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Microfacies and sedimentary environment of the dariyan formation from Banesh (North and Northwest of Shiraz, Iran)

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Key words: Banesh, Dariyan Formation, Carbonated platform, Ramp.

Abstract

The Dariyan Formationin studied section is in the vicinity of Dare-sefid village. The studies on this region show the sedimentation of Dariyan Formation between two discontinuities in a carbonated platform of ramp type. In this region, eight microfacies including five types of faciesbelts namely open marine, restricted environment, submarine ridges (i.e. shoal), Lagoon and tidal flat environment can be detected. The comparison of analyzed facies with current environments and considering the formation environment of each set of facies, lack of reef facies, expansion of peloidsfacies and absence of iteratively deposited facies show that Dariyan Formation in Banesh region is formed in a carbonated platform of ramp type. The associated analyses show that in the length of middle aptian, carbonated depositions include aggregations saturated with foraminifera and calcareous algae within Dariyan Formation of the intended region so that the accumulation of bioclasts, especially benthic foraminifera, rise from open marine to subtidal and inter-tidal side. In section 8 (i.e. S1 Microfacies), the prevalence of foraminifera gets to more than 95% while their lowest prevalence is found in open marine and tidal flat. The formation environment of Dariyan Formation in the studied region is mainly associated with tidal to lagoon environment so that 74% of the formation is made in these two environments.

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Introduction

The Dariyan Formation is part of the Lower Cretaceous deposits of southwest of Iran. This formation is one of the important hydrocarbon reservoirs for Khami group in southwest of Iran. The existence of economically significant resources, especially oil and gas, in Zagros region drew the attention of geologists to its formations such as Dariyan that is at the end of raw group and is regarded as significant resource rock (Afshar-harb, 2002). For the first time the section measurement at Gadvan Mountain in north of Dariyan village of northeast of Shiraz led to calling the existing formation of the region as "Dariyan Formation" (James and Wynd, 1965). In the typesection, this formation includes 286.5 m of brown andthick-bedded gray limestone as well as rough and rock-making mass which is characterized by the abundance of *Orbitolina* with Aptian age. The lower boundary of Dariyan Formation and Gadvan Formation is gradual but this is particularly true in the top section. It is highly eroded with Kazhdumi Formation and its glauconite and oolitelayers separate it from Kazhdumi Formation. This Formation is equivalent with Shaiba Formation in countries in south of Persian Gulf (Motii, 1994) and Tizkuh Formation in Alborz region (Aghanabati, 2007).

Dariyan Formation deposited on a carbonate platform developed across the Zagros Basin. Little work has been done on the effects of relative sea level changes during deposition of the Cretaceous carbonate sediments in the Zagros Basin. In this research, Dariyan Formation was investigated in a surface section of Kuh-e-Zena in the Folded Zagros Zone. Since there aren't any studies on the microfacies of Dariyan Formation at the studied area or the re lated reports are not available and also study on other properties are not enough.

The main aims of this paper are: 1- to describe and interpret the microfacies of deposits of Dariyan Formation in Banesh. 2- interpret the sedimentary environment represented by the Dariyan Formation in the studied area. 3- comparison of Dariyan Formation in the studied area and type section

Geological setting of studied area

The studies section is 85 km away from northwest of Shiraz (fig. 1) and is located in high-altitude Zagros zone (Stocklin, 1968), at the southern side of Zena Mount and north of Banish with longitude of 26'55.25 (52° Eastern) and latitude of 0,9'16.25 (30° Northern). It is accessible by Marvdasht-Doroodzan road (fig. 2). The placement of Dariyan Formation in the analyzed section at the southern side of Zena Mount is shown in fig. 3.

