Biostratigraphy and Microfacies of Qom Formation in Urumieh – Dokhtar Zone, Iran

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Abstract - Qom Formation is well developed in Urumieh–Dokhtar Zone, Iran. Three different measured sections were studied in this area in order to interpret the biostratigraphy and microfacies of QomFormation. In the Ashtian and Hezar Abad sections, the Qom Formation disconformably overlies and underlies Lower Red and Upper Red formations, respectively.In the Rakin section, the lower boundary of Qom Formation with tuffs of Urumieh–Dokhtar magmatic arc is sharp and its upper boundary is covered by the recent alluvium. Based on the recognized foraminifera, the age of Qom Formation in the Rakin stratigraphic section is determined as Chattian–Aquitanian and in the Ashtian stratigraphic section as well as the Hezar Abad stratigraphic sections is determined as Chattian. In this study 21microfacies types have been recognized which can be grouped into three depositional environments: Lagoon, shallow and deep open marine. The Qom Formation in three sections represents sedimentation inan open shelf.The great abundance of bryozoans and red algae as well as low diversity of foraminifera indicates that carbonate sediments of the Qom Formation were deposited in a mestrophy to eutrophy conditions.

Keyword: Chattian, Open shelf, Urumieh–Dokhtar, Qom Formation

1. INTRODUCTION

Based on the sedimentary sequence, magmatism, metamorphism, structural setting and intensity of deformation, the Iranian Plateau was subdivided into eight continental fragments(Heydari et al., 2003), including Zagros, Sanandaj–Syrjan, Urumieh–Dokhtar, Central Iran, Alborz, Kopeh–Dagh, Lut, and Makran.

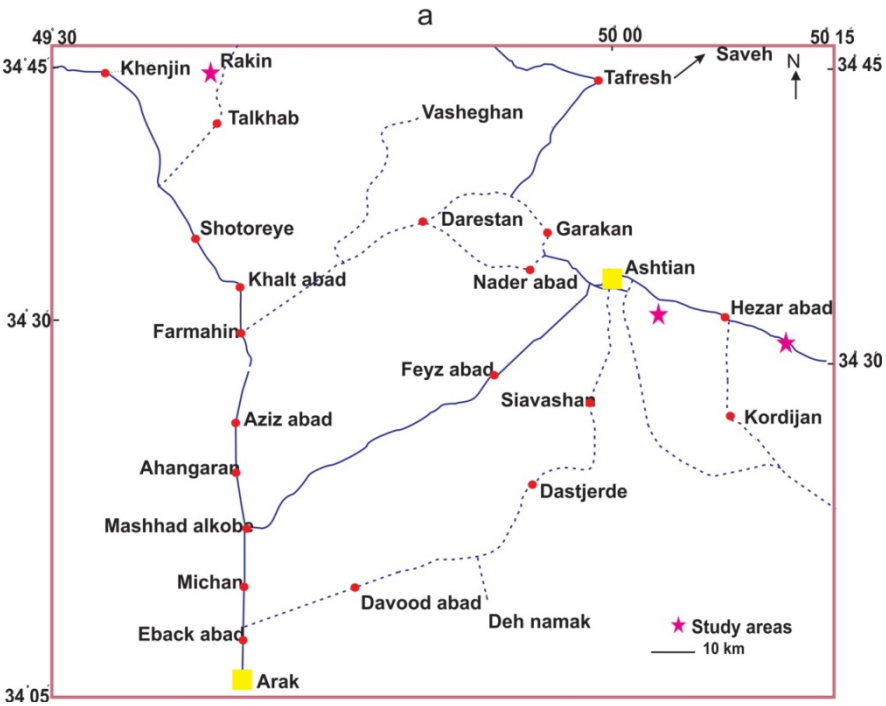

Fig 1a. Location map of the studied area in UDMA;

Urumieh–Dokhtar Magmatic Belt (UDMA) is mainly a magmatic belt with northwest–southeast direction.This belt with some 1500 km length and 100 km width is extended from Sahand to the Bazman and then enters in Pakistan. Mgmatism in the UDMA started since Ypresian in Eocene with a highest activity in the Middle Eocene (Emami, 1981). Sea level drop in Oligocene time caused the removal of underlying Eocene bedsover sunstsntial areas. The pronouncedsea level fall exposed almost the entire the UDMA.The mid–Oligocene global sea level rise constricted marine citculation from the Mediterranean to the Indian Ocean (Rahaghi, 1980, Khaksar and Maghfouri Moghaddam, 2007; Reuter et al., 2008, 2009). Mohammadi and Ameri (2015)reported that the Qom Formation is the last transgression of the sea in the UDMA.

The Qom Formation is composed of Limestone, argillaceous limestones andnsandstone.It is present throughout theCentral Iran Zone, Sannadaj-Sirjan Zone and UDMA (Mohammadi et al., 2011). The objectives of this study are to establish abiostratigraphic framework and demonstration of the paleobiofacies of the Qom Formation in the UDMA based on the distribution of the larger benthic foraminifera.

2. STUDY AREA

This research involves three stratigraphic sections from the Qom Formation in UDMA in the central part of Iran.

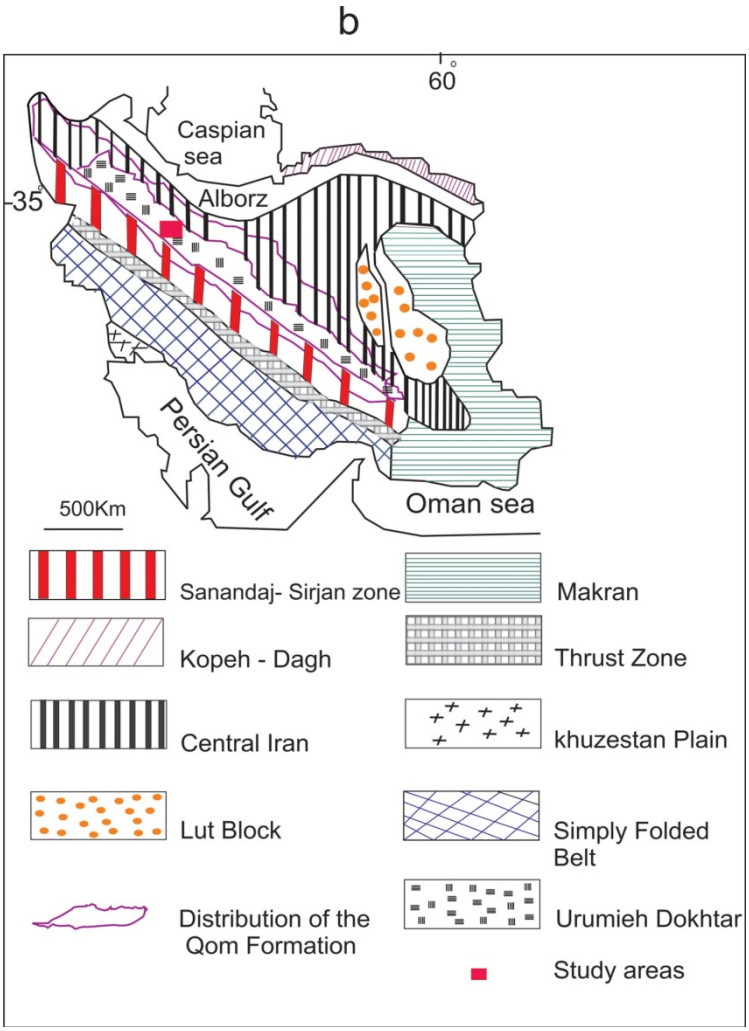

Fig 1b. Subdivisions of Iran (modified from Heydari, 2003);

The study area in the Rakin section is located about 70 Km north of Arak (Central Province). The section was measured in detail at 49° 33' 09" N and 34° 46' 01" E. The study area in the Ashitan section is located about 1Km east of Ashtian (Central Province). This section was measured in detail at 50° 02' 09" N and 34° 31' 07" E.The study area in the Hezar Abad section is located about 23 Km southeast of Ashtian. The section was measured in detail at 50° 14' 19" N and 34° 27' 11" E.

