



**Biostratigraphy of Early Oligocene - Early Miocene Asmari
Formation at the Southern Flank of Mish Anticline, Izeh Zone, SW Iran**
Bioestratigrafia do Oligoceno Inferior-Mioceno Inferior da
Formação Asmari, Flanco Sul do Anticlinal Mish, Zona Izeh, SW Irã

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Resumo

Nesta pesquisa, é discutida bioestratigrafia relacionada com a Formação Asmari na margem sul do anticlinal Mish, Zona Izeh. Na secção estratigráfica em estudo, a Formação Asmari sobrepõe a Formação Pabdeh e sustenta sedimentos do Quaternário. Um estudo com 192 amostras da Formação Asmari com 328 m de espessura conduziram à identificação de 16 espécies e 26 gêneros de táxons de foraminíferos e quatro zonas biológicas de oligocénicos. As Zonas de Criação de *Globigerina* spp. e *Nummulites intermedius-vascus* representam a idade Rupeliana. A idade Rupeliana- Chattiana é também definida pela Zona de Criação *Lepidocyclina- Operculina- Ditrupa* e pelas Zonas de Criação *Archias asmaricus- Miogyosinoides* spp. que indicam uma idade Chattiana.

Palavras-chave: Formação Asmari; foraminíferos; bioestratigrafia; Bacia de Izeh; Irã

Abstract

In this research, biostratigraphy related to the Asmari Formation at the southern flank of Mish anticline, Izeh Zone, is discussed. In the studied stratigraphic section, the Asmari Formation overlies the Pabdeh Formation and underlies Quaternary sediments. A study of 192 samples of the 328 m-thick Asmari Formation led to identification of 16 species and 26 genera of foraminifera taxa and identification of four Oligocene biozones. The *Globigerina* spp. and *Nummulites intermedius-vascus* Assemblages Zones represent the Rupelian age. The Rupelian- Chattian age is also defined by *Lepidocyclina- Operculina- Ditrupa* Assemblages Zone and *Archias asmaricus- Miogyosinoides* spp. Assemblages Zones that indicates a Chattian age.

Keywords: Asmari Formation; foraminifera; biostratigraphy; Izeh Basin; Iran

1 Introduction

Based on the sedimentary sequence, magmatism, metamorphism, structural setting and intensity of deformation, the Iranian Plateau has been subdivided into several zones, including Zagros, Sanandaj- Syrjan, Urumieh-Dokhtar, Central Iran, Alborz, Kopeh-Dagh, Lut and Makran (Figure 1A).

The Zagros Mountain is southern part of an Alpine orogenic (Alavi, 2004). It extends from southeastern Turkey through the northern Syria and Iraq to western and southern Iran (Ghazban, 2007). Post tectonic and sedimentary events in Zagros resulted in formation of several definable basins (Figure 1B): Thrust Zone, Lorestan, Izeh, Dezful Embayment, Abadan plain, Fars, Bandar Abbas Hinterland (Falcon, 1974).

