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Microbiostratigraphy of the Qom Formation in Southwestern Tafresh, Central Iran

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Abstract

The Qom Formation, a series of shale, sandstone and carbonate deposits, is a result of the last transgression of the sea in the Central Iran sedimentary basin. Foraminifera are one of the most important and numerous fossil groups present in the Qom Formation. In this study, the micropaleontology of the Qom Formation, located in southwestern Tafresh is divided into three measured stratigraphic sections (Rakin, Band-e-Ali Naghi Beig and Hezar Abad). From a stratigraphic point of view, except for the Rakin section, the lower and upper boundaries of the Qom Formation are similar to Lower and Upper Red formations. There is, however, no outcrop on the upper boundary of the Rakin stratigraphic section. The study of 78 samples taken from the studied sections led to the identification of 34 genera and 39 species of benthonic foraminifera, 2 genera and 2 species of planktonic foraminifera, 4 genera of red algae and 3 genera of bryozoan. Based on the recognized foraminifera such as *Lepidocyclina* (*Nephrolepidina), Miogypsioides* sp.*, Meandropsina anahensis and Ammonia beccarii* the age of the Qom Formation in the Rakin stratigraphic section was determined to be Chatian-Aquitanian while the Band-e-Ali Naghi Beig and Hezar Abad stratigraphic sections were determined to be Aquitanian.

Keywords: *Qom Formation, Iran, Tafresh, Foraminifera, Oligocene, Miocene.*

Introduction

The Qom Formation, a series of shales, sandstones and carbonate deposits (Oligocene-Miocene), is a result of the last transgression of the sea in the Central Iran zone (Reuter et al., 2007). The Qom Formation was introduced by Loftus (1855) as a *Nummulitic* series of Oligocene age. After oil was discovered in 1934 [1], this formation became a part of scientific research, such as Gansser [2], Furrer and Suder [3], Abaie et al. [4], Bozorgnia [5], Rosenberg [6], Khaksar and Maghfouri-Moghadam [7] and Daneshian and Ramezani Dana [8].

Furrer and Suder [3] divided the Qom Formation into five members (*a-f* members) and introduced the mountains in the vicinity of Qom as type locality. Later, Abaie et al. [4] divided the *c* member into four sub-members (c_1-c_4) (Fig. 1) and Furrer and Suder introduced another evaporate member (*e* member). Also, Bozorgnia [5] also considered an unnamed member at the base of the Qom Formation in the Kashan area. As mentioned above, the Qom Formation is divided into 9 members. Listed from the base to the top they are as follows:

• Member a (basal limestone, 34-80 m): brown, massive and thick-bedded organodetrital limestone, sandy in the lowermost part. These deposits contain Corals bryozoan fragments, miliolids, textularids, rotalids and *Scutella*.

• Member b (149-319 m): marls, sandy marls and sandstones, partly glauconitic, contain *Miogypsinoides complanata*, *Miogypsina* sp., *Rotalia viennoti* and *Globorotalia opima opima*.

• Member c1 (130-380 m): alternating organodetrital limestones and marls, the latter increasing top ward. This member is rich in microfauna such as: *Miogypsinoides complanata*, *Miogypsina* sp., *Rotalia viennoti*, *Anomalinella rostrata*, *Discorbis magna aquitanica*, *Eulepidina elephantine*, *Operculina* cf. *complanata*, *Heterostegina antillea*, *Amphistegina* cf. *lessonii*, *Nephrolepidina* sp., *Globigerina ouachitaensis ciperoensis*, *G. praebulloides*, *G. angustiumbilicata*, *Globigerinoides triloba immature* and *G. triloba triloba*. This assemblage is replaced in the uppermost part of the member by a brackish water fauna with *Ammonia beccarii*, *Elphidium* sp., *Ilyocypris bradyi*, etc.

• Member c2 (6-150 m; locally in a partial volcanic facies up to 300 m): red and grey shales, sandstones and gypsum locally, with lava and pyroclastic beds and brackish to fresh water ostracods.

• Member c3 (30-70 m): bryozoan limestone having a persistent oolithic bed at the base and containing *Lepidocyclina* (*Eulepidina*) sp., *Lepidocyclina* (*Nephrolepidina*) sp., *Amphistegina lessonii*, bryozoan fragments.

• Member c4 (about 30 m): mostly marls, but in places

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passing laterally into calcareous shales and reefal limestones containing *Globigerinita stainforthi*, *G. unicava*, *Globigerina ouachitaensis ciperoensis*, *G. praebulloides*, *Globigerinoides triloba triloba*.

• Member d (20-40 m): gypsum with some red shale, barren.

• Member e (80-650 m): green marls, partly gypsiferous, with slight intercalations of argillaceous limestone containing *Globigerina ouachitaensis*, *G. angyustiumbilicata*, *G. praebulloides*, *Globigerinoides triloba triloba*, *G. triloba* n. subsp., *G. sacculifera*, *G. bisphaerica*, *Robulus calcar*, *R. vertex*, *Cibicides ungerianus*, *C. dutemplei*, *C. floridanus* and *Globigerinatella insueta*.

• Member f (top limestone, 180-320 m): whitish-yellow limestone, interfingering with green marls of the e-Member contain *Neoalveolina melo curdica*, *Peneroplis evolutus*, *Dendritina rangii*, *Meandropsina anahensis*, *Acervulina* sp., *Archaias* sp., bryozoan and gastropods.

Aims

The aim of this paper is to clarify the stratigraphic setting of the Qom Formation in southwestern Tafresh based on recorded foraminifera assemblages.

Material and methods

In this research three stratigraphic sections (Rakin, Band-e-Ali Naghi Beig and Hezar Abad) in southwestern Tafresh, Markazi province were studied (Fig.4). Each section was measured and logged. Samples were taken from Rakin stratigraphic section 27 at less than 3 meter intervals. Twenty six samples were collected from the Band-e-Ali Naghi Beig stratigraphic section at 3 to 4 meter intervals along with 23 samples from the Hezar Abad stratigraphic section.