The Qom Formation in the Ashtian and Chenar sectionsunderliestheLower Upper Red Fotmation while in Rakin section, its upper boundary is not exposed.

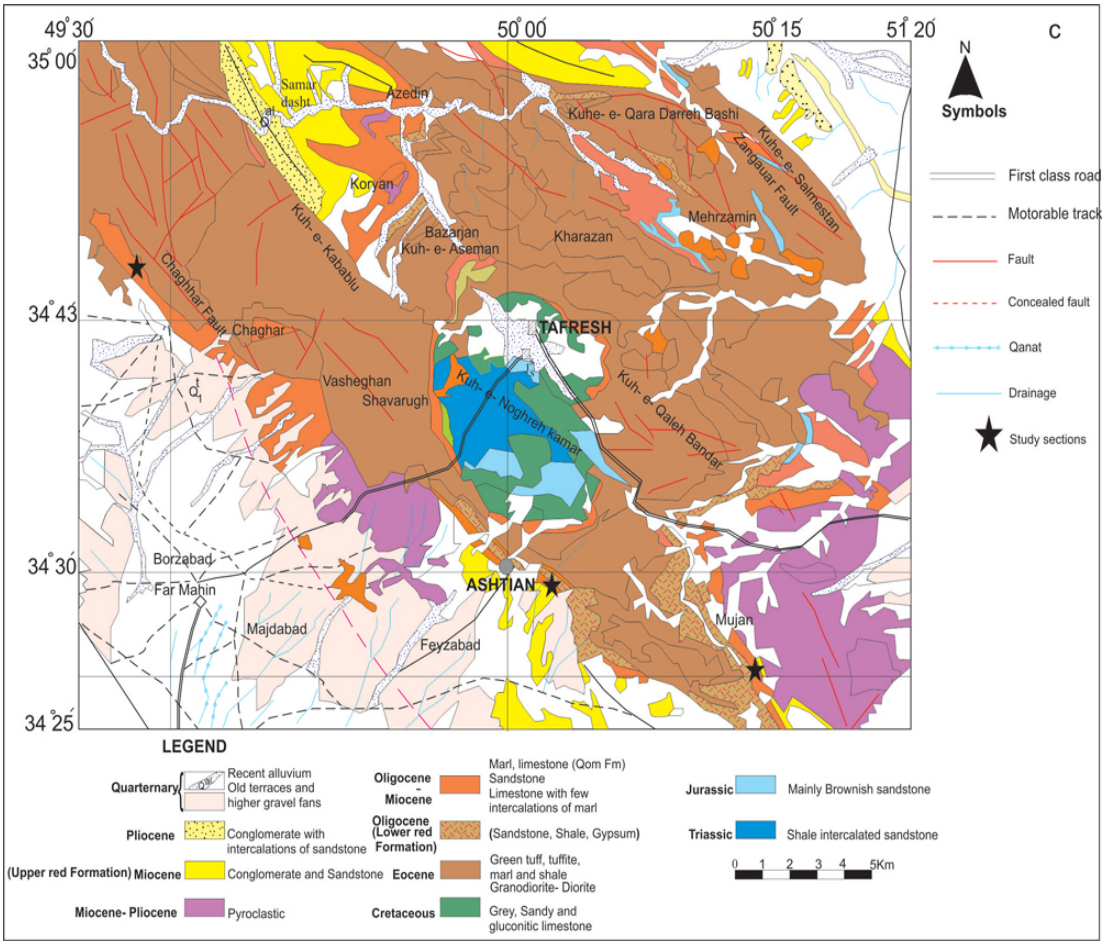

Fig 1c. Geological map of the stydy area (adopted from Emami,1991).

The Qom Formation in the Ashtian and Hezar Abad sections conformably overlies the Lower Red Formation.In the Rakin section, the lower contact of the Qom Formation with the underlyingtuff of the Karaj Formation is conformable.The total thickness of the Qom Formation is about 148m, 150 and 148 m in Rakin, Ashtian and Hezar Abad sections, respectively.

3. MATERIAL AND METHODS

For this research, 168 samples from the Qom Formation in the selected stratigraphic sections were studied. The rocks were classified in the field using the depositional fabric of Dunham (1962)fossils and facies characteristics were described in thin sections.All rock samples and thin sections have been housed in the Department of Geology, Lorestan University. Facies were determined for each palaeoenvironment according to carbonate grain types, textures and interpretation of functionalmorphology of larger foraminifers.In biostratigraphic studies, 17 foaminifera species belonging to 18 genera were identified and 6 biozones recognizedin these three sections.They are distinguished based on thezonal scheme proposed by Van Buchem et al. (2010).

4. BIOSTRATIGRAPHY

Three assemblages of foraminifera were recognized in the studied areas and were discussed in ascending stratigraphic order as follows:(e.g., Fig 9“ and Fig 10 is about here).

Assemblage 1. This assemblage occurs in thickness of 52m in the lower part of QomFormation only in Rakin section.