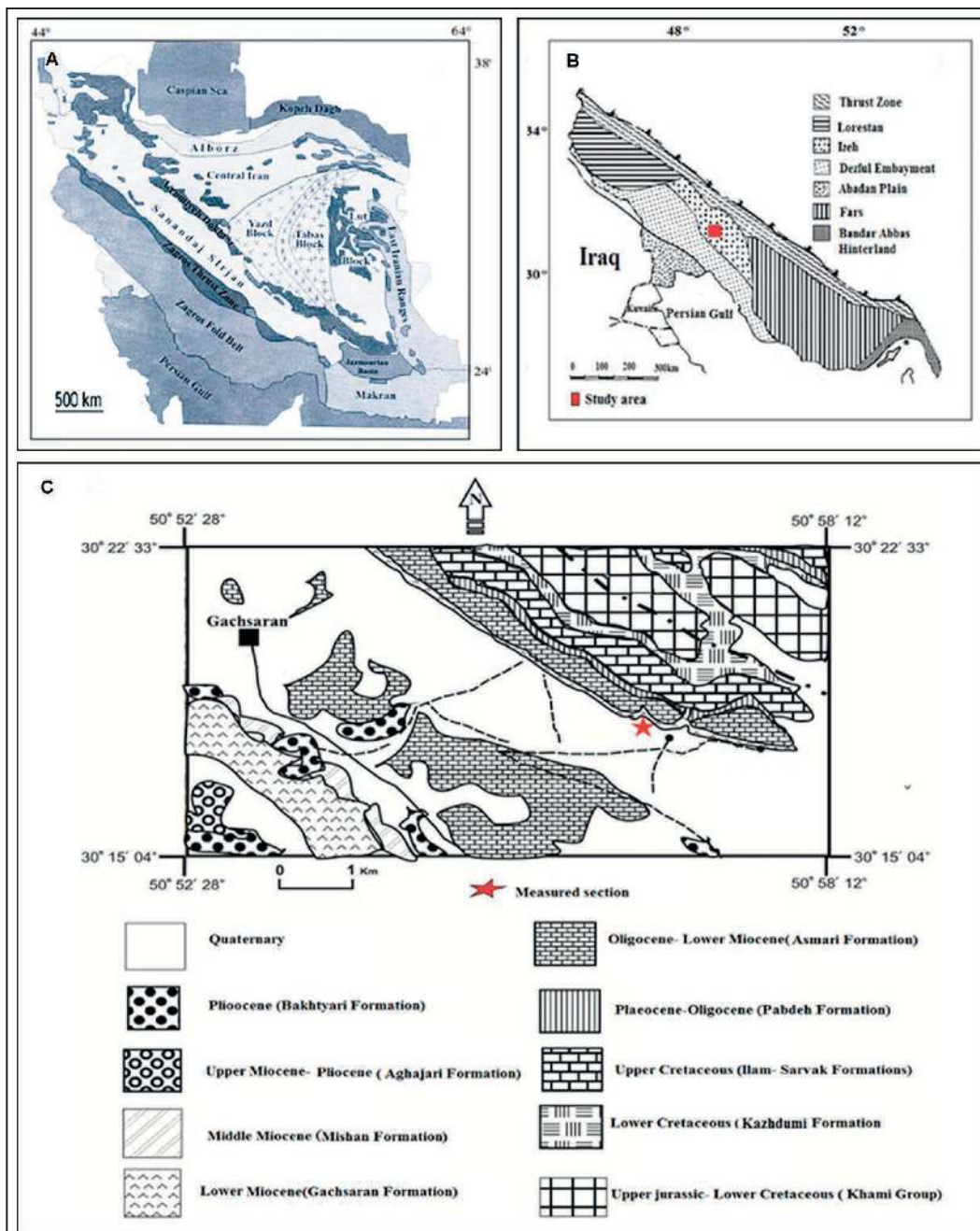


Figure 1 A. General map of Iran showing eight geologic provinces (adopted from Berberian and King 1981); B. Structural-sedimentary zones of Zagros province, Sherkaty & Letouzey, 2004; C. Geological map of the study area at southern flank of Mish anticline, southwest Iran (Gachsaran Geological Compilation map, 1:100000, [11]).

The Oligocene- Miocene marine deposits of Iran, Qom and Asmari Formations, are one of the best known carbonate reservoirs in the world. The Asmari Formation is present in most of the Zagros foreland basin. Biostratigraphy of the Asmari Formation has been the subject of detailed study ever since the first petroleum reservoirs were discovered, in Masjed Soleyman area. The Oligo- Miocene reservoirs are currently being utilized prolifically not only in Iran but also in other parts of the Middle East e.g. Kirkuk Field in Iraq (Murriss, 1980).

Because of the economic importance, it pays to concentrate on the different properties of the oil-bearing Asmari Formation. Van Buchem *et al.* (2010) proposed that lateral facies changes may cause stratigraphic traps to appear in the Asmari Formation. This paper deals with biostratigraphy study of Asmari Formation outcrop at southern flank of Mish anticline (Tang-E Malaghon in the Izeh Zone), whose results could contribute to a better understanding of the subsurface Asmari Formation in adjacent oilfield areas. The studied stratigraphic section is located at southern flank of Mish anticline (Figure 3c) with geographic coordinates 50° 56' 22" E and 30° 18' 11" N. The Asmari Formation is 336 m thick in study section and overlies the Pabdeh Formation and underlies the Quaternary sediments.

2 Previous Studies

The Asmari Formation was named as a Cretaceous–Eocene interval by Busk and Mayo

(1918). It was defined as an Oligocene Nummulitic limestone and described as an Oligocene–Miocene carbonate sequence (Taheri *et al.*, 2015). The biostratigraphic framework of the Asmari Formation was established by Wynd (1965) and revised by Adams & Bourgeois (1967). The age of the Asmari Formation was defined from Rupelian to Burdigalian. It is divided into lower (Oligocene), middle (Aquitanian) and upper (Burdigalian) parts. Van Buchem *et al.* (1965) applied strontium isotope dating to the Asmari Formation and established biozonation of wynd (1965) and Adams & Bourgeois (1967). This also enabled the introduction of new biozonation for the Asmari Formation and clearly differentiated Rupelian from Chattian intervals (Figure 2).

More recent studies of the Asmari Formation have been conducted on biostratigraphic, depositional environment and sequence stratigraphy criteria. A few of them are: Amirshahkarami *et al.* (2007a, b); Hakimzadeh & Seyrafian (2008); Maghfouri Moghaddam (14); Mosadegh *et al.* (2009); Rahmani *et al.* (2012); Seyrafian & Hamedani (2003); Seyrafian *et al.* (1996); Shabafrooz *et al.* (015a , b); Taheri *et al.* (2015) and Vaziri-Moghaddam *et al.* (2006, 2010).

3 Geological Setting

By the end of Mesozoic time, the principle palaeogeographic features of southwestern Iran were the main trough of the Tethys to the north and

Figure 2
 Zonation in Asmari Formation (Adams & Burgeous, 1967; Van Buchem *et al.*, 2010; Wynd, 1965).

Series	Stage	Wynd(1965)	Adams and Bourgeois (1967)	Van Buchem et al. (2010)
Miocene	Burdigalian	<i>Borelis melocurdica</i>	<i>Borelis melocurdica- Meandropsina ieanica</i>	<i>Borelis melo curdica- Borelis melo melo</i>
	Aquitanian	<i>Austrotrillina howchini</i> <i>Peneoplis evolutus</i>	<i>Elphidium sp.- Miogypsina sp.</i> <i>Miogypsinoidea</i> <i>Archias</i> <i>Vahvunid</i> <i>Archias asmaricus</i> <i>A. hensoni</i>	Indeterminate <i>Miogypsina sp.</i> <i>Elphidium sp. 14</i> <i>Peneoplis farsensis</i>
Oligocene	Chattian	<i>Achias operculinoformis</i> <i>Nummulites vascus</i> <i>N.intermedius</i>	<i>Eulepidina</i> <i>Nephrolepidina</i> <i>Nummulites</i> <i>Globigerina spp.</i>	<i>Archias asmaricus</i> <i>A. hensoni</i> <i>Miogypsina complanatus</i>
	Rupelian	<i>Operculina</i> <i>Lepidoocyclina</i> <i>Ditrupe</i>		<i>Nummulites vascus</i> <i>N.intermedius</i> <i>Operculina</i> <i>Lepidoocyclina</i> <i>Ditrupe</i>

the smaller minor trough which run from eastern Iraq southwestward trough southwest Lorestan and Khuzestan towards Central Fars province with an elongate ridge between these two troughs (Murriss, 1980). In the center of troughs (Foredeep of Zagros foreland) the Pabdeh Formation was deposited (Figure 3). By the end of Eocene time, the widespread regression caused the greater portion of the region except the central parts of the troughs to emerge. The resulting disconformity is present over the entire area where Jahrum and Shahbazan formations are developed.

Zagros Basin gradually shallowed in Oligocene- Early Miocene time and was covered by the carbonate of the Asmari Formation (James & Wynd, 1965). The local variations in lithology within the Asmari Formation are mainly recognized as members such as the Kalhur anhydrite and the Ahvaz sandstone. Locally, favorable conditions for deposition of evaporate had developed during this time as evidenced by the Kalhur Member of Asmari Formation and other thin evaporate Tongues (Motiei, 1993).