Geological Setting and Micropaleontological Studies

The basal portion of the Cenozoic rocks in the Tafresh area are of Eocene age. The Karaj Formation consists of exposed turbiditic and pyroclastic rocks and is part of the Urumieh–Bazman volcanic belt (figs. 5 & 6). Orogenic movement in the Late Eocene- Early Oligocene resulted in the creation of a lagoon to continental sedimentary regime characterized by detritus sediments of Lower Red Formation. Qom Formation carbonates represent marine transgressions in this area with calcareous marl sedimentation. During this period andesitic volcanism occurred locally. In the Late Miocene, thick lagoon continental deposits of Upper Red Formation were replaced by marine depositions of the Qom Formation [9].

This study is based on micropaleontological analysis of 76 thin sections. Four marly shale samples were used for washing and micropaleontological study. In addition, 37 thin sections were made from isolated larger foraminifera. The systematic determination of the foraminifera mainly follows the description of Leoblich-Tappan [10]. Planktonic foraminifera are rare in the studied sections, making a correlation to the standard planktonic zonation difficult. Biostratigraphic zonation is therefore based on the larger foraminifera which are abundant. Considerable similarities can be observed between the foraminifera from the Qom and the Asmari formations (in Zagros basin, SW Iran). The correlation between these formations has been noted by various authors such as Daneshian and Ramezani Dana [8].

Larger foraminifera are the main means for the stratigraphic zonation of carbonate sediments. The biostratigraphical contents of the Asmari Formation were described by Wynd (1965) and reviewed by Adams and Bourgeois [11]. Therefore, we applied the biozonation of Adams and Bourgeois [11] which comprises an Oligocene-Miocene carbonate sequences for the bio-correlation of the Qom Formation. Adams and Bourgeois [11] divided the Asmari Formation into three biozones and correlated these zones to lithostratigraphic subdivisions of Less [12] (Fig. 2).

Recently, Sr-isotope measurements clearly show that the zonation of Adams and Bourgeois [11] is fairly robust and the marker species are more stratigraphicaly restrained [13-15]. The age assignment of the *Archias asmaricus–Archias hensoni* Assemblage subzone previously assigned to Aquitanian by Adams and Bourgeois [11] has changed to Chattian [16] (Fig. 3).

Rakin stratigraphic section

The Qom Formation outcrop is exposed in the north-northeastern section of Farmahin, 25 km west of Tafresh. The exposure of the Qom Formation at this location is 121.4 m thick and is light-gray in color. From a microfaices point of view, it contains benthic foraminifera packstone, bryozoan, corallinacea packstone and rudstone. Particles of spongia and pelecypoda are also present (Fig.7).

The interval from base of the section to 63 m belongs to Assemblage Zone 56 of Wynd (1967) and to Assemblage Zone no.3 of Adams and Bourgeois [11]. The upper part of the section belongs to Assemblage Zone 59 of Wynd (1967) and Assemblage zone no.2a of Adams and Bourgeous [11]. The lowest occurrence of complex benthic foraminifera can be found 17 m above the section. The boundary between Chattian and Aquitanian stages is marked by the first occurrence of *Miogypsina* sp. and last occurrence of *Lepidocyclina (Nephrolepidina)*. Assebblage Zone 56 contains microfauna such as:

Age	Rock Units		Lithology
Burdigalian	Evaporate Member		Gypsum, Marl, Sandstone
	Member f		Reefal limestone
	Member e		Light green to gray Marl, Gypsum
	Member d		Clay, Gypsum, Marl
Aquitanian	Member C	C_4	Marl, Limestone
		C_3	Limestone, Marl, Packstone (superficial)
		C_2	Gypsum, Limestone, Marl
		C_1	Sandstone, Marl, Glauconite, Limestone
	Member b		Sandy marl, Sandstone, Reefal limestone
Chatian	Member a		Sandy limestone, Sandstone
Reuplian	Unnamed Member		Limestone, Marl

Fig 1. Lithostratigraphic units of the Qom Formation.

Age	Rock units	Biozone	
Burdigalian	Upper Asmari	*Borelis melo* group, *Meandropsina iranica* Assemblage zone	
Upper Aquitanian	Upper middle Asmari	*Miogypsinoides*, *Archaias*, Valvulinid sp.1 Assemblage zone	*Miogypsina*, *Elphidium* sp. 14 Assemblage subzone
Lower Aquitanian	Lower Middle Asmari		*Archaias asmaricus*, *Archaias hensoni* Assemblage subzone
Chatian Reuplian	Lower Asmari	*Eulepidina*, *Nephrolepidina*, *Nummulites* Assemblage zone	

Fig. 2. Traditional biostratigraphical units of the Asmari Formation after [11]

Traditional Zonation				New Zonation	
Age interpretation		Wynd(1965)	Adams&Bourgeous (1969)	Age interpretation	
Miocene	Burdigalian	Borelis melocurdica (zone 61)	*Borelis melocurdica-Meandropsina iranica*	Burdigalian	Miocene
	Aquitanian	*Austrotrilina howchini Penroplis evolutus (zone 59)*	*Eiphidiun* sp *14.Miogypsina* sp	Aquitanian	
			Miogypsinoides Archias Valvulinid / Archias asmaricus Archias hensoni	Chatian	Oligocene
Oligocene	Oligocene undivided	*Archias Operculiformis (zone 58) Nummulites vascus N intermedius (Zone 56)*	*Eulepidina Nepherolepidina Nummulites* / *Globigerina*	Ruplian	
		Lepidocyclina Operculina Ditrupa(zone 59)			

Fig. 3. New age interpretation of zones after Sr-evaluation (After [16])

