Biostratigraphy and paleo-ecological reconstruction on Scleractinian reef corals of Rupelian-Chattian succession (Qom Formation) in northeast of Delijan area

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Abstract
In this research, biostratigraphy and paleo-ecological reconstruction of the Qom Formation deposits in Bijegan village, northeast of Delijan, are discussed. The studied section is situated in the western margin of the Urumieh-Dokhtar magmatic arc (the intra-arc basin). The Qom Formation deposits at the studied area are Rupelian-Chattian in age. Larger benthic foraminifers are used for biostratigraphy with the occurrence of 14 genera and 16 species, which led to the identification of two faunal assemblages: 1 *Nummulites vascus-N.fichteli*, and 2. Lepidocyclina-Operculina-Ditrupa. Oligocene coral assemblages from the studied section are investigated with regard to its palaeoecological implications. These corals comprise four species of four genera and are compared with faunas from the Mediterranean Tethys and Indo-pacific Ocean, and they have an affinity to corals of the Mediterranean Tethys. Re-deposited branching Porites coral assemblages probably occurred in patchy dense frameworks which were destroyed during storm events and re-deposited in the present stratified horizons. The Porites-Faviidae assemblage represented a common feature of Oligocene coral faunas and increasing water energy.

Keywords: *Qom Formation, Rupelian-Chattian, Biostratigraphy, Paleo-ecology.*

Introduction

Qom Formation deposits are widespread at the north-eastern coast of the Tethyan Seaway (Reuter *et al*., 2008) and ranged from the Early Oligocene to the Early Miocene (Stöcklin & Setudehina, 1991). The Qom Foramtiondeposits including marine limestone and marls with gypsum and siliciclasticsis contrasting in lithology and color with the red beds of the underlying Lower Red Formation (Oligocene) and overlying Upper Red Formation (Miocene).

Furrer and Soder (1955) defined the lower and upper limits of the Qom Formation and alsosubdividedthe Qom Formation deposits into six members, from bottom to top including “a(basal limestone), b(sandy marls), c (alternating marls and limestone), d(evaporites), e(green marls) and f(top limestone)”. Soder (1959)subdivided the c member into four subunits as c_1-c_4 Bozorgnia (1965) proposed ten members for the Qom Formation and introduced the oldest member of the Qom Formation in Kashan area in name “unknown member” with Rupelian age. Bozorgnia and Kalantari (1965) havestudied the faunal assemblage and the lithology of different members of Qom Formation deposits and correlated this formation with Asmari Formation in southwest of Iran.

Biostratigraphic studies on larger benthic foraminifera carried out by Rahaghi (1973, 1976 and 1980) andproposed an Oligocene-Miocene age for the Qom Formation deposits.Biostratigraphy revision of the Qom Formation was carried out by Zhu *et al*. (2007) and Yazdi-Moghaddam (2011). Paleobiogeography reconstructions of the Qom Formation were studied by Reuter *et al*. (2008). Karevan*et al*. (2013) have studied the sedimentary facies and sequence stratigraphy of the Qom Formation in the Bijegan section. More recent researches about the different properties of the Qom Formation were done by Vaziri-Moghaddam and Torabi (2004), Seyrafian and Torabi (2005), Daneshian and Ramezani Dana (2007), Berning *et al*. (2009), Seddighi*et al*. (2012) and Mohammadi *et al*. (2012).

Okhravi and Amini (1998) reported a high percentage of in situ reef corals in the upper part of the limestone successions in three sections, located in the vicinity of Qom. Schuster and Wielandt (1999) are proposed palaeoecology and palaeobiogeography of Oligocene and Early Miocene coral faunas from Iran and described coral species from the Oligocene of the Abadeh section and Burdigalian of the Qom and Chalheghareh areas. The Iranian fauna is considered by Schuster

(2002b) as an ''experimental fauna consisting of old-fashioned Mediterranean Tethyan species and modern (Miocene) species from the Indo-West Pacific Region.''

Torabi (2003) reported several Cenozoic species of corals from Esfahan and Western Ardestan.Reuter *et al.* (2008) recorded *Tarbellastraea* sp., *Leptoseris* sp. and *Porites* sp. from Oligocene–Miocene deposits of Zefreh, south of Esfahan and *Goniopora* sp. and *Porites* sp. from the Qom area.Yazdi*et al.* (2012) focused on the paleo-bathymetry and paleoecology of the carbonate sediments of the Oligocene-early Miocene Qom formation in northeastern Isfahan on the basis of some colonial coral assemblages.

The study of the Qom Formation deposits in the studied section have continued three goals:
1. the biostratigraphy of the Qom Formation based on the distribution of the larger benthic foraminifera 2. the paleo-ecological reconstruction of the Qom Formation deposits using scleractinianreef corals and 3.comparison the coralswith coral faunas from the Mediterranean Tethys and Indo-pacific Ocean. A biostratigraphic framework has been developed for the Qom Formation herein using the biozones introducted for the Asmari Formation in the Zagros Basin (southwest of Iran) by Adams and Bourgeois (1967), Laursen*et al*. (2009) and Van Bouchem *et al*. (2010).

However, the present work is the first study of the biostratigraphy and paleo-ecological of the Qom Formation in the Bijegan section,in northeast of Delijan.

Study Area and Geological Setting

Closure of the Tethyan seaway during the Miocene, formation of a fore-arc (Sanandaj-Sirjan Basin) and a back-arc basin (Qom Basin) on the Iranian Plate originated during subduction of African-Arabian plate beneath the Iranian plate during the Mesozoic (Stöcklin & Setudehina, 1991). These basins are separated by a volcanic arc system which was formedin Eocene (Stöcklin & Setudehnia, 1991; Schuster & Wielandt, 1999; Reuter *et al*., 2008; Berning *et al*., 2009).