The Calcareous sandstones and sandy limestone of the Ahvaz Member unconformably overlies the Eocene- Oligocene Jahrum Formation in the Dezful Embayment. They record near- shore deltaic environments which passed eastward into shallow carbonates (Motiei, 1993).

4 Methods

For this research, 192 samples from the Asmari Formation in the selected stratigraphic section were studied.

All rock samples and thin sections are housed in the Department of Geology, Lorestan University. The taxonomic determination of the foraminifers is based on the foraminiferal classifications: BouDagher-Fadel (2008); BouDagher-Fadel & Lokier (2005); Loeblich & Tappan (1988) and Rahaghi (1980).

5 Biostratigraphy of Study Section

Benthic foraminifera are abundance and diverse in most samples of the Asmari Formation at the study section. The zonal scheme presented here consists of 4 zones on the basis of the stratigraphical distribution of benthic foraminifera recognized in thin section (Figure 4). They are described in ascending order, following the stratigraphic development; 26 genera and 16 species of benthic foraminifera were recognized (Figures 5, 6 and 7).

1) *Globigerina* spp. Assemblage Zone

Author: Wynd, 1965

Type locality: Dezful Embayment (Masjed Soleyman, Kuhe Asmari, Haftkel, Mamatin, Lali and Kazeron oil Fields).

Definition: This biozone is characterized by the rich small planktonic foraminifera such as *Globigerina* spp. The lower limited of this zone is marked by last occurrence of *Turborotalia cerroazulensis* and *Hantkenia* sp, and an abundance of *Globigerina* sp., and the upper limit by the first

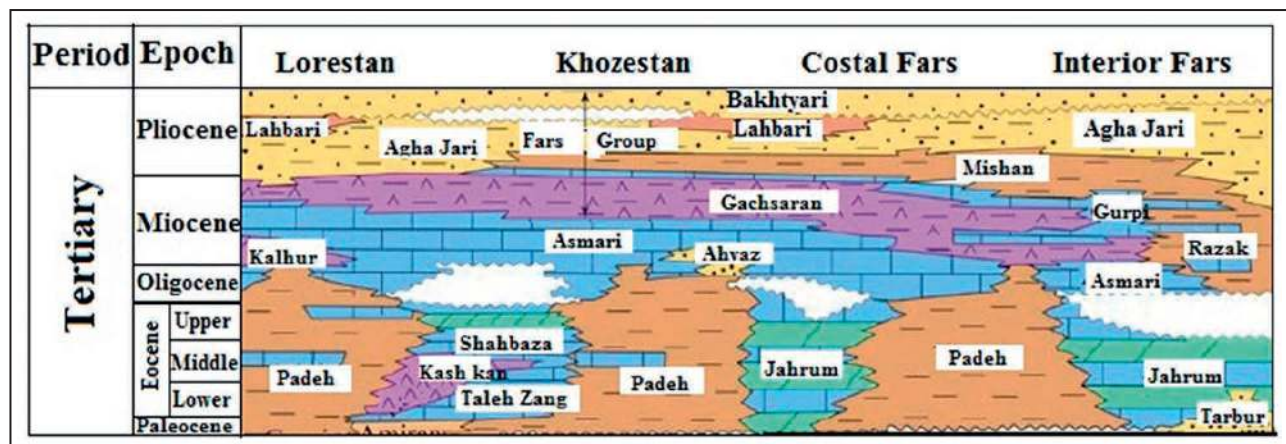


Figure 3 Schematic stratigraphic section showing the Asmari Formation within the Cenozoic rocks of the Zagros Basin (after Gulf Petrolink , 1998).

occurrence of *Nummulites vascus* and *N. intermedius*. In the Mish anticline, this zone spans 16 m of light gray marl of top of the Pabdeh Formation and base of the Asmari Formation.

In northern Dezful Embayment and adjusting are, it is placed in transitional beds between Pabdeh and Asmari Formations but to the south on the evaporative layers, as called basal anhydrite (Vaziri-Moghaddam *et al.*, 2010), is placed. To the northeast, with decreasing depth, planktonic frequency decreases instead the number and diversity of benthic fauna increases. In this area, they are called by the name of *Ditrupa* sp., *Eouvigerina* sp., *Haplophragmium slingeri* Assemblage Subzone (Wynd, 1965).

In the northern Lorestan and along Main Thrust Zagros fault, there is a red clastic limestone bed that contains plenty of planktonic foraminifera. It is belonging to Razak Formation. The Razak Formation is interpreted as the distal facies of a clastic wedge whose proximal facies presumably extended to the northeast into the Zagros thrust zone (Ghazban, 2007). The age of the formation is generally Early Miocene.

Characterization: This interval also characterized by the presence of *Ditrupa* spp. (Worm Tube).

Age: Early Oligocene (Rupelian).

2) *Nummulites vascus*- *Nummulites intermedius* Assemblage Zone

Type locality: Dezful Embayment

Authors: Wynd, 1965; Van Buchem, 2010

Definition: This biozone is characterized by the rich larger benthic foraminifera such as *Nummulites vascus*, *N. intermedius*. The lower and upper limited of this zone are marked by first and last occurrence of *Nummulites vascus* or *N. intermedius*. In the study section, this zone spans 43 m (from 16 to 59 m thick) of light gray thin marly limestone.

Characterization: This interval also characterized by the presence of *Amphistegina* sp., *Eulepidina* sp., *Heterostegina costata*, *Heterostegina* sp., *Lepi-*

docyclina sp., *Neorotalia viennoti*, *Operculina complanata*, *Operculina* sp., *Planorbulina* sp., *Sphaerogypsina globulus*. The non- foraminifera assemblages includes Bryozoan, Echinoid spine and Red algae (*Subterraneaniphylum* sp., *Lithophyllum* sp.).