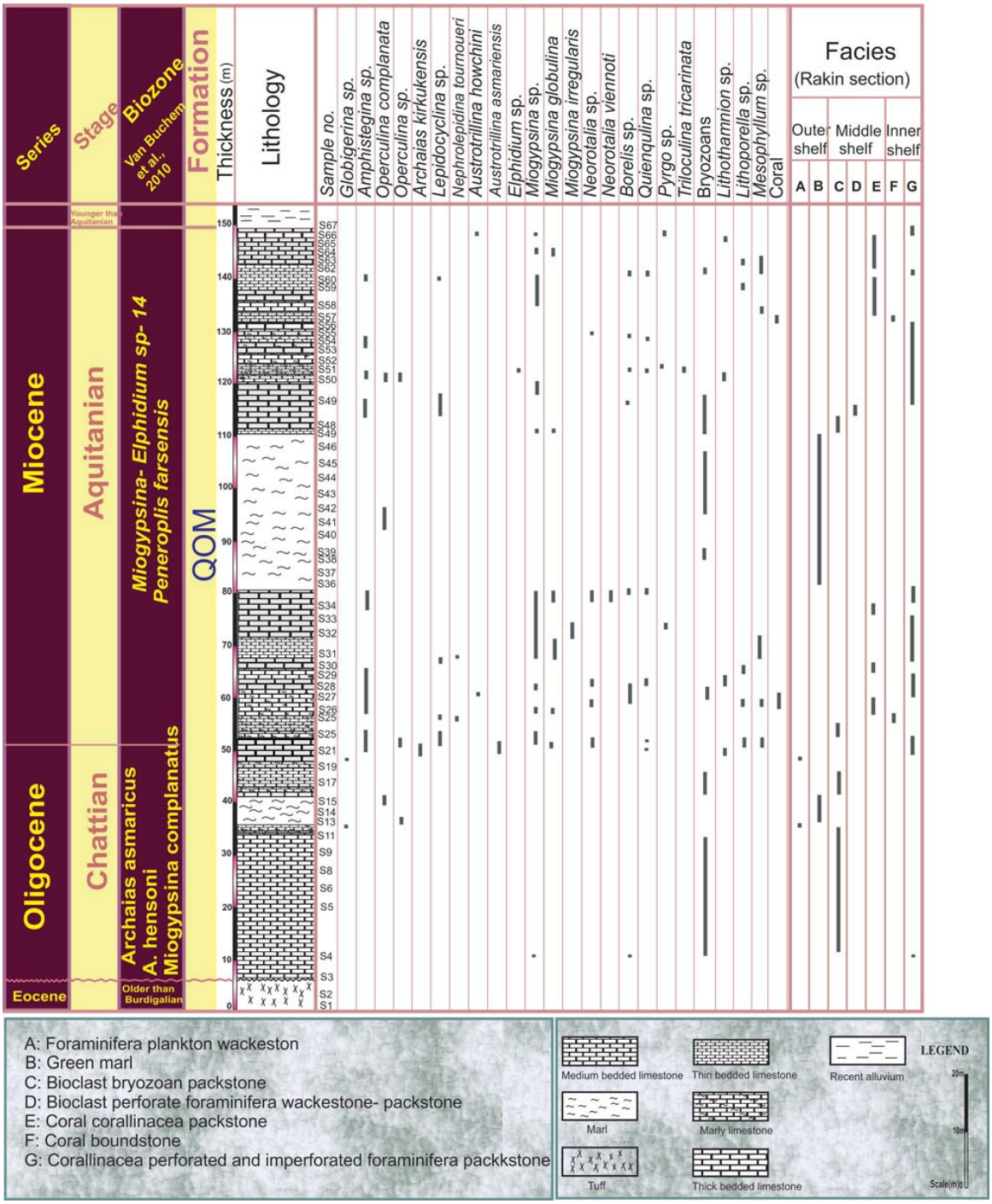

Fig 2. Lithology, biostratigraphy, paleoenvironment for Qom Formation in Rakin section.

The most importantmicrofossils are:*Archaias hensoni*, *Borelis* sp. *Globigerina* sp., *Lepidocyclina* sp., *Nephrolepidina tournoueri*, *Lithothamnion* sp., *Lithoporella* sp. Bryozoan.This assemblagecorresponds to the*Archaias asmaricus- Archaias hensoni* assemblage zone of Van Buchem et al. 2010. The assemblage is considered to be Chattian in age.

Assemblage 2.This assemblage is present in thickness 96m in the upper part of the QomFormation only in the Rakin section.The most important and common microfossils in sections are:*Amphistegina* sp., *Austrotrillina asmariensis*, *Austrotrillina howchini*, *Miogypsina globulina*, *Miogypsina irregularis*, *Miogypsina* sp., *Neorotalia*sp., *Neorotalia viennoti*, *Nephrolepidina tournoueri*, *Pyrgo* sp.,*Quienquelina*sp., L*ithoporella* sp, *Mesophyllum* sp., *Lithothamnion* sp., Bryozoan.This assemblage is correlated with *Miogypsina*–

Elphidium sp. 14–Peneroplis farsenensis assemblage zone of van Buchem et al. (2010) and are attributed to the Aquitanian.

Assemblage 3.This assemblage is recorded in thickness 150 and 148m in Ashtian and Hezar Abad sections, respectively.

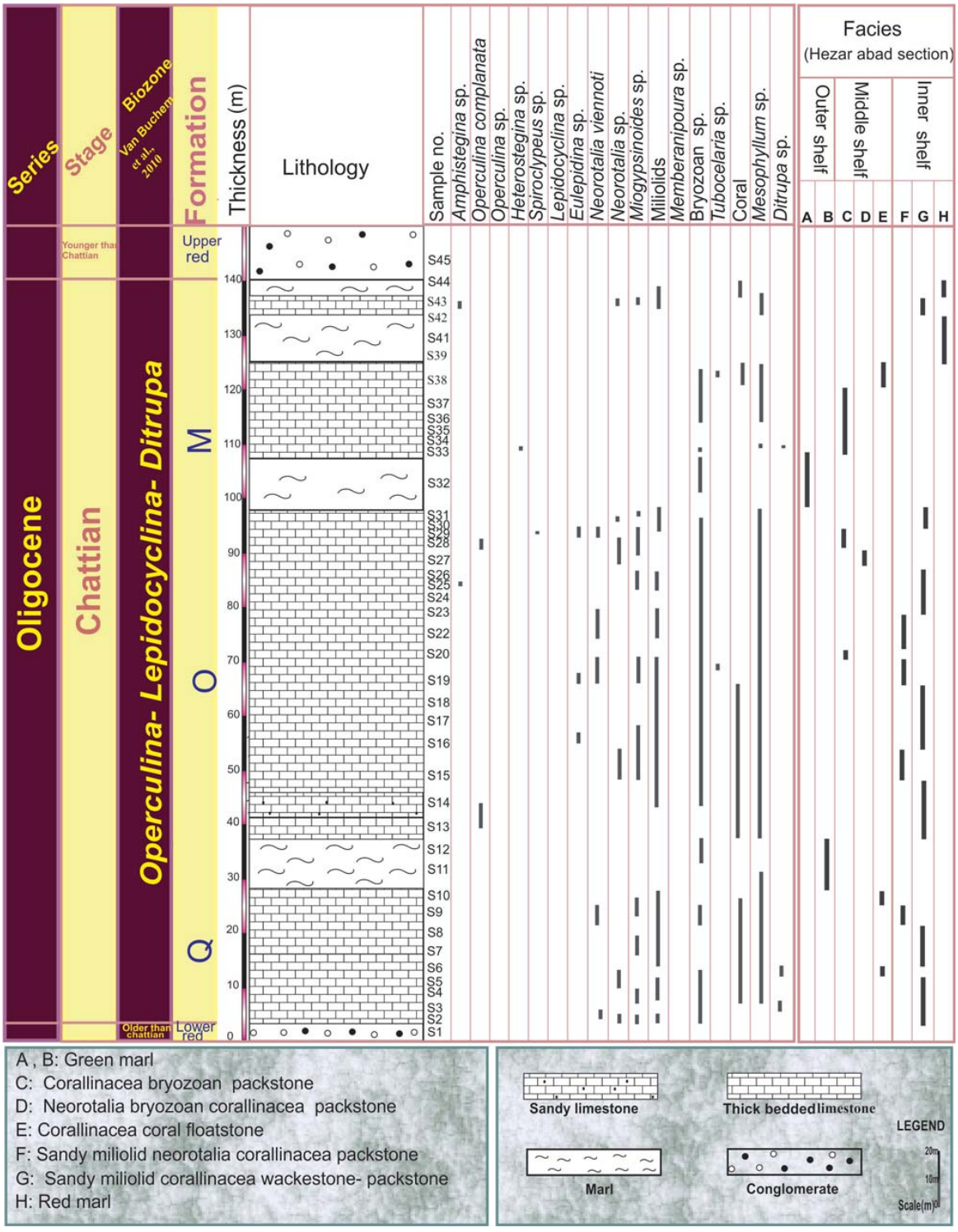

Fig 3. Lithology, biostratigraphy, paleoenvironment for Qom Formation in Hezar Abad

