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# Biostratigraphy and microfacies analysis of Gadvan Formation (late Barremian-early Aptian) in Coastal Fars zone, (Zagros, SW Iran)

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## Abstract

The investigation of lithostratigraphy, biostratigraphy and the microfacies analysis of the Gadvan Formation as an oil reservoir of Lower Cretaceous in the Zagros Basin is crucial. In this study Naser Abad section (Coastal Fars region, SW of Iran), consists of 170 meters thin to medium-bedded limestone with interbeds shale and marly limestone. According to stratigraphic distribution of identified foraminifers, two biozones are established which are: Paleorbitolina lenticularis zone and Hedbergella infracretacea Zone. Based on the investigated faunal assemblage, the age of Gadvan Formation is assigned to late Barremian-early Aptian. Microfacies studies led to the identification of five microfacies types which include: Algal-intraclast- bioclast wackestone, Intraclast- bioclast wackestone, Planktonic- bioclast wackestone, Radiolarian packstone and Orbitolina- bioclast wackestone. These microfacies show that the Gadvan Formation was deposited in both shallow water ramp and hemipelagic paleoenvironments. According to microfacies, carbonate platform of Gadvan Formation in the studied area corresponds to a moclinal platform which was affected by basement of Kazerun Fault zone.

***Keywords:*** *Gadvan Formation, Early Cretaceous, Biostratigraphy, Microfacies, Zagros Belt.*

## 1. Introduction

The Zagros Belt is a part of the Alpine-Himalayan orogenic belt, which has been formed by the closure of the Neo-Tethys Ocean as a result of the collision of Africa-Saudi plate with the Eurasia plate (Takin 1972, Berberian and King 1981). During the Jurassic-Middle Cretaceous, sediments in the Zagros Basin were deposited in a steadily subsiding basin (Berberian and King 1981) in which vertical movements and flexures along major basement Faults controlled the subsidence. The Zagros Belt, due to the large and young folds, contains huge hydrocarbon reservoirs so, the study of geological Formations in the Zagros Basin is important. Carbonate succession of the Gadvan formation of Early Cretaceous age is considered as an oil reservoir in the Zagros Basin and type section of this formation was studied at 50 Km from eastern Shiraz by Wynd (1965). The Zagros Basin was divided into four zones, which are Khuzestan, Lurestan, Coastal Fars and Interior Fars regions (Fig 1) (James and Wynd 1965; Ghavidel Syooki et al. 2003). The Gadvan Formation is distributed in Khuzestan, Coastal Fars and Interior Fars zones (Ghavidel Syooki et al. 1965). The Gadvan Formation is well known oil source rock in the Zagors area (Kobraei et al. 2017; Hatampour et al. 2014). Since the most petroleum exploration of the Zagros region has been focused in Khuzestan province, and the necessity of new oil fields explorations is required. The Coastal Fars zone is comprised of several outcrops of the Gadvan Formation. Selected stratigraphic section of the mentioned zone is called here Naser Abad section.

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It should be noted that many previous studies have been carried out on the Gadvan Formation in terms of biostratigraphy and microfacies (Shakib 1990, Abyat et al. 2012, Hamedanian et al. 2017; Afghah et al. 2016). The most target of this investigation on Gadvan Formation in Naser Abad section is biostratigraphic based on foraminiferal biozones and microfacies analysis, in order to provide high-resolution sedimentary environment and paleogeographic reconstruction.

## 2. Materials and Methods

In this study, a section of Gadvan formation was selected in the southern flank of the Mish anticline. Lithostratigraphic succession of Gadvan Formation and its lower and upper limits were determined by detail field work. Additionally, 79 samples were collected from the studied section and thin sections were prepared. Microscopic figures were deposited in Islamic Azad University of Shiraz. The foraminifers and calcareous algae were distinguished based on published works by Holbourn and Kaminski (1995), Premoli Silva and Verga (2004), Husinec and Sokač (2006), Afghah (2006), Hosseini and Conrad (2008), Parvaneh Nejad Shirazi (2009), Schroeder et al. (2010), Bucur et al. (2012), Abyat et al. (2016), Afghah et al. (2016), Brovina (2017), Coccioni (2019) and Abedpour et al. (2021). The stratigraphic distribution of foraminifers and calcareous algae supported establishment of biozones and the relative age of the Gadvan Formation. Based on the types of the grains (both skeletal and non- skeletal), textural framework (sorting, rate and orientation of the grains) and type of matrix and cement, the index microfacies were investigated and the classification of the

microfacies is determined according to Dunham (1962). The paleoenvironment of the studied formation is distinguished by stratigraphic distribution of the recognized microfacies.