The Asmari Formation has relatively few species of *Nummulites*, *N. vascus* (synonym *N. incrassatus*) and *N. fichteli* (synonym *N. intermedius*). Both species of *Nummulites* have similar stratigraphic ranges with an extinction event just above the Rupelian – Chattian boundary, close to the top of global planktonic foraminiferal zone P21 (Cahuzac & Poignant, 1997). Cahuzac and Poignant (1997) define a larger foraminiferal biozone SB22 on the co- occurrence of *N. vascus* and *N. fichteli* and *Lepidocyclina* spp., of the Mediterranean region. This zone straddles the Rupelian- Chattian boundary and thus corresponds to the Middle Oligocene. Co-occurrence of *Nummulites* with *Lepidocyclina* in the study section being no older than Late Rupelian.

Age: Early Oligocene (Rupelian).

3) *Lepidocyclina*-*Operculina*-*Ditrupa* Assemblage Zone

Type locality: Dezful Embayment (Masjed Soleyman, Kuhe Asmari, Haftkel, Mamatin, Lali and Kazeran oil Fields).

Authors: Wynd, 1965; Adams & Bourgeois, 1967

Definition: This biozone is characterized by the rich larger benthic foraminifera such as *Eulepidia* sp., *Nepherolepidina* sp., *Operculina complanata*, *Ditrupa* sp. The lower limited of this zone is marked by last occurrence of *Nummulites vascus* and upper limited by last occurrence of *Nepherolepidina*. In the study section, this zone spans 161 m (from 59 to 220 m thick) of light gray thick to massive limestone.

Characterization: This interval also characterized by the presence of *Amphistegina* sp., *Austrorillina howchini*, *Borelis pygmaea*, *Discorbis* sp., *Elphidium* sp., *Gypsina* sp., *Heterostegina costata*, *Meandropsina* sp., *Neorotalia viennoti*, *Operculina* sp., *Peneroplis thomasi*, *Schlumbergerina* sp., *Sphaerogypsina globules*, *Planorbulina* sp.,

Valvulinid sp., *Victoriella* sp., The non- foraminifera assemblages includes bryozoa, echinoid spine and red algae (*Subterraniphyllum* sp., *Lithophyllum* sp.).

Age: Early to Late Oligocene (Rupelian- Chattian).

4) *Archaias asmaricus-Miogypsinoides* spp. Assemblage Zone

Type locality: Dezful Embayment (Masjed Soleyman, Kuhe Asmari, Haftkel, Mamatin, Lali and Kazeron oil Fields).

Authors: Wynd, 1965; Adams & Bourgeois, 1967

Definition: This biozone is characterized by the rich larger benthic foraminifera such as *Archaias asmaricus*, *Miogypsinoides bantamensis*. The lower limited of this zone is marked by first occurrence of *Archaias asmaricus* and upper limited by last occurrence of *Archaias asmaricus*. In the study section, this zone spans 108 m (from 220 to 336 m thick) of light gray thick to massive marly limestone. Macrofossil assemblages consist of rare to common bryozoa, corallinacean, bivalves and gastropods.

Characterization: This interval also characterized by the presence of *Amphistegina* sp., *Archaias asmaricus*, *Archaias kirkukensis*, *Archaias operculiniformis*, *Austrotrillina* sp., *Discorbis* sp., *Dendritina rangi*, *Gypsina* sp., *Miogypsinoides* sp., *Meandropsina anahensis*, *Neorotalia viennoti*, *Operculina* sp., *Peneroplis evolutus*, *Peneroplis thomasi*, *Peneroplis* sp., *Sphaerogypsina globulus*, *Triloculina* sp., *Valvulinid* sp., The non- foraminifera assemblages includes bryozoa and red algae (*Lithophyllum* sp.).

Age: Late Oligocene (Chattian)

6 Correlations

The lowermost part of Asmari Formation in the study section coincides with *Globigerina* ssp. *Nummulites vasculus- N. intermedius* Assemblage zones and extends through a thickness of 59m. These biozones were reported where the Asmari Formation lies directly above the Pabdeh Formation (James & Wynd, 1965). Sooltanian *et al.* (2011) recorded these biozones from Naura anticline (Interior Fars Zone). Towards east of the Mish section, SE of

Dezful Embayment, the Rupelian sediments of the Lali section are much thinner than those of the Mish section (Mossadegh *et al.*, 2009, Figure 8). In Lali section, only *Nummulites vasculus- N. intermedius* Assemblage zones occurs at the Rupelian deposits of Asmari Formation. In this section equivalent of *Globigerina* spp. Assemblage Zone is the uppermost part of Pabdeh Formation (Mossadegh *et al.*, 2009).

In Mish section, Upper part of Rupelian and Chattian deposits comprises of *Lepidocyclina-Operculina-Ditrupea* and *Archaias asmaricus-Miogypsinoides* spp. Assemblages Zones and are recorded in thickness 272m. In areas such as Lali (Sadeghi *et al.*, 2009); Sabou sections (Mosadegh *et al.*, 2009, Figure 8) and Kaviz anticline (Dezful Embayment, Rahmani *et al.* 2009) *Lepidocyclina-Operculina-Ditrupea* Assemblage Zones underlies *Archaias asmaricus-Miogypsinoides* spp. Assemblages Zones. But in areas like Darreh Shahr, Dehluran and Kabir Kuh (Lorestan Zone, Vaziri Moghaddam *et al.*, 2010), this Zone underlies *Miogypsina* sp.- *Elphidium* sp.-14 Assemblage Zone (Aquitanian in age, Sadeghi *et al.*, 2009) . Therefore, in this area, the age of upper part of the *Lepidocyclina-Operculina-Ditrupea* Assemblage Zones is younger than previous areas. So that, Adams & bourgeois (1967) and Van Buchem *et al.* (2010) attributed upper part of *Lepidocyclina-Operculina-Ditrupea* Assemblage Zones to late Chattian

Archaias asmaricus-Miogypsinoides spp. Assemblages Zones comprises of *Archaias asmaricus*, *A. kirkukensis* which were regarded as indicator of Chattian time (Adams & Bourgeois, 1967). According to Eames and Banner (1962), *Archaias asmaricus* and *A. hensoni* range from the Early to Late Chattian. Their last occurrence has been considered near or just after the base Miocene based on Sr isotope dating by Ehrenberg *et al.* (2007). Therefore, in this area, the *Lepidocyclina-Operculina-Ditrupea* Assemblage Zone based on its stratigraphical position is considered to be Late Rupelian- Early Chattian in age.