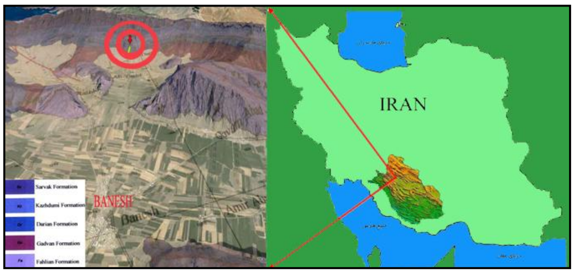

Fig. 1. Geographical location of studied area.

Fig. 2. Access way to the studied region (Shiraz-Marvdasht-Banesh).

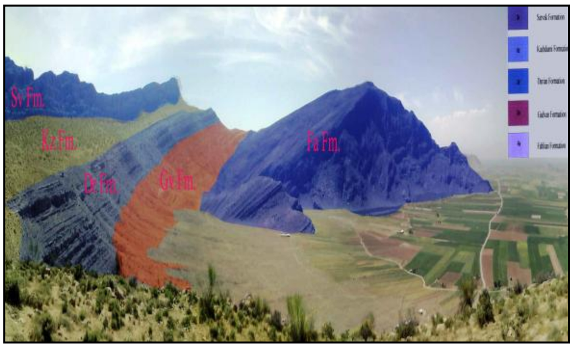

Fig. 3. Arragement of Fahlian, Gadvan, Dariyan, Kazhdumi and Sarvak formations at southern side of Zena mount in Dare-sefid village (Eastern View).

Material and methods

Studied area

The studies were done in some general parts as follows.

1- Study of different regions through topographic and geologic maps to find proper region.

2- Field studies to sample and photograph the region so as to define the limits of studied regional foundations.

3- Laboratory analysis and measures to prepare thin sections.

4- Analysis and photographing sections.

Sampling and Laboratory analysis in studied area

In these studies, 108 samples were collected and a thin section of each sample was prepared. The necessary studies were done in which different types of *Orbitolina* were identified. For naming the rocks, the classification method of Folk (1974) was applied and for carbonated rocks, the classification method of Dunham (1962) as modified by Embry and Klovan (1971) was used. Based on works of Wilson (1975) and Flügel (2004), the interpretation of carbonated facies was done.

Results and discussion

Introducing of Sample Stratigraphic Section of Dariyan Formation in Zena Mount

The thickness of Dariyan Formation in the studied section is 176m and its lithology is divided into three parts:

1- 114.5 m limestone of median layer with light grey color.

2- 43.5 m of thick-layered limestone with grey to brown color.

3- 18m of mass limestone with grey to brown color.

The Dariyan Formation was located between two discontinuities in the studied section the top boundary of Kazhdumi Formation in eroded form while the bottom boundary is discontinuous with Gadvan Formation (fig. 4). Based on genealogical studies and identification of foraminifera species in the studied section, this formation age is middle Aptian - late Albian.

Fig. 4. Iron nodules of Dariyan-Kazhdumi formations boundary (right), large iron nodules of Dariyan-Gadvan formations boundary (left).

Analysis of Facies and Sedimentary Microfacies

In the present study, 8 microfacies in 5 types of facies belts including open marine, restricted environment, submarine ridges (i.e. shoal), lagoon and tidal flat environment were identified. The identified microfacies from the beach to the sea were respectively the following:

Tidal Flat Environment

T1 Microfacies (Lime Mudstone)

The T1 facies are uniformly micritic, lack allochem and are closely connected to the sub-environment of a carbonated ramp. During the field study, these microfacies included middle-layer and thick (mass-like) limestone without evident layering. It also included skeletal grains (bivalvia) along with silt particles and fenstral fabric (bird-eye network, fig.7a). This microfacie is comparable with SMF19 and RMF22 (Wilson, 1975; Flügel, 2010). The fine-grains with fenstral fabric and without fauna of species show low energy at the zone between intertidal and supratidal (Wilsone and Evans, 2002; Sahraeyan *et al.,* 2013-2014). This microfacie forms almost 55m of the top thickness of the formation which ends in discontinuity and iron nodules at the top part and is completely distinguishable from Kazhdumi Formation in lithological terms because it has a hard and facing structure (hard limestone) and at the top (Kazhdumi Formation) it is made of shale.