According to Berberian and Yasini (1983), Schuster and Wielandt (1999), Reuter *et al*. (2008), Mohammadi *et al*. (2012), Heydari *et al*. (2003), Aghanabati (2004) and different geological maps of Iran, the Qom Formation is deposited in Tethyan Seaway in Sanandaj–Sirjan (Esfahan-Sirjan fore-arc basin), UDMA (intra-arc basin) and Central Iran (Qom back-arc basin) as geological units of Iran. Based on reconstruction of UDMA and distribution of the Qom Formation deposits (Mohammadi *et al*., 2012), the Qom formation deposits of the studied section which were previously considered as back-arc basin deposits, in fact are deposited in the intra-arc basin(Fig.1).

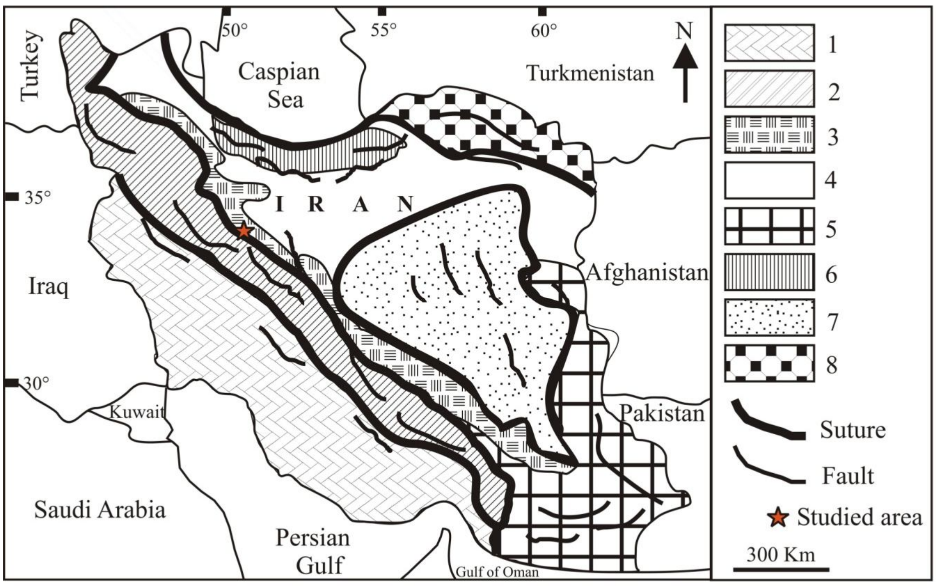

Figure 1: General map of Iran showing the eight geological provinces and geological setting of the studied area: 1. Zagros Province, 2. Sanandaj-Sirjan Province, 3. Urumieh-Dokhtar Province, 4. Central Iran Province, 5. Makran Province, 6. Alborz Province, 7. Lut Province and 8. Kopeh Dagh Province. (modified from Heydari *et al*., 2003).

The study area is in the western margin of Urumieh-Dokhtar magmatic arc (Intra arc basin) (Fig. 1) and is located at the Bijegan village, at the north flank of Varan anticline, 22 km northeast of Delijan. The Bijegan section is measured in detail at 34° 03' 47" N and 50° 46' 76" E (Fig. 2a). At the study area, the Qom Formation deposits, disconformably overlies the Lower Red Formation (Oligocene) and the upper boundary is covered by recent alluvium deposits(Fig. 2b, 3).

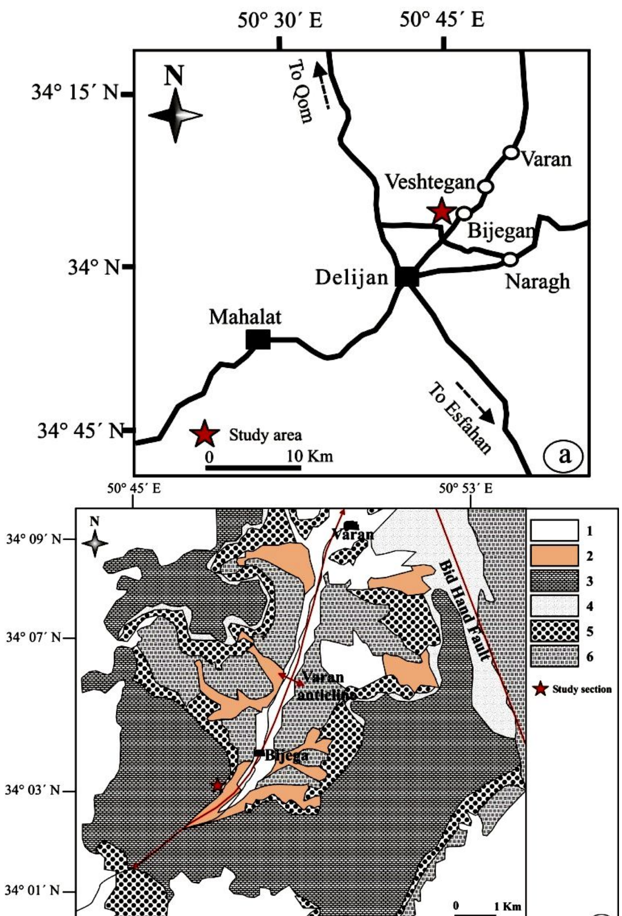

Figure 2: a) Location of the studied area at the northeast of Delijan. b) Geological map of the studied area (simplified from Ghalamghash *et al.* (1996)). 1. Young terraces and low gravel fans (Quaternary sediments), 2. Old terraces and high gravel fans (Quaternary sediments), 3. Oligocene-Miocene cream organo-detritic limestone with intercalations of marl (Qom Formation), 4. Oligocene-Miocene light green conglomerate, sandstone and sandy marl (Qom Formation), 5. Red conglomerate (Lower Red Formation), 6. Eocene tuffaceous sandstone and shale.

Material and Methods

This study involves one stratigraphic section of the Qom Formation deposits in Bijegan area that was measured and investigated sedimentologically. 133 samplesfrom this outcrop of the Qom Formation with the total thickness of 145.5 meters were collected to identify the distribution of benthic foraminifera and biostratigraphical characteristics of the section.

The Qom Formation in the studied areais mainly characterized by marly limestone, limestone, sandy limestone and sandstone and subdivided into 4 members including unknown, a, b and c_1.

