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MICROBIOSTRATIGRAPHY AND SEDIMENTARY ENVIRONMENT OF THE SARVAK AND KAZHDUMI FORMATIONS IN BAHREGANSAR OIL FIELD

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ABSTRACT

The aim of this paper is investigation of microbiostratigraphy and sedimentary environment of the Sarvak and Kazhdumi formations in Bahregansar oil field. To investigate these units, microbiostratigraphy and microfacies analyses were carried out on nearly 600 m of cuttings, including cutting plug samples and thin sections prepared from Bahregansar oil field in the Persian Gulf, SW Iran. 22 Species and genera of foraminifera were recognized and four biozones were identified. Also the microfacies analysis of the Sarvak and Kazhdumi formations in Bahregansar oil field is led to recognition fourteen microfacies of three facies belts (depositional environment) including open marine, bar and lagoon environments.

Contribution/Originality: This study is one of very few studies which have investigated the Upper Cretaceous of oil fields. The results of this study will help to make Upper Cretaceous biozones, interpretation of microfacies and depositional environments.

1. INTRODUCTION

Many geologists have focused on the carbonate petroleum reservoirs of the Persian Gulf because of the well-known oil productivity of this region (Afghah and Farhoudi, 2012). The Sarvak Formation is one of the most significant carbonate reservoirs known to be an oil producer in the Bahregansar oil field (Tabiyejou *et al.*, 2014). Bahregansar field consists of several separate hydrocarbon accumulations within following formations and from top to bottom respectively includes Ghahr, Asmari, Sarvak, Kazhdumi and Fahliyan formations.

Although the Bangestan carbonates are known as significant reservoirs in the Middle East, their detailed biostratigraphy is still ambiguous. The stratigraphic position of the Sarvak Formation is also another reason for the importance of the biostratigraphic study. According to James and Wynd (1965) Zagros is divided into four main zones: Khuzestan, Lurestan, Coastal Fars and Interior Fars (James and Wynd, 1965). They suggested that Cenomanian benthic foraminifers are well expanded in the Khuzastan, Coastal and Interior Fars areas whereas pelagic facies are well dominant in the Lurestan region in order to determine the lower and upper lithostratigraphic boundary of the Sarvak Formation (Wynd, 1965).

Sarvak Formation consists of limestone and dolomitic limestone. The depositional environment shows a carbonate shelf near to the reef grading downward to open and deep marine facies. The top of this formation is characterized by an erosional surface in this field which truncates the reservoir creating an unconformity trap (Madadi, 1986). This formation has been drilled within 7 wells of this field and shows an average thickness of about 128m. The period of erosion and non-sedimentation in this field towards the northern areas (e.g. Hendijan, Tangu fields) is remarkable and. cover the western part of this field. The Variety of thickness in the Sarvak Formation is presumably due to middle cretaceous uplifting (Touronian). The age of the formation has been defined as Albian-Cenomanian

Kazhdumi Formation is consisted of marl, limestone and dolomitic limestone. Nahr-Umr Formation is its equivalent in the south of Persian Gulf.

In the Bahregansar oil field, 3 wells were drilled in the Kazhdumi Formation. The average thickness in this field is about 194m. Toward the south and south-eastern part of the field the thickness of the basal sandy unit increased. This unit has been distinguished as hydrocarbon bearing zone.

The age of Kazhdumi Formation is Lower Cretaceous (Albian to Cenomanian) and the depositional environments include Neritic to Pelagic environments.

The Ilam Formation overlies the Sarvak Formation disconformable and lower boundary of Sarvak Formation is conformable with Kazhdumi Formation.

The main objectives of this paper are to describe and interpret the microbiostratigraphy, facies and depositional environments of Sarvak and Kazhdumi formations in the Bahregansar oil field, Persian Gulf in order to understand the geological evolution of the area during that time interval.

2. MATERIAL AND METHODS

This study is based on data from one well drilled in the Bahregansar oil field in the Persian Gulf, SW Iran. 200 collected samples from the well (600m) were examined and microbiostratigraphy of the Sarvak and Kazhdumi formations used to characterize biozones which are equivalent of Wynd`s biozones (Wynd, 1965). For classification purposes the concepts of Dunham (1962) and Flugel (2010) have been used for carbonate facies.

3. STUDY AREA

This oilfield is located 56 kilometers, west of Bahregan District. It includes a main platform and 7 satellite platforms, with 12 wells. The oil produced from Bahregansar platform is transferred to onshore installations of Bahregan District for treatment and storage by a 16inch pipeline.