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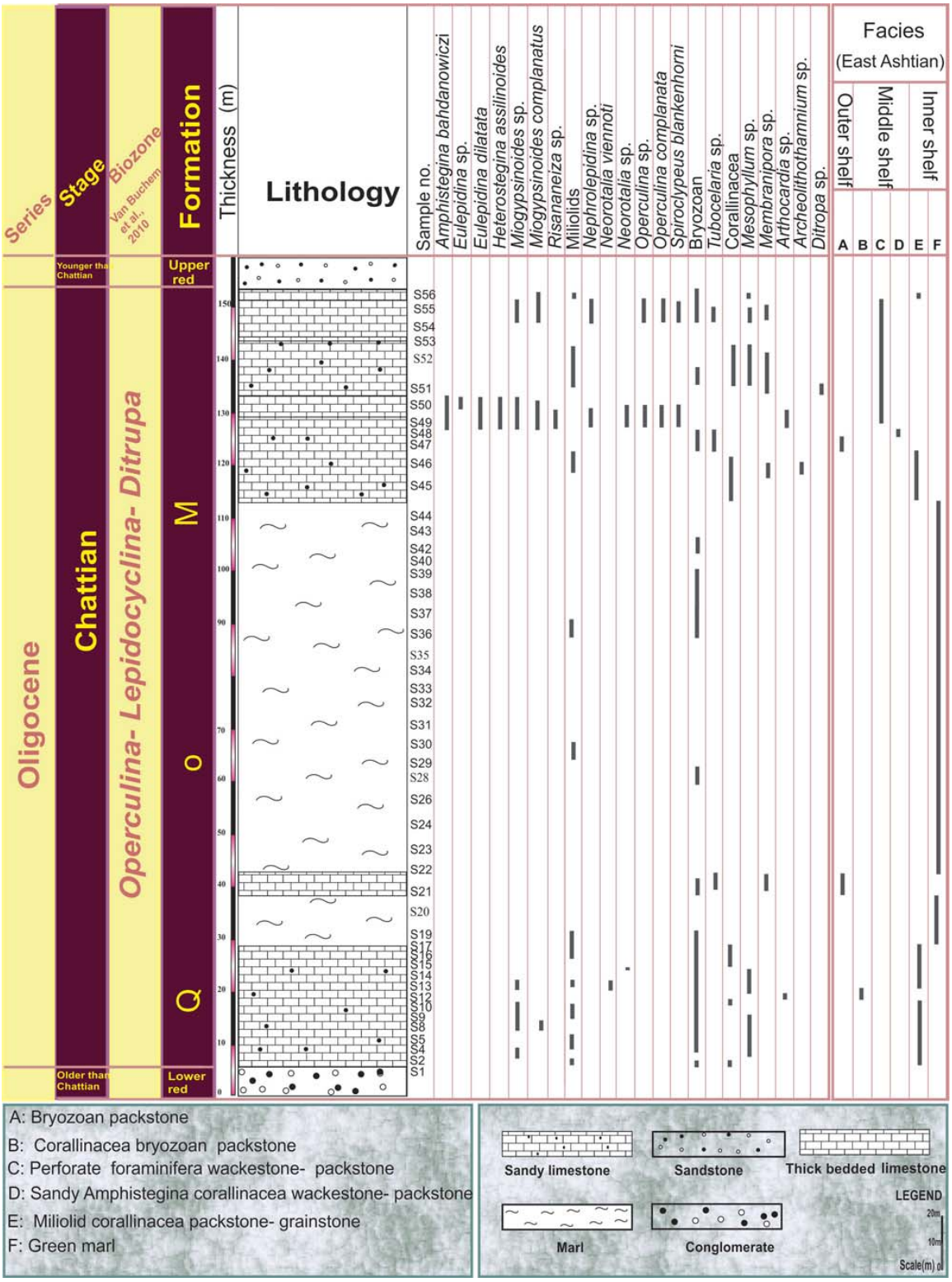

Fig 4. Lithology, biostratigraphy, paleoenvironment for Qom Formation in Ashtian section

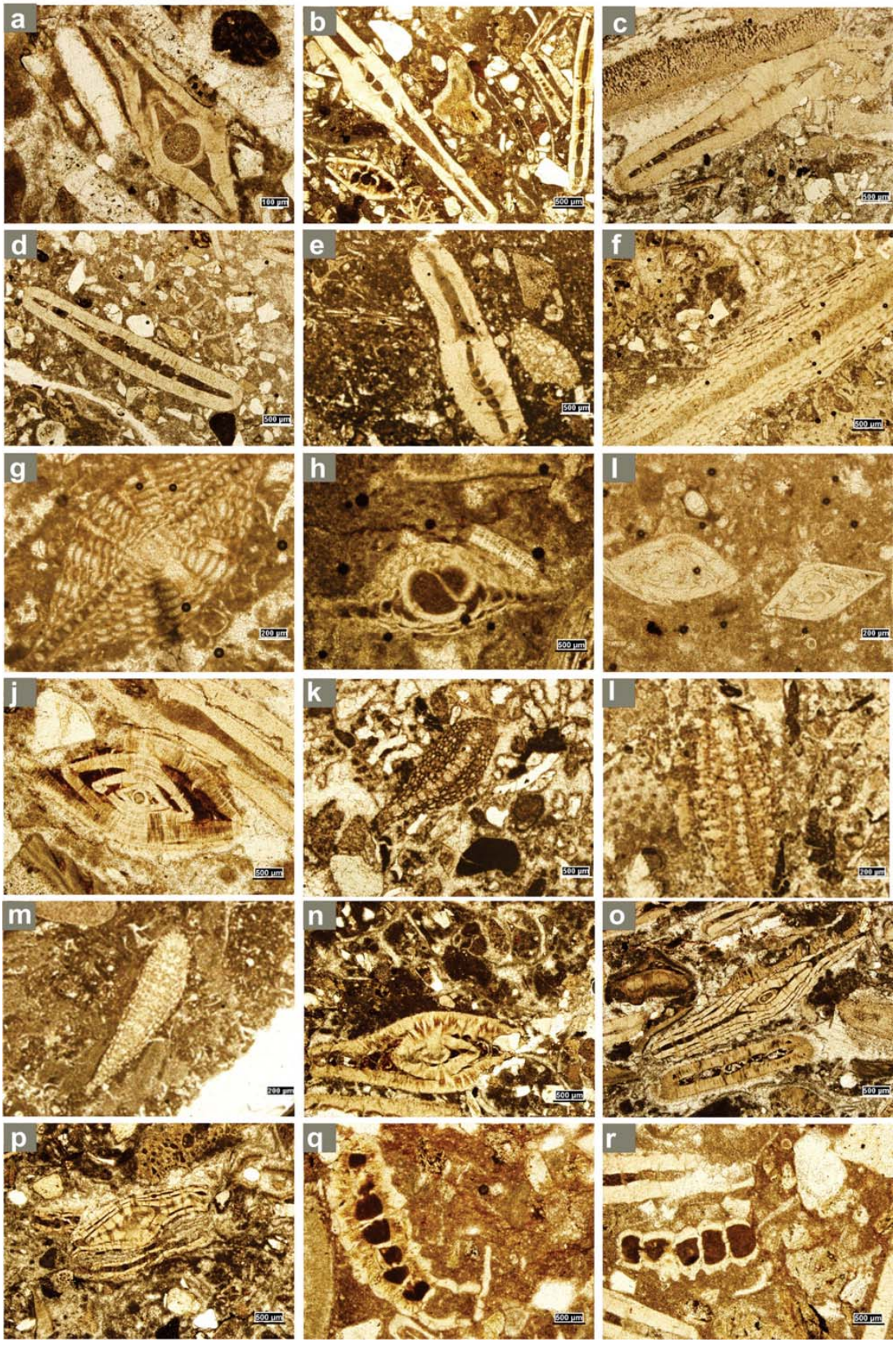

Fig 5. Benthic Foraminifera of the Qom Formation in study sections.

