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Microfacies, Diagenetic and Depositional Environment of Kazhdumi Formation (Aptian-Albian), Dezful Embayment, Zagros, NW Iran

Soleimani B[1]*, Monjezi K[2] and Malaki S[3]

[1]Department of Earth Science, Shahid Chamran University of Ahvaz, Iran
[2]Tahghighat Sci. of Azad University, Tehran, Iran
[3]Behbehan Azad University, Khuzestan, Iran

Abstract

Facies determination of the Kazhdumi Formation in Solabdar and Chilingar oil wells which are the oldest Iranian oil wells is very important since the Kazhdumi was known as a source rock in these fields. Lithological composition of this formation is limestone, shale and glauconite bearing sandstone in the base which is an obvious sign of disconformity between Kazhdumi and Dariyan formations. The Diagenetic effective processes in this area include: dissolution, substitution (hematitization, glauconitization), micritization and bioturbation, cementation, compaction, stylolitization and porosity (interapartical, moldic, intercrystaline, channel). These processes are in relation to diagenetic environments such as meteoric, marine phreatic and deep burial. Kazhdumi Formation in the studied fields is composed of seven carbonate facies and two clastic facies (shale and sandstone) as follows: bioclast wackestone/packstone- bioclast packstone– bioclast wackestone/packstone–sandstone (lagoon facies) and bioclast wackestone-globigerin, wackestone (planktonic wackestone)/crinoidal globigerina wackestone –oligosteginid wackestone (open marine facies). By considering these facies, it is suggested lagoon and open marine sedimentary environments for Kazhdumi Formation in the studied fields.

Keywords: Kazhdumi formation; Solabdar; Chilingar; Carbonate microfacies

Introduction

The Kazhdumi Formation was considered as a part of the ammonite-bearing shale in old reports and sometimes it has been called the Ebad Formation. The thickness of the Kazhdumi Formation was calculated 137 m [1]. Kazhdumi Formation is extended in Fars and Dezful Embayment areas and from northern Dezful Embayment to the north east of Lorestan gradually becomes converted to carbonated series. The formation is substituted with Garu Formation in central and southwestern Lorestan. The formation includes bitumen-bearing black shales and dark clay limestone in Dezful Embayment and the northeastern Fars. The Kazhdumi Formation has tongue coincide with Burgan Formation and Omar Nahar in Kuwait and southwestern Iraq, from Dezful Embayment into southwestern area. In other areas of the Persian Gulf, the formation would have shallow sedimentary properties and includes laterite and iron oxides zones and sandstone and silt layers.

Kazhdumi Formation's lithology is composed of calcareous shale, shale limestone, clay and sandstone. This limestone is dark brown to green and is greatly bitumen and pyrite and a sandstone horizon is in the middle part.

Several geologists have studied the Kazhdumi Formation in southwest Iran: Crichton [2] predicate the name of Bangestan lime to the Middle Cretaceous limestone. James and wynd [1] upgrade the name to the Bangestan Group and considered it including Kazhdumi, Sarvak, Surgah and Ilam formations. They counted Sarvak and Kazhdumi as a sedimentary cycle and have justified positing the Kazhdumi Formation in Bangestan Group. Setudehnia [3] stated positing these two formations in Bangestan Group are more operative due to limited development of Surgah Formation in some areas. Wynd [4] presented the environmental facies of southwest Iran and have compared the stratigraphic of Kazhdumi Formation in Masjed-e- Soleiman field up Mongesht Mountain Zone (Izeh zone) with each other. Templeton [5] have studied the sequence of shale limestone from Kazhdumi Formation in southwest Iran. Bolz [6] has reevaluated the Bangestan Group's biozones and has presented new theories in this regard. Wynd [4] presented biostratigraphic studies in Mesozoic and Cenozoic formations of the Zagros into a coherent set, so that, these formations were been identified in 66 biozones. In connection with Kazhdumi Formation the total microscopic fossils lied in chart of biozones No. 17, 18, 19 and 26, and attributed the age of Kazhdumi Formation to the Aptian–Albian stage. However, the biozone no 19 has been developed in the Gulf region and rendered lateral into zone 26 toward Khuzestan. Khalili [7] has perused a rather comprehensive study on Kazhdumi, Sarvak, Ilam, Surgah (Bangestan Group) formations in south and southwest of Iran and in this regard, has provided a lithofacies map for each chronostratigraphy unit and has compared the mentioned unit biozones in drilled wells and surface sections with each other. Eshghi [8] has performed the most comprehensive available report in stratigraphy of Garau Formation and has specified the regions in that Garau Formation has been recognized in surface outcrops and subterraneous sections. Sissingh, [9] has introduced newer subdivisions for biostratigraphic units that had been arranged by Wynd [4] and has presented a lecture in biostratigraphic of lime nanoplanktons of Cretaceous system. Koop et al. [10] have preformed some investigations on thickness of chronostratigraphy units and development of facies regard to the Khami and Bangestan groups formations. Ghavidel [11] has investigated Kazhdumi Formation palynomorphs in well no. 1 in the Rudak field. Koop et al. [12] have discussed about the history of Zagros basin subsidence in the Middle East and have described and analyzed geological events in the region from the Permian to the present. Eghtesadi et al. [13] studied Kazhdumi and Sarvak formations in terms of sedimentology and sequence stratigraphy in Padena and Meymand (higher Zagros) layers and identified two sedimentary sequences

***Corresponding author:** Soleimani B, Department of Earth Science, Shahid Chamran University of Ahvaz, Iran, Tel: 98 21 22 56 51 49; E-mail: Soleimani_bscu@.ac.ir

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in Kazhdumi Formation and four sedimentary sequences in Sarvak Formation. They accounts Kazhdumi Formation facies as deposited in a carbonate ramp and Sarvak Formation facies as deposited in a rimmed shell carbonate platform.