Figure-1. Location map of the study area which represent Bahregansar oil field in Northwestern part of the Persian Gulf.
Source: Kalantary (1969)

4. MICROBIOSTRATIGRAPHY OF THE SARVAK FORMATION IN THE STUDIED WELL

In this study, 13 genera and 9 species of benthic foraminifera and 5 genera and 8 species of planktonic foraminifera were detected, based on which the following 3 biozones were recognized:

1- *Nezazata- Alveolina* assemblage zone

This biozone is located on the upper side of Sarvak Formation and has a thickness of 130 meters (2805m-2678m). The biozone can be specified with the concentration of the following fossils:

Ovalveolina ovum, *Prealveolina* sp.

Microfossils of this zone are as follow:

Alveolina sp.; *Nezzazzata* sp.; *Dicyclina* sp.; *Heterohelix globulosa*; *Heterohelix reussi*; *Ticinella primula*; *Favusella washitensis*; *Rotalipora reichli*; *Trocholina* sp., Miliolids

This biozone is relevant to biozone (21) by Wynd. Also Khalili (1974) divided this zone into two subzones. He marked the lower zone with *Orbitolina-Nezzazata* and believes that the upper zone (which contains *Orbitolina*) can also be divided based on the different species of *Orbitolina*, Bolz 1977 claims that this zone base on selected samples only represents the upper part of Sarvak Formation. Bourgeois (1969) believe that the upper part of this biozone shows the Late Cenomanian (Husinec *et al.*, 2000) that all *Alveolinids* of this zone were diminished during the Late Cenomanian due to a word wide Oceanic Anoxic Event known as OAE2. It should be noted that this is a major disconformity which is common among the various parts of the SW Iran and the surrounding areas in the Middle East (Husinec *et al.*, 2000).

2-*Trocholina- Orbitolina* Assemblage zone

This biozone which is located in the middle of the Sarvak Formation include the sediment of Albian- middle to Late Cenomanian. The thickness of this biozone is 50m (2840m-2805m).

The biozone can be specified with the concentration of the following fossils:

Lenticulina sp., *Trocholina* sp., *Orbitolina concava*

Microfossils of this zone are as follows:

Textularia sp., *Prealveolina cretasea*, *Trocholina arabica*; *Trocholina intermedia*, *Trocholina* sp., *Orbitolina concave*, *Dictytoconus* sp., *Nezzazzata* sp., *Ovalveolina ovum*, *Pesudolitunella reicheli*, *Hemicyclammina* sp., *Cuneolina pavonia*, *Cylindroporella* sp., Miliolids

This biozone is equivalent to Wynd biozone (25).This zone is well-developed in the costal Fars (Motiee, 1992).

3- *Favusellawashitensis* Rang zone

This biozone located in the lower Sarvak Formation include the sediment of Albian -Cenomanian in the studied stratigraphic section of the Sarvak Formation. The thickness of this biozone is 70m (2898m-2840m). The biozone can be specified with the concentration of the following fossils:

Favusella washitensis, *Oligostegina* sp., *Prealveolina* sp., Algae. This biozone is equivalent of Wynd biozone (23), and its microfossils include:

Calsipherula sp., *Lenticulina* sp., *Rotalipora* sp., *Ticinella* sp., *Rotalipora gandolfii*, *Rotalipora subticinensis.*

In this zone, due to the fact that *Prealveolina* and *Oligostegina* are dominated, it can be proved that it was formed at the beginning of Albian to Cenomanian. This zone is viewed in Coastal Fars with *Prealveolina*–Algae Assemblage zone together (Motiei, 1992).

5. MICROBIOSTRATIGRAPHY OF THE KAZHDUMI FORMATION IN THE STUDIED WELL

In the study of Kazhdumi Formation, 9 genera and 3 species of benthic foraminifera and 3 genera and 2 species of planktonic foraminifera were identified and 2 biozones were recognized as follow:

1- *Oligostegina* facies

This biozone includes Albian-Cenomanian sediments and is equivalent to Wynd biozone (26). This facies is widespread in the Zagros area. The biozone can be specified with the concentration of the following fossils:

Calcisphaerula sp., *Stomiosphaera conoida*. This biozone has a thickness of 150m (3040m-2900m). Its microfossils include:

Favusella washitensis, *Oligostegina* sp.; *Calsipherula* sp., *Textularia* sp., *Trocholina* sp., *Orbitolina concave*, *Dictytoconus* sp., *Nezzazzata* sp., *Cylindroporella* sp., Miliolids.

By seen Stomiosphaeraconoida in begging of this zone, it concluded that it belongs to the beginning of the Albian period.