Lagoon Facies

The skeletal components of lagoon facies are highly varied which include different types of foraminifera with agglutinated shell (O*rbitolina*) and porcelaneou (miliolida and *Textularia*), different kinds of green algae from Dasycladaceae family which are similar to peloidsin regard to their non-skeletal body. These facies represent low depth with proper salinity, water rotation and sufficient nutritive conditions (Bachmann and Hirsch, 2006). The associated parts of Lagoon formation with above characteristics comprise the highest thickness of Dariyan Formation in the studied section (almost 75m) which they include three microfacies of L1, L2 and L3.

The L1 microfacies called "BioclasticPackstone"

For most part include molluscs, benthic foraminifera (e.g. *Dictyocaulus arabicus*, *Orbitilina* sp., *Mesorbitolina subconcava*) with packstone fiber with calcareous algae and an insignificant amount of peloids (Fig. 7b). These microfacies are comparable with RMF 20 (Wilson, 1975; Guoqiang *et al.*, 2007; Flügel, 2010) which are found in an environment with mean latent energy which verifies the existence of dasycladacean green algae as well as shallowness of the tidal region.

The L2 microfacies are also called "Orbitolina Bioclastic Packstone".

The presence of skeletal components such as green algae and benthic *Orbitolina* (e.g., *Mesorbito linaparva*, *M. pervia*, *M. texana*, *Iraqia* sp., *Dictyocuonusarabicus*, miliolids) in a micrit context represents a low level of environmental energy in the lagoon parts (Bachmann and Hirsch 2006). The sub-skeletons in these facies belong to echinoderms, gastropod and dasycladacean green algae. The existence of these green algae represents the tidal region down to shallow depth of 15 m (De Castro, 1997). These macrofacies are comparable to RMF20, their content of peloids is less than 10% and their matrix include fine micritic grains. The existence of large and flat foraminifera with thin walls such as *Orbitolina* and *Dictioconus* in the environment represents low level of energy, low intensity of light and low amount of available nutrition (Sinclar *et al.,* 1998; Fig.7c).

The L3 microfacies also called "Orbitolinapeloidals Wackestone".

It includes the types of *Orbitolina* (e.g., *Mesorb-itolinaparva*, *M. pervia*, *M. texana*, *Marsonella* sp., *Miliolids*), peloids, bivalves, gastropod, *Textularia*, and a level of green algae. The existence of benthic foraminifera such as *Orbitolina* (Pittet *et al.*, 2002), *Textularia*, miliolid and dasycladacean algae (Penny *et al.*, 2004) and a significant amount of peloids (Adachi *et al.,* 2004) represent deposition in lagoon low energy conditions. In this microfacie, the grains have medium sorting with fine to medium grain sizes of relatively spherical shape. Regarding these characteristics, it is comparable with RMF 13 and SMF 18 (Wilson, 1975; Flügel, 2010). The presence of foraminifera with thick and small shells such as miliolid represent a shallow sea and high level of energy and light (Sinclair *et al.*, 1998; Fig. 7d).

Shoal Facies

S1Microfacies (Orbitolinds Grainstone)

These microfacies have an abundant level of *Orbitolina* (e.g. *Mesorbitolinaparva*, *Orbitolina kurdika*, *Orbitolina* sp., *Mesorbitolina texana*, *Pseudochrysalidina conica*) which amounts to 50% along with small level of peloids (Fig. 7e) which itself includes low level of green algae (i.e. *Salpingoporella*). These microfacies are comparable to RMF27 (Flügel, 2010) which represent an environment of medium-to-high level of energy and low depth. This might be due to displacement, iterative deposition of bioclasts and absence of micrite. These characteristics imply a turbulent water stream which constituted 30 m of the studied formation.