The *Archaias asmaricus-Miogypsinoides* spp. Assemblages Zones has been identified from the shallow-marine carbonate sequence while

Lepidocyclina- Operculina- Ditrupa Zone is an indicator of deep waters.

At the study section, upper part of Asmari Formation is not exposed; therefore we are not able to describe its biostratigraphical criteria.

7 Conclusions

The Asmari Formation in the Mish anticline, Izeh Zone, overlies on the Pabdeh Formation and underlain unconformably by the Gachsaran Formation. According to distribution of the foraminiferal assemblages, the age of the Asmari Formation in the study section is defined as Early Oligocene (Rupelian) - Early Miocene (Aquitainian). The most important species are: *Nummulites vascus*, *Heterostegina costata*, *Lepidocyclina* sp., *Neorotalia viennoti*, *Nepherolepidina* sp., *Operculina complanata*, *Archias asmarius*, *Miogyosinoides bantamensis*. Based on the distribution of the foraminifera, five assemblages biozones are recognized. Biozones 1-4 (The *Globigerina* spp.; *Nummulites intermedius-vascus* Assemblages Zones represent the Rupelian age and the Chattian age is also defined by *Lepidocyclina- Operculina- Ditrupa* and *Archias asmarius- Miogyosinoides* spp. Assemblages Zones) reported from other parts of the Zagros Basin. Because Biozone 5 lacks index fossil and only based on its stratigraphical position, it is Early Miocene in age. It has not been reported in adjustment area.

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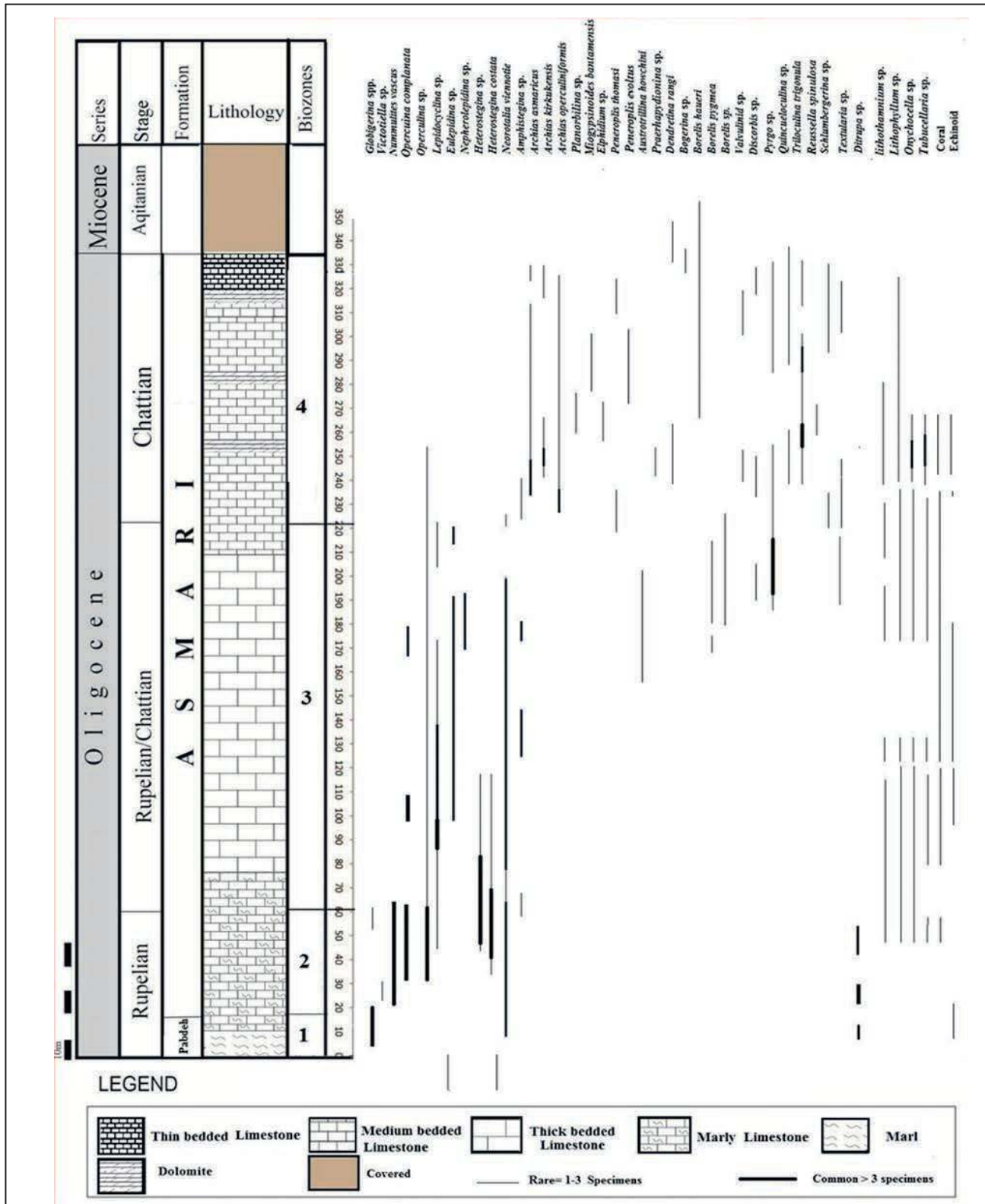


Figure 4 Biostratigraphy column of the Asmari Formation at the studied section, Izeh Basin, Iran.