2- Favusella Washitensis Rang Zone

This biozone located in the lower Sarvak Formation include the sediment of Albian -Cenomanian in the studied stratigraphic section of the Sarvak Formation. The thickness of this biozone is 150m (3040m-3100m).

This biozone is equivalent to Wynd biozone (23), and its microfossils include: *Orbitolina concava*; *Textularia* sp., *Orbitolina* sp., *Heterohelix* sp., *Rotalipora gandolfii*, *Ticinella* sp.

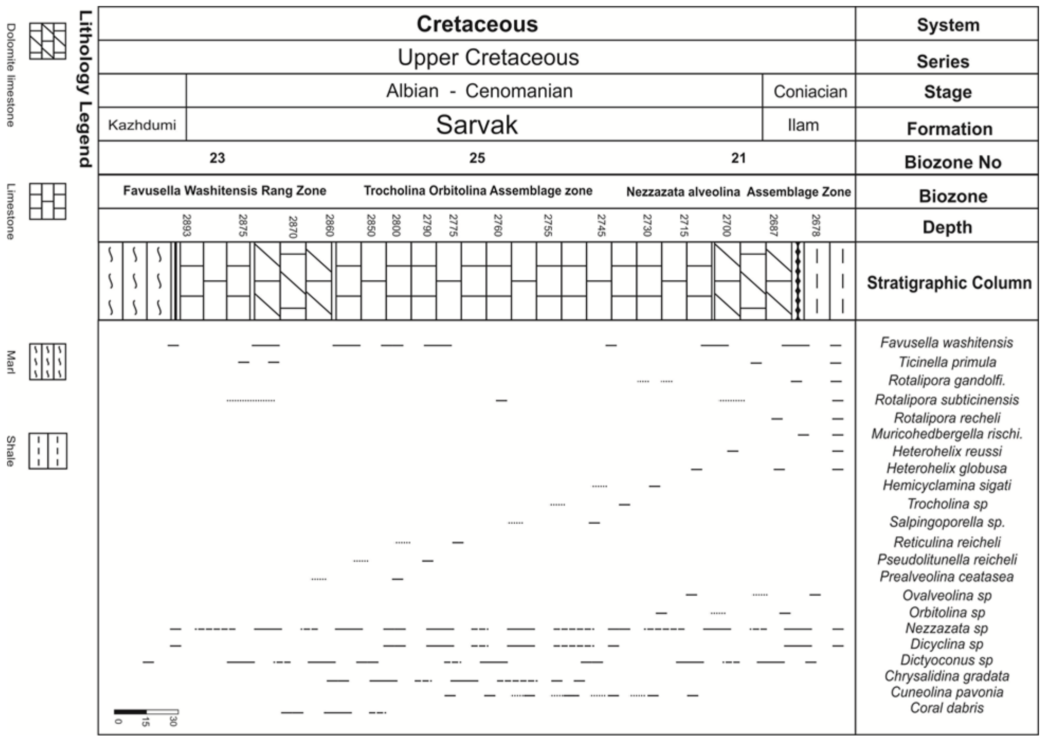

Figure-2. Biostratigraphy chart of the studied section. In the biozones column.1-*Nezzazata- Alveolina* assemblage Rang zone, 2 -*Trocholina- Orbitolina* Assemblage Zone, 3- *Favusella washitensis* Rang Zone

Source: Ahmadi (2016)