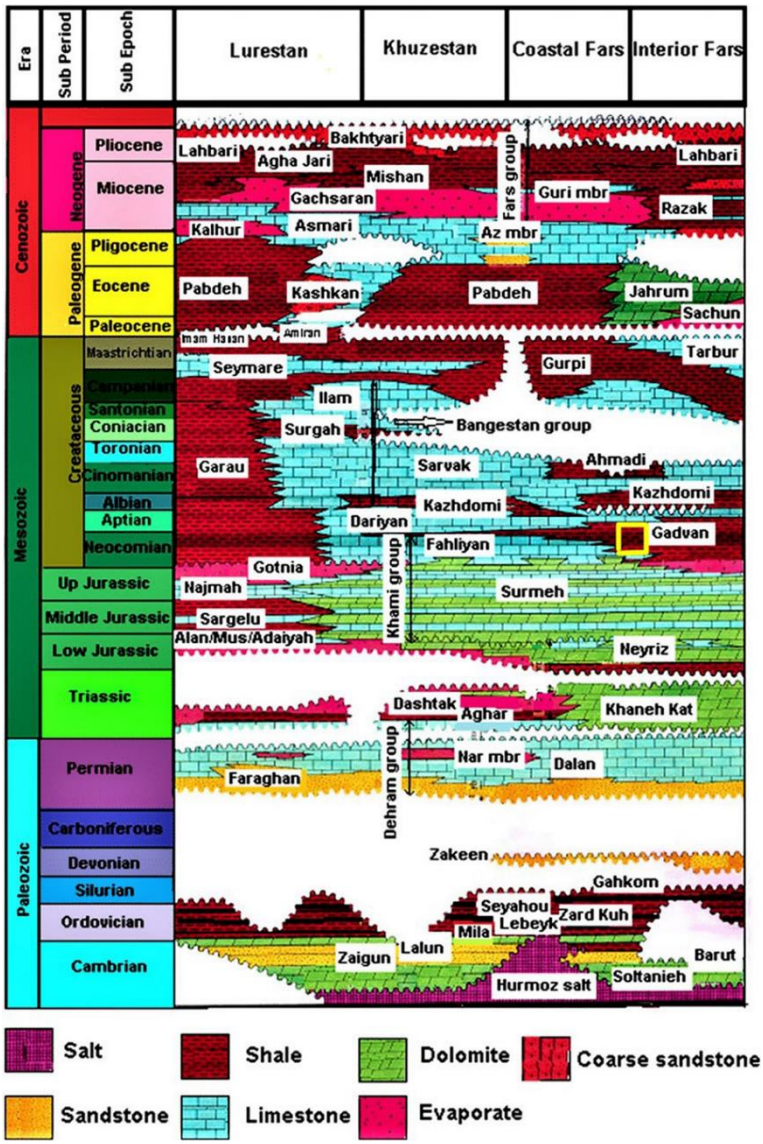


Fig 1. Simplified lithostratigraphic chart of the Zagros area (Ghavidel Syooki et al. 2003).

## 3. Geographical and geological setting

Upper Neocomian carbonates of the Fahliyan Formation (Figs. 1 and 2b) represent continuous sedimentation along the Fars region. Generally, shallow water carbonate system is predominately recognized in the Early Cretaceous. deposits of the Fars region, but Lower Cretaceous pelagic facies was also locally reported (Afghah 2006; Afghah and Shaabanpour Haghighi 2014, Abedpour et al. 2020 a and b; Keshavarzi et al. 2020). Both previous stratigraphic and micropaleontological data confirmed well distributed shallow water Lower Cretaceous carbonate along the Coastal and the Interior Fars zones. These successions are represented by: Fahilyan (Berriasian- Hauterivian), Gadvan (Barremian), Dariyan (Aptian), Kazhdumi (Albian) and Sarvak (Cenomanian) formations. Studied section is located in Coastal Fars Zone. 25 km southeast of Gachsaran city, with geographical coordination N: 33˚55′26″ E: 49˚33′15″ (Fig 2a).

It corresponds to the southern flank of the Mish anticline in the northern region of the Dezful embayment zone and the southern region of the Izeh zone in the simply folded Zagros belt Alavi (2004). Lower Cretaceous sequence (Hauterivian-Aptian) is well cropping out in the studied area (Fig 2b and 2c). forming the Fahliyan, Gadvan and Dariyan formations.

Actually, the selected section is located in the Kazerun Fault zone which is one of the most Faulted area in the Zagros Basin (Sephr and Cosgrove 2005). The Mish anticline shows a continuous Mesozoic to Cenozoic

succession consisting of Lower Jurassic to Paleogene deposits corresponding to the Khami group (Hith, Surmeh, Fahliyan, Gadvan and Dariyan formations), Kazhdumi, Sarvak, Ilam, Gurpi, Pabdeh and Asmari formations (Figs.1, 2d).

## 4. Lithostratigraphy

The type section of the Gadvan Formation is located in the Kuh-e Gadvan (east of Shiraz city). In the Naser Abad section, Gadvan Formation is extended approximately 170 meters thickness and consists of light gray thin to medium-bedded limestone, shale and with marly limestone levels (particularly in mid portion). The mentioned shale is recognized as interbed with marly limestone. The Gadvan Formation covers the massive limestone of Fahliyan formation (Berriasian-Lower Barremian) with sharp contact whereas the Gadvan Formation is covered by sandy limestone of the Dariyan.