Figure 3: Outcrop of the Bijegan section, northeast of Delijan

Biostratigraphy and foraminiferal ranges

In order to absence of planktonic foraminifers in the studied section, correlation with the standard planktonic zonation is impossible and biostratigraphy zonation is based on the larger benthic foraminifera. A standard biozonation has not been reported for the Qom Formation deposits but a considerable similarity is observed between the foraminifera from Qom Formation in Central Iran and the Asmari Formation in the Zagros Basin in southwest of Iran.

Laursen *et al*. (2009) and Van Buchem*et al*. (2010) have established a new biozonation for the Asmari Formation based on strontium isotope stratigraphy (Table 1). So, we applied the biozonation of Adams and Bourgeois (1967), Laursen *et al*. (2009) and Van Buchem *et al*. (2010) which are used for the Asmari Formation in Zagros Basin. A total of 14 genera and 16 species were encountered in the study area and their distributions have been plotted (Fig. 4). Two assemblges of foraminifera have been recognized and are discussed in ascending stratigraphic order as follow.

Biozone-1

From base upward to 124 m of the Qom Formation deposits in the studied section, *Nummulites* sp., *Nummulites fichteli-intermedius* group, *Nummulites* cf. *vascu, Nephrolepidina* sp., *Eulepidina* sp., *Eulepidina dilitata*, *Austrotrillina howchini, Operculina complanata, Peneroplis* cf. *evolutus, Peneroplis thomasi, Peneroplis farsensis, Valvulinid* sp., *Neorotalia viennoti, Borelis pygmaea, Borelis* sp., *Triloculina tricarinata, Discorbis* sp., *Pyrgo* sp., *Elphidium* sp., *Sphaerogypsina globula, Triloculina trigunula, Tubucellaria* sp., *Textularia* sp., *Bigenerina* sp. are present (Fig. 5A-I).

Table 1: Biozonation of the Asmari Formation (after Laursen *et al*., 2009; Van Buchem *et al*., 2010).

Stage	No.	Assemblage zone	Ma.
Burdigalian	7	**Borelis melo curdica-Borelis melo** *Dendritina rangi* + *Meandrospina* spp. + *Spirolina* spp. + polymorphinids + *Discorbis* sp. + Small peneroplids + Peneroplids evolutus + miliolids + Echinoids debris	18.2 to 20.2
Aquitanian	6	**Indeterminate zone** Very poor of fossils + Unidentified Miliolids + *Dentritina rangi*	20.2 to 22.2
Aquitanian	5	**Miogypsina – Elphidium sp. 14 – Peneroplis farsensis** *Miogypsina* spp. + *Elphidium* sp. 14 + *Peneroplis farsensis* + *Faverina asmaricus*	20.2 to 23
Chattian	4	**Archaias asmaricus / hensonsi – Miogypsinoides complanatus** *Archaias hensoni* + *Archaias asmaricus* + *Miogypsinoides complanatous* + *Spiroclypeus blanckenhorni*	23 to 28.2
Rupelian to Chattian	3	**Lepidocyclina – Operculina – Ditrupa** *Eulepidina dilatata* + *Heterostegina* spp. + *Rotalia viennoti* + *Haplophragmium slingeri* + *Planorbulina* spp. + Algae	23 to 32.3
Rupelian	2	**Nummulites vascus – Nummulites fichteli** *Operculina complanata* + *Heterostegina* spp. + *Rotalia viennoti* + Eulepidina Eelephantine+ *Archaias operculiformis* + *Subterranophyllum thomasi* + *Haplophragmium slingeri* + *Ditrupa* sp.	28.2 to 33.4
E. Oligocene to Eocene	1	**Globigerina spp. - Turborotalia cerraozulensis – Hantkenina** *Globigerina* spp. - Turborotalia cerraozulensis – *Hantkenina* sp.	30 to 33.5

This faunal assemblage is time equivalent to *Eulepidina- Nephrolepidina- Nummulites* Assemblage zone of Adams and Bourgeios (1967) indicating Oligocene in age and is equivalent to lower Asmari Formation. Also, this assemblage is correlated with *Nummulites vascus- Nummulites fichteli* Assemblage zone of Laursen *et al*. (2009) and Van Buchem *et al*. (2010) and is attributed to the Rupelian time.

Biozone- 2

From 124 to 145.5 m, *Heterostegina* sp., *Lepidocyclina* sp., *Neorotalia* sp., *Operculina* sp., *Amphistegina* sp., are present (Fig. 6A-H). This faunal assemblage is time equivalent to *Lepidocyclina– Operculina– Ditrupa* assemblage zone of Laursen *et al*. (2009) and Van Buchem *et al*. (2010) indicating Rupelian- Chattian in age. As a result, the Qom Formationin the studied section is Oligocene (Rupelian-Chattian) in age.

Corals

Most scleractinian corals live in shallow and clear waters (typically 50m) with low salinity variations.

But some azooxanthellate scleractinian corals can live in very deep (more than 1000 m) and cold water (Adkins *et al*., 1998; Smith *et al*., 2000; Adkins *et al*., 2003). The skeletal sleractinian coral assemblage comprise one of the dominant carbonate components of the Qom Formation that are widely considered in environmental interpretations such as salinity, paleo-depth, paleoclimate and paleotemperature (Veron, 1995; Rosen, 1999; Bosellini & Russo, 2000; Brandano *et al.,* 2010).