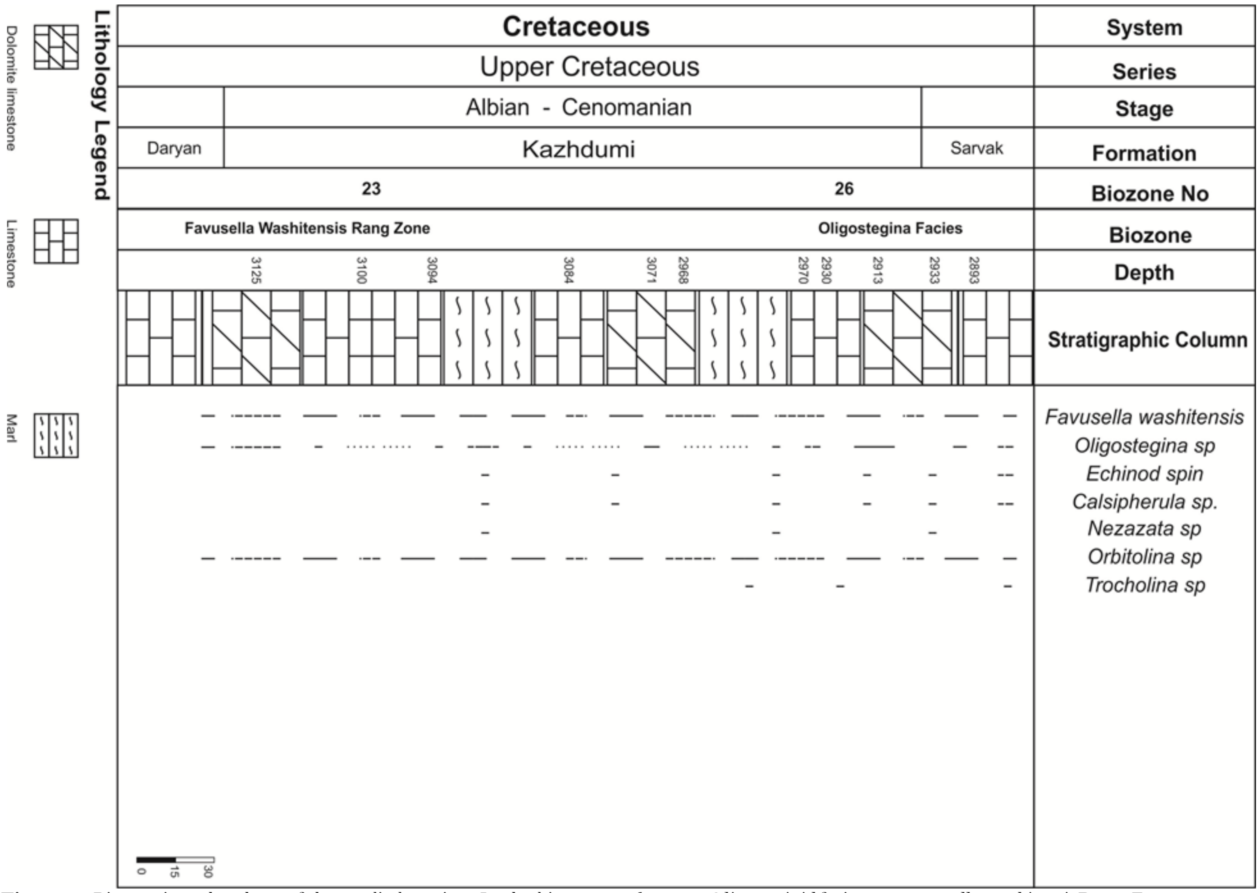

Figure-3. Biostratigraphy chart of the studied section. In the biozones column.1-*Oligosteginid* facies, 2- *Favusella washitensis* Rang Zone.
Source: Ahmadi (2016)

6. MICROFACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENTS OF THE SARVAK FORMATION IN THE STUDIED WELL;

The microfacies analysis of the samples taken from the Sarvak Formation in Bahregansar oil field led to the recognition of 7 microfacies of 3 facies belts (deposition environment) based on Flugel (2010) including open marine (A), bar (B), lagoon (C) environment. Open marine facies (A) consist of oligostegina wackestone (A1), pelagic foraminiferal packestone (A2) pelagic foraminiferal wackestone (A3). This facies is characterized by pelagic foraminiferal such as *Favusella washitensis*, *Oligosteginid* and context of lime mud and represent low energy environment that demonstrate open marine

Bar facies (B) consist of bioclastic grainstone (B1) and dolomitized peloid grainstone (B2). It consists of coral debris, bioclast, dolomitized peloid grinstone. Context of grainstone and very high energy condition indicates in barrier environment.

Lagoon facies (C) consist of benthic foraminiferal wackestone (C1) and bioclast peloid wackestone (C2). This facies zone is mainly consisted of benthic and some pelagic forams. The skeletal allochems are abundant and diversity. With benthic foraminiferal such as *Nezzazata* and Miliolids in context of lime mud and represent low energy environment that demonstrate lagoon.

7. MICROFACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENTS OF THE KAZHDUMI FORMATION IN THE STUDIED WELL

Microfacies analysis of the samples taken from the Kazhdumi Formation indicate 7 microfacies of 3 facies belts (deposition environment) based on Flugel (2010) including open marine (O), barrier (BA), lagoon (L) environment. Open marine facies (O) consist of bioclast packestone (O1), Bioturbated limy mudstone (O2), Oligostegina pelagic wackestone (O3) Oligostegina wackestone (O4), Spicule sponge oligostegina wackestone (O5). This facies zone is characterized with pelagic forams such as *Favusella* sp., Oligosteginids, spicule sponge, and to Echinoid fragments and bioturbated limy mudstone which indicates deep open marine environment. This facies is characterized by pelagic foraminifera such as *Favusella washitensis*, Oligosteginid and context of lime mud and represent low energy environment that demonstrate open marine. Barrier (BA); consist of Algal peloid grainstone (BA1), bioclast, and peloid graistone. Context of grainstone and very high energy condition indicates in barrier environment. Lagoon facies (L); consists of peloid bioclast packestone (L1). This facies is mainly consisted of benthic foraminifera such as *Orbitolina* sp., *Nezzazzata* sp., miliolids. The skeletal allochems are abundant and diversity. Benthic Foraminifera in context of limy mud represent Low energy environment that demonstrate Lagoon.