a–d: *Operculina complanata* (Axial section), a: Rakin section, Sample no. 50, b, c:, Ashtian section, Sample no. 56, 49, d: Hezarabad section, Sample no. 28, e: *Operculina* sp. (Axial section), Rakin section, Sample no. 16, f:

Eulepidina dilatata (Axial section), Ashtian section, Sample no. 50, g: *Lepidosyclina* sp.Axial section)., Rakin section, Sample no. 50, h: *Nephrolepidina* sp. (Axial section), Ashtian section, Sample no. 55, I: *Amphistegina* sp. (Axial section), Rakin section, Sample no. 54, j: *Amphistegina bohdanowiczi* (Axial section), Ashtian section, Sample no. 50, k: *Miogypsina irregularis* (Axial section), Rakin section, Sample no. 32, l, m: *Miogypsina globulina* (Axial section), Rakin section, Sample no. 21, 64. n: *Heterostegina asiilinoides* (Axial section), Ashtian section, Sample no. 50, o: *Spiroclypeus blankenhorni* (Axial section), Ashtian section, Sample no. 50, p: *Spiroclypeous* sp. (Axial section), Hezarabad section, Sample no. 38, q: *Miogypsinoides complanatus* (vertical section) , Ashtian section, sample no. 50, *Miogypsinoidse* sp. (vertical section) Hezarabad section sample no. 43

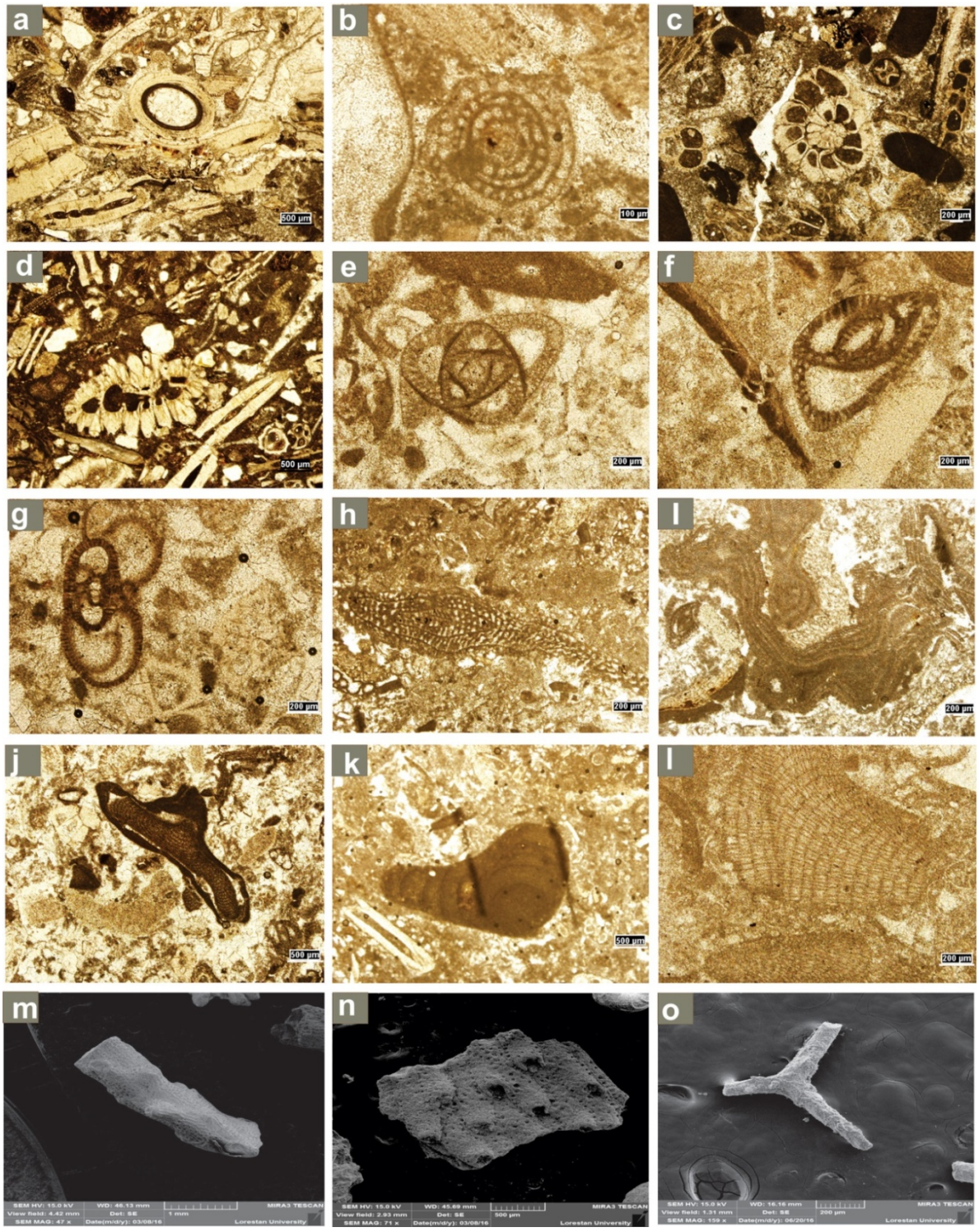

Fig 6. Benthic Foraminifera of the Qom Formation in study sections.

a: *Ditrupa* sp., Ashtian section, Sample no. 50, b*: Borelis* sp. (Equatorial section), Rakin section, Sample no. 27, c: *Neorotalia viennoti* (Equatorial section), Hezarabad section, Sample no. 30, d: *Risananeiza* sp. (Oblique section), Ashtian section, Sample no. 35, e:*Austrotrillina howchini* (Equatorial section), Rakin section, Sample no. 65, f: *Austrotrillina asmariensis* (Equatorial section), Rakin section, Sample no. 27, g: *Elphidium* sp. (Equatorial section), Rakin section. Sample no. 51, h: *Archaias kirkukensis*(Axial section), Rakin section, Sample no. 21,i: *Lithoporella* sp. Rakin section. Sample no. 59, J*: Mesophyllum* sp., Rakin section, Sample no. 31, k: *Lithothamnion* sp., Rakin section, Sample no.65, l: *Subterraniphyllum* sp., Rakin section, Sample no. 26, m: Bryozoan, Ashtian section, Sample no. 12, n: Bryozoan, Hezarabad section, Sample no. 11, o: Spicul sponge.

The most important andcommon microfossils in both sections are:*Amphistegina bahdanowiczi*, *Amphistegina* sp., *Eulepidina dilatata*, *Heterostegina* sp., *Lepidocyclina* sp., Miliolids, *Miogypsinoides complanatus*, *Miogypsinoides* sp., *Neorotalia* sp., *Neorotalia viennoti*, *Nepherolepidina* sp., *Operculina complanata*, *Operculina* sp.,Risananeiza sp., *Spiroclypeus blankenhorni*, *Spiroclypeus* sp., *Membranipoura* sp., *Tubucellaria* sp., *Mesophyllum* sp., *Ditrupa* sp. These foraminifera are correlated *with Miogypsina–Elphidium* sp. 14–Peneroplis farsenensis assemblage zone of van Buchem et al. (2010) and are attributed to the Aquitanian.