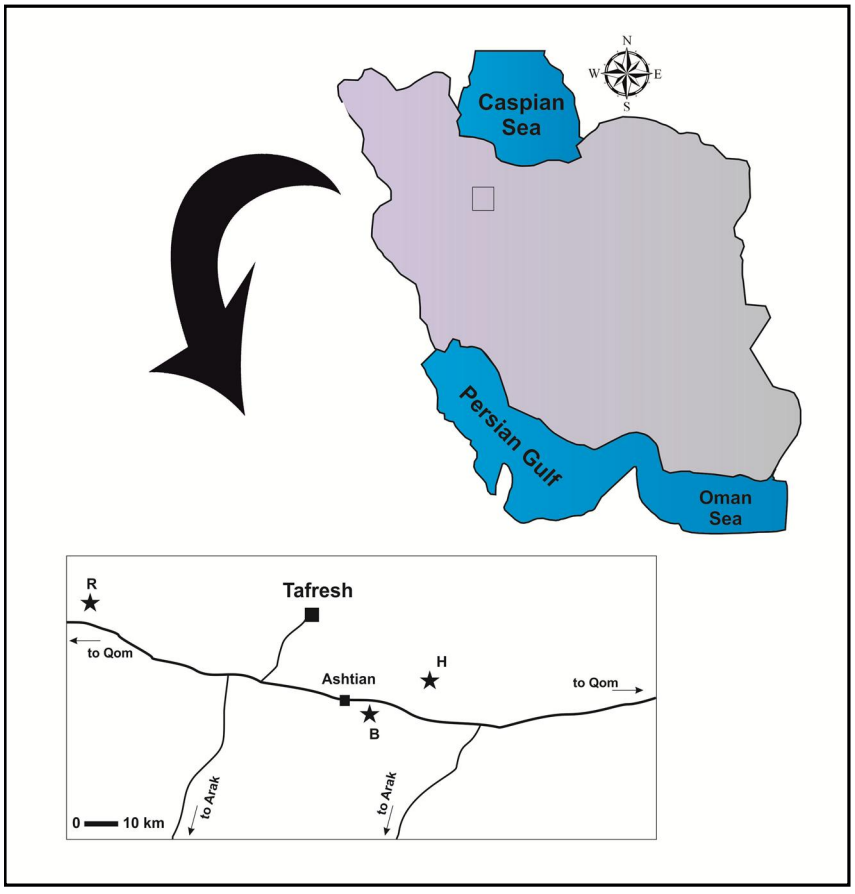

Fig. 4. Road map of the studied stratigraphic sections (B: Band-e-Ali Naghi Beig, H: Hezar Abad, R: Rakin)

Lepidocyclina (Nephrolepidina), Miogypsioides sp., *Austrotrillina paucialveolata, A. howchini, Borelis pygmea, Asterigerina* sp., *Dendritina rangi*, *Miogypsina* sp., *Operculina complanata*, *Operculina* sp., *Amphistegina* sp., *Discorbis* sp.2, *Nephrolepidina* sp., *Borelis melogroup*, *sphaerogypsina* sp., *Globorotalia* sp., *Rotalia viennoti*, *Heterostegina* sp., *Ruessella* sp., *Cibicides* sp., *Bigerina* sp., *Asterigerina rotula*, *Miogypsinoides* sp., *Lenticulina* sp.1, *Planorbulina* sp., *Globigerina* sp., *Austrotrilina howchini*, *Triloculina* sp., *Miliolina* sp., *Pyrgo* sp., *Textularia* sp., *Lithophyllum* sp., *Lithothamnium* sp., *Lithoporela* sp., *Onycocella* sp., *Tubocellaria* sp.

The biozones, with respect to the occurrence of microfauna were determined to be *Miogypsinoides* sp.-*Miogypsina* sp. zone, which is the same as biozone no.2 of Adams and Bourgeois [11]. These rocks can be correlated with the Middle Asmari Formation and b**,** c1 members of the Qom Formation in type locality.

Based on these microfauna, the outcrop of the Qom Formation, Rakin section is Early Miocene (Aquitanian) in age while *Nephrolepidina* with *Nummulites* suggest it is Oligocene in age. However without *Nummulites* the age is reported as Early Miocene [8].

Band-e-Ali Naghi Beig stratigraphic section

The Qom Formation outcrop is exposed in the eastern portion of the city of Ashtian, 42 km south of Tafresh. The exposures of the Qom Formation at this location are 144.2 m thick and consist of conglomerates, silt, limestone, shale and sandy limestone. From a microfacies point of view, it contains benthic foraminifera and corallinacea packstone to wackstone and bryozoa wackstone. Benthic foraminifera, bryozoans and corallinacea are the predominant allochems. Particles of mollusca and echinodermata are also present (Fig.8).

The following microfauna were identified in the limestone of the Qom Formation in the Band-e-Ali Naghi Beig stratigraphic section (Fig.8):

Bozorgniella sp., *Archaias* sp., *Miogypsina* sp., *Elphidium* sp., *Operculina complanatus, Miogypsinoides* sp., *Ammonia beccarii, Amphistegina* sp., *Rotalia viennoti, Asterigerina rotula, Textularia* sp., Miliolid, *Operculina* sp., *Austrotrillina* sp., *Quinqueloculina* sp., *Triloculina* sp., *Asterigerina* sp., *Heterostegina* sp., *Ruessella* sp., *Textularia* sp., *Rotalia* sp., *Triloculina trigonula, Discorbis* sp., *Pyrgo* sp., *Lithothamnium* sp., *Lithoporella* sp., *Mesophyllum* sp., *Lithophyllum* sp., *Tubucellaria* sp., *Cellepora* sp., *Onycocella* sp.

Based on the studied microfauna, the outcrop of the Qom Formation in this section is Lower Miocene (Aquitanian) in age. The biozone, with respect to the occurrence of microfauna was determined as *being Miogypsinoides-Ammonia beccarii* Zone, which is the same as biozone no.2 of Adams & Bourgeois [11].

Hezar Abad stratigraphic section

The outcrops of the Qom Formation located in the Hezar Abad stratigraphic section are 7 km from the city of Ashtian and 46.8 km south of Tafresh. The Qom Formation exposures at this location are 78.2 m thick and consist of conglomerate, limestone, shale and marl. From the microfacies point of view, it contains bryozoa wackstone and corallinacea packstone, wackstone and benthic foraminifera packstone, as well as grainstone. Benthic foraminifera, bryozoans and corallinacea are the predominant allochems. Particles of mollusca and echinodermata were also identified (Fig10).