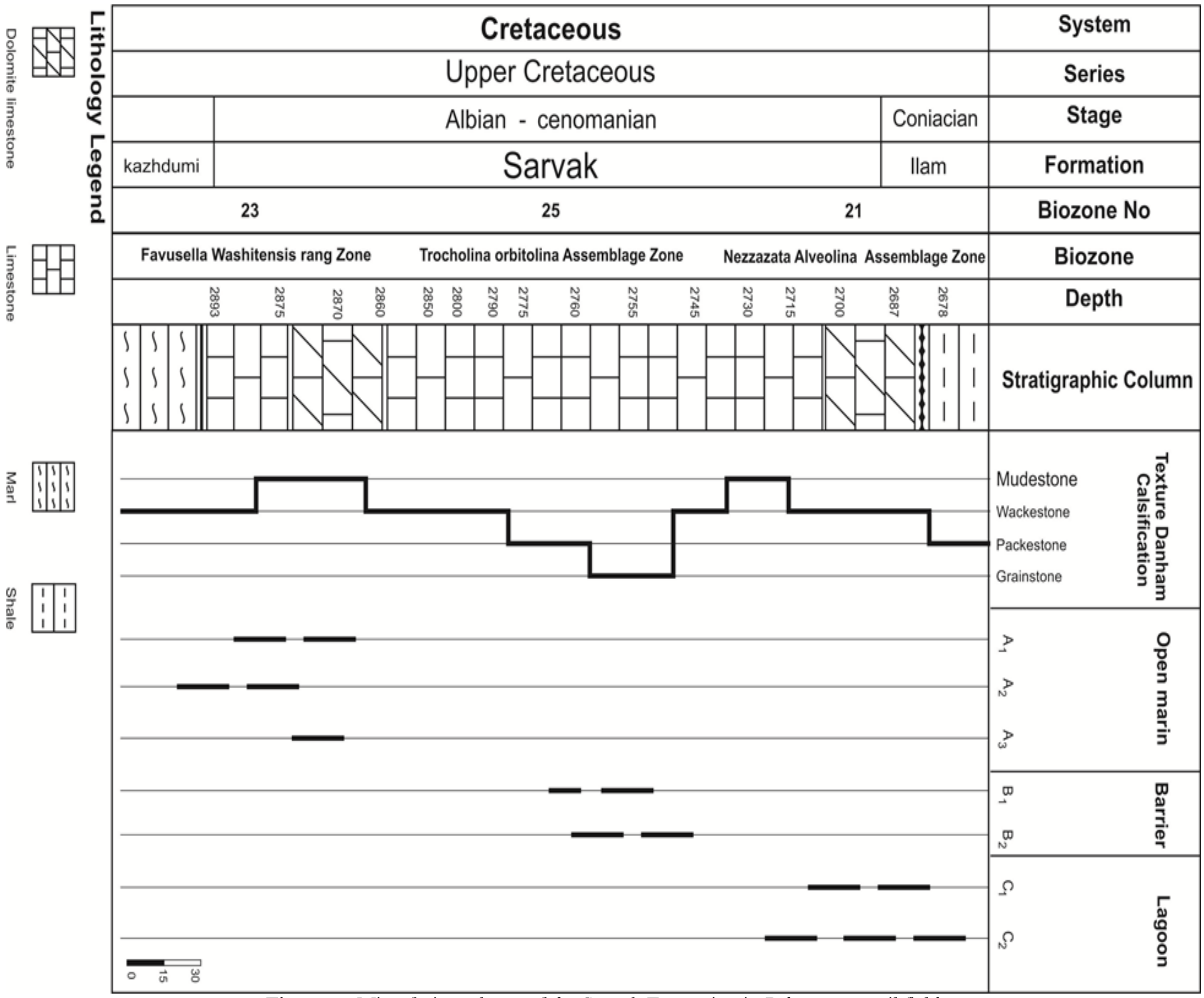

Figure-4. Microfacies column of the Sarvak Formation in Bahregansar oil field

Source: Ahmadi (2016)