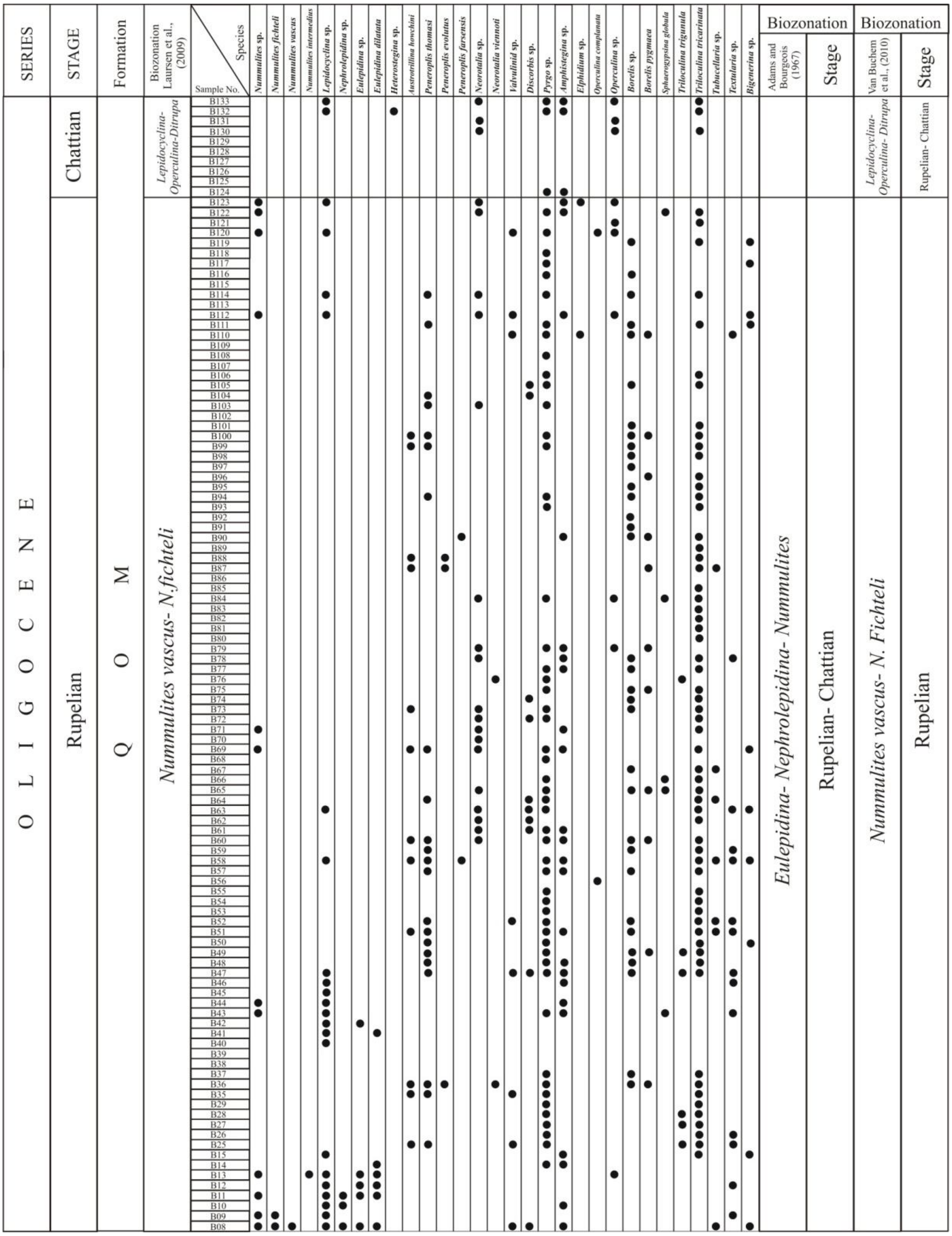

Figure 4: Biostratigraphic column of the Qom Formation deposits in the Bijegan section, northeast of Delijan

Corals are the best known fossils for paleo-ecological reconstruction in the studied section.The coral genera have been recognized by examining some external preserved features or through thin sections. Corals are dominant facies in the studiedsection (Karevan *et al*., 2013) and are often encrusted by various coralline algae, foraminifera and bryozoans.

Isolated and well preserved specimen of branching Porites corals find in marly limestone beds. This coral occurrence is scattered with massive and branching colonies that became more frequent upward the succession. Therefore, the coral fauna of the studied section is relatively low diverse (4 genera of 4 species). The coral growth occurred during short periods in the Early and Late Oligocene. The dominant growth form of scleractinian coral colonies is massive-globular, branching with thin and thick branches ranging in size from 1 to 2cm in diameter and 5 to 20cm in height and form a continuous framework up ward the studied section.