The following microfauna are identified in the limestone of the Qom Formation at Hezar Abad (Fig.9): *Elphidium* sp., *Archaias* sp., *Elphidium crispum*, *Austrotrillina asmariensis, Miogypsinoides* sp., *Massilina* sp., *Spiroloculina* sp., *Ammonia beccarii, Rotalia* sp., *Textularia* sp., Miliolid, *Rotalia viennotti*, *Austrotrillina* sp., *Quinqueloculina* sp., *Triloculina* sp., *Triloculina trigonula, Asterigerina* sp., *Discorbis* sp., *Textularia* sp., *Pyrgo* sp., *Miliola* sp., *Lithothamnium* sp., *Lithoporela* sp., *Lithophyllum* sp., *Mesophyllum* sp., *Tubucellaria* sp., *Cellepora* sp. and *Onycocella* sp..

Based on these microfauna, the Qom Formation exposures in this section are Lower Miocene (Aquitanian) in age. The bryozoans, with respect to the occurrence of microfauna were determined as *Miogypsinoides- Ammonia beccarii* Zone, which is the same as Biozone-2 of Adams & Bourgeois [11].

Conclusion

The Qom Formation was deposited with extended mixed carbonate-siliclastic sediments on the north-eastern coast of the Tethys. Detailed studies of the diverse assemblage of larger foraminifera recovered from the studied stratigraphic sections have enabled biostratigraphic conclusions to be drawn. Hence, the outcrops of the Qom Formation in all studied stratigraphic sections are Lower Miocene (Aquitanian) in age, which is the same as biozone no.2 of Adams & Bourgeois [11]. As a result, these rocks can be correlated with the Middle Asmari and top *b* and c_1-c_2 members of the Qom Formation at the type locality.

The existence of the different fauna here is due to lateral variations of the paleoenvironment and paleoecology in the studied stratigraphic sections. In the Rakin stratigraphic section, the Qom Formation was deposited under reef, to open marine conditions. However, in the other studied stratigraphic sections, this formation was deposited under a restricted, to near-shore environment.

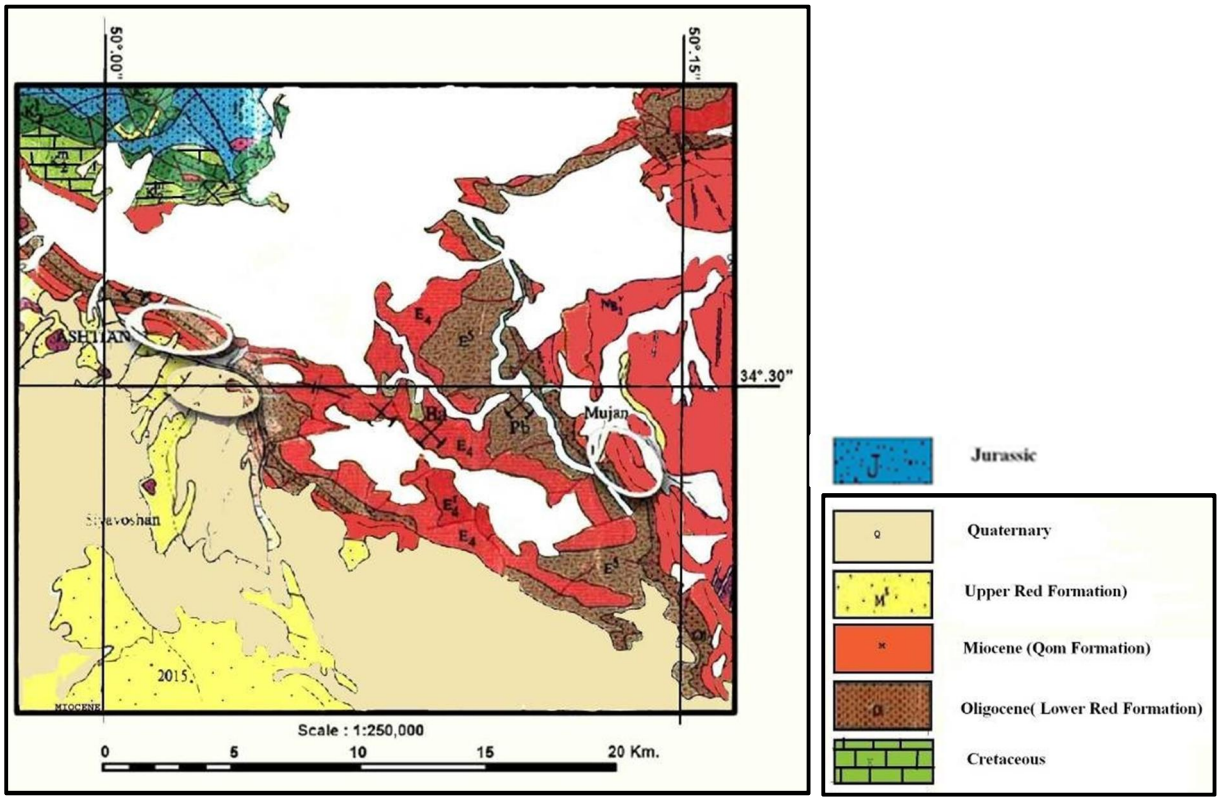

Fig. 5. Geological map of Band-e-Ali naghi beig and Hezar-Abad stratigraphic sections [17]