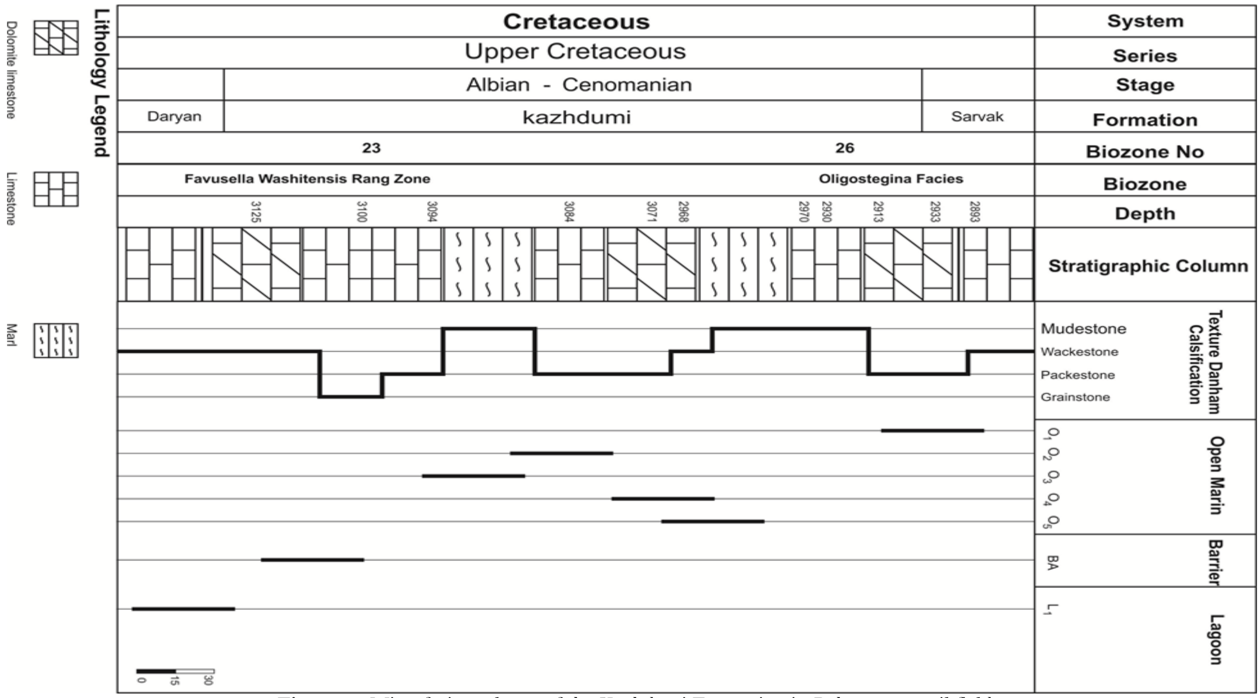

Figure-5. Microfacies column of the Kazhdumi Formation in Bahregansar oil field.

Source: Ahmadi (2016)

8. CONCLUSION

Biostratigraphic study of the Sarvak Formation in Bahregansar oil field shows 13 genera and 9 species of benthic foraminifera and 5 genera and 8 species of planktonic foraminifera. As a result, 3 biozones were introduced including 1-*Nezzazata- Alveolina* Assemblage Range Zone, 2-*Trocholina- Orbitolina* Assemblage Range Zone, 3-*Favusella washitensis* Range zone.

Biostratigraphic study of the Kazhdumi Formation shows 9 genera and 3 species of benthic foraminifera and 3 genera and 2 species of planktonic foraminifera. As a result, 2 biozones were introduced including 1-*Oligostegina* facies 2- *Favusella washitensis* Range Zone. Those zones are according to introduced zones by Wynd (1965). Foraminiferal study indicated an Albian-Cenomanian for the Sarvak and Kazhdumi formations. The microfacies analysis of the samples taken from the Sarvak and Kazhdumi formations in Bahregansar oil field led to the recognition of 7 micrifacies for Sarvak Formation and 7 microfacies for Kazhdumi Formation, all microfacies divided into three facies belts (depositional environment) including open marine, bar and lagoon environments. The facies analyses represent the Sarvak and Kazhdumi formations in Bahregansar oil field were formed in a carbonate ramp.