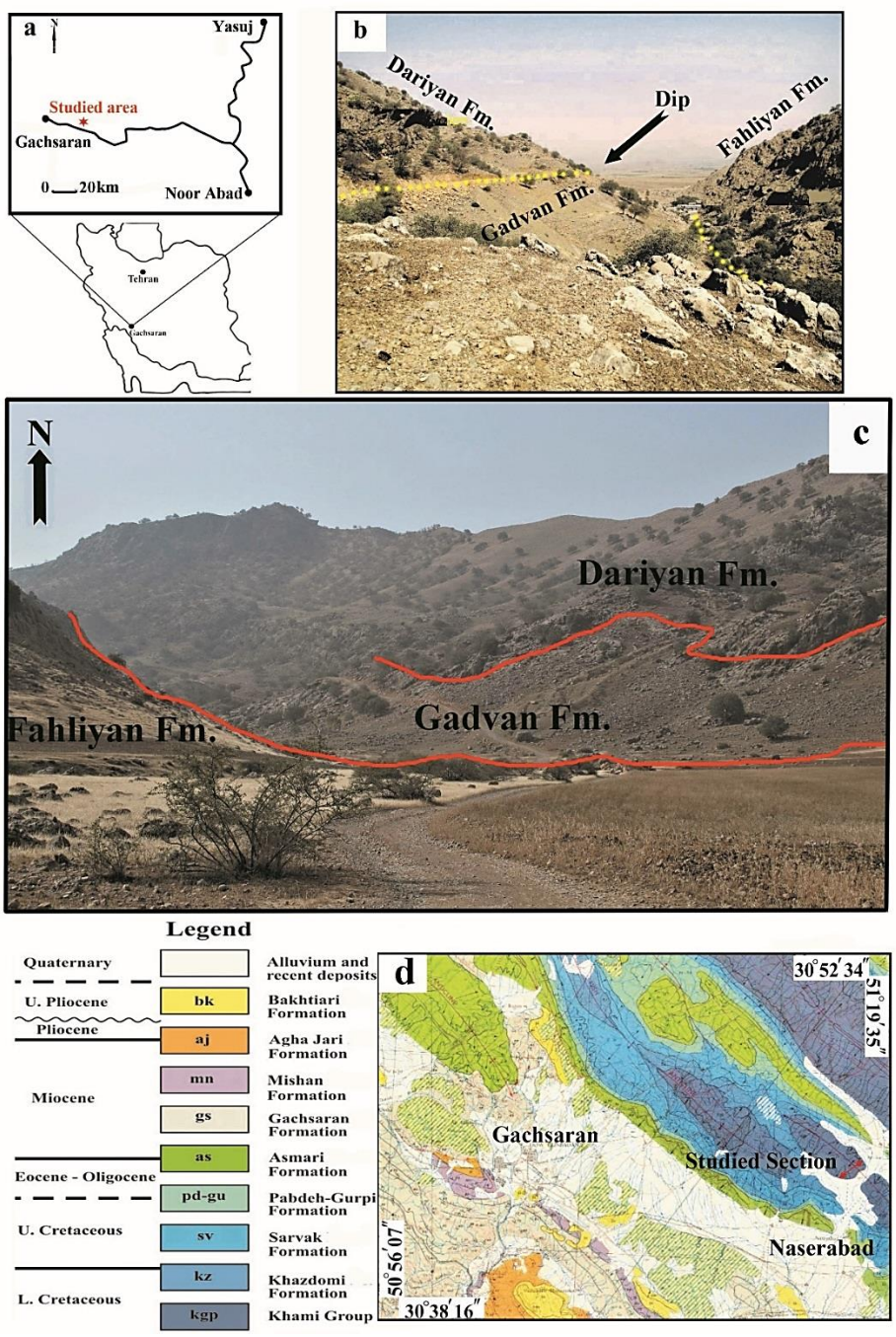


Fig 2. a. Geographical location of the studied section (Naser Abad), b and c. Lower Cretaceous sequence of the Mish anticline at Naser Abad section, showing the Fahliyan, Gadvan and Dariyan formations the d. Geological map of the studied area and location of Naser Abad section.

## 5. Biostratigraphy

Based on systematic studies 79 rock samples collected from the Gadvan Formation in the Naser Abad section, 12 genera, 13 species of benthic foraminifers, 4 genera, 8 species of planktonic foraminifers and 4 genera, 5 species of calcareous algae were identified. Due to the stratigraphic distribution of both benthic and pelagic foraminifers, two biozones were identified for the studied section, that confirmed the late Barremian-early Aptian age of the Gadvan Formation (Fig 3). The mentioned biozones consist of *Paleorbitolina lenticularis* as biozone 1 which is correspond to lowermost part of the Naser Abad section (Fig 3) and the other identified zone is attributed to *Hedbergella infracretacea* as biozone 2, correspond to lower part of Naser Abad section (Fig 3).

Actually, benthic foraminifers and calcareous algae are recognized at the base of the Gadvan Formation (Fig 3). The first established biozone is described as *Paleorbitolina lenticularis* Zone. The microscopic study confirms vertical distribution of planktic foraminifers (particularly Hedbergellids) and pelagic non-foraminifers biofacies (*Calcisphaerulla innominata* BONET and Radiolarian) which is described as a secondary biofacies of the *Hedbergella infracretacea* Zone. Eventually, the *Orbitolina* sp. Zone of Dariyan Formation covers the *Hedbergella infracretacea* Zone which is generally consisted of orbitolinids (Fig 3). The mentioned zone is attributed to Dariyan Formation.