Based on biostratigraphy data, the sediments of the Qom Formation is Oligocene in age in theRakin section, whereas of the Qom Formation was deposited in Early Miocene in the Ashtian and Hezar Abad section.

5. SEDIMENTARY MODEL

Based on the sediments' fabric features and the dominant biotic components, 21 microfacies types were identified in the study sections. Microfacies analyses have allowed reconstruction of the palaeoenvironments of the Qom Formation in the study sections. Larger benthic foraminifera and red algae are common biotic comonents of Qom Formation deposits. Distribution and morphology of larger benthic foraminifera depend on intrabasinal conditions including depth, light, temperature, salinity, nutrient and water energy (Geel, 2000).The red algae, which use blue and green wavelengths of light in their photosynthetic process, are tremendously useful as paleoenvironmental indicatos, particulary for determining paleobathymetry(Banner and simmons, 1994). The microfacies analyses from study section of the Qom Formation show open marine, patch reef, lagoon, semi–restricted lagoon environments.

These depositional environments of the Oligocene–Miocene in the study area are similar to those found in a Shelf basin (Moissette et al., 2007, Mateu–Vicens et al., 2009;).

During the Chattian, outer shelf facies was predominant in the Rakin Section (facies a and b). The general lack of sedimentary structures, the fine–grained character, and the presence of undisturbed whole fossils from planktonic foraminifera, bryozoan and *Ditrupa* sp. suggest that facies a was deposited in calm, deep, below storm wave base (SWB), normal–salinity water and aphotic zone (Hallock., 1986, Cosovic et al., 2004;). Bryozoan is highly adapted to eutrophic and nutrient–deficient conditions (Mateu–Vicens et al., 2009). The presence bryozoan and lack of oligotrophic fauna as foraminifera and the absence of photo taxa as algae in facies b suggest that this microfacies was deposited below the photic zone and eutrophic conditions. A similar microfacies has also been reported from the south of Kashan (Central Iran) succession of Qom Formation (Mohammadi et al., 2011).

Outer shelf biota in the Hezar Abad section is characterized by abundant Sponge spicule, echinoid and bryozoan debries (facies a and b). Simultaneously, outer shelf conditions occurred in the Ashtian section (facies a). The lack of the larger benthic foraminifera and red algae represents aphotic zone and eutrophic condiions (Moissette et al. 2007, Mateu–Vicens et al. 2009).

The most common microfacies of the middle shelf in Rakin section are wackestone, packestone with bryozoanand imperforate foraminifera (microfacies c,d and e). The predominate fauna in fcies c are larger benthic foraminifera with perforate walls (*Lepidocyclina*).

The presence of large flat *Lepidocyclina* indicates that sedimentation took place in relatively deep water. Flatter test and thinner walls with increasing water depth reflect the decreased light levels at greater depths (Romero and Rosse, 2002). This biofacies has a fine grained matrix. Other bioclasts include *Amphistegina* and echinoid debris. The foraminifera assemblage of this facies shows close affinities to that described by Cosovic et al. (2004) of the Adriatic carbonate platform (Istrian Peninsula). Such assemblages are characteristic of lower shelf carbonate environments.Microfacies econsist of bioclastic packstones containing significant amounts of corallinacean and corals. Other bioclasts such as bryozoan, echinoid, *Miogypsina* are also present. The diverse fauna of this facies is interpreted as an open marine facies that formed seaward of the platform margin and within the storm wave base and well–oxygenated conditions.

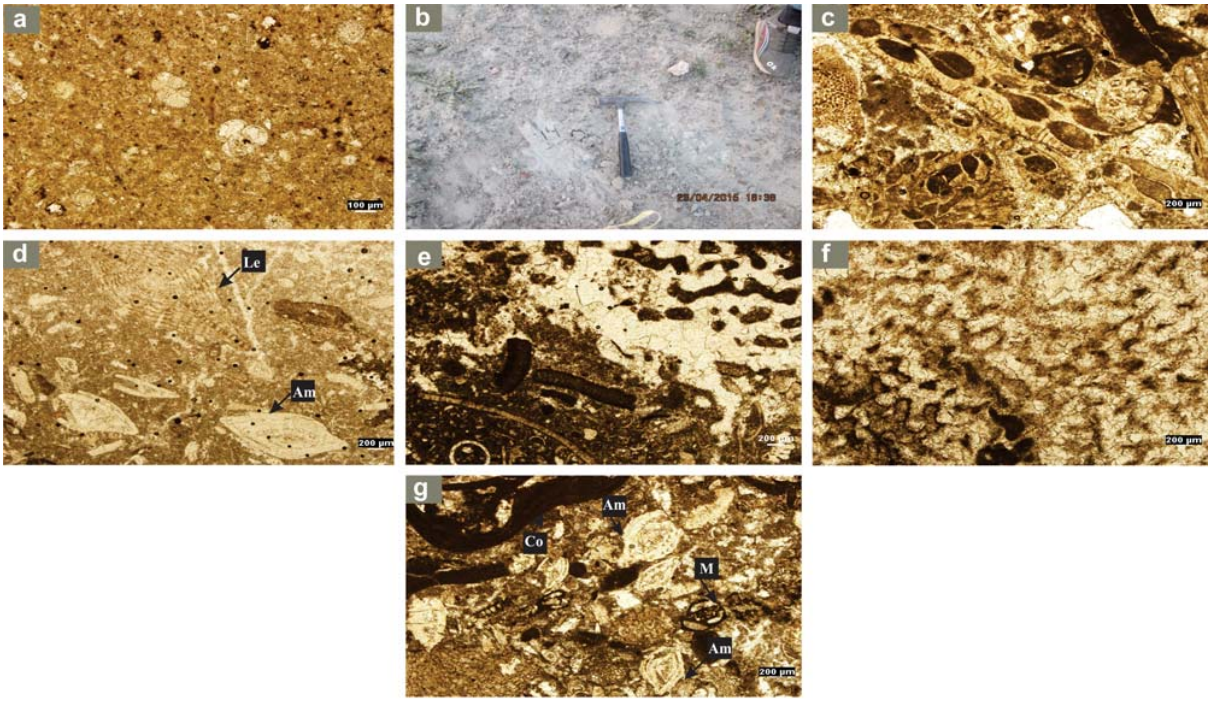

Fig 7. Microfacies types of the Qom Formation in Rakin section.

a)Bioclastic planktonic foraminifera, Sample no. 10, b) Green marl, Sample no. 42 c) Bioclast bryozoan packstone, d) Bioclast *lepidocyclia amphistegina* wackestone– packstone, Sample no. 50, e: Coral corallinacea packstone, Sample no. 59, f: Coral boundstone, Sample no. 52, g: Bioclast porfrate and impofrate foraminifera packstone, Sample no. 31.