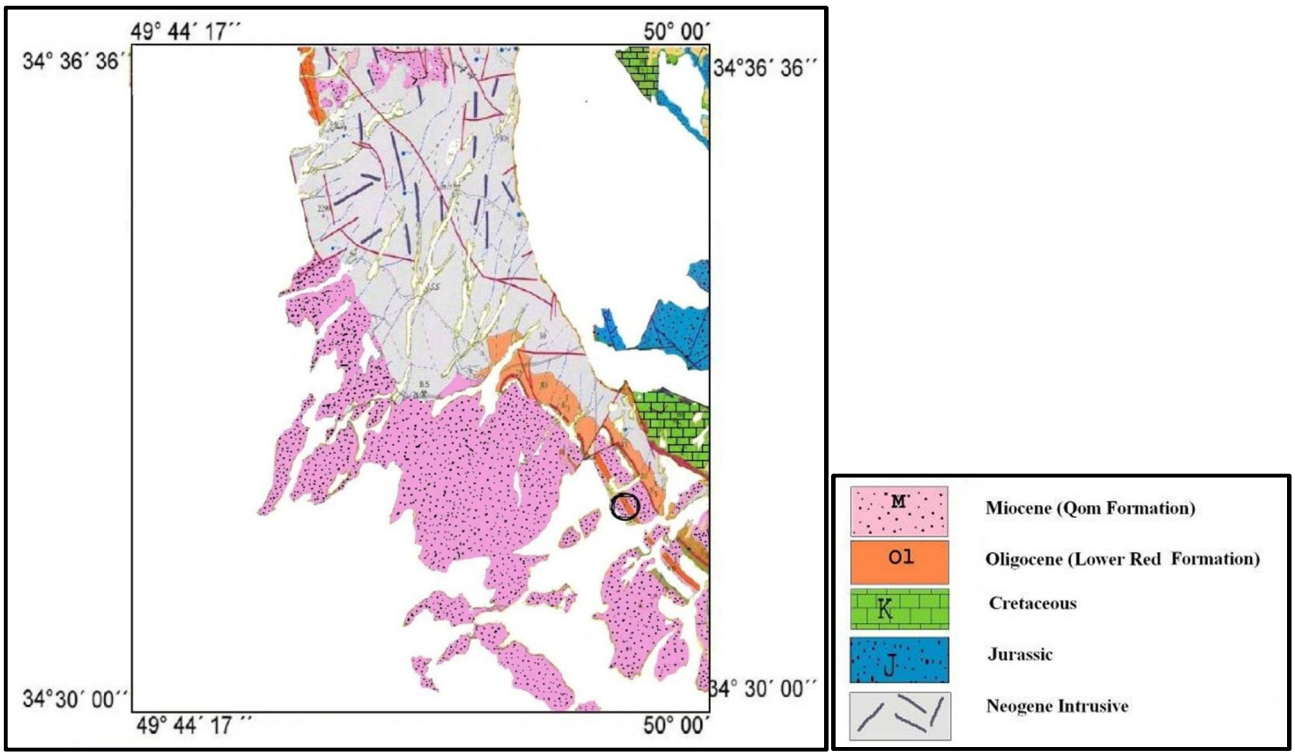

Fig. 6. Geological map of the Rakin stratigraphic section [17]

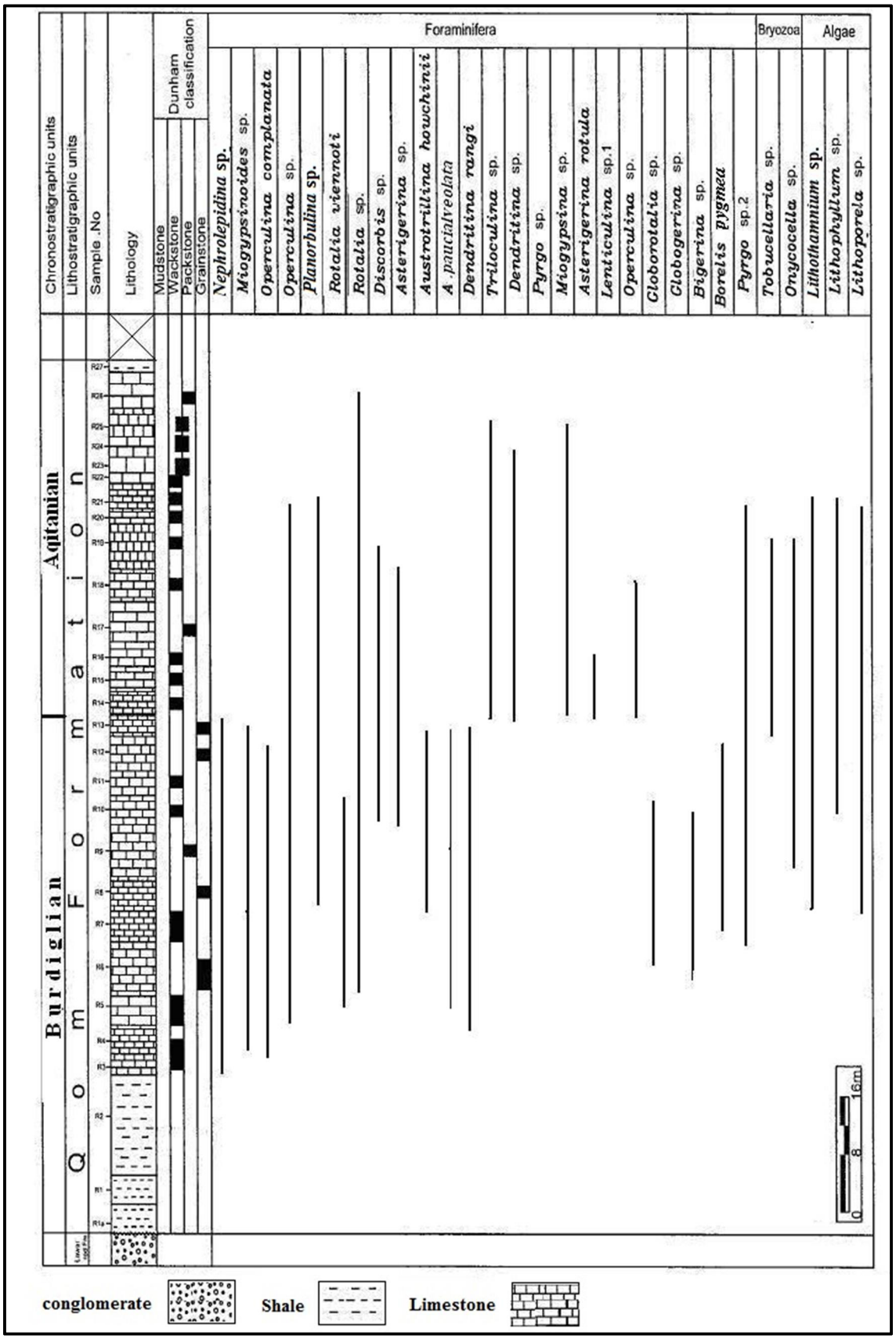

Fig. 7. The relative abundance, occurrence and range of foraminifera, with different biostratigraphic zonation schemes of the Qom Formation in the Rakin stratigraphic section.