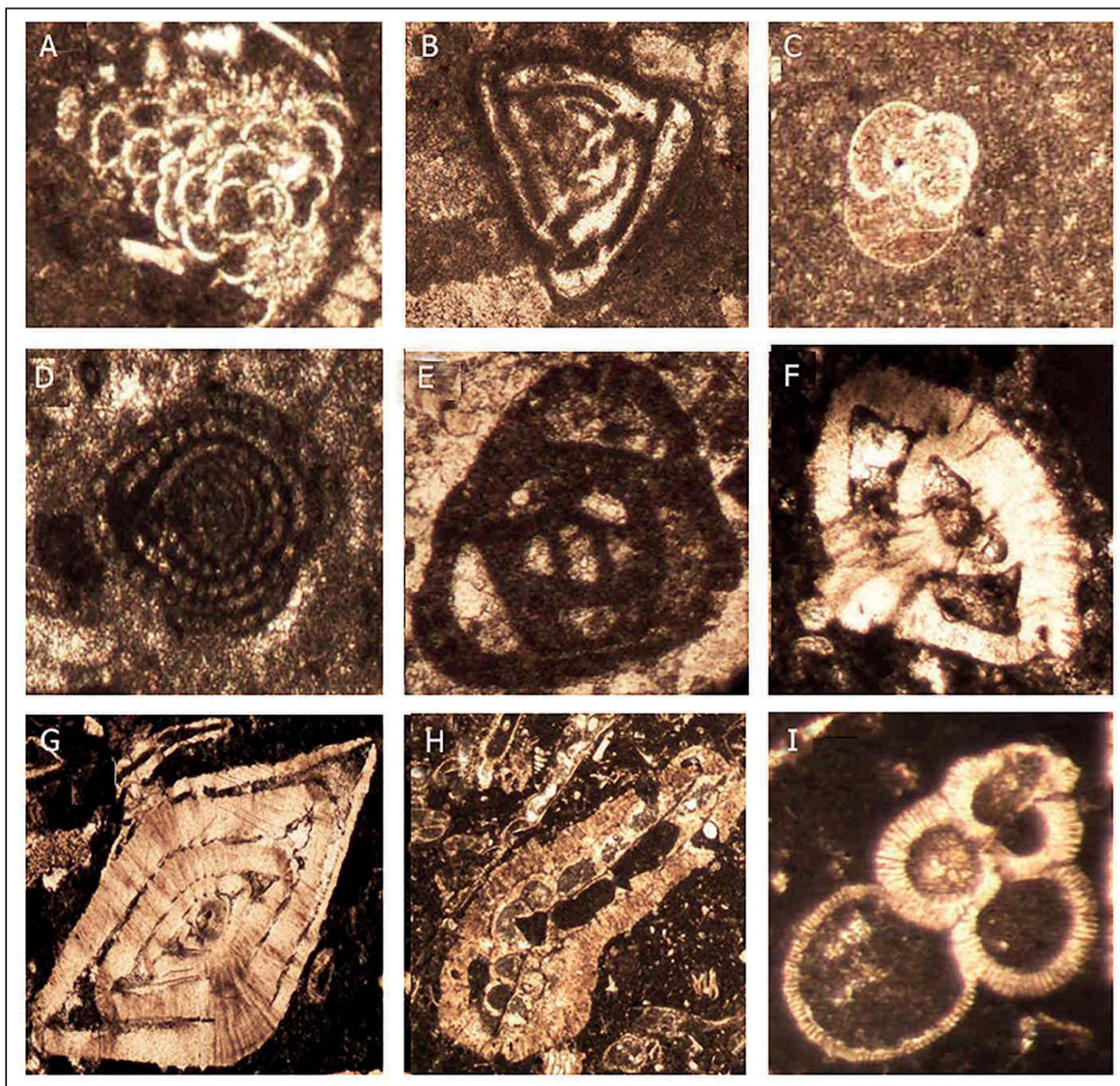


Figure 5 A. *Planorbulina* sp., oblique section, sample no. 63m, X40; B. *Triloculina trigonula*, axial section, sample no. 140m, X40; C. *Globigerina* sp., oblique section, sample no.14m, X40; D. *Borelis pygmea*, oblique section, sample no.186m, X40; E. *Austrorillina howchini*, transvers section, sample no.180 m, X40; F. *Neorotalia viennoti*, transvers section, sample no.108 m, X40; G. *Nummulites vascus*, axial section, sample no.49 m, X35; H. *Miogypsinoides bantamensis*, axial section, sample no. 70 m, X35; I. *Victoriella* sp., sub axial section, sample no.24 m, X40 .