Restricted Environment

R1 (Orbitolinids Wackestone)

These microfacies were found in small portion of the studied area and it includes some types of Orbitolinids (e.g. *Mesorbitolina texana*, *M. parva*, *Or* sp., *Marsonella* sp.) the aggregation of which amount to 30-40%. In these microfacies, lower level of miliolid, worm holes and skeleton of echinoderm are in micritic context which is relatively substituted by sparite cement. These microfaciesare comparable with SMF18 (Wilson, 1975) and RMF13 (Flügel, 2010) which exist in a lagoon-limited high-energy environment. These microfacies compose 10 m of the formation thickness (Fig.7f).

Open Marine

O1: Bioclastic Orbitolinds Wackestone

These microfacies include microskeletons such as sponge spicule, echinoderms, a low level of micro-scale algae and *Orbitolina* foraminifera which are in a micritic context (Fig. 7g).

This microfacie deposits in shallow part of open-to-lagoon sea the components of which pass a short path in lagoon section. The existence of Spicule sponges represents low regional energy (Flügel 2001; Bachmann and Hirsch, 2006; Adabi, 2010). These microfacies are comparable to SMF9 and RMF13 (Wilson, 1975; Flügel, 2010). They are made below the effective surface of waves which compose almost 6m of the formation.

O2 (Planktonic Foraminifera Bioclastic Wackestone)

These microfacies include skeletal grains such as spicule sponge, gastropod, parts of pelagic foraminifera and echinoderm bryozoan in wackestone context. The existence of spicule sponge in micritic context, small size and suspension of bioclasts along with stenohaline creatures such as bryozoair and echinoderm along with a high level of mud show the low energy level of the environment below the effective line of waves (Flügel, 2001, Bachmann and Hirsch, 2006; Adabi, 2010). These microfacies are comparable with standard microfacies SMF5 and RMF9 (Wilson, 1975; Flügel, 2010; Fig. 7h).

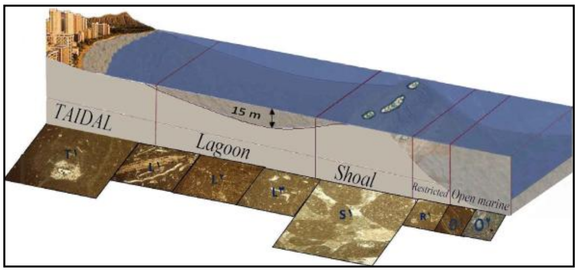

Fig. 5. Sedimentary model of Dariyan Formation in Dare-sefid section (north of Banesh).

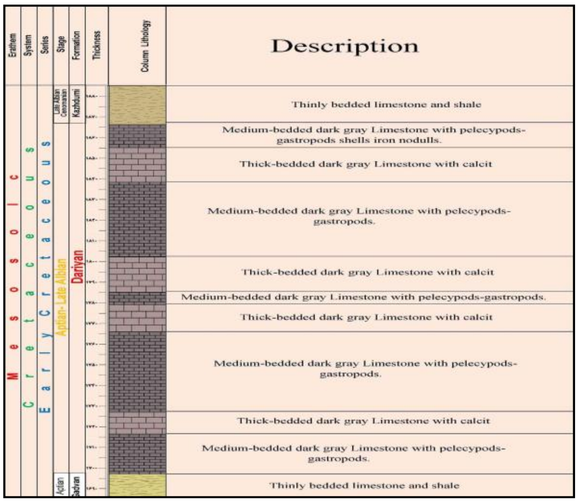

Fig. 6. Stratigraphic column of Dariyan Formation in a section of Dare-sefid (north of Banesh).

Comparison of Stratigraphic Column of Dariyan Formation in Zena Mountain and Gadvan Mountain

Based on the above stratigraphic column, the following points can be mentioned regarding the desired section of Zena Mountain in north of Banesh and its comparison with the sampled section of Gadvan Mountain.

1- The type section of the sample is made of two parts of thick-layered to mass limestone and a medium-layered part. In the studied section, 5 middle-layered parts, 3 thick-layered sections and one mass part can ne denoted.