In general, the lower limit of Kazhdumi shale Formation correlated with Dariyan Formation is determined by existence of red zones including iron oxides and probably associated with the diastema. The Kazhdumi Formations and Dariyan formations are laterally equivalent to each other in some parts. For example, in North of Dezful Embayment, the Kazhdumi Formation is converted to limestone row, so it is not possible to separate the Bangestan limestone and Dariyan Formation. Then, it is expressed that the Bangestan limestone is placed directly over the Dariyan Formation. The phenomenon could be seen in Mongesht Mountain located northern Dezful Embayment, and sometimes the only separation factor in the basement is the existence of high natural radioactivity in the carbonates is equivalent to utilized Kazhdumi Formation and as has been mentioned about the Dariyan Formation, sometimes a tongue has developed from Kazhdumi Formation into Dariyan Formation. The upper limit of Kazhdumi shale can coincide with Bangestan limestone gradually and sometimes firmly and being determined with a carbonate. Kazhdumi Formation fossils are including plankton types as *globigerina washitensis, hedbergella sp., ticinella sp., biglobigerinella sp., planomalina sp., radiolaria.* Ammonites and echinoderms could be mentioned as other microfossils. The age of Kazhdumi shale is usually Albian to Cenomanian and in some areas due to existence of parahoplites ammonite indicates the late Aptian age.

Geological Setting of Studied Region

Studied area is located in Southwest Iran and is mainly in the northwest – southeast direction that is in agreement with Zagros structures trend. The fields were used in this paper to study Kazhdumi Formation are located in the south branch Dezful Embayment, including the Sulabdar and Chilingar fields. Two subsurface geological sections of the Kazhdumi Formation in the Sulabdar oil field (well no. 3) and Chilingar oil field (well no. 7) have been investigated to infer microfacies, sedimentary environments and diagenetic processes. General characteristics of the studied area are given below.

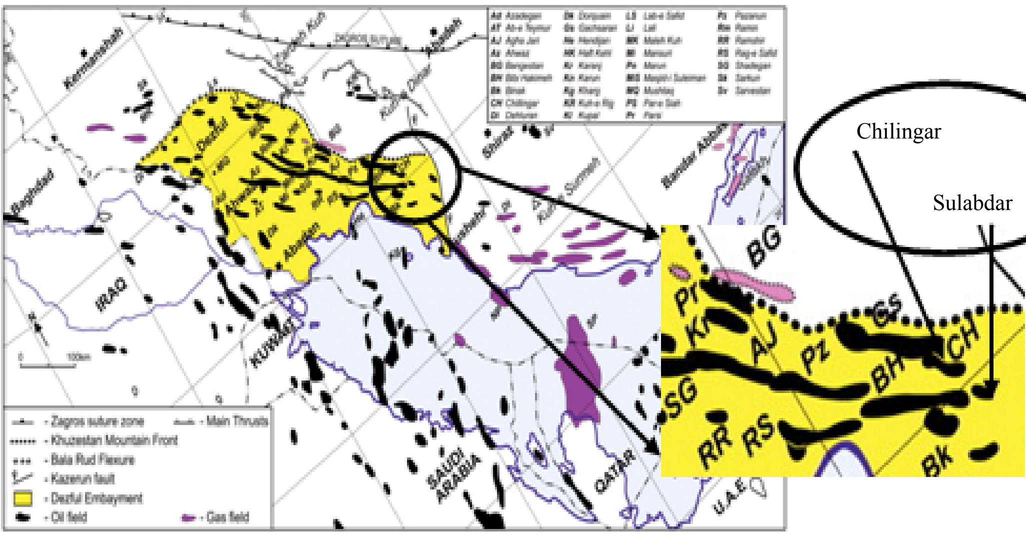

Figure 1: Parsi oil field position in Dezful Embayment.

Kazhdumi Formation	Depth (ft)	Lithology	Available microfossils	Age
Upper shale	5645-5495	Lime shale and shale limestone Chile in the middle of a lime sub-unit and bitumen-bearing dark shale.	*Hemicyclammina sp., Orbitolina sp. Favusellawashitensis, Dasyclad algae, Hedbergella sp., Globigerinelloides sp., Serpolids, Oligosteginids*	
Limestone	5715-5645	Limestone	*Orbitulina sp., orbitulina lenticularis, crinoid Ostropode, green alge, fossil debris, hemicyclamina sigsli*	
Shale	5870-5715	Dark-green shale and silty; with interbeded limestone	*Gastropode, pellet, green alge, fossil debris, orbitulina lenticularis*	
Upper limestone (Limestone and shale)	5955-5870	Dark brown clay Limestone + pyrite-bearing lime shale.	*Hemicyclammina sp., Orbitolina spp., Favusellawashitensis, Dasyclad algae. Hedbergella sp.*	Albian
Middle shale (Limestone and shale)	6065-5955	Black to dark green calcareous shale and among shale limestone layers	*Hemicyclammina sp., Orbitolina sp. Favusella washitensis, Dasyclad algae. Hedbergella sp.*	
Middle limestone	6250-6065	White to gray limestone in the upper chert-bearing part	*Hemicyclammina sp., Orbitolina sp. Favusella washitensis, Dasyclad algae*	
Sandstone	6260-62-50	Quartzarenite + Silty sandy shale		
Lower limestone	6285-6065	Dark brown limestone and glauconite-bearing	*Conical Orbitolina sp., Globigerinelloides sp., Hemicyclammina sp., Favusella washitensis, Serpolids., Hedbergella sp.*	
Lower shale	6295-6285	Limestone, gray to black shale pyrite-bearing	*Globigerinelloides sp. , Tintinids, Hemicyclammina sp., Orbitolina sp.., Favusellawashitensis, Radiolaria sp.., conical Orbitolina sp.*	upper Aptian- lower Albian

Table 1: Kazhdumi Formation description, well no. 3, Sulabdar oil field.

