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 Qom Formation. 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 in an 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 mesotrophy 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. Magmatism 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 bedover sunstntial areas. The pronounced sea level fall exposed almost the entire the UDMA. The mid–Oligocene global sea level rise constricted marine circulation from the Mediterranean to the Indian Ocean (Rahaghi, 1980, Khaksaar 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 and sandstone. It is present throughout the Central Iran Zone, Sanandaj–Sirjan Zone and UDMA (Mohammadi et al., 2011). The objectives of this study are to establish a biostratigraphic 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.

![Subdivisions of Iran](image)

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 Ashtian section is located about 1 Km 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 sections underlies the Lower Upper Red Formation while in Rakin section, its upper boundary is not exposed.
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 underlying tuff 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 functional morphology of larger foraminifers. In biostratigraphic studies, 17 foraminifera species belonging to 18 genera were identified and 6 biozones recognized in these three sections. They are distinguished based on the zonal 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 Qom Formation only in Rakin section.
Fig 2. Lithology, biostratigraphy, paleoenvironment for Qom Formation in Rakin section.

The most important microfossils are: *Archaias hensoni*, *Borelis* sp., *Globigerina* sp., *Lepidocyclina* sp., *Nephrolepidina tournoueri*, *Lithothamnion* sp., *Lithoporella* sp. *Bryozoa*. This assemblage corresponds 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 Qom Formation 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., *Lithoporella* sp., *Mesophyllum* sp., *Lithothamnion* sp., *Bryozoa*. This assemblage is correlated with *Miogypsina – Elphidium* sp. 14–*Peneroplis farsensis* assemblage zone of van Buchem et al. (2010) and are attributed to the Aquitanian.
Assemblage 3. This assemblage is recorded in thickness 150 and 148 m in Ashtian and Hezar Abad sections, respectively.

Fig 3. Lithology, biostratigraphy, paleoenvironment for Qom Formation in Hezar Abad.
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, n: Heterostegina asiilinoides (Axial section), Ashtian section, Sample no. 50, o: Spirolypeus blankenhorni (Axial section), Ashtian section, Sample no. 50, p: 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: *Australotrillina howchini* (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: *Subterraniophyllum* 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 and common microfossils in both sections are: *Amphistegina bahdanoviczii*, *Amphistegina* sp., *Eulepidina dilatata*, *Heterostegina* sp., *Lepidocyclina* sp., *Miogypsina* sp., *Miogypsinaoides planatus*, *Miogypsinoidea* sp., *Neorotalia viennoti*, *Nephrolepidina* sp., *Operculina complanata*, *Operculina* sp., *Risananeiza* sp., *Spiroclyes blankenhornii*, *Spiricalyes* sp., *Membraniporella* 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 the Rakin 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 components 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 palaeoenvironmental indicators, particularly 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 debris (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 conditions (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 facies e 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 Rossé, 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 ecosist of bioclastic packstones containing significant amounts of corallineacean 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 perforate and imporfatere foraminifera packstone, Sample no. 31.

| Facies                                      | Description                                                                                                                                 |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Bioclastic planktonic Foraminifera wackstone | Abundant planktonic 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                                                                                                                                          |
| Bioclast 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 foraminifera presents Rare to common echinoid and corallinacea |

During Chattian, middle shelf conditions in Hezar Abad are characterized by bioclastic corallinacea–bryozoan wackestone–packstone (facies c), *Neorotalia*, bryozoan, corallinacea wackestone–packstone (facies d), corallinacea coral floatstone (facies e). Simultaneously, middle shelf conditions occurred at the Ashtian section characterized by the presence of corallinacea bryozoan wackestone–packstone (facies b), Bioclastic perforate foraminifera wackestone–packstone(facies c) and Sandy *Amphistegina* corallinacea wackestone–packstone (facies d). The characteristic of the microfacies b is grainsupported texture in a micritic matrix with abundant bioclasts. The texture includes wackestone–packstone with coarsegrained bioclasts of bryozoans. Other bioclasts are corallinaceaenanalgae 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) Bioclastic bryozoan– corallinacea wackestone–packstone, Sample no. 20; Br: Bryozoan, Co, Corallinacea; c) Bioclastic, *Neorotalia*, bryozoan, corallinacea 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 bryozans; rare echinoid fragments.                                 |
| *Neorotalia* bryozoan wackstone–packstone | Abundant bryozoan and hyaline foraminifera (commonly *Neorotalia*). |
| Corallinacea corallinacea floatstone | Large coral and corallin fragments.                                          |
| Sandy miliolid corallinacea packstone–grainstone | Abundant Miliolids and corallinacea, rare hyaline Foraminifera (Neorotalia, Amphistegina) and fragment quartz |
| Sandy miliolid corallinacea packstone–grainstone | Common smaller porcellaneous imperforate foraminifera and corallinacea, and fragments quartz |

Red marl

This microfacies has been deposited in an open marine environment. The bioclastic corallinacean bryozoan packstone microfacies indicate the lack of an effective barrier (Flugel, 2010) to the marine environment. Bioclastic *Neorotalia* bryozoan corallinacean wackestone–packstone is dominated by *Neorotalia*, large bryozoan debris with encrusting coralline 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 grain supported texture in parry calcite cement. The major allochems are rhodolite and coral debris. Echinoid and bryozoan fragments are also present. The depositional setting of this microfacies is the photic zone 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, Water depth 50–100m (Reiss and Hottinger, 1984).

The main characteristic of bioclastic perforate Foraminifera corallinacean wackestone- packstone is abundant fragments of corallinacean and *Amphistegina*. Echinoid and bryozoan fragments are also present. The presence of high diverse red algae, bryozoan, echinoid and larger foraminifera indicated that the sedimentary environment was situated in the oligotrophic zone near a fair–water wave base on the proximal middle shelf (Corda and Brandano, 2003; Cosovic et al., 2004).

Shoal condition is characterized by coral 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 Inner ramp 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 because of the lack of abrasion of the subaerial exposure (such as a vesicular fabric, microcodium, bryozoan and fenestral).

The most common microfacies of the inner shelf section are bioclastic perforate and impoferate wackestone–packstone (facies g, in Rakin section respectively), sandy miliolid *Neorotalia* corallinacea wackestone–packstone; lithoclast miliolid *Corallinacea* 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 of restricted marine fauna such as imperforate foraminifera and open marine 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*, *Spiroclypeus*, d) Bioclastic *Amphistegina* corallinacean wackestone–packstone, sample no. 53, Am: *Amphistegina*, Co: *Corallinacea*, Q: Quartz, e) Bioclastic miliolids corallinacean wackestone–packstone, Sample no. 45, C0: *Corallinacea*, 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 planctonic foraminifera, rare fragments of bryozoan; echinoid and Ditrupa. Some planktonic chambers are field with sparly cement |
| Corallinacea bryozoan packstone | Abundant bryozons and corallinacea; rare echinoid fragments.                |
| Perforate foraminifera wackstone-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 restricted lagoon environment suggests deposition in a relatively nutrient-rich (mesotrophy) with a slightly hypersaline habitat (Hallock and Gleen 1986; Geel, 2000) colonized by seagrasses suggested by the presence of epiphytic foraminifera such as: 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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