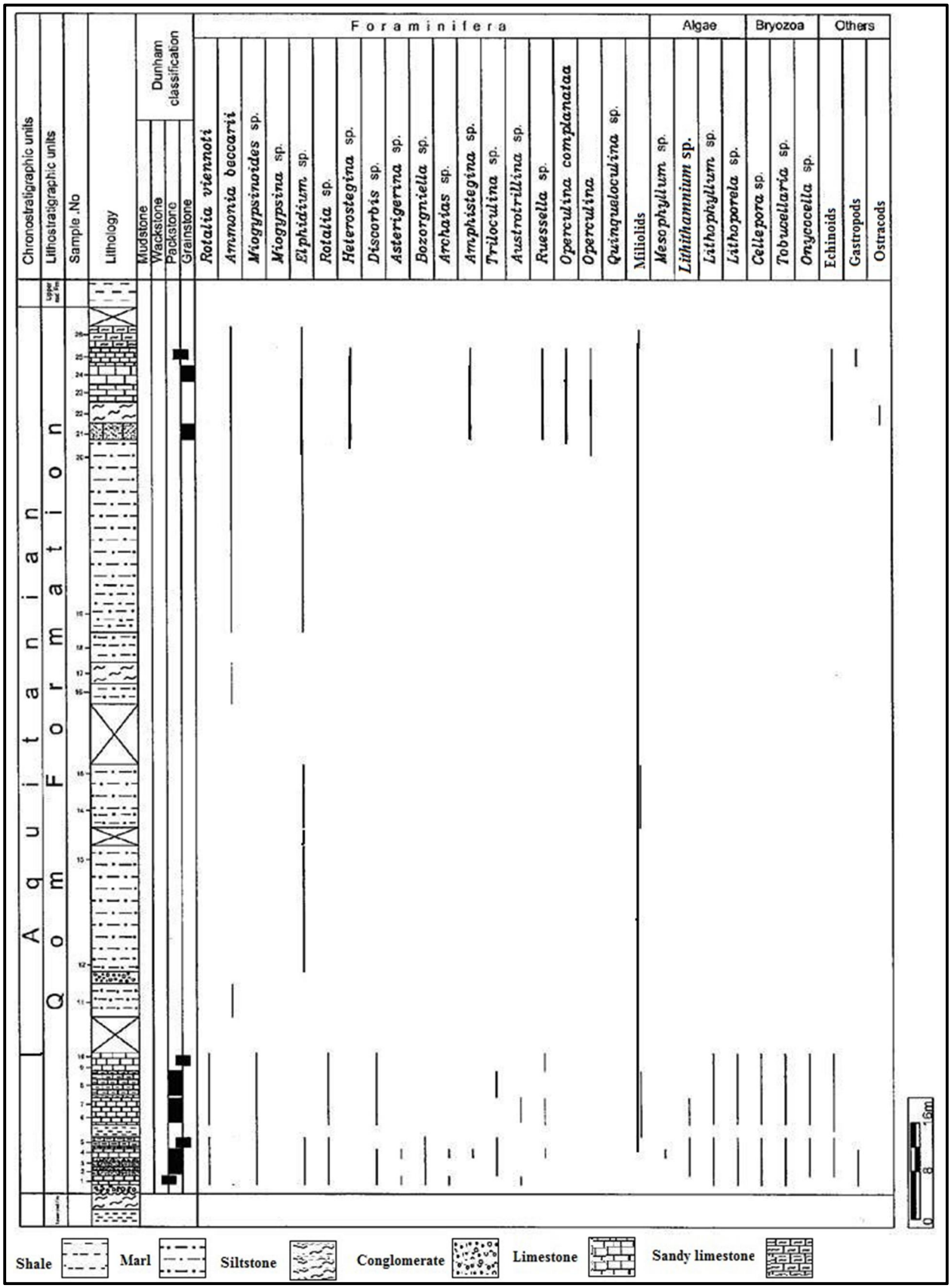

Fig. 8. The relative abundance, occurrence and range of foraminifera, with different biostratigraphic zonation schemes of the Qom Formation in the Band–e Ali Naghi Beig stratigraphic section.