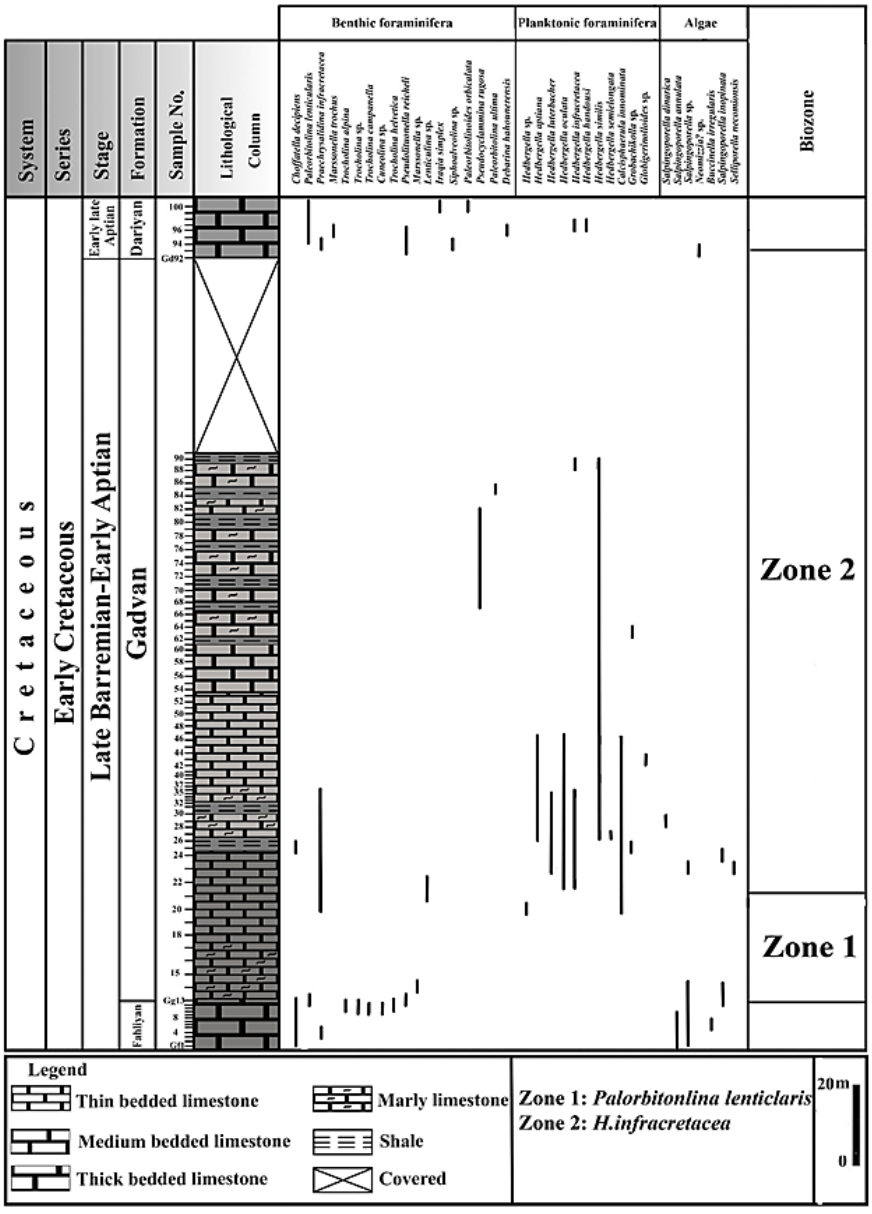


Fig 3. Stratigraphic distribution foraminifers and calcareous algae of the Gadvan Formation in the Naser Abad section.

**5.1 *Paleorbitolina lenticularis* Zone (Biozone 1)**

This zone is marked by presence of benthic foraminifers and calcareous algae of the studied section are comprised of: *Iraqia simplex* HENSON (Fig 4a), *Paleorbitolina lenticularis* BLUMENBACH Fig 4b), *Paleorbitolinoides orbiculata* ZHANG (Fig 4c), *Trocholina alpina* LEUPOLD (Fig 4d), *Trocholina* sp. (Fig 4e), *Trocholina campanella* ARNAUD-VANNEAU et al. (Fig 4f), *Pseudolituonella reicheli* MARIE (Fig 4g), *Praechrysalidina infracretacea* LUPERTO SINNI (Fig 4h), *Choffatella decipiens* SCHLUMBERGER (Fig 4i), *Cuneolina* sp., *Marssonella trochus* D'ORBIGNY, *Trocholina campanella* ARNAUD-VANNEAU et al., *Cuneolina* sp., *Marssonella* sp., *Lenticulina* sp., *Iraqia simplex* HENSON, *Siphoalveolina* sp., *Pseudocyclammina rugosa* D'ORBIGNY, *Debarina hahounerensis* FOUCADE, RAOULT & VILA, *Paleorbitolina ultima* CHERCHI & SCHROEDER. As mentioned before, the pelagic foraminifers zone which is consisted of Hedebergelids [e.g. *Hedbergella similis* LONGORIA (Fig 4j), *Hedbergella aptiana* BARTENSTEIN (Fig 4k)].

The calcareous algae assemblage of this zone is consisted of *Salpingoporella* sp., *Salpingoporella dinarica* RADOIČIĆ, *Salpingoporella annulata* CAROZZI (Fig 4l), *Salpingoporella inopinata* GOLLESTANEH (Fig 5a, b), *Neomizzia*? sp., *Actinoporella podolica* (ALTH) (Fig 5c), *Clypeina* sp. (Fig 5d), *Bacinella irregularis* RADOIČIĆ.

The mentioned faunal assemblage is distinguished in Intraclast bioclast wackestone and algal intraclast bioclast wackestone microfacies.

*Pseudolituonella reicheli* MARIE was reported from Barremian through Cenomanian succession of Central Iran (Rezaei Roozbahani 2011). Many records reveal that this taxon is referred to Cenomanian (Velić 2007; Afghah and Fadaei 2015). Among the identified foraminifers, *Trocholina campanella* ARNAUD-VANNEAU et al., *Trocholina alpina* LEUPOLD, *Choffatella decipiens* SCHLUMBERGER, *Marsonella trochus* D'ORBIGNY (Fig 6a), *Pseudocyclammina rugosa* D'ORBIGNY (Fig 6b), *Debarina hahounerensis* FOUCADE, RAOULT & VILA were previously recorded from Gadvan Formation as Barremian taxa (James and Wynd 1965, Kalantari 1976, Shakib 1990, Afghah et al. 2016). Schroeder et al. (2010) documented *Choffatella decipiens* SCHLUMBERGER and *Paleorbitolina lenticularis* BLUMENBACH as late Barremian/early Aptian taxa. *Paleorbitolinoides orbiculata* ZHANG reported from late early Aptian before (Schroeder et al., 2010). The mentioned taxa are generally associated with *Bacinella irregularis* RADOIČIĆ (Fig 6c) which was recorded from shallow water carbonate system of latest Kimmeridgian-early Aptian (Banner et al. 1990; Rameil et al. 2010; Sequero et al. 2019).

The mentioned taxon is associated with *Paleorbitolina ultima* CHERCHI and SCHROEDER as latest early Aptian age in south of Iran (Schroeder et al. 2010). However, the *Choffatella decipiens* SCHLUMBERGER and investigated Trocholinids confirm the Upper Barremian age of the Gadvan Formation lower portion. It should be noted that the *Choffatella decipiens* SCHLUMBERGER was known as long range taxon in the Zagros area (Khosrow Tehrani and Fonooni 1994).

On the other hand several stratigraphic ranges of *Choffatella decipiens* SCHLUMBERGER were reported from the Middle East. Witt and Gökdağ (1994) documented this taxon from Upper Barremian sequence of north Oman whereas Simmons (1994) recognized from early Early Aptian tp mid Early Aptian strata of central Oman Mountains. Moreover, Afghah (2006) documented this specimen from Barremian succession of Interior Fars zone of the Zagros area. With regards to planktonic association and presence of *Paleorbitolinoides orbiculata* ZHANG, determination of Barremian-Aptian boundary is applicable. With Regards to stratigraphic range of *Paleorbitolina lenticularis* BLUMENBACH and co-occurrence of *Paleorbitolinoides orbiculata* ZHANG the boundary of Barremian-Aptian is attributed before the first appearance of *Paleorbitolinoides obriculata* ZHANG.