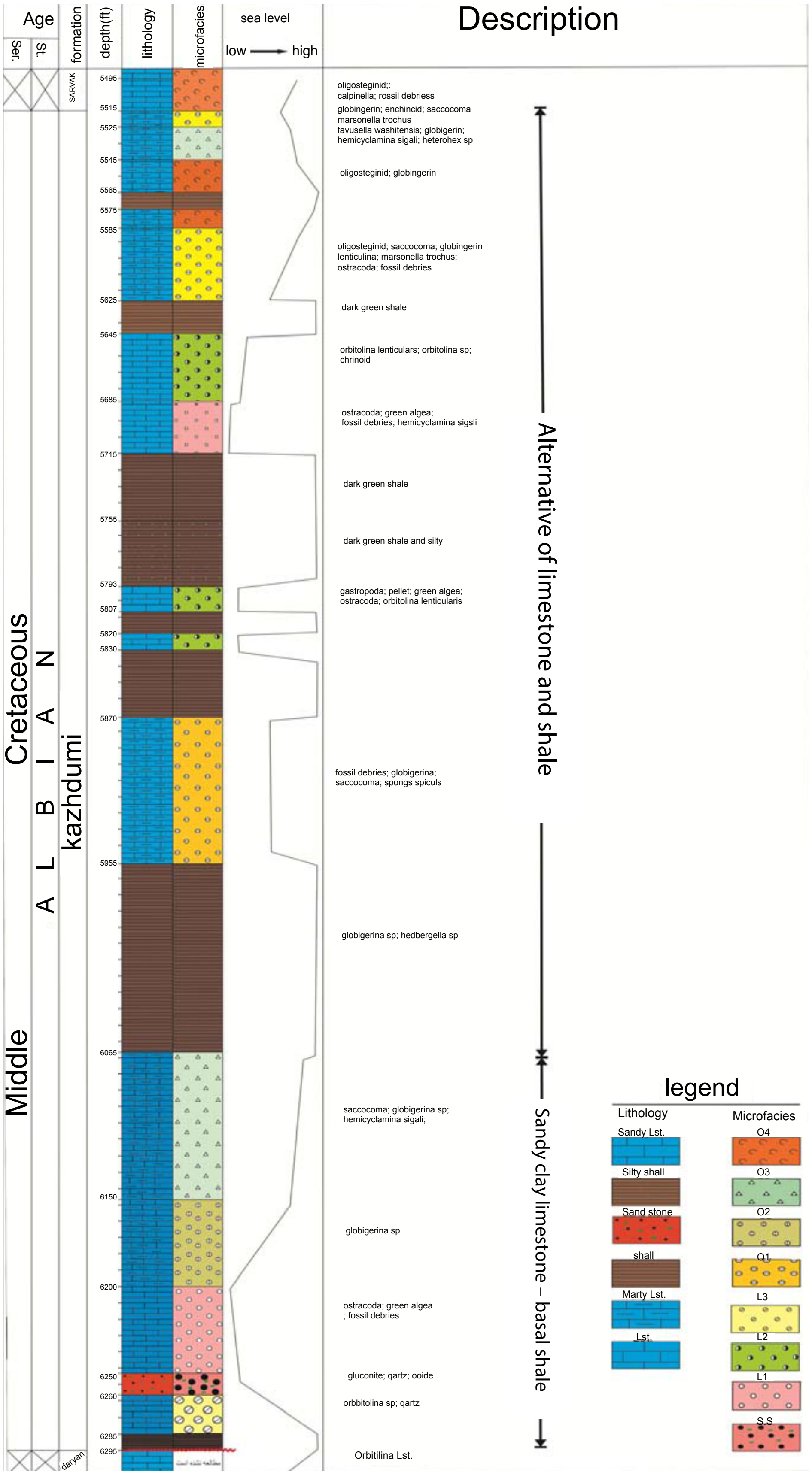

Figure 2: Stratigraphic column of the Kazhdumi Formation (Sulabdar well no. 3).

Sulabdar oilfield, well no. 3

The oilfield has been geographic located in southern Dezful Embayment and about 50 km southeast of Gachsaran at a distance of 45 km from the Persian Gulf coast (Figure 1). Five wells have been drilled in this field so far. The well no. 3 was drilled in 1971 and reached the oil in the reservoir of Upper Khami Group (Fahliyan - Gadvan - Dariyan). Drilling the well no. 4 began in 1357 to describe the structure and production of oil from Khami Group, but was completed after a stop in 1374.

Chilingar oilfield, well no. 7

Chilingar anticline locates at 30 km southeast of Gachsaran and in the extreme of Dezful Embayment Basin. The field has located between Gachsaran field in the North, Bibi-Hakime field in the south, Garnagan field in west and Chahar Bishe field in the east (Figure 1). It can be concluded from the aerial photographs and the geology and topography maps of the southwest Iran, that the region of Fars and Lorestan are higher than the middle section (Dezful Embayment). The Balarud normal fault is the boundary between Lorestan and Dezful Embayment (Balarud Fault).

The well is along the Eastern Chilingar oil field, located on the top of anticline. Chilingar anticline is almost asymmetric and its dimension on the earth's surface is not clearly identified. The layers slope on the ground is along the ridge varies between 5 to 3 degrees, increased toward the edges so that it is about 20 to 15 degrees northern edge and about 35 to 30 degrees southern edges. Surface outcrops of the anticline constitute Aghajari, Mishan and Gachsaran formations. The northern fault moves the Gachsaran blocks upward and falls Chilingar and Garangan fields, and south fault has caused the rise in these fields than Bibi Hakime field. The trusts' slope is towards the northeast and southwest, but the exact amount of tilt and trusts shift are not properly identified. There has not been reported any fault between Garangan, Chilingar.

Methodology

In this study, 260 thin sections of drilled core and chips were examined by polarizing microscope to determine the microfacies and identify the components and diagenetic processes. To interpret and classify microfacies, the Flugel method [14] was used. This step involves the collecting and studying resources, mapping UGC (underground par curve) of studied fields and choosing two well rings from the Sulabdar and Chilingar fields. In this paper there is an attempt to study the microfacies and sedimentary environment of Kazhdumi Formation in Sulabdar oil field (wells no. 3, Table and Figure 2) and Chilingar oil field (well no 7, Table 2 and Figure 3).