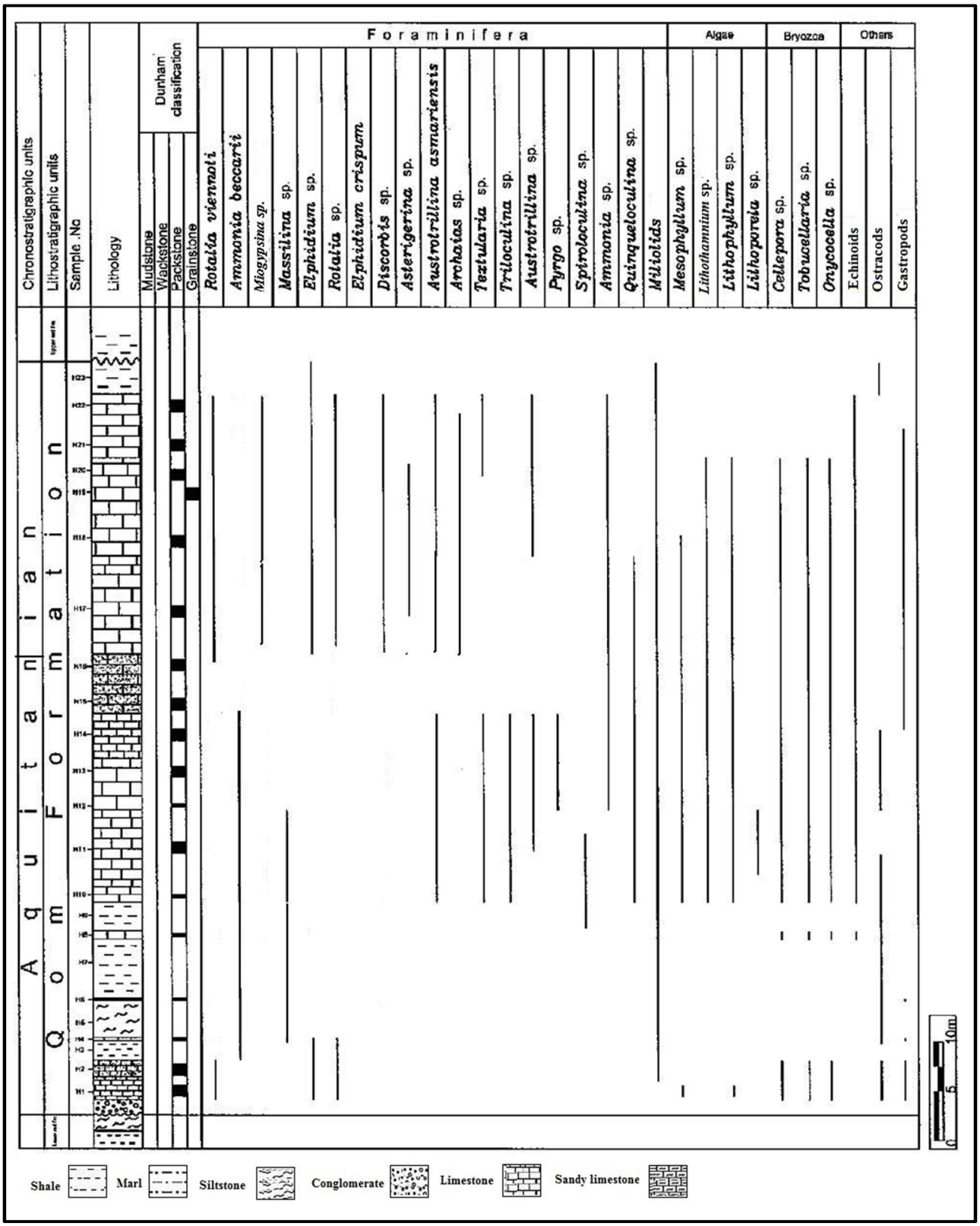

Fig. 9. The relative abundance, occurrence and range of foraminifera, with different biostratigraphic zonation schemes of the Qom Formation in the Hezar Abad stratigraphic section.