Actually, this boundary is described as an intraformational boundary in the studied section. Calcareous algae are common organic components which are well distributed in shallow water facies of the Gadvan Formation. In addition, the algae are associated with benthic foraminifers. The identified calcareous algae (in this study) are previously recorded from Gadvan Formation (Afghah et al. 2016). It is necessary to note that the recognized calcareous algae are referred to long stratigraphic range. These taxa were found from shallow water carbonate of Zagros Cretaceous rock units particularly Fars carbonate platform (e.g. Fahliyan (Neocomian), Dairyan (Aptian), Sarvak (Cenomanian) and Tarbur formations (Campanian-Maastrichtian) (Afghah 2006; Hosseini and Conrad 2008; Afghah and Farhoudi 2012; Afghah and Shabaanpour Haghighi 2014; Afghah and Fadaei 2015; Afghah et al. 2016, Abedpour et al. 2016).

**5.2 Hedbergella infracretacea (Biozone 2)**

As mentioned before, the planktons are well developed on the benthic interval of the Gadvan Formation in studied section. Microscopic study supports the presence of plankton wackestone and plankton packstone as major microfacies in the zone of planktons which is named *Hedbergella infracretacea* Zone.

Diagnosed planktons of this zone are comprised of *Gorbachikella* sp. (Fig 6d), *Hedbergella aptiana* BARTENSTEIN, *Hedbergella* sp., *Hedbergella luterbacheri* LONGORIA, *Hedbergella occulta* LONGORIA (Fig 6e), *Hedbergella infracretacea*

GLAESSNER, *Hedbergella handousi* (SALAJ), *Hedbergella similis* LONGORIA, *Hedbergella semielongata* LONGORIA, *Calcisphaerulla innominata* BONET, *Gorbachikella* sp. (Fig 6d), *Globigerinolloides* sp. and radiolarian. The lower limit of this zone is marked by the first occurrence of *Hedbergella infracretacea* GLAESSNER. its upper limit is not clear, because the upper portion of the Gadvan Formation is covered by soil.

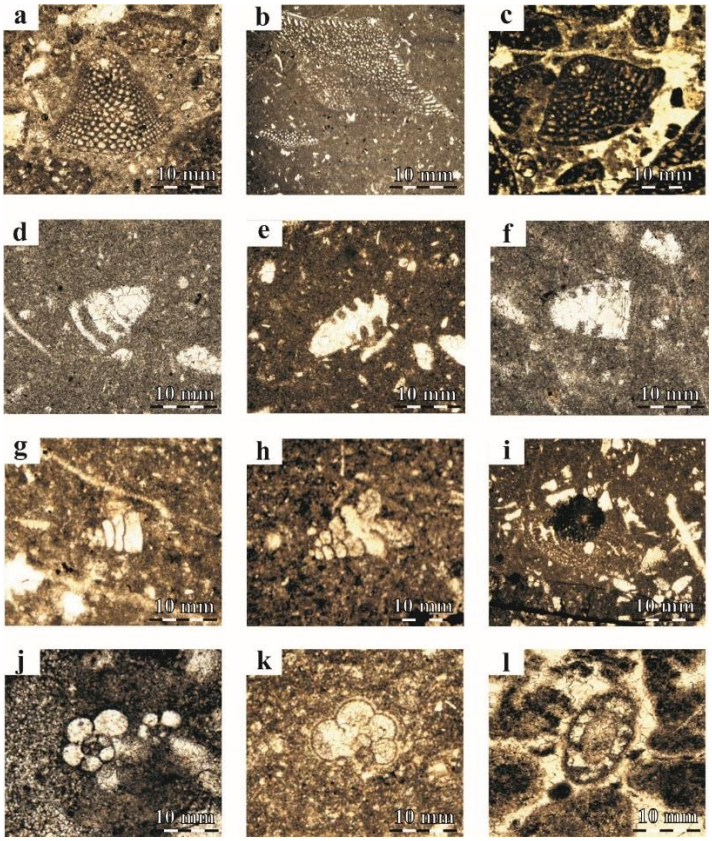


Fig 4. Benthic and pelagic foraminifera and calcareous algae of the Naser Abad section, (a) *Iraqia simplex* HENSON, sample Gd 100, (b) *Paleorbitolina lenticularis* BLUMENBACH, sample Gd97, (c) *Paleorbitolinoides orbiculata* ZHANG, sample Gd 100, (d) *Trocholina alpina* LEUPOLD, sample Gf 12, (e) *Trocholina* sp., sample Gf 12, (f) *Trocholina campanella* ARNAUD-VANNEAU et al., sample Gf 11, (g) *Pseudolituonella reicheli* MARIE, sample Gd 96, (h) *Praechrysalidina infracretacea* LUPERTO SINNI, sample Gg 20, (i) *Choffatella decipiens* SCHLUMBERGER, sample Gf 11, (j) *Hedbergella similis* LONGORIA, sample Gg 27, (k) *Hedbergella aptiana* BARTENSTEIN, sample Gg 43, (l) *Salpingoporella annulata* CAROZZI, sample Gf 2.

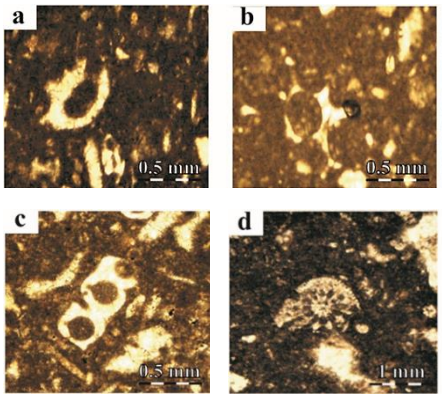


Fig 5. Calcareous algae of the Gadvan Formation, (a, b) *Salpingoporella inopinata* GOLLESTANEH, sample Gf 15, (c) *Actinoporella podolica* (ALTH), sample Gf 13, (d) *Clypeina* sp., sample 14.