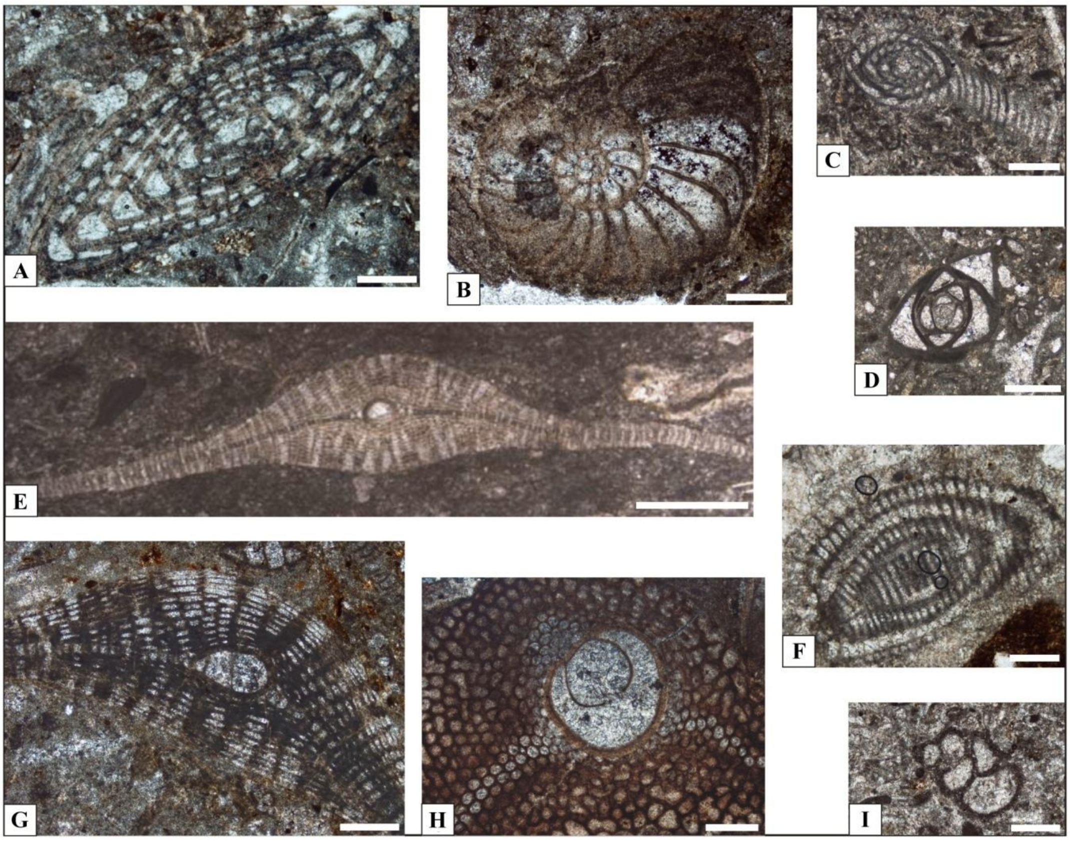

Figure 5: A) *Nummulites fichteli*; sample no. B 08, B) *Operculina complanata*; sample no. B 56, C) *Peneroplis thomasi*; sample no. B 25, D) *Triloculina tricarinata*; sample no. B 29, E) *Lepidocyclina* sp., sample no. B 43, F) *Borelis pygmaea*; sample no. B 36, G) *Eulepidina dilatata*; sample no. B 14, H) *Eulepidina* sp., sample no. B 12, I) *Valvulinid* sp., sample no. B 52. Scale bars represent 500µm

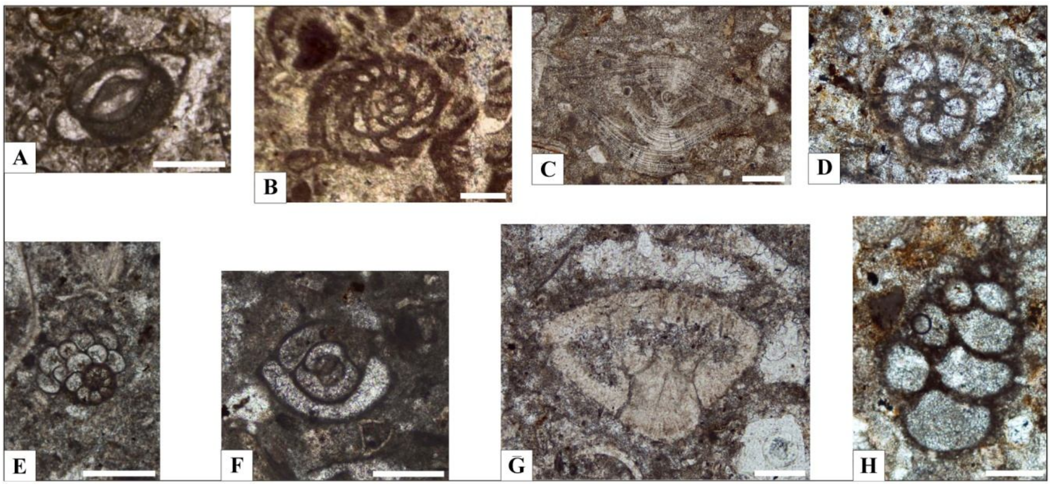

Figure 6. A) *Austrotrillina howchini*; sample no. B 88, B) *Peneroplis farsensis*; sample no. B 58, C) *Amphistegina* sp., sample no. B 48, D) *Neorotali viennoti*; sample no. B 76, E) *Sphaerogypsina globula*; sample no. B 122, F) *Pyrgo* sp., sample no. B 116, G) *Neorotalia* sp., sample no. B 71, H) *Textularia* sp., sample no. B 52. Scale bars represent 200µm.

In the coral reefs of the studied area, the massive-globular coral frameworks are composed of poritid (*Porites* sp.), faviid (*Favia* sp.) and branching coral frameworks are composed of (*Tarbellastrea* sp., *Caulastrea* sp.) corals. Thus, the reefs are characterized by poorly diversified assemblages of corals. The dominant frame builders are the poritids and faviids.

Paleoecology

From the basal sediments of the Qom Formation towards the upper parts in the studied section, two coral assemblages were identified including:
1. redeposited branching Poritescorals assemblage;
2. a shallow water Porites-Faviidae assemblage.
The first assemblage occured only in Rupelian (biozone I) and the second assemblage occured in Rupelian-Chattian time (biozone II). Rupelian zooxanthellate scleractinian coral assembleges are *Porites*sp., *Tarbellastraea*sp., *Caulastrea*sp. and also redeposited branching Poritescorals. These coral assemblages are distributed in unknown, a, b and lower part of c_1 members of the Qom Formation deposits. Schuster (2002b) identified three different assemblages from the section of Abadeh, central Iran including: 1. a solitary coral assemblage, 2. a *Leptoseris-Stylophora* assemblage of a low light environment, and 3) a Poritid-Faviidae assemblage forming patch reefs and we have just the third assemblage in our studied section.

We observed redeposited branching Poritescoral assemblages in marly limestone beds, in unknown and also b members. Coral reef assemblages such as *Caulastrea*sp. with thick branching formed are distributed with lateral extensive in "a" member of the Qom Formation. *Favia* sp. and *Porites* sp. with massive formed and *Tarbellastrea* sp. with thin branching formed are widely distributed in lower part of "c_1" member.

While the number of known Chattian zooxanthellate coral reef is not significantly different from the Rupelian, these zooxanthellate coral assemblages are distributed in the upper part of c_1 member.The most widespread genera are *Porites* sp. and *Favia* sp. which are also well distributed (Fig. 7).