In order to provide a stratigraphic column of Kazhdumi Formation in the studied wells, graphic well log and gamma and neutron well logging diagrams has been used, that finally was plotted for each well after viewing thin sections and matching them with well log diagrams of lithostratigraphic column.

Lithostratigraphic description

To distinguish lithological and microfacies variation, two stratigraphic columns were provided (Figures 2 and 3). These borehole columns indicate that limestone increases to the top while shale decreases. These facts reflect a new depositional environment to form Sarvak Formation (mostly limestone). In Sulabdar, the presence of fault caused to decrease the basal shale thickness and also more lithological changes.

Sulabdar well no.3: The upper limit of Kazhdumi Formation is located at 5517 feet depth. The lower boundary with Dariyan Formation is almost crucial and the upper boundary with Sarvak Formation is sharp. The Kazhdumi Formation's rough thickness is 237m and its effective thickness is 131.4 m and its effective hydrocarbon column has been calculated 15.2 m. The upper part's microfossils of Kazhdumi Formation are also in lower parts of Sarvak Formation. Biozone no. 23 and 26 are also seen in these parts.

The upper limit of Sarvak Formation is located at 4039 feet depth. Its lower boundary with Kazhdumi Formation is gradual. Its gross thickness is 450 m and its effective thickness is125.9 m.

The lower boundary of the Kazhdumi Formation in studied area is associated with ablation disconformity. In Sulabdar -3 oil well the existence of glauconite sands limestone and glauconitized sandstones with hematite and iron compounds, is consistent with the disconformity at the base of this formation and indicates that an erosional phase was occurred prior to the deposition of this part, and Dariyan Formation

Kazhdumi Formation	Thickness (ft)	Lithology	Available microfossils	Age
Alternative Limestone and Shale	5531	Argillaceous shale	globigerina, crinoids, hedbergella	Albian
	5590	Limestone and shale	globigerina, crinoids, fossil debris	
	5676	Dark brown shale		
	5722	Limestone and shale	globigerina, crinoids, fossil debris	
	5754	Dark brown shale		
	5794	Shale and limestone	Globigerina	
	5827	Dark brown shale		
Clayey- Sandy Limestone	5918	shale and limestone layers	Globigerina, saccocoma	Albian
	5958	shale and limestone	Globigerina, favusella washitensis, leticultina, oligosteginid	
	5964	calcareous shale and limestone layers	Favusella washitensis, globigerina	
	6155	limestone and sandstone	Globigerina, saccocoma, hedbergella	
	6214	limestone and sandstone	Hemicyclamina sigali, saccocoma, heterohex. Sp.	
	6260	limestone and glauconite-bearing argillacous sandstone	Crinoid, pelagic foraminifera	
	6312	Glauconite bearing sandstone	Chrinoid	
Lower shale	6388-6427	Glauconite, gray-brown shale	globigerina, crinoids,	upper Aptian- lower Albian

Table 2: Kazhdumi Formation description, well No. 7, Chilingar oil field.