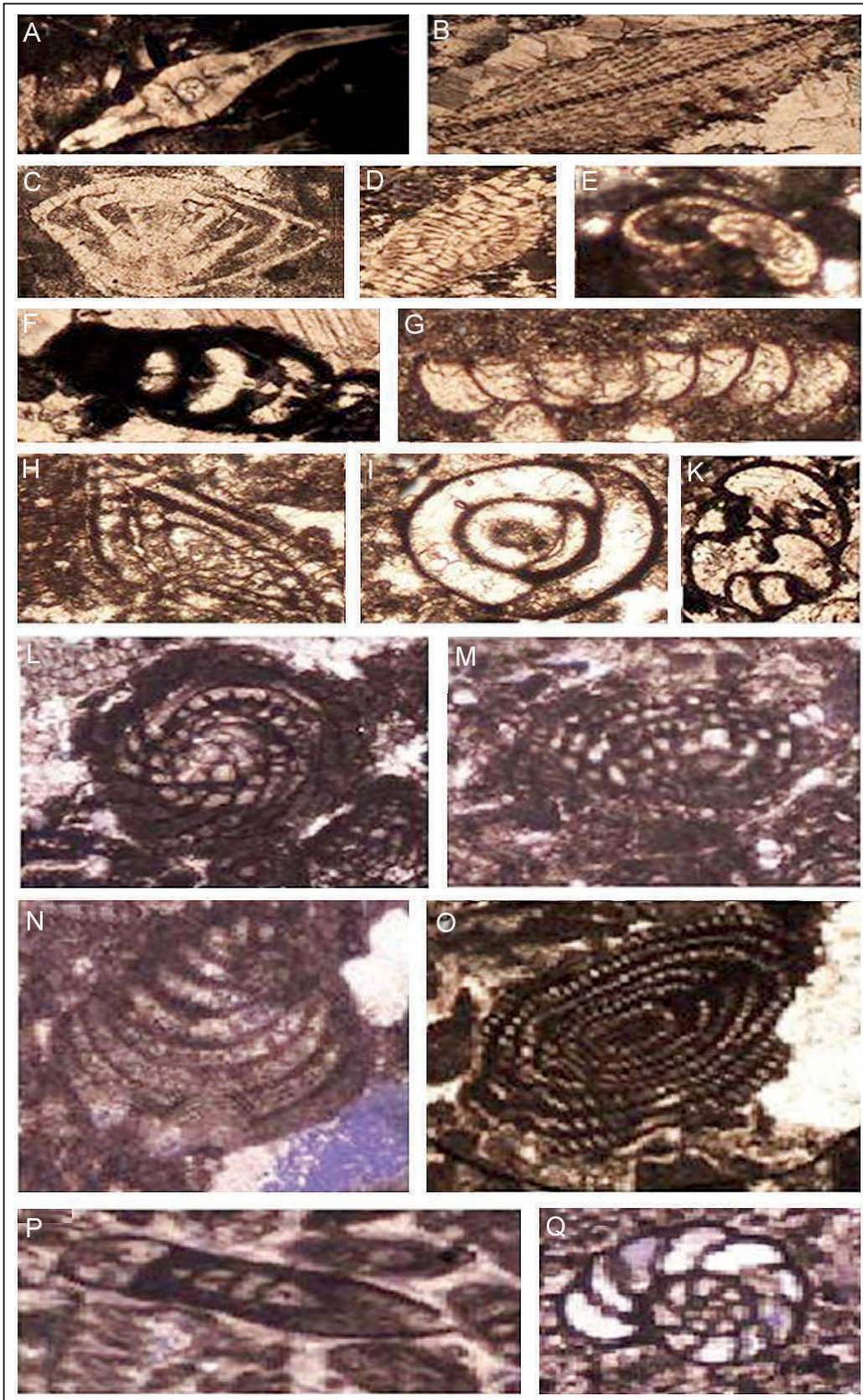


Figure 6 A. *Operculina complanata*, sub-axial section, sample no.46m, X20; B. *Lepidocyclina* sp., sub- axial section, sample no. 140m, X20; C. *Amphistegina* sp., sub- axial section, sample no.54m, X35; D. *Heterostegina* sp., sub- axial section, sample no.60 m, X30; E. *Discorbis* sp., sub-axial section, sample no.320 m, X40; F. *Praerhapydionina* sp., transverse section, sample no.34 m, X 35; G. *Spiroloculina* sp., axial section, sample no.36 m, X40; H. *Peneroplis thomasi*, sub-axial section, sample no. 70 m, X 35; I. *Pyrgo* sp., transvers section, sample no.36 m, X40; K. *Valvulinid* sp., transvers section, sample no.38 m, X35; L. *Archaias operculiniformis*, sub- axial Section, sample no.138m,* 35; M. *Archaias operculiniformis*, Oblique Section, sample no.138m, *35; N. *Peneroplis thomasi*, equatorial section, sample no.d116m, *35; O. *Borelis pygmea*, Sub-axial section, sample no.188M; P. *Dendritina rangi*, sub-axial section, sample number.114m; Q. *Dendritina rangi*, equatorial section, sample no.74m., *35.

