinger, L., 1984. The Gulf of Aqaba, Ecological micropaleontology. Berlin: Springer, 354.
89. Sadeghi, A., Vaziri-Moghaddam, H., and Taheri, A., 2009, «Biostratigraphy and paleoecology of the Oligo-Miocene succession in Fars and Khuzestan areas (Zagros Basin, SW Iran)», Historical Biology, 21,17–31.

90. Sajadi, S.H., Baghbani, D. & Daneshian, J., 2014, Facies Distribution, Paleoecology and Sedimentary Environment of the Oligocene-Miocene (Asmari Formation) deposits, in Qeshm Island, SE Persian Gulf.Advances in Environmental Biology, 8, 2407–2418.

91. Samankassou, E., 2002, Cool-water carbonates in paleo equatorial shallow-water environment: the paradox of the Auering cyclic sediments (Upper Pennsylvanian, Carnic Alps, Austria-Italy) and its implications. Geology, 30,655–658. doi: 10.1130/0091-7613(2002)030< 0655:CWCIAP>2.0.CO;2

92. Schlager , W. (2005), Carbonate sedimentology and sequence stratigraphy, vol. 8, SEPM, USA, p. 200.

93. Serra-Kiel, J., Hottinger, L., Caus, E., Drobne, K., Ferrandez, C., Jauhri, A.K., Less, G., Pavlovec, R., Pignatti, J., Samso, J.M. and Schaub, H., 1998, «Larger foraminiferal biostratigraphy of the Tethyan Paleocene and Eocene», Bulletin de la Société géologique de France, 169, 281–299.

94. Serra-Kiel, J., Gallardo-Garcia, A., Razin, P., Robinet, J., Roger, J., Grelaud, C., Robin, C., 2016, «Middle Eocene-Early Miocene larger foraminifera from Dhofar (Oman) and Socotra Island (Yemen)», Arabian Journal of Geosciences 9(5).

95. Sirel, E., Özgen-Erdem, N., & Kangal, Ö. (2013), «Systematics and biostratigraphy of Oligocene (Rupelian-early Chattian) foraminifera from lagoonal-very shallow water limestone in the eastern Sivas basin (central Turkey)», Geologia Croatica 66, 83–110.

96. Stocklin, J., 1968, Structural history and tectonics of Iran: a review. Bull Am Assoc Pet Geol 52:1229–1258.

97. Stöcklin, J. & Setudehnia, A., 1991, Stratigraphic lexicon of Iran. Geological Survey of Iran Report, 18, 1–376.

98. Taheri, M.R., Mogaddam, H.V., Taheri, A., Ali Ghabeishavi, A., 2017, Biostratigraphy and paleoecology of the Oligo-Miocene Asmari Formation in the Izeh zone (Zagros Basin, SW Iran), Boletín de la Sociedad Geológica Mexicana.

99. Tomassetti, L., Brandano, M., 2013, Sea level changes recorded in mixed siliciclastic-carbonate shallow-water deposits: The Cala di Labra Formation (Burdigalian, Corsica): Sedimentary Geology, 294, 58–67.

100. Vega, F.J., Gholamalian, H. & Bahrami, A., 2010, First record of Miocene crustaceans from Hormozgan Province, Southern Iran. Paläontologisch Zeichrift, 84: 485–493.

101. Vega, F.J., Gholamalian, H., Hassani, M.J., Sajadi, S.H. & Schaaf, P., 2012, Miocene Crustacea from northern Bandar Abbas, South Iran. Neues Jahrbuch fur Geologie und Paläontologie Abhandlungen, 265, 221–234.

102. Wilson, J.L., 1975, Carbonate facies in geologic history. Berlin: Springer, 471.

103. Yazdi, M., Bahrami, A., Abbasi, P., Sadeghi, R. & Vega, F.J., 2013, Miocene brachyuran Crustacea from Konar-Takhteh and Ahram sections, southwestern Iran. Boletín de la Sociedad Geológica Mexicana, 65, 225–233.