Generally, except the first assemblage, other corals are formed reef structures with up to 100m of lateral extension and frequently occur with 2m height. Growth forms and the relationship to recent genera are used for the paleo-ecological reconstructions i.e. concerning water depth, illumination and water energy (Schuster & Wielandt, 1999). The growth of reef communities is controlled by abiotic factors such as intensity of light, hydraulic energy, topography, and nature of the substrate (Dodd & Stanton, 1990).

Corals have adapted to different environmental conditions through variation in colony morphology. Free-living corals, delicately branching, and thin plate-like corals tend to be most common in low energy environments. Massive, encrusting, and robust branching corals tend to be more common in high-energy environments. Variations in colony morphology also influence a corals ability to harness available light, and effectively remove large amounts of sediment. Platy or tabular corals can be more effective at collecting light while branching corals are more effective at removing sediment from their polyps (James & Bourque, 1992).

Redeposited branching Porites corals assemblage

In the lower and middle parts of the studied section, the redeposited branching Porites corals assemblage observed (Fig. 7) and infrequently distributed in green to gray marly limestones (Fig.9a) and associated with larger benthic foraminifera (e.g., Nummulites and Lepidocyclinids) and coralline red algae.The branches are partly oriented in one direction and are generally broken (Fig. 9b). This assemblage shows stratified deposits with accumulations of mainly broken and redeposited branches of isolated and preserved specimens of branching Porites corals (Fig.9c-f). In situ growth of Porites colonies is not observed.The lateral extension of these layers reaches less than 100 meters. The thickness of the coral layers varies between 5 and 6 meters. Upward the studied section, in situ massive and branching colonies forming dense frameworks.

The branching Poritescoral assembalgesof the studied section is interpreted as allochthonous horizons probably formed during a storm event. The fragmentation of the branches point to occasional occurring higher water movement. The storm bed serves as substrate for the subsequent growth of corals which represent the recolonisation of the environment. Branching Poritescorals probably occurred in patchy dense frameworks which were destroyed during storm events and redeposited in the present stratified horizons. (Schuster, 2000). Many of the branching Porites corals were extensively encrusted by coralline red algae and larger benthic foraminifera are in deep fore-reef, middle ramp environment (Frost & Weiss, 1979) with low-light conditions in the studied section (Fig. 8).

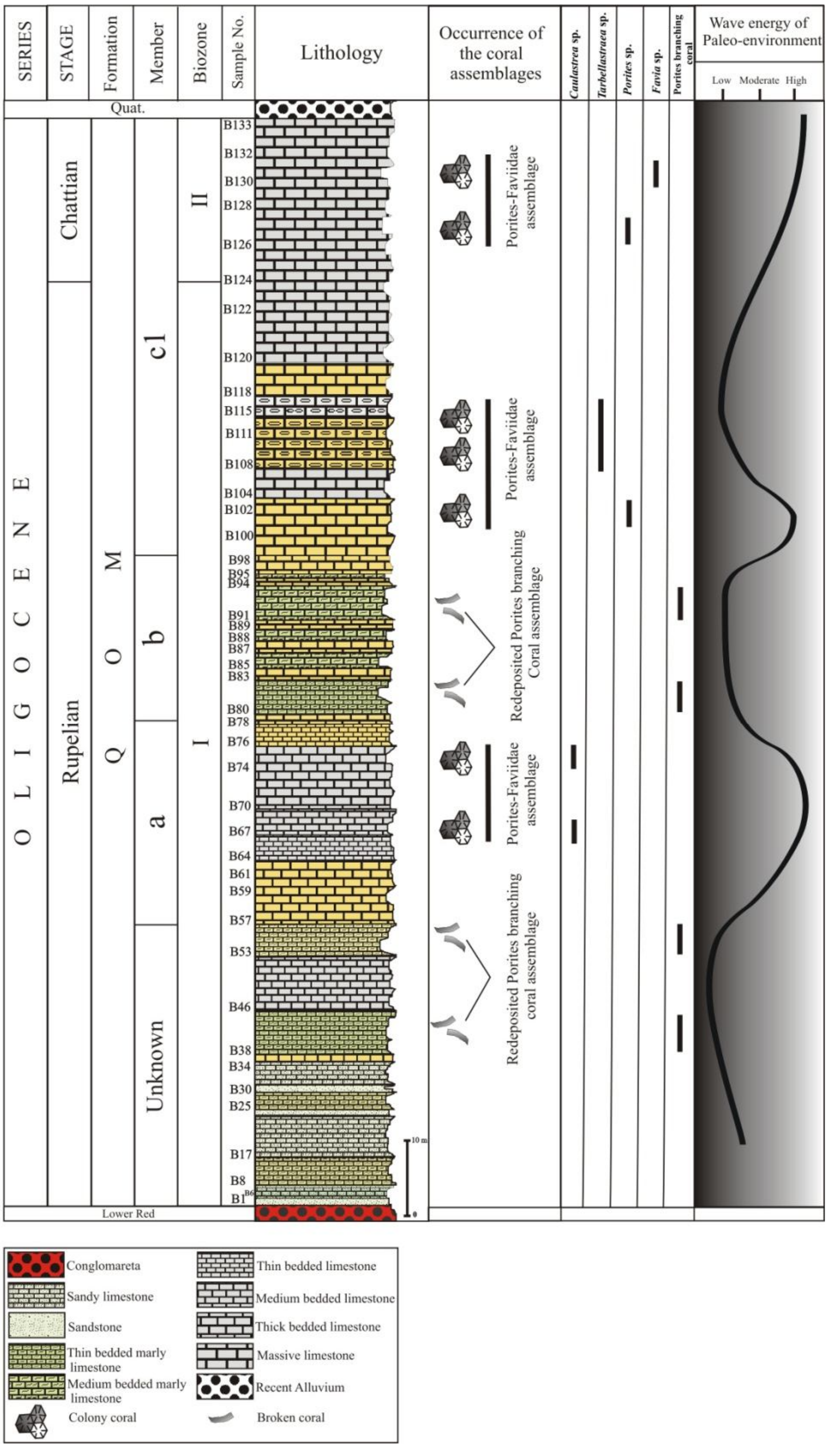

Figure 7: The studied section with the occurrence of the two coral assemblagesw

The down-cutting through the reef have resulted either from upward of the shelf margin and consequent shallow marine or subaerial erosion or by submarine fore-reef sediment chutes and debris flows eroding through the submerged terrace-like reef framework concomitant with drowning of the shelf (Frost *et al*., 1983).