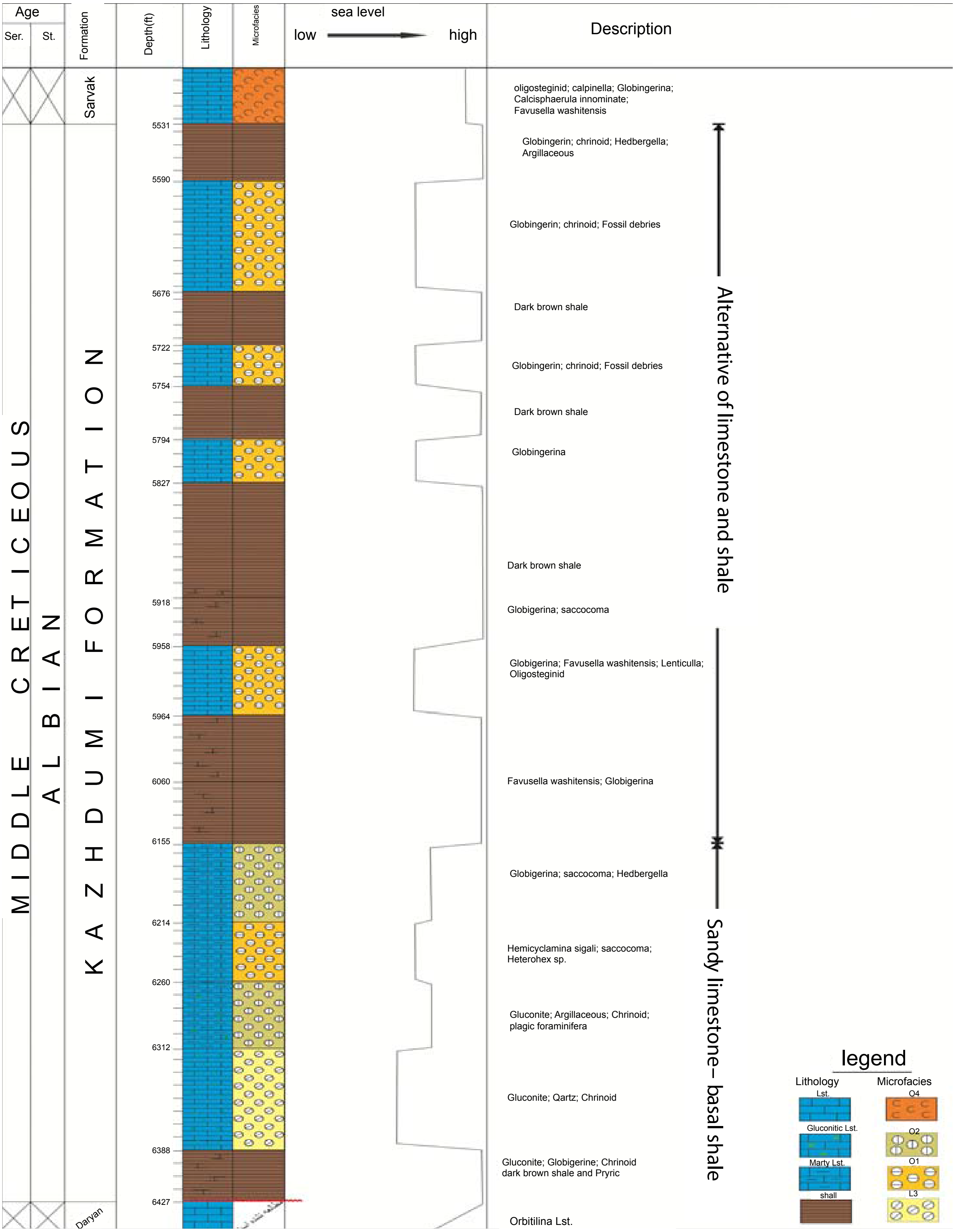

Figure 3: Stratigraphic column of the Kazhdumi Formation (Chilingar well no. 7).

has been out of the water for sometimes. The disconformity is just along with glauconite sand limestone in Chilingar oil well 7.

On the upper limit, Kazhdumi Formation's limestone is gradually end to the Sarvak Formation which represents the same slope and gradual border of the basin. So it seems the almost same sea conditions during the Albian – Cenomanian era.

Since Kazhdumi Formation's lithology in studied wells in thin sections is consisted of bitumen shale and carbonate parts and also regard to sedimentary environment of the formation, that is mostly deep parts of open sea. Then the mentioned formation is considered as oil source rock potential, in this area.

Some of the most important skeletal carbonate particles in Kazhdumi Formation could be pelagic foraminifera (globigerine, fausla washitensis), benthic foraminifera (lentiviral culina, hemi sichlominasigaly, rotalia), non-pelagic foraminifera (calcisphaerola, oligosteginidae), green algae, ostracoda. Peloid and ooiid constitute two of the most important non-skeletal carbonate particles of Kazhdumi Formation. Non carbonate components can be mentioned as single-crystal quartz, iron and glauconite compounds. Iron compounds have been observed mainly as successor in the pelagic and benthic foraminifers'cells and ooiid building. In studied layer of Kazhdumi Formation, most of samples were rich in mudstone.

Chilingar well no. 7: Describing the structure and oil production of Khami reservoir are the purpose of the drilling (Surme Formation) and a normal stratigraphic column have been drilled from the surface (Gachsaran member 7) to a final depth of 2,965 meters. The drilled and logged formations in the well include the terminal portion of Sarvak, Kazhdumi, Dariyan, Gadvan, Fahliyan, Heath and Surmeh formations. Sarvak Formation is totally composed of hard and dense limestone with minor shale and lack of effective thickness. Kazhdumi Formation is mainly composed of shale calcareous or limestone shale together with thin substrates containing hydrocarbon, their production depends precise experiments. Dariyan Formation in upper part is composed of hard and dense shale limestone in the upper part and composed of shale calcareous with pure limestone substrates in the lower part; Lower Darian is mainly composed of shale limestone along with pure limestone substrates. The thickness of the formation in Chilingar oil field is about 120 meters. The upper limit is located at the depth of 1958 meters (6425 feet). The formation's conical orbitolina limestone is turned to Kazhdumi shale by the facies change towards the Dezful Embayment namely intermediate areas such as Khark, Dashtak, Sulabdar, Chilingar and Chaharbishe, and on the other hand, this shale layers is referred to the lower parts of Kazhdumi Formation, laterally; and the shale called Kazhdumi tongue since the limestone underlying the shale, belongs to Dariyan Formation. The Dariyan and Kazhdumi formations' border is specified by a layer intensely impregnated with sand and silt iron compounds along with glauconite located on orbitolina limestone. The effects indicate the end of receding phase of the Darian carbonate cycle. The upper Khami reservoir consisted of three zones. Zone-1 is determined as upper Dariyan (thickness 30m), zone-2 is Kazhdumi top (thickness 51m) and zone-3 is also Kazhdumi as lower Dariyan (thickness 42m). Some of the existing microfossils in this formation are: *conical orbitolina, discoid orbitolina, choffatella decipenis., dictyoconous arabic sp., hensonella cylinderica, lithcodinm sp., salpingo porella sp.* Gadvan Formation has composed of shale limestone and calcareous shale in upper and lower parts and pure limestone in middle part of the basin; Fahliyan Formation has mainly composed of hard and dense limestone along with different shale percentages in different parts and anhydrite substrate in the lower part; Hith Formation has composed of anhydrite along with minor percentages of dolomite; and Surmeh Formation has mostly composed of pure limestone with an anhydrite substrate in the upper part and a dolomite and calcareous dolomite substrate in the lower part.

Micofacies

Cretaceous sequence in the Zagros Basin is very important and recognized from about 27 different formations in the Mesozoic Zagros, 17 of which are owned Cretaceous and 3000 m from the total of 11,000 m of Mesozoic- Cenozoic sediments is deposited in Cretaceous time. Available present data on the lithology of the existence formations of the Zagros Cretaceous sequence and their fossil content indicates that three different and distinct facies has been formed during the Cretaceous period: (1) deep marine facies areas that are seen in the Lorestan and northern Khuzestan has naturally pelagic type, (2) much deeper facies is a colorful mixture and ophiolite organization; it is especially visible around the Neyriz, and (3) shallow marine facies that developed in Dezful Embayment, Coastal Fars and Inner Fars and of composed of different types of neritic facies. For the first time, Brown [15] proposed microfacies to characterize a sedimentary unit which contains individual lithology and paleontology. By these it is possible to distinguish sedimentary facies from each other [16,17]. Facies analysis can yield paleontology, and sedimentology data of stratigraphic units. Thin sections studies were indicated that the Kazhdumi Formation consisted of 7 carbonate and 2 clastic facies in this part of Zagros region. They have deposited in open marine and lagoon environments.