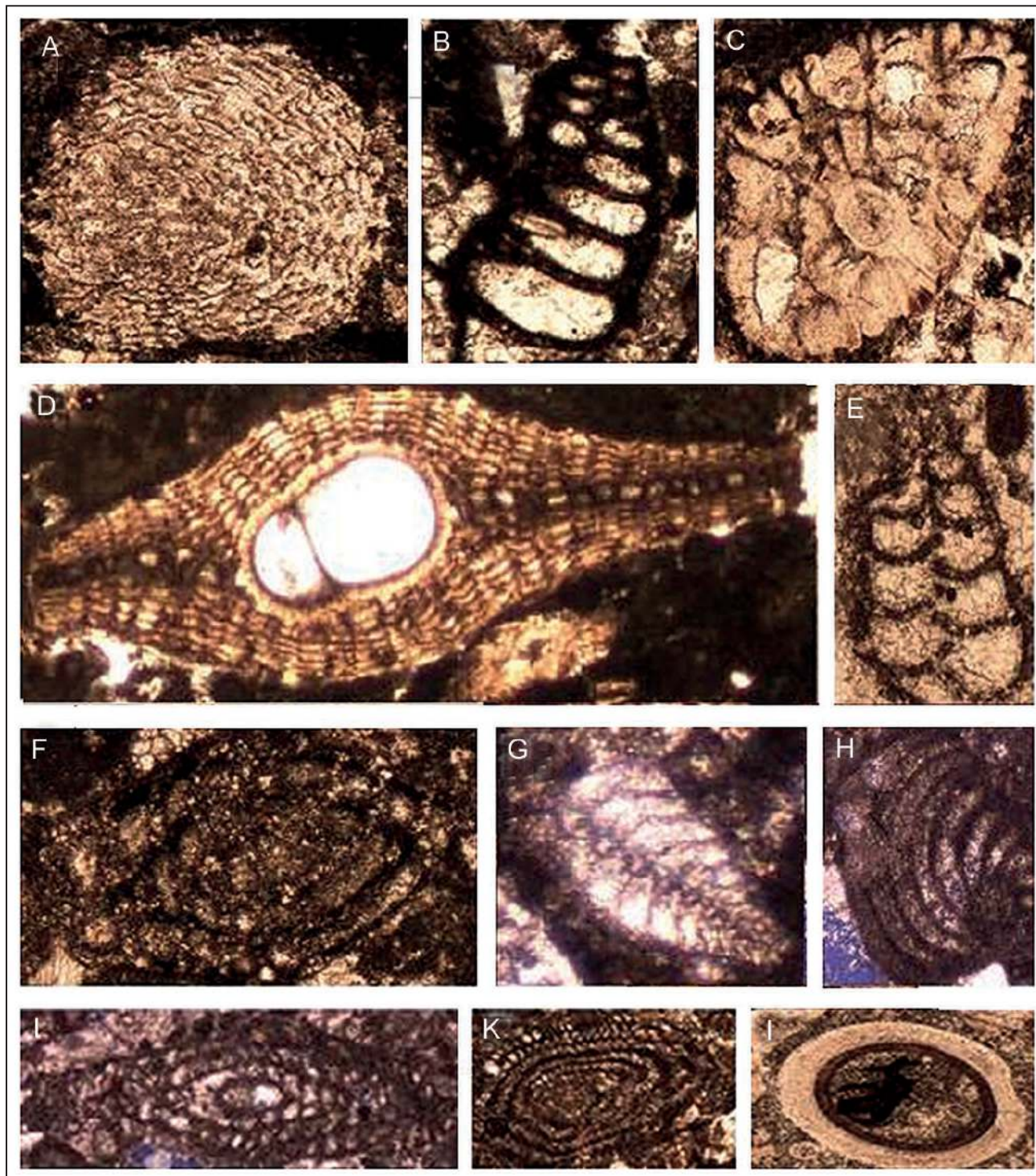


Figure 7 **A.** *Sphaerogypsina globulus*, transvers section, sample no.40m, X40; **B.** *Bigerina* sp., sub- axial section, sample no. 112 m, X40; **C.** *Elphidium* sp., sub- axial section, sample no. 70 m, X 40; **D.** *Nephrolepidina tournoueri*., axial section, sample no. 90 m, X35; **E.** *Textularia* sp., longitudinal section, sample no.31 m, X 40; **F.** *Schlumbergerina* sp., longitudinal section, sample no.56 m, X40; **G.** *Reussella spinulosa*, longitudinal section, sample no.72 m, X 35; **H.** *peneroplis evolutus*, sub-axial section, sample no. 74 m, X35; **I.** *Archaias asmaricus*., sub- axial section, sample no.134 m, X35;**K.** *Borelis haueri*., sub- axial section, sample no.188 m, X30; **L.** *Ditrupa* sp., transverse section, sample no.18 m, X 30.

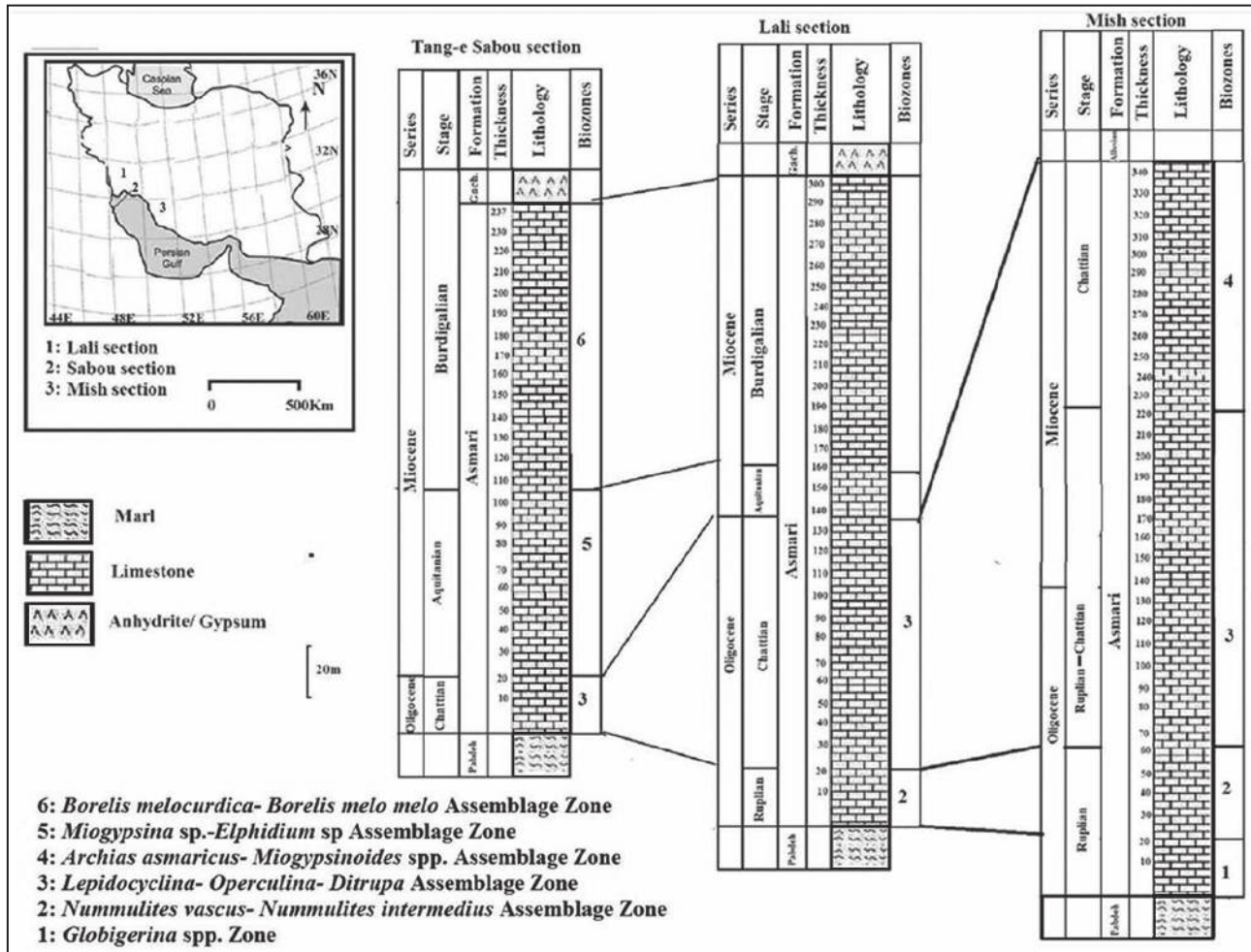


Figure 8 Generalised biostratigraphical scheme for the Asmari Formation in Mish section, Tang-e sabou (adopted of Mosadegh *et al.*, 2009) and Lali section (adopted of Sadeghi *et al.*, 2009).

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