Schuster (2002e) has reported isolated corals and one horizon with allochthonous corals (mainly branching Porites and Acropora) in the Lordegan section of the upper part of the Asmari Formation (Burdigalian) in Southwest of Iran. Also Frost *et al*. (1983) has mentioned tothe broken branching Porites corals assemblage of Oligocene marine deposits, the outcropping mid-tertiary seaward reef-to-island slope facies in Puerto Rico, in the Caribbean-Western Atlantic region.

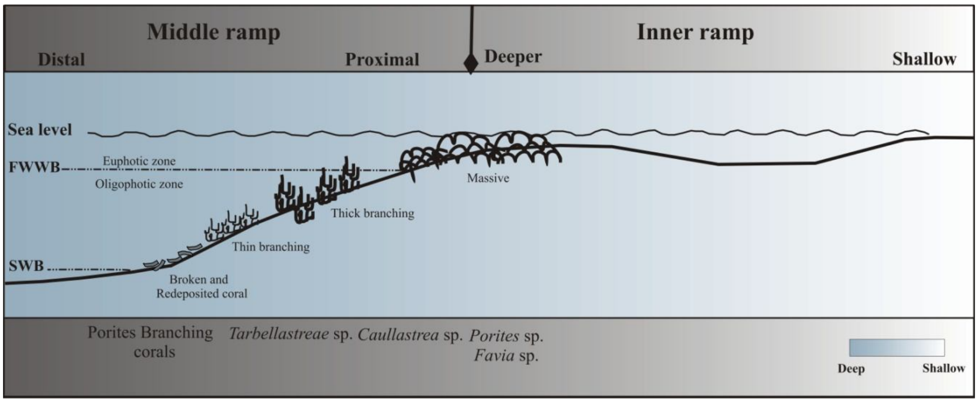

Figure 8: Distribution of corals growth morphologies in inner and middle ramp of the studied section

Figure 9: Redeposited branching Porites corals from the Bijegan section. a) Exposure of the branching Porites corals layer in marly limestone. b) Close-up of branching Porites corals layer, branches are partly unidirectional oriented. c,d) Detail of branching Porites corals specimens, e,f) transverse and axial thin sections of same specimen as figure d

Porites- Faviidae assemblage
In the intermediate and upward the studied section, the Porites-Faviidae assemblage observed (Fig. 7). The contributors to the assemblage are *Porites* sp. and *Favia* sp. (massive-shaped) and *Caullastrea* sp. and *Tarbellastreae* sp. in thick and thin branching-shaped (Fig. 10b-f). The Porites- Faviidae assemblage represents a common feature of Oligocene coral faunas. A dense framework is formed by Caullastrea colonies growing in 2 m height and more than 100 m lateral extension (Fig. 10a).