Carbonate facies-Open sea Facies belt

O1- Bioclast wackestone- It composed of micro bioclast, crinoidal and ostracode. Other bioclasts are plancktonic foraminifera such as globigerina, favucella, and marcellona (Figure 4A). Replacement (calcitization) and fracturing are main diagenetic processes. The facies is equal to RMF7 of Flugel [14] which is deposited in inner ramp. The same facies is identified in other parts of NW Iran, such as Khormuj, Shahneshin, Khartang, Darang and Kangan.

O2- Globigerina packstone- The facies consists mainly of globigerina, bentic foraminifera (hemicyclamina) associated with pitonella, oligostegenida, spicules and saccocoma crynoid. They are distributed uniformly (Figure 4B). Calcitization and hematitization effects in foraminifera chambers are widespread of diagenetic processes. The facies is belong to outer ramp and equal to RMF5 of Flugel classification.

O3- Crinoidal globigerina wackeston/Packstone-including globigerina and hedbergella with some saccocoma crinoid, bentic foraminifera (hemicyclamina), and hetrohelkis (Figure 4C). Neomorphism is the main diagenetic process which subjected plancktonic foraminifera and micritic matrix. It is equal to RMF5 of Flugel classification.

O4- Oligosteginid packstone/wackestone- The facies containing oligosteginid as the main allochem associated globigerina (Figure 4D), favucella washitensis, calcifera (Figure 4E). Replacement detected as calcification.

All these microfacies, O1, O2, O3, O4, were deposited in barrier front of a carbonate platform toward deeper part of the basin, respectively. The presence of oligosteginid is solely the indicator of hemiplagic environment [18] and supported by the lack of lagoonal biofacies such as gastropode and milliolide. These are documented an open sea for the facies. The facies of O-group are similar to deep deposits of Bahamas [19] and Florida [20,21] present platforms.

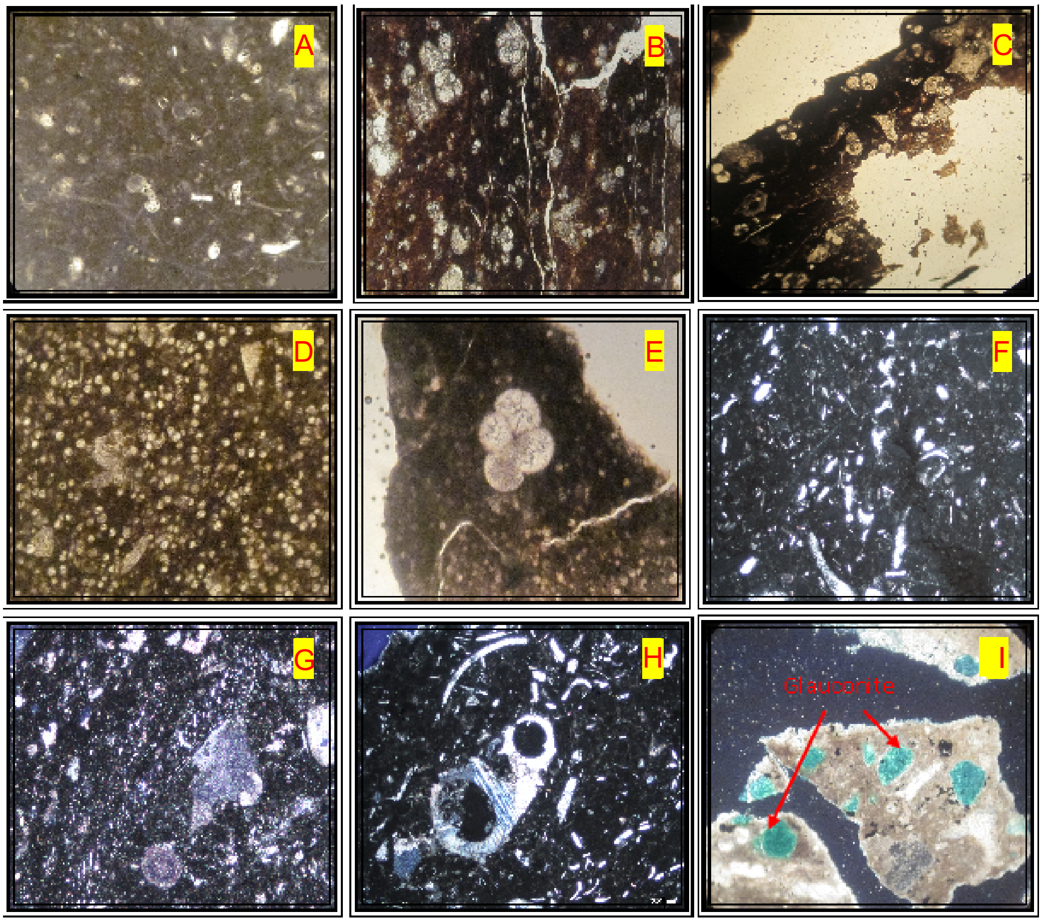

Figure 4: Microphotographs of carbonate microfacies of Kazhdumi Formation:
A-O1-Bioclast wackestone facies with microbioclast and globigerina (Chilingar-7).
B-O2-Globigerina wackestone with transparent calcite cement.
C-O3-Crinoidal globigerina wackestone/packstone containing planktonic globigerina and saccocomma with spary cement (Sulabdar-3).
D-O4-Oligostigenide packstone/wackestone containing oligosteginide, calcifer and bioclast debris
E-O4- Oligostigenide packstone/wackestone with favusella washitensis in a matrix floated on oligosteginide orthochem.
F- L1-Bioclast wackestone/packstone with bioclast debris (sulabdar-3)
G- L2-Bioclast wackestone-containing orbitulina and crinoid debris
H- L2-Bioclast wackestone with Gastropod cross section that replaced by calcite.
I- L3-Bioclast wackestone/ sandy wackestone- crinoids replaced by glauconite (Chilingar-3)

Lagoonal Facies belt

L1- Bioclast wackestone/packstone- The matrix composed of micrite. Bioclastic debris, gastropod, spicule, alge, and ammonite are the main constituents and echinoid and crinoid debris are minor phases (Figure 4F). Peloid is also found. Micritization, solution, replacement (dolomitization) and stylolitization are major diagenetic processes. They affected the texture of packstone and resulted in fracturing and dissolution seams such as stylolite. The microfacies placed in mid ramp and equal to RMF18 of Flugel.