Table 1. Microfacies found in samples from the Rakin section

Facies	Description
Bioclastic planktonic Foraminifera wackstone	Abundant plantonic foraminifera, rare fragments of bryozoan; echinoid and *Ditrupa*. Some planktonic chambers are field with spary cement
Green marl	Abundant bryozoans; rare echinoid fragments.
Bioclast bryozoan packstone	Abundant bryozoans; rare to common echinoid, corallinacea
Boclastic perforate Foraminiferawackstone-packstone	large coral and corallin fragments; hyaline foraminifera (commonly *Lepidocyclina- Operculina and Amphistegina*), rare bryozoan and echinoid fragments.
Bioclastic coral corallinacea packstone	Large colonical coral and corallinacea
Coral Boundstone	Coral fragments
Bioclastic perforate and impoferate wackestone-packstone	Common larger perforate benthic foraminifera; smaller porcellaneous imperforate foaminifera presents Rare to common echinoid and corallinacea

During Chattian, middle shelf conditions in Hezar Abad are characterized by bioclasic corallinacea–bryozoan wackestone–packstone (facies c), *Neorotalia*, bryozoan, corallinacean wackestone–packstone (facies d),corallinacea coral floatstone (facies e).Simultaneously, middle shelf conditionsoccurred at the Ashtian sectionis characterized by the presence of corallinacean bryozoan wackestone–packstone (facies b), Bioclastic perforate foraminifera wackestone–packstone(facies c) andSandy*Amphistegina* corallinacean wackestone–packstone (faciesd).The characteristic of the microfacies b is grainsupportedtexture in a micritic matrix with abundant bioclasts. Thetexture includes wackestone–packstone with coarsegrained bioclasts of bryozoans.Other bioclasts are corallinaceaenalgae and fragments of Mollusca.A similar microfacies occurs in Asmari Formationin Zagros basin (Saleh and Seyrafian, 2013).

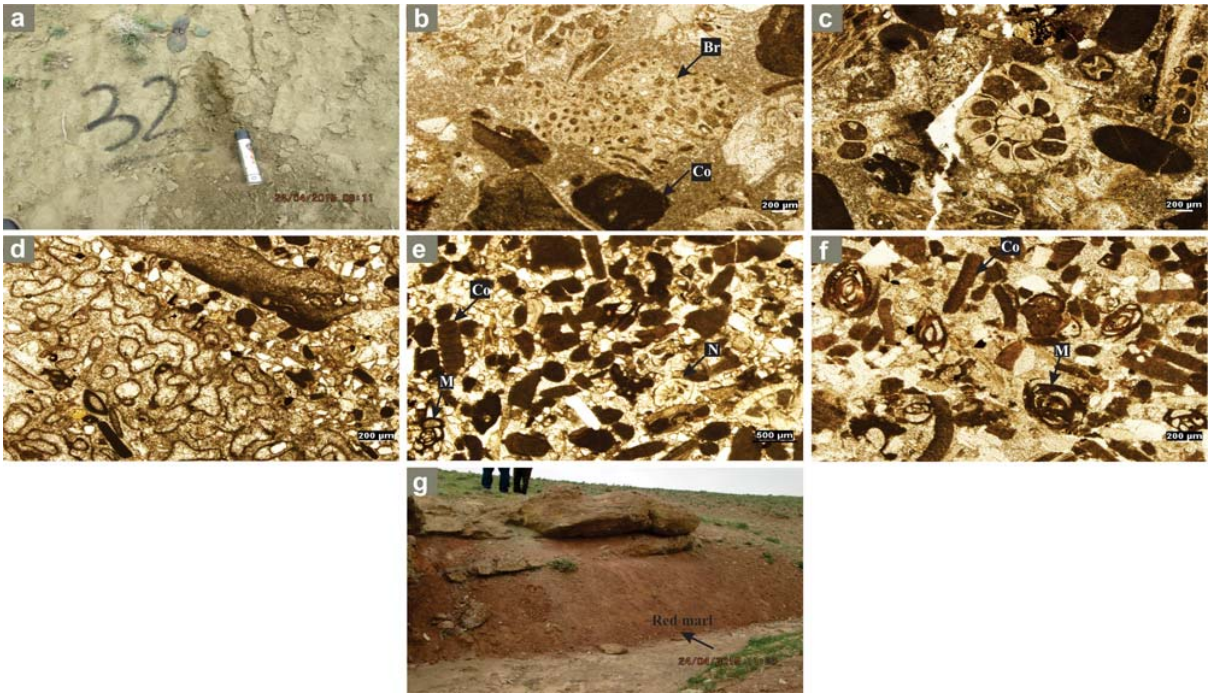

Fig 8. Microfacies types of the Qom Formation in Hezar Abad section

a)Green marl,Sample no.32,b)Bioclasic bryozoan– corallinacea wackestone–packstone, Samle no.20, Br: Bryozoan, Co, Corallinacea,c) Bioclastic, *Neorotalia*, bryozoan, corallinacean wackestone- packstone,Sample no.27,d)Bioclastic coral corallinacea floatstone, Sample no.38; e)Lithoclast miliolid, *Neorotalia*, corallinacea wackstone-packstone, Sample No.23; f)Sandy miliolid, corallinacea wackstone–packstone, Sample No.7, Co: corallinacea, M:Miliolids.

Table 2. Microfacies found in samples from the Hezar Abad section

Facies	Description
Green marl	Abundant bryozoan, sponge spicul, rare fragments of; echinoid
Corallinacea bryozoan packstone	Abundant bryozons; rare echinoid fragments.
Neorotalia bryozoanwackstone–packstone	Abundant bryozoan and hyaline foraminifera (commonly *Neorotalia*).
Corallinacea coralfloatstone	Large coral and corallin fragments;.
Sandy miliolid neorotalia corallinacea packstone–grainstone	Abundant Miliolids and corallinacea, rare hyaline Foraminifera (*Neorotalia, Amphistegina*) and fragment quartz
Sandy miliolid corallinacea packstone–grainstone	Common smaller porcellaneous imperforate foaminifera and corallinacea, and fragments quartz
Red marl	

This microfacies has been deposited in an open marine environment.The bioclastic corallinaceaen bryozoan packstonemicrofacies indicate the lack of an effective barrier (Flugel, 2010) to the marine environment. Bioclastic *Neorotalia* bryozoancorallinacean wackestone–packstone is dominated byNeorotalia, large bryozoan debris with encrustingcoralline algae; rare fragments of larger hyaline form (*Miogypsinoides*).The presence of high diverse stenohaline fauna such as red algae, bryozoan, echinoid and larger foraminifera (Neorotalia) indicate that the sedimentary environment was situated in the oligophotic zone in a shallow open marine environment or near a fair–water wave base on the proximal middle shelf(Cosovic et al., 2004).Bioclastic coral corallinacea floatstone has a graine supported texture insparry calcite cement. The major allochems are rhodoliteand coral debris.Echinoid and bryozoan fragments are also present. The depositional setting of this microfacies is the photiczone of open marine environment with medium to high energy. That formed between the fair weather wave base and the storm wave base (Flügel, 2010).

Bioclastic perforate foraminifera wackestone–packstone is characterized by a lithoclastic wackestone–packstone texture with perforate foraminifera such as *Operculina* and*Spiroclypeus*and *Amphistegina*. The presence of large flat *Operculina* indicates that sedimentation took place in relatively deep water, Wter depth 50–100m (Reiss and Hottinger, 1984).

The main characteristic of bioclastic perforate Foraminifera corallinacean wackestone- packstone is abundantfragments of corallinacean and *Amphistegina*. Echinoid and bryozoanfragments are also present.The presence of high diverse red algae, bryozoan, echinoid andlarger foraminifera) indicatethat the sedimentary environment was situated in theoligophotic zonenear a fair–water wave base on the proximal middle shelf (Cordaand Brandano, 2003; Cosovic et al., 2004).

Shoal condition is characterized bycoral boundstone and has been identified only in the Rakin section (microfacies f).The discontinuous coral boundstone layers indicate a patch reef depositional environment. Coral reef communities are adapted to oligotrophic environments (Flügel, 2010).