Plate 1

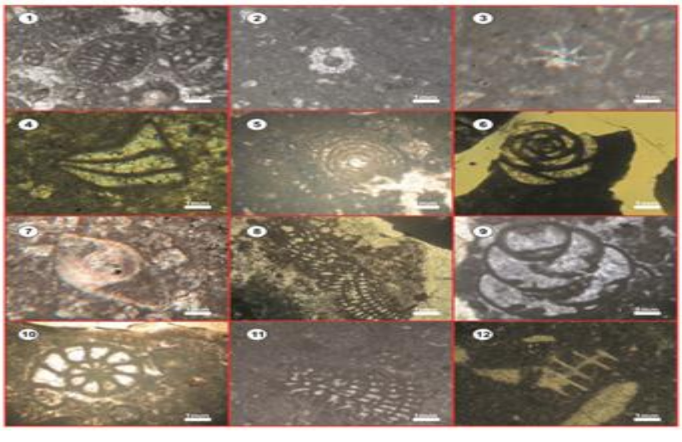

Plate-1.

Fig.-1.*Reticulina reicheli*,depth 2610m, Sarvak Formation.
Fig.-2.*Salpingoporella* sp., depth 2880m, Sarvak Formation.
Fig.-3.*Cylindroporella* sp., depth 2881m, Sarvak Formation.
Fig.-4. *Nezzazzata simplex* Omara 1956, depth 3739m, Sarvak Formation.
Fig.-5.*Prealveolina cretacea* Darchiaci 1837, depth 2706m, Sarvak Formation.
Fig.-6.*Quniqueloculina*, Axial section, depth 2720m, Sarvak Formation.
Fig.-7. *Lenticulina* sp. Lamark 1804, Axial section, depth 2870m, Sarvak Formation.
Fig.-8. *Dicyclina*sp., Munier–CHa lmas 1887, Equatorial section, depth 2754m, Sarvak Formation.
Fig.-9.*Chrysalidina gragata* Dorbigny 1839, depth 2690m, Sarvak Formation.
Fig.-10. *Hemicyclammina* signalimaynei, depth 2720m, Sarvak Formation.
Fig.-11. *Cuneolina pavonia* Drbigny, depth 2754, Sarvak Formation.
Fig.-12. *Cylindroporella* sp. Sarvak Formation.

Plate2

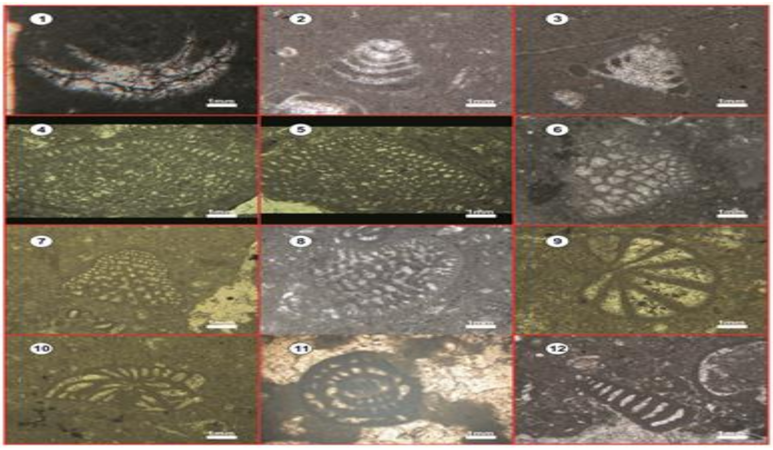

Plate-2.

Fig.-1.*Trocholina Arabica* Hensoni 1948, Axial section, depth 2687m, Sarvak Formation.

Fig.-2.*Trocholina intermedia* Hensoni 1948, Axial section, depth 2815m, Sarvak Formation.

Fig.-3.*Trocholina* sp. Paalzow 1922, Axial section, depth 2800m, Sarvak Formation.

Figs.-4-5.*Orbitolina concava*, Lamark 1816, depth 2815m, Sarvak & Kazhdumi Formation.

Figs.-6-7-8. *Dictytoconus* sp., depth 2616m, Sarvak Formation.

Fig.-9.*Nezzazzata* sp. Omara1956, Axial section, depth 2716m, Sarvak Formation.

Fig.-10.*Nezzazzata* sp., Omara1956, sub axial section, depth 2715m, Sarvak Formation.

Fig.-11. *Ovalveolina ovum*, Dorbigny, Equatorial section, depth 2716m, Sarvak Formation.

Fig.-12.*Pesudolitunella reicheli* ,Mariei 1955, depth 2845m, Sarvak Formation.