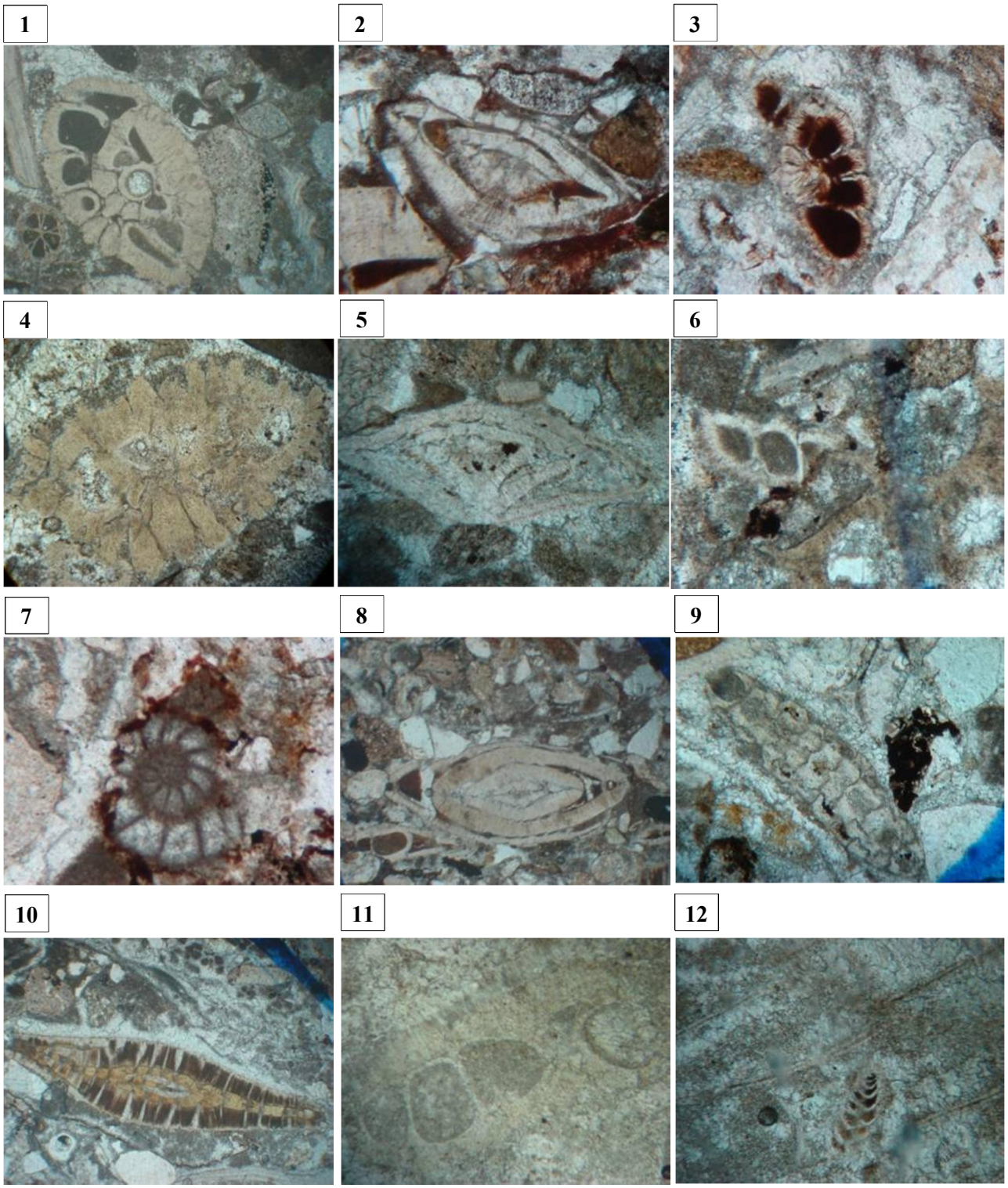

Fig. 10. (1) *Rotalia viennoti* (Sample No. 21, Band-e-Ali Naghi Beig stratigraphic section, 18X), (2) *Amphistegina* sp. (Sample No. 25, Band-e-Ali Naghi Beig stratigraphic section, 18X), (3) *Ammonia becarii* (Sample No. 2, Band-e-Ali Naghi Beig stratigraphic section, 18X), (4) *Bozorgniella* sp. (Sample No. 3, Band-e-Ali Naghi Beig stratigraphic section, 15X), (5) *Asterigerina* sp. (Sample No. 25, Band-e-Ali Naghi Beig stratigraphic section, 18X), (6) *Discorbis* sp. (Sample No. H25, Hezar abad stratigraphic section, 18X), (7) *Elphidium* sp., (Sample No. R19, Rakin stratigraphic section, 18X), (8) *Heterrrstegina* sp. (Sample No. R29, Rakin stratigraphic section, 18X), (9) *Miogypsina* sp. (Sample No. 14, Rakin stratigraphic section, 18X), (10) *Operculina* sp. (Sample No. R14, Rakin stratigraphic section, 18X), (11) *Miogypsinoides* sp. (Sample No. H23, Hezar abad stratigraphic section, 15X), (12) *Reussella* sp. (Sample No. H20, Hezar abad stratigraphic section, 18X).

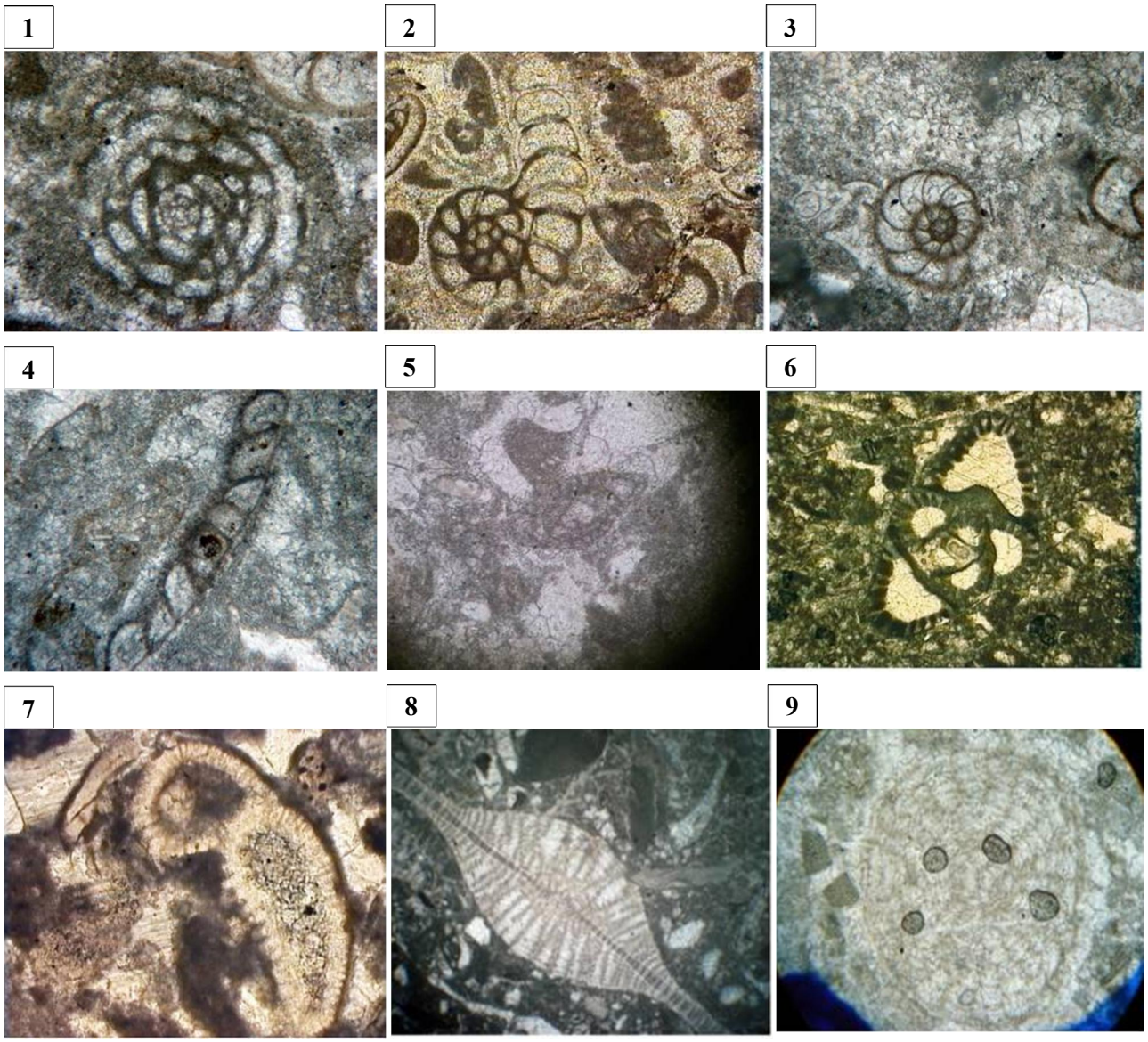

Fig. 11. (1) *Boerlis melo* (Sample No. R9, Rakin stratigraphic section, 14X), (2) *Dendritina rangi* (Sample No. R4, Rakin stratigraphic section, 14X), (3) *Elphidium* sp. (Sample No. R23, Rakin stratigraphic section, 14X), (4) *Planorbulina* sp. (Sample No.R9, Rakin stratigraphic section, 14X), (5) *Austerotrillina asmariensis* (Sample No. R7, Rakin stratigraphic section, 14X), (6) *Austerotrillina howchini* (Sample No. R10, Rakin stratigraphic section, 14X), (7) *Discorbis* sp. (Sample No. R8, Rakin stratigraphic section, 14X), (8) *Nephrolepidina* sp. (Sample No. R5, Rakin stratigraphic section, 14X), (9) *Sphaerogipsina* sp. (Sample No. R10 Rakin stratigraphic section, 4X).

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