Many of Gadvan Formation investigated planktons are assigned to Hedbergellids which are referred to *Hedbergella aptiana* BARTENSTEIN, *Hedbergella* sp., *Hedbergella luterbacheri* LONGORIA, *Hedbergella occulta* LONGORIA, *Hedbergella infracretacea* GLAESSNER, *Hedbergella handousi* SALAJ, *Hedbergella similis* LONGORIA, *Hedbergella semielongata* LONGORIA, and other planktons are also recognized (e.g. *Gorbachikella* sp., *Globigerinolloides* sp.) as separated zone of *Hedbergella infracretacea* which is distinguished in some part of the lower portion and the base of the mid portion of the studied section. *Calcisphaerulla innominata* BONET is generally found with the plankton faunal assemblage. Actually, the mentioned zone indicates as open marine facies which is mainly made of calcareous mud as matrix and the skeletal grains are assigned to planktons and *Calcisphaerulla innominata* BONET. The upper limit of the *Hedbergella infracretacea* Zone is covered and the first occurrence of orbitolinids which is assigned to Dariyan formation. The mentioned taxon was previously recorded from Upper Barremian-Aptian sediments of southern Tibet (Fang et al. 2021) while this taxon was documented from Upper Barremian strata of North Sea (Rückheim et al. 2006). some biostratigraphic records (e.g. Kumar Mishra et al. 2020) confirmed similar range of *Hedbergella infracretacea* in south-east India. It is necessary to note that the Barremian-Aptian boundary of the pelagic facies was determined by *Blowiella blowi* (BOLLI)and *Leupoldina cabri* (SIGAL) as standard zone of early Aptian by Moullade et al. (1998). Moreover, Karpuk et al. (2018) documented *Blowiella blowi* (BOLLI) as zone from early Aptian sediments of south-eastern Crimea while none of them have been yet recorded from the Zagros area. However, this biozone is equivalent to the zones no. 15 and 16 of James and Wynd ( 1965), which contains: *Orbitolina Choffatella Salpingoporella dinarica* (Gollestaneh 1965 , Kheradpir 1975), *Pseudocyclammina littus* and *Pseudochrysalidina arabica Choffatella decipiens* and *Pseudocyclammina rugosa* Kalantari (1976), *Choffatella decipiens, Leupoldina carbi* Shakib (1990).

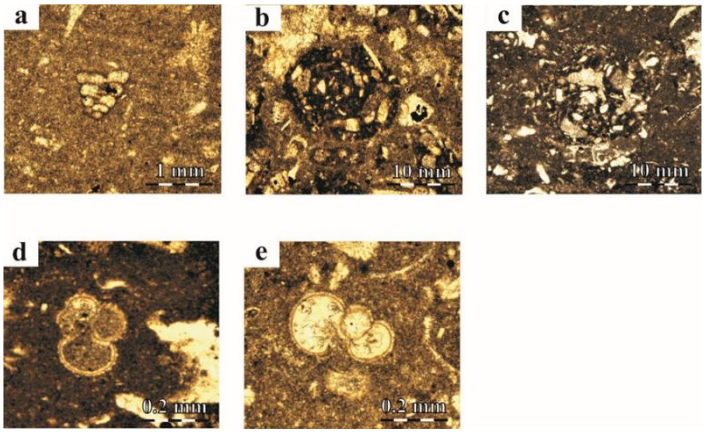


Fig 6. Benthic and pelagic formaminifers of the Gadvan Formation, (a) *Marsonella trochus* D'ORBIGNY, sample Gf 16, (b) *Pseudocyclammina rugosa* D'ORBIGNY, sample Gf 14, (c) *Bacinella irregularis* RADOIČIĆ, sample Gf 20, (d) *Gorbachikella* sp., sample Gf 43, (e) *Hedbergella occulta* LONGORIA, sample Gf 46.

## 6. Microfacies

According to microscopic investigation, five types of microfacies are recognized in the upper part of Fahliyan, Gadvan, and the lower part of Dariyan formations at the Naser Abad section (Fig 7). In addition, type and rate of skeletal and non-skeletal grains are determined. Moreover, the size, shape and sorting of the investigated grains are distinguished. Type of matrix, textural characteristic analysis of the grains led us to determine both type of microfacies and paleoenvironment of microscopic data.

**Microfacies** 1: Algal-intraclast-bioclast wackestone

This microfacies occurs at the upper part of the Fahliyan Formation (Fig 8a). The mentioned microfacies is referred to dark gray massive limestone of this rock unit which is extended about 2.5 meters and underlaid by Gadvan Formation. Bioclasts are in low to moderate abundance (7%-50%). Skeletal grains are mainly composed of foraminifers, and echinoderm fragments. Other skeletal grains (ostracods, gastropods, bivalves, and brachiopods) are not common. Sponge and bryozoan fragments are occasionally observed whereas calcareous algae (dasycladales) are common. Non skeletal grains are made of intraclast (7%-40%) and pellet and the rate of pellet is scarce as well. Unsorted to medium sorted of fragmented bioclasts and intraclasts are possibly imported from the high-energy facies into the low-energy lagoon. Well diversified dasycladacean algae are predominately recognized as various taxa of *Salpingoporella* in this microfacies. Matrix is composed of argillaceous calcareous mud which encompasses the grains. The fillings are composed of micrite-microsparite and some parts sparite. According to Solak et al. (2016), the presence

abundance of calcareous algae indicates a warm shallow environment which is assigned to restricted lagoon with low to moderate energy. As a result, the presence of more dasycladales with bioclast grains and mud-dominated facies witnesses sedimentation in a restricted lagoon environment related to the inner ramp which is equivalent to the RMF-17 facies (Flügel 2010 and Abedpour et al. 2018). According to Emraninasab et al. (2017), type of skeletal and nonskeletal grains, type fabric and textural characteristics support lagoon paleoenviornment.