The Innerramp is recognised by lagoon environment.There is no evidence of tidal flat and shoreline or beach environments in the Qom Formation sediments in the Hezar Abad and Ashtian sections beacause of the lack of abrasion of the subaerial exposure (such as a vesicular fabric, microcodium, birdseye and fenestral).

The most common microfacies of the inner shelfsection are bioclastic perforate and impoferate wackestone–packstone(faciesg, in Rakin section respectively),sandy miliolid*Neorotalia*corallinacea wackstone–packstone; lithoclast miliolidcorallinacea packstone–grainstone and red marl (microfacies f, g and h in Hezar Abad section respectively) and bioclastic miliolids corallinacean packstone–grainstone and Green marl (microfacies e and f in Ashtian section respectively).A semi–restricted lagoon in the Rakin section is recognized by coexistence ofrestricted marine fauna such as imperforate foraminifera and openmarine fauna such as perforate foraminifera (microfacies g).

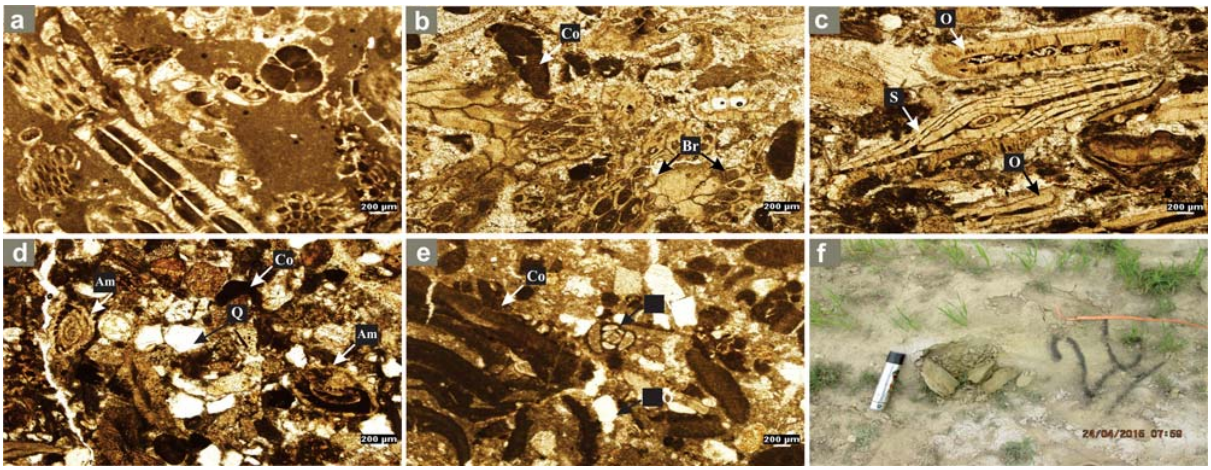

Fig 9. Microfacies types of the Qom Formation in Ashtian section.

a)Bioclastic bryozoan packstone, Sample No.21,b)Bioclastic, bryozoan, corallinacean wackestone- packstone, Sample No 22, Br: Bryozoan, Co:Corallinacea;c)Bioclastic perforate foraminifera wackestone–packstone,Sample 50, S:O:*Operculina, Spiroclpeus*,d).Bioclastic *Amphistegina* corallinacean wackestone–packstone, sample no.53,Am:*Amphistegina*, Co.*Coralinacea*, Q:Quartz,e) Bioclastic miliolids corallinacean wackestone- packstone, Sample no.45, C0:Coralinacea,Q:Quartz; f)Green marl, Sample no.26 .

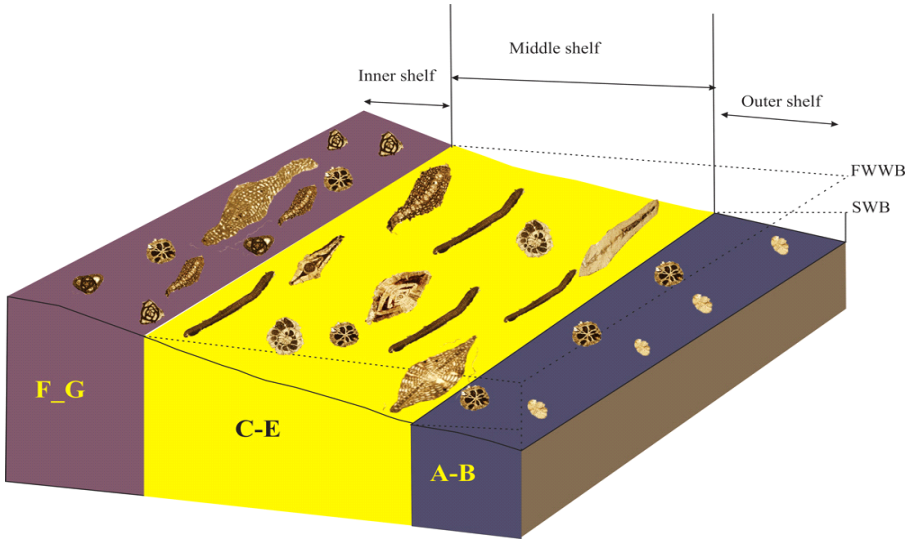

Fig 10. Depositional model for the carbonate platform of the in the study sections

Table 3. Microfacies found in samples from the Ashtian section

Facies	Description
Bryozoan packstone	Abundant plantonic foraminifera, rare fragments of bryozoan; echinoid and *Ditrupa*. Some planktonic chambers are field with spary cement
Corallinacea bryozoan packstone	Abundant bryozons and corallinacea; rare echinoid fragments.
Perforate foraminiferawackstone-packstone	Abundant hyaline foraminifera (commonly *Lepidocyclina* and *Operculina, Spiroclypeus*).
Sandy amphistegina corallinacea wackestone–packstone	Large coral and corallin fragments; hyaline foraminifera (Commonly *amphistegina*), rare bryozoan and echinoid fragments.
Milliolid corallinacea packstone–grainston	Abundant Miliolid and corallinacea
Green marl	Abundant Miliolid, bryozoan

Restricted conditions are suggested in the Hezar Abad and Ashtian section by the lack of a normalmarine biota and abundant skeletal components of restricted biota (benthic foraminifera such as miliolids).The biotic assemblage of the restrictedlagoon environment suggests deposition in a relatively nutrientrich (mesotrophy) with a slightly hypersaline habitat (Hallock and Gleen 1986; Geel, 2000) colonized by seagrassas suggested by the presence of epiphytic foraminifera suchas: *Archaias*, *Peneroplis* and *Borelis* (Brandano et al., 2009).

6. CONCLUSION

Micropaleontological and biostratigraphical studies indicate that the age of the Qom Formation in the Rakin section ranges from Chattian to Aquitnian. The age of the Qom Formation in the Ashtian and Hezar Abad sections is Chattian.Based on the paleoecology and lithology, three distinct depositional setting can be recognized: inner shelf, middle shelf and outer shelf.

Biogenic components of the Qom Formation are dominated by benthic foraminifera and corallinacea. Based on biogenic components and textures, 21 biofacies have been recognized and grouped into 3 depositional environments that correspond to the inner and middle shelf environments, and are interpreted as a carbonate platform developed in an open shelf settings.

The biotic assemblages of the Qom Formation suggest that carbonate sedimentation took place in mesotrophy to eutrophic conditions.

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