L2- Bioclast packstone-Orbitulina and crinoid are the major skeletal components. There is also detected bioclast debris, bivalves, large gastropods, and peloid. Lenticulina, hemicyclamina, green alge, ostracode, and marcelona are found as minor components (Figure 4G and 4H). Replacement, micritization, cementation, and boring are main diagenetic processes. This facies is similar to RMF18 of Flugel.

L3- sandy bioclast packstone / wackestone-Bentic foraminifera is the main allochem. Crinoid debris is as a minor phase. Quartz and glauconite are also present (Figure 4I). It may be cited that replacement dominated as ferroginous minerals and glauconitization.

These facies are interpreted as low energy part of the lagoon. The presence of micrite as a main constituent and skeletal components found individually in this part such as milliolide and ostracode are all supported the result. While crinoid and bentic forams are belong to high energetic part of the lagoon.

Clastic Facies

Sandstone

This facies is found in the base of Kazhdumi Formation that is equal to Bourgan sandstone flames in south of Persian Gulf. In Chilingar oil field having glauconite (Figure 5A) indicating an epirogenic phase resulted to uplift the Kazhdumi Formation. The thickness of sandstone in Sulabdar oilfield is estimated 9 m and appeared as red –brown mature-supermature quartz arenite with chert and ferroginous-glauconitzed ooids (Figure 5B). These characteristics and also crinoid debris represent oxidized conditions in high energetic part of a lagoon.

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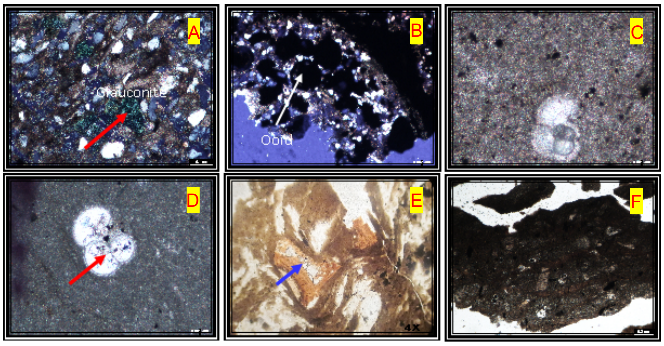

Figure 5: Microphotographs of clastic microfacies of Kazhdumi Formation:
A- Glauconite and quartz bearing Sandstone (Chilingar 7).
B- Sandstone containing ooids which are replaced by hematite completely (Sulabdar 3).
C- Shale with pelagic globigerina that replaced diagenetically by calcite (Sulabdar 3).
D- Shale having favusella washitensis (Sulabdar 3).
E- Representing organic matter rich shale (Sulabdar 3).
F- Argillaceous matter of shale (Chilingar 7).

Shale

It is mainly consisted of calcareous shale, clayey and silty shale which bearing bitumen and pyrite. It varies in color from dark brown to green. There are observed planktonic fossils, spore, fossilized wood traces and in some cases dolomitic matrix (Figure 5C-E). By considering shale facies characters, in view of hydrocarbon aspects, it seems the Kazhdumi Formation is a candidate for petroleum source rocks. Shale horizons deposited in open sea as interbeding layers with limestone. The following fossils are recognized in shale facies: ammonite, pelagic crinoid and planktonic foraminifera such as hedbergella, globigerina, favucella washitensis concerned to open sea.

All these facies both carbonate and clastic are presented spatially in the area understudy (Figure 6). Main diagentic processes which were subjected the Kazhdumi Formation along with their sequential order is also given in Table 3.

Depositional Model

In Carbonate ramps predominant deposition was lime mud during middle and upper Cretaceous [22] before changing atmospheric conditions such as lowered CO_2 and Ca^{+2} in oceanic water that favoured for skelletal components [22,23]. In the present shallow carbonate environment Bentic foraminifera are a useful tool to depth determination and plot sea level curve [25]. These results coincide to several paleo environmental studies [24,26]. In this paper we attempt to develop a depositional model for Kazhdumi Formation based on vertical and lateral variation of facies according to Wilson, [28] and Flugel [14] classifications (Figure 7). The results documented rim-shelf and open sea. Slumping and sliding facies, calciturbidite, cortoid, oncoides, pizoid, aggregate and free barrier facies are individually found in rim-shelf Flugel [14]. The changed laterally and developed open sea conditions which marks carbonate ramp. The ramp divided into outer, mid and inner with different water depth [29,30] in view of distance to beach. This ramp is found and reported from many depositional environments such as foreland, intra cratonic and passive basins [29]. The best modern example is the Persian Gulf depositional environment [31,32]. The Kazhdumi Formation deposited in mid and outer ramps based on available present data. Petrographic and microfacies analysis demonstrated that this formation is rich of organic matter and deposited in a favor condition which is responsible to make the formation as a prone petroleum source rock in Zagros Basin.

Conclusions

The microscopic thin sections examinations indicate the Kazhdumi Formation in studied wells is composed of carbonate and bituminous shale parts. The formation is related to different parts of Lagoon sedimentary environments and shallow to deep parts of the open sea. The studies indicates the production basin of formation becomes deeper

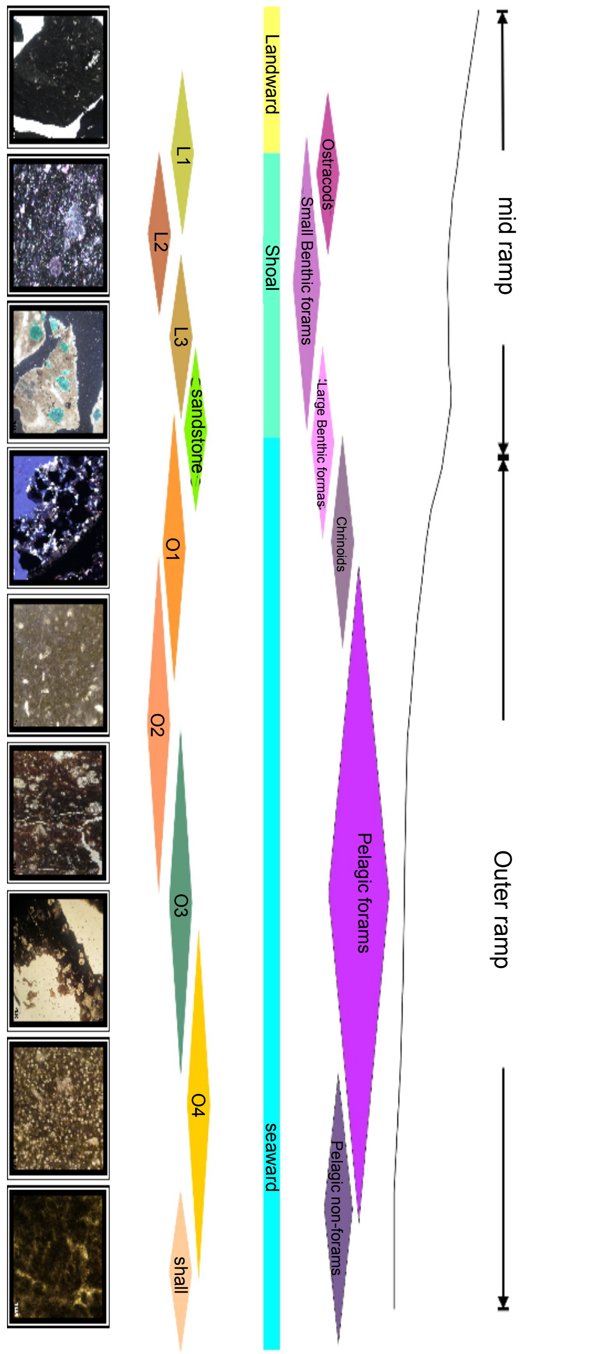

Figure 6: Depositional setting of microfacies distribution of the Kazhdumi Formation in study area.

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Time ← Marine Late	Diagenetic Process
	-Bioturbation
	-Boring and micrite coating
	-Primary porosity (inter particle, intra particle, shelter, boring)
	-Protodolomite
	-Equant calcite cement
	-Blocky cement
	-Secondary porosity (moldic, fracture)
	-Drusy cement
	-Hematitization
	-Glauconitization
	-Fracturing and grain deformation
	-Solution seam
	-Stylolitization

Table 3: Sequential order of diagenetic processes in the study area.

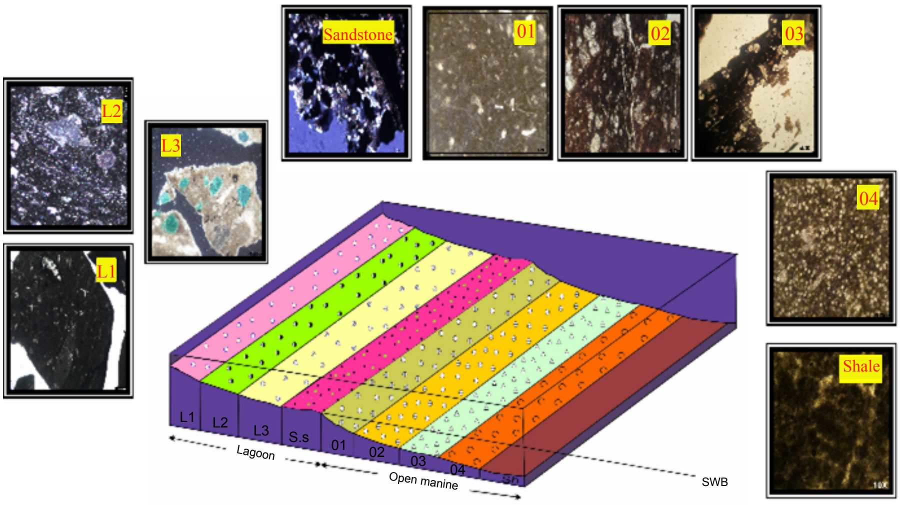

Figure 7: Depositional model of the Kazhdumi Formation with microfacies distribution in study area.

in the Sulabdar well No.3 towards Chilingar well no.7 and most of facies are from open sea's belt and are mainly shale. Carbonate and clastic facies are diagnosed by Subsurface sections' examination of Kazhdumi Formation. Carbonate facies are: mudstone bioclast, packstone bioclast, sand packstone / mudstone bioclast (L-facies belt), green algae (chlorophyta), ostracoda, miliolid, mollusks include gastropods and bivalves and peloid are the main characteristic of this facies which depends on their lagoonal environment position. Mudstone bioclast- globigerina packstone (planktonic mudstone) crinoidal globigerina mudstone- packstone/ mudstone oligosteginidae (O-facies) globigerina, favusella washitensis, hetrohelix and oligosteginidae are as facies' allochem, which live in deep parts of sea and are related to the open sea's basin.

Clastic facies are: shale and glauconite sandstone. Various diagenetic processes such as dissolution, cementation, chemical and physical density, neomorphism, dolomitization, micritization were effectively subjected the Kazhdumi deposits. These processes represent different environments. Micritization process demonstrates biological chaos in marine pheriatic environment; a pendant or attraction cement in climate environment and carbonate cementation (as granular, druses and block) is related to the funeral environment. The most important diagenetic process in the Kazhdumi Formation is the pressure solution which can be detected as stylolite formation. Stylolite has occurred in a deep burial and high temperature zone. This secondary porosity type can play an important role in passing hydrocarbon fluids.

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