**Microfacies 2**: Intraclast-bioclast wackestone

The Intraclast-bioclast wackestone facies with a low rate of intraclast occurs at the top of the Fahliyan and the base of Gadvan formations (Fig 8b), with a thickness of about 23 meters in the studied section. It appears cream, thin-bedded marly to dark, thin-bedded limestone of the lowermost stratigraphic limit of the Gadvan Formation. Skeletal grains are in low to moderate abundance and the content of bioclasts is estimated 4%-44%. The mentioned grains are mainly made of well diversified foraminifers, ostracods, small gastropods, bivalves, echinoderms, and some non-identified shell fragments. The bioclast components are distinguished with various size (0.2-20mm). The skeletal grains are generally recognized as angular grains. The calcareous algae (dasycladace) are commonly recognized. The presence of mud-dominated matrix with unsorted bioclasts accompanying a very small quantity of calcareous algae indicates that this microfacies is considered to be formed in mid-ramp with low current energy. According to Burchette and Wright (1992), the mid ramp sediment is generally deposited below fair weather. The mentioned microfacies is comparable to the RMF-9 facies Flügel (2010).

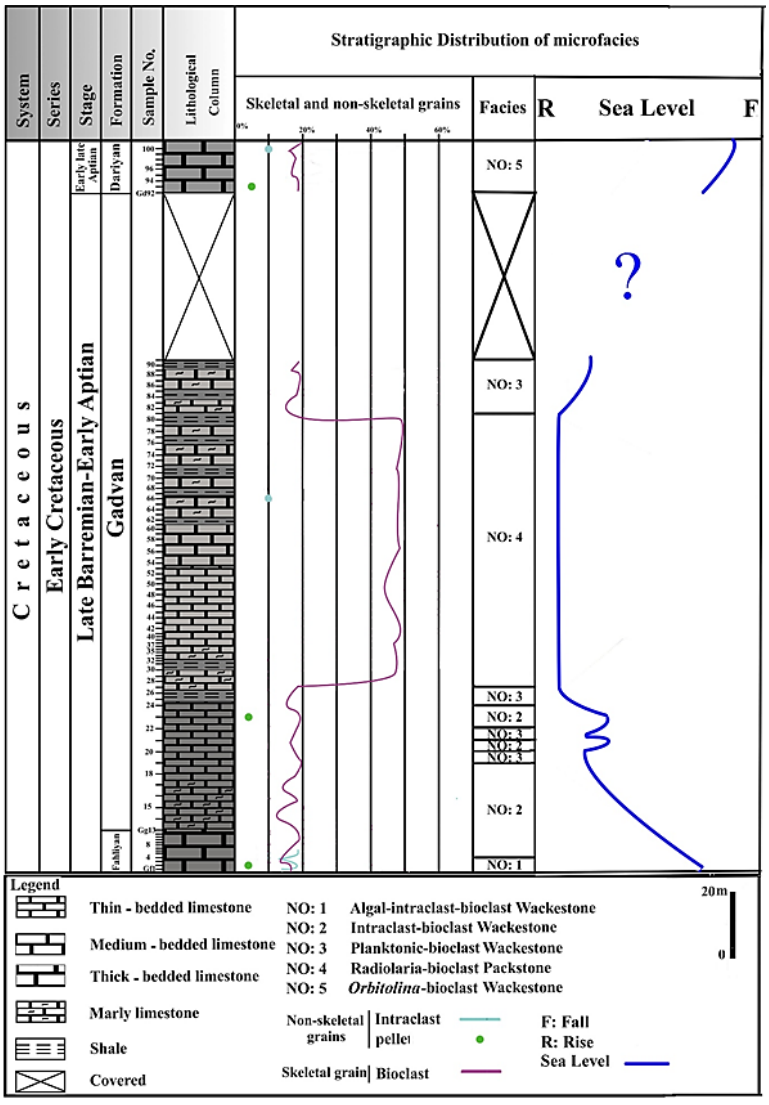


Fig 7: Stratigraphic distribution of index microfacies of the Gadvan Formation, and Frequency of skeletal and non-skeletal grains

**Microfacies 3**: Planktonic-bioclast wackestone
This microfacies occurs almost at the top of the Gadvan Formations (Fig 8c), with about 17 m in thickness, and light gray, thin to medium-bedded limestone. The main component of this microfacies includes planktonic foraminifers (Hedbergellids), Radiolarian and *Calcisphaerulla innominata* BONET which are encompassed by calcareous mud as micrite texture with sparry calcite veins in a few thin sections. However, the skeletal rate is estimated approximately 65%. According to the mud-dominated facies and the abundance of planktonic foraminifers, deep open sea and low-energy condition related to the transition of inner ramp to outer ramp are proposed for this microfacies which is comparable to the RMF-5 facies (Flügel 2010). Similar facies was documented from the Upper Cretaceous strata of NE of Turkey by Türk Öz and Özyurt (2019) and was referred to deep shelf paleoenvironment. (Esmeray-Senlet et al. 2015) recorded similar microfacies as transition of between mid and outer ramp environment.

**Microfacies 4:** Bioclast Radiolarian packstone
**Bioclast** Radiolarian packstone facies is observed in about 50 m the middle to the top part of the Gadvan Formation (Fig 8d). This microfacies is referred to alternation of light gray, thin to medium-bedded limestone and dark gray to brown shale. Radiolarian are the main component of this microfacies and other bioclasts are planktonic foraminifers (generally Hedbergellids) and sponge spicules. The content of the bioclast is up to 65% in entirely micritic calcite matrix. According to the mud-dominated facies and the abundance of Radiolarian, deep water sea and low-energy condition related to the transition outer ramp to basin are proposed for this microfacies. Abyat et al. (2014) reported Radiolarian microfacies as hemipelagic facies of Fahliyan formation. Similar data had been recorded from Fahliyan formation before Afghah (2006). Sagular and Algburi (2018), determined Radiolarian wackestone microfacies (Balambo formation, NE of Iraq) as bathyal zone paleoenvironment. However, this microfacies is deepest compared with the Planktonic-bioclast wackestone microfacies. This microfacies is comparable to the RMF-5 facies Flügel (2010).