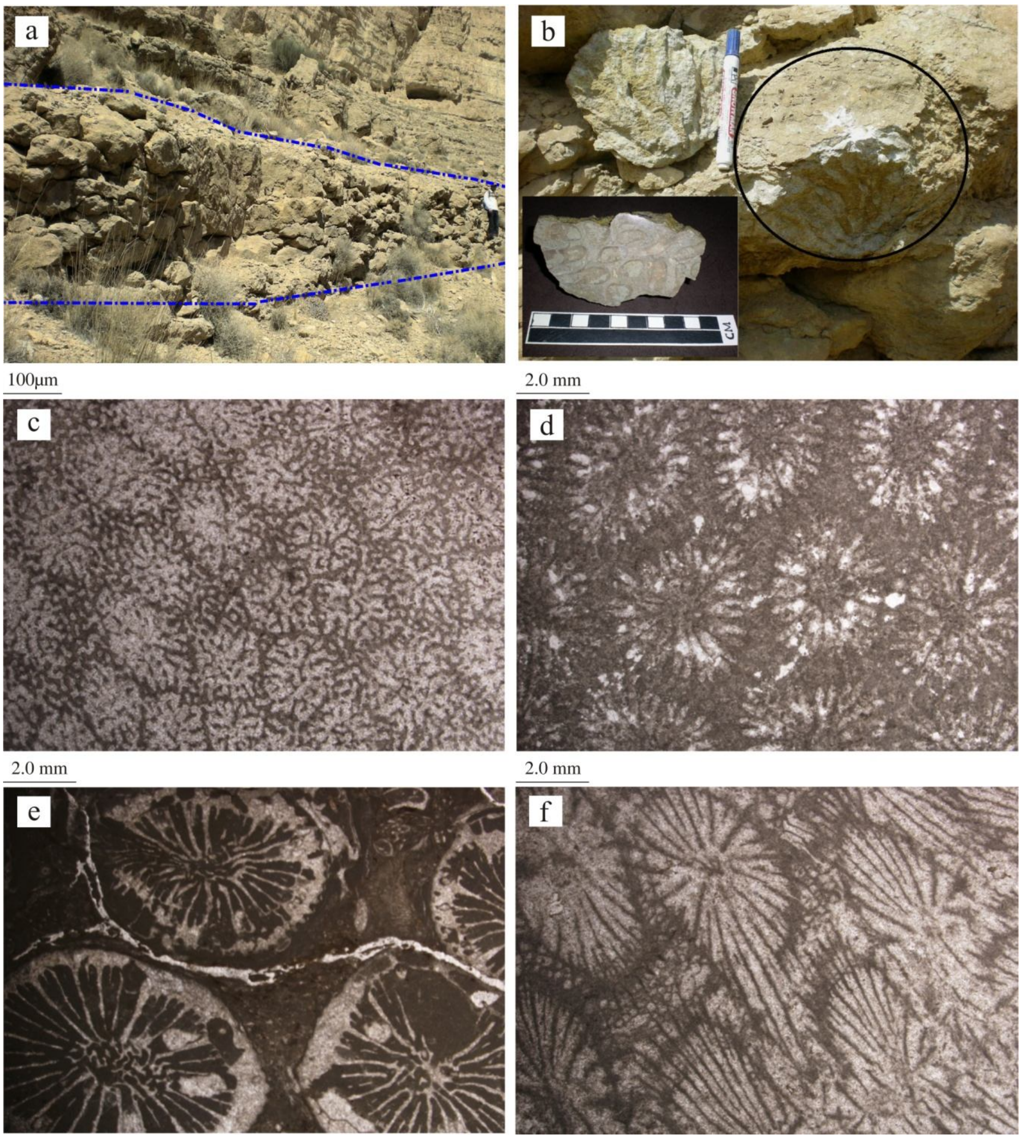

Figure 10: Porites- Faviidae assemblage from the Bijegan section. a) A dense framework formed by Caullastrea colonies. b) Close-up of *Caullastrea* sp. in thick branching-shaped. c) *Porites* sp., d) *Favia* sp., e) *Caullastrea* sp., f) *Tarbellastreae* sp. c-f: all transverse thin sections

The layers of Caullastrea branches with thick branching-shaped are interpreted as the result of storm events and increasing water energyin shallow to mid-depths water and Tarbellastreae branches with thin branching-shaped tend to be most common in low energy environments (James & Bourque, 1992) in the studied section. The branching colonies were adapted to a light intensity regime ranging from the lower euphotic zone to oligophotic zone characteristic of middle ramp setting (Karevan *et al*., 2013) in the studied section. Also, the coral associations composed of massive colonies (e.g. *Porites* sp. and *Favia* sp.) indicating the upper photic zone with depth of less that 20 m and a higher energy water regime (Yazdi *et al*., 2012) in the studied section. The nearshore inner ramp (Karevan *et al*., 2013) colonies were dominated by massive forms and rare branching forms developed in the upper photic (euphotic) zone with high light intensity (Fig. 8).

Modern assemblages dominated by poritids and faviids suggest a water depth of 5–20m or more (McCall *et al*., 1994). Recent coral faunas of the Indo-pacific (Perrin *et al*.,1995) and of the Red Sea (Riegl & Piller, 1997) show that both the Porites and faviidae assemblage soccur in mid-depths water. Toward the top of the succession the frequency of coral colonies increased and developed. In Oligocene time, the warming allowed the formation of diverse reef systems along the northern coast of the Tethys (Schuster 2002a, b, d). Therefore, thechanges in the composition of the coral assemblages and also in the sedimentary facies (Karevan *et al*., 2013), characterizing a gradual shallowing upward trend in the depositional succession of the studied section (Fig. 7).

Comparison of coral faunas

The connection between the Mediterranean Tethys in the northwest and the Indo-pacific Ocean in the southeast of Tethyan Seaway in the region of Iran can help us to palaeobiogeographic reconstructions.

The corals from northern Iran are generally regarded as being strongly related to faunas of the Mediterranean Tethys (Kühn, 1933). Schuster and Wielandt (1999) and Schuster (2002b) proposed that in Iran, the Abadeh Oligocene coral fauna is a mixture of Mediterranean and Indo-Pacific elements, while the Makran Burdigalian corals are entirely of Indo-Pacific affinity (McCall *et al*., 1994).

Divergence of Indo-Pacific and Mediterranean zooxanthellate coral faunas is in its maxium level after the Aquitanian (Schuster & Wielandt, 1999).The coral fauna of the Western Tethys and the Proto-Mediterranean has been revised in detail by Schuster and Wielandt (1999) and Schuster (2002a-e). The Oligocene center of diversity developed in the Iranian basins (the section of Abadeh), where reef formation is contributed by 61 species of 39 genera (Schuster, 2002b), whereas the western faunas (e.g. Greece) are less diverse and comprise about 31 species of 25 genera (Schuster, 2002d). Several species of scleractinian coral fauna from the formation were described by Schuster and Wielandt (1999) from Abadeh, Qom and Chalheghareh regions. Torabi (2003) and Reuter *et al.* (2008) also described some more scleractinian corals from western Ardestan (NE Isfahan), Zefreh (NE Isfahan) and Qom section.

The coral species occurring in the studied section have an affinity to corals of the Qom and Chalheghareh sections in the Qom back arc Basin in Central Iran that studied by Schuster and Wielandt (1999) and are related to faunas of the Mediterranean Tethys.The low diversity of Oligocene coral faunas in the studied section can probably be attributed to restricted marine connections with the Mediterranean Tethys. Secondly, local factors, such as situation of the study area in the western margin of the Urumieh-Dokhtar magmatic arc (Intra arc basin) could have had an influence on the low diversity of coral communities.

Conclusions

The exposed Qom Formation in northeast of Delijan, in the western margine of the Urumieh-Dokhtar magmatic arc (Intra-arc Basin) was studied on the basis of biostratigraphy and paleo-ecological factors. 14 genera and 16 species of the benthic foraminifera were recognized in the studied section. Based on the distribution of the larger benthic foraminifera, two assemblage biozones have been recorded. Assemblage 1 (*Nummulites vascus– N. fichteli*) considered to be Rupelian in age. Assemblage 2 (Lepidocyclina–Operculina–Ditrupa) indicates Rupelian- Chattian.

The Oligocene sedimentary sequence in the studied section included several beds with coral occurrences with can be grouped in two distinct assemblages. Redeposited branching Porites coral assemblages probably occurred in patchy dense frameworks which were destroyed during storm events and redeposited in the present stratified horizons and are associated with larger benthic foraminifera (e.g., Nummulites and Lepidocyclinids) and coralline red algae in deep fore-reef, in middle ramp environment. The Porites-Faviidae assemblage represented a common feature of Oligocene coral faunas and increasing water energy. The changes in the composition of coral faunas showing a shallowing-upward trend in the depositional sequence of the studied section.The Oligocene coral faunas in the Bijegan section have an affinity to corals of the Mediterranean Tethys.

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