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Microfacies Analysis and Reconstruction of the Ancient Sedimentary Environment of Jahrom Formation in Kuhsokhteh, High Zagros (West of Iran)

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Abstract : The Jahrom Formation has been studied in terms of facies analysis and reconstruction of the ancient environment in the stratigraphic section of Kuhsokhteh and located in south west of Shahrekord. This formation is 157 m in thick, and composed of the succession of limestones, marls and inter bedded of dolomites. Based on field studies and lithological characters, about 9 sedimentary rock units have been identified and introduced. On the other hand, based on microscopic studies, 8 facies including mudstone, dolostone/ dolomitic limestone, Interaclastic wackestone, Miliolid ¬ pellet wackestone, orbitolites- Miliolid ¬ pellet wackestone, bioclastic grainstone, hyaline-procellaneous foraminifera wake stone and hyaline foraminifera wakestone have been introduced. The diversity of variety of foraminiferal fauna and texture evidences suggests that these microfacies are expanded from coastal environment to shallow platforms (fore shoal) and deposited in a carbonate ramp from inner to middle carbonate ramp.

Keywords: Microfacies, Ancient sedimentary environment, Kuhsokhteh, High Zagros, West Iran.

Introduction

Iran is located in the middle part of Alpine-Himalayan orogenic belt. This orogeny is started from Western Europe, after passing through Turkey, Iran, Afghanistan to Tibet, and it is possibly continued to near of Burma and Indonesia. The geological setting of these mountains is located at suture line of the Eurasia and Gondwana. In this reason, the origin of this orogenic belt is related to geosynclinals and plate tectonics hypothesis. The present morphology of Iran is the result of numerous orogeny in the middle and late Alpine.

There are several factors involved for the zonation of geology of Iran. These factors have played in the zonation of Iran, in separate geological zones. On the one hand, the special situation of Iran between the Eurasia and Gondwana and the other hand, the existence of separate continental blocks where surrounded by ophioltic units. At last, the conditions governing the ancient sedimentary environment played a major role in the diversity and continuity of stratigraphic succession (Aghanabati, 2004). In fact, the geological zonations represent various sedimentary basins such as Zagros (Foldded Zagros, High Zagros and Khuzestan Plain), Alborz including the North, South and Central Alborz, also the East and West Alborz, KopetDagh, Central Iran, Sanandaj-Sirjan, Urumieh-Dokhtar, Lut Bloc, Eastern Zone of Iran, Makran (Fig.1).

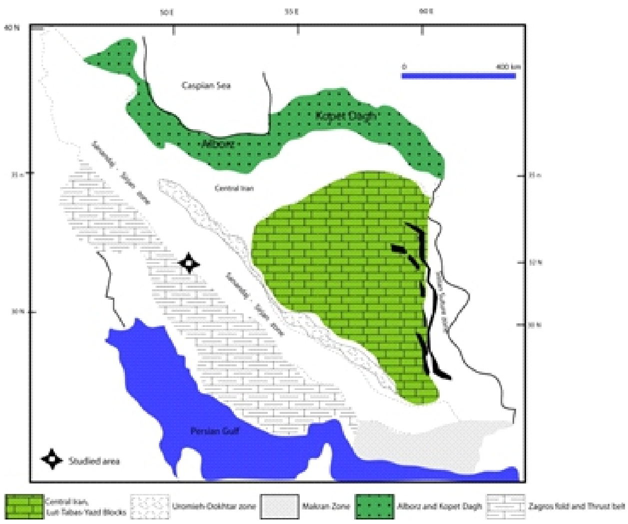

Fig.1: Iran map showing different geological zones, redrawn by Babazadeh, (2005).

The Zagros Mountain Ranges are extended as a narrow strip with a NW- SE trend from northeastern Turkey to southwest of Iran. The mountain ranges are as a result of the collision between Iran continental plate and Arabian plate and located in the middle parts of the Alpine-Himalayan orogenic belt (Fig. 2) (Alavi, 2004).

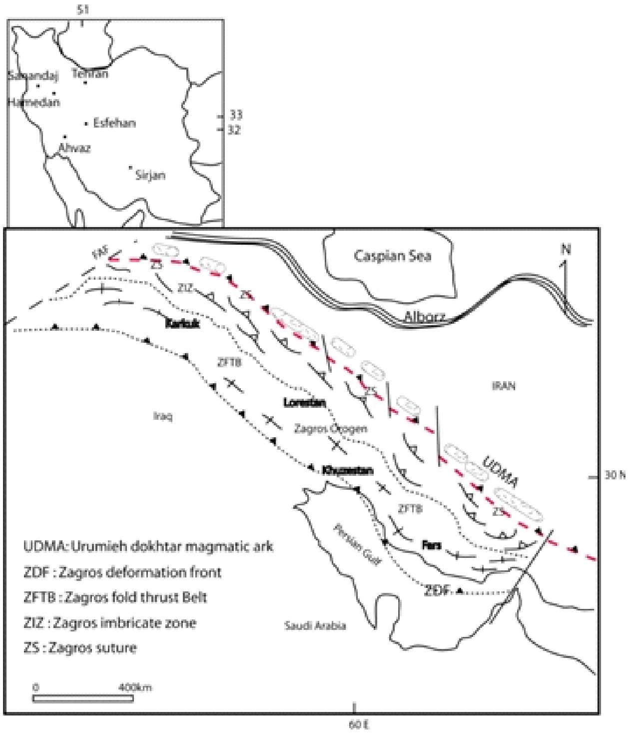

Fig. 2: The subdivisions of the Zagros belts in south-west Iran (Alavi, 2004).

In the point of view of the plate tectonic theory, the Zagros Mountain Ranges belong to an active edge of the northeastern Arabia shield (Berberian and King, 1981). The Zagros Basin covers the geographical areas of Lorestan, Fars, and Khuzestan. Based on the salt accumulation in Hormoz series or Hormoz complex, Zagros is divided into two parts: southeast or the Hormoz basin and the northwest or Ahvaz basin, which corresponds to the separation boundary of the Qatar-Kazerun line.

In terms of geomorphology, from the northeast to the southwest, the Zagros includes high Zagros (internal Zagros), folded Zagros (outer Zagros) and Khuzestan plain. Based on structural pattern from northeast to the southwest, Zagros includes thrust zone, folded belt, Downfall of Dezfuland Abadan plain.Based on the lithofacies and tectonic events, the sedimentary succession of Zagros could be divided into several Tectono-stratigraphy Units (Alavi, 1994):

1) Gondwana continental shelf facies, from late Precambrian to Middle Triassic,

2) South Tethys continental shelf facies, Jurassic-Cretaceous

3) The foreland marine and non-marine sediment accumulation, Cenozoic Erathem/Era, correspond to the Alpine orogeny and retrogration toward the southwest of Iran

Central Iran is separated from Arabian Shield and created Neo-Tethys Ocean along the Zagros crushed zone in the late Triassic. This ocean was started to closed from the late Cretaceous to late Paleogene and then, the central Iran and the Arabian continental shelf will