2- In the type section of Dariyan Formation, the bottom boundary is continuous and the top one is eroded. In regard to the intended section, the bottom and top boundaries are both eroded.

3- The thickness of sample section is 286.5 m and the thickness of intended section is 176m.

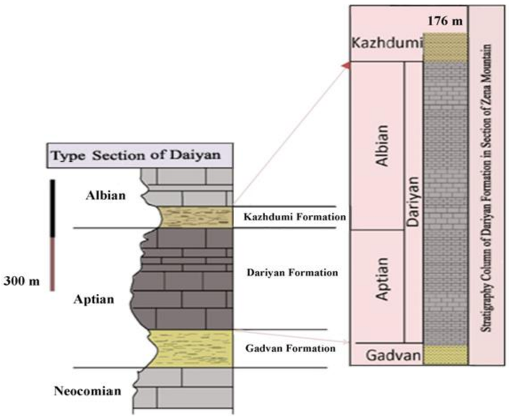

Fig. 7. Strategraphic column of Dariyan Formation and its comparison with a section of Dariyan Formation in Gadvan Mountatin.

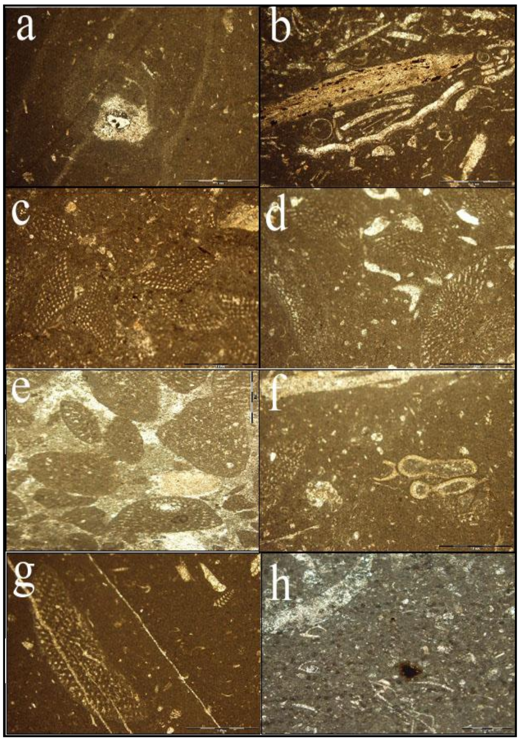

Fig.8. a. Lime mudstone; b. Bioclasticpackstone; c. *Orbitolina* bioclasticpackstone; e. Orbitolinds grainston; d. Orbitolinds peloidals wackestone; f. Bioclastic Orbitolinds wackestone; g. Planktonic foraminifera bioclastic wackestone.

Conclusion

Based on the studies of thin sections, field studies and petrography of Dariyan Formation in the studied area (southern side of Zena Mountain at north of Banesh), 8 microfacies associated with 5 facies belts of tidal flat environment with the thickness of 55m, lagoon with thickness of 75m, submarine ridges with thickness of 30m, limited environment with thickness of 10m and open marine with thickness of 6m were identified. The comparison of analyzed facies with current environments and considering the formation environment of each set of facies, lack of reef facies, expansion of peloidsfacies and absence of iteratively deposited facies show that Dariyan Formation in Banesh region is formed in a carbonated platform of ramp type. The associated analyses show that in the length of middle aptian, carbonated depositions include aggregations saturated with foraminifera and calcareous algae within Dariyan Formation of the intended region so that the accumulation of bioclasts, especially benthic foraminifera, rise from open marine to subtidal and inter-tidal side. In section 8 (i.e. S1 Microfacies), the prevalence of foraminifera gets to more than 95 % while their lowest prevalence is found in open marine and tidal flat. The formation environment of Dariyan Formation in the studied region is mainly associated with tidal to lagoon environment so that 74 % of the formation is made in these two environments.

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