Plate 3

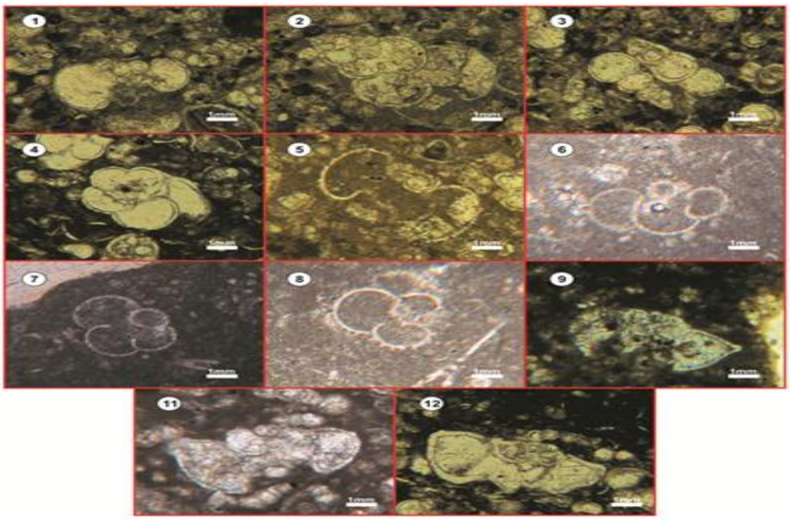

Plate-3.

Figs.-1, 5. *Muricohedbergella rischi*, Moullade 1966, Axial section, depth 2830m, Sarvak Formation.

Fig.-2. *Heterohelix globulosa*, Ehrenberg 1840, Axial section, depth 2678m, Ilam Formation.

Fig.-3. *Heterohelix reussi*, Cushmani 1938, Axial section, depth 2675m, Ilam Formation.

Fig.-4. *Ticinella primula*, Luterbacher 1963, Axial section, depth 3060m, kazhdumi Formation.

Figs.-6-7-8. *Favusella washitensis*, Carsey 1926, Axial section, Depth2840m, Sarvak Formation.

Fig.-9. *Rotalipora subticinensis*, Gandolfi 1957, Axial section, depth 2865m, Sarvak Formation.

Fig.-11. *Rotalipo rareichli*, Mornodi 1950, Axial section, depth 2713m, Sarvak Formation.

Fig.-12. *Rotalipora gandolfii*, Luterbacher & Permolisilva1962, Axial section, depth2716, Sarvak Formation.

Plate4

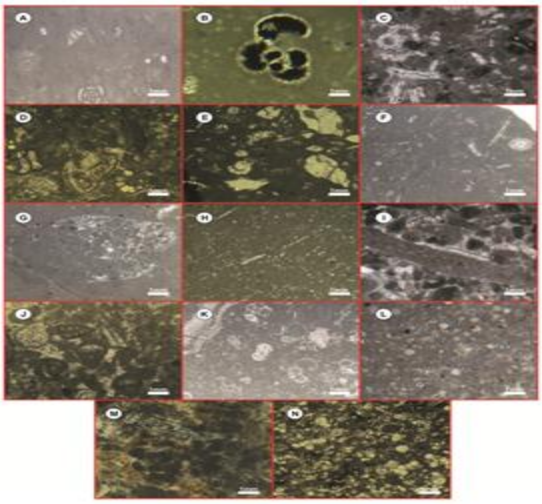

Plate-4.

Fig.-A. Benthic foraminiferal wackestone, Lagoon (C1), Sarvak Formation.

Fig.-B. Oligostegina pelagic wackestoe, Open marin (O3), Kazhdumi Formation.

Fig.-C. Peloid bioclast packestone, Lagoon (L1), Kazhdumi Formation.

Fig.-D. Bioclast peloid wackestone, Lagoon (C2), Sarvak Formation.

Fig.-E. Bioclast packestone, Open marin (O1), Kazhdumi Formation.

Fig.-F. Spicule sponge oligostegina wackestone, Open marin (O 5), Kazhdumi Formation.

Fig.-G. Bioturbated lim mudstone, Open marin (O2), Kazhdumi Formation.

Fig.-H. Oligostegina wackestone, Open marin (O4), Kazhdumi Formation.

Fig.-I. Algal peloid grainstone, Bar (Ba1), Kazhdumi Formation.

Fig.-J. Bioclast grainstone, Bar (B1), Sarvak Formation.

Fig.-K. Pelagic foraminiferal wackestone, Open marin (A3), Sarvak Formation.

Fig.-L. Oligostegina wackestone, Open marin (A1), Sarvak Formation.

Fig.-M. Dolomitized peloid grainstone, Bar (B2), Sarvak Formation.

Fig.-N. Pelagic foraminiferal packestone, Open marin (A2), Sarvak Formation

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