**Microfacies 5:** Bioclast *Orbitolina* wackestone
This microfacies is characterized by mostly *Orbitolina* that is accompanied by other benthic foraminifers and rare bivalve fragments (50%). Micrite and locally sparite matrix encompass the grains. This microfacies is about 8 m thick at the base of Dariyan Formation including dark gray and massive limestone (Fig 8e). According to the mud-dominated facies and the abundance of the *Orbitolin*a as a main component of the grains, the investigated of this microfacies are referred to shallow tropical and low-energy water. Similar data was recorded from Cenomanian strata of northwestern Iraq before Al-Hajj et al., (2016). This microfacies indicates restricted to open marine environment related to the inner ramp that is comparable to the RMF-13 facies (Flügel 2010; Hamedanian et al. 2016; Abedpour et al. 2018).

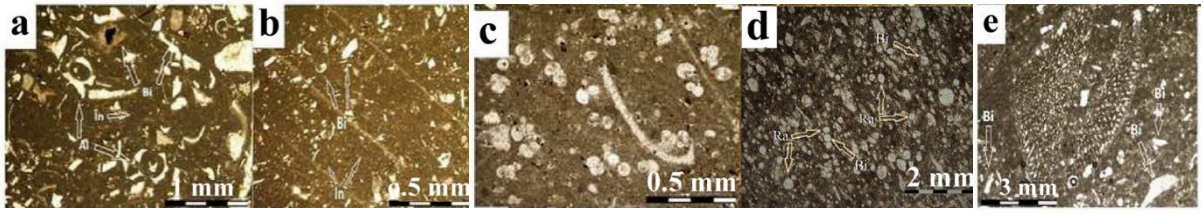


Fig 8. Investigated microfacies of the Gadvan formation: (a) Algal-intraclast-bioclast wackestone, facies Al: *Neomizzia*? sp., In: intraclast Bi: un-identifable bioclast, (b) Intraclast-bioclast wackestone, facies Bi: un-identified bioclast In: intraclast, (c) Planktonic-bioclast wackestone, facies Planktic foraminifers and *Calsisphaerulla innominata* and un-transported bioclast, (d) Bioclast Radiolaria packstone, facies Both un-identified bioclast and Radiolaria are calcified, (e) Bioclast *Orbitolina* wackestone facies

## 6. Discussion

Previous biostratigraphic dase confirmed various biostratigraphic limits of the Gadvan Formation (James and Wynd 1965; Kalantari 1976; Afghah et al. 2016; Abyat et al. 2016). But, the age determination of the Gadvan Formation was attributed to mid Barremian to late Barremian in Coastal Fars whereas Afghah et al. (2016) represented upper Hauterivian to Barremian age of Gadavan Formation. Actually, some foraminifer taxa are known as tool for age determination in the Zagros area (Afghah 2006) (e.g. *Pseudocyclammina lituus* YOKOYAMA and *Pseudochrysalidina arabica* HENSON). Biostratigraphic study revealed the role of vertical movement of basement Fault activity in well-known Zagros Fault zones. Our biostratigraphic and microfacies data show rapid transgression and regression during the deposition of Gadvan Formation (Barremian- Aptian). As mentioned before, the studied area is affected by two major basement Fault zone such as: Kazerun Fault. Moreover, the major direction of the mentioned Fault zone is described as S-N trend. Many of previous records confirmed that the Kazerun Fault influenced the Cretaceous succession during sedimentation in this area

(e.g. Afghah and Shaabanpour Haghighi 2014; Yousefi et al. 2019). Several previous works represented strike-slip behavior of the mentioned Fault Sepehr and Cosgrove (2005) It is necessary to note that the mentioned Fault behavior was distinguished by recent data whereas biostratigraphy and microfacies analysis represent the paleo-Fault behavior. According to Vergés et al. (2011), the studied area was mainly affected by Kazerun Fault zone. Based on stratigraphic distribution of identified foraminifers and microfacies, vertical displacement of sedimentary basin simultaneously occurred with deposition of limestone, shale and marly limestone of the Gadvan Formation. Regards foraminiferal content (orbitolinids) of basal part of Dariyan Formation, another vertical displacement was occurred which caused the rapid regression in the early Aptian time. Lithostratigraphic difference of both Fahliyan and Gadvan formations reflect argillaceous sediments of the Gadvan Formation and on the other hand similarity on faunal assemblage of both rock units without obvious paleo-bathymetric divergence between Gadvan and Fahliyan formations support similar depositional system of upper portion of Fahliyan and lower part of the Gadvan formations. Stratigraphic position of pelagic facies which covers shallow water facies of Gadvan Formation supports the rapid transgression which caused by basement Fault effect. However, similar faunal assemblages were recognized in both mentioned rock units (Afghah et al. 2016; Hosseini and Conrad 2008) (e.g. Trocholinids and calcareous algae). Moreover, basement Fault effects were documented in other Fars Carbonate Platform of the Zagros area (Afghah and Shaabanpour Haghigh 2014; Afghah and Fadaei 2015, Keshavarzi et al. 2020). Despite the mentioned data confirmed Aptian, Albian and Cenomanian sequences of the Fars Zone, the received, data determined Upper Barremian to Lower Aptian interval (Gadvan Formation) which was affected by vertical displacement of Kazerun Fault. Actually the pelagic lithofacies which is comprised of planktons and radiolarian indicates rapid transgression. However, investigated microfacies data confirms that depositional system of Gadvan Fomation is attributed to moclinal ramp setting.

## 7. Conclusion

The investigation of lithostratigraphy, biostratigraphy and microfacies analysis of Gadvan Formation as an oil reservoir of Lower Cretaceous in Zagros Basin is crucial. Biostratigraphic study reveals that the Gadvan Formation sedimentation was Fault control in the studied section. In order to reconstruct the sedimentary basin, it is required to collect other biostratigraphic and facies database of other exposures and subsurface of Gadvan Formation in this Fault zone.

Based on the identification of foraminifer, the age of Gadvan Formation in this area is assigned to late Barremian-early Aptian. According to microfacies carbonate platform the Gadvan Formation in the studied area is a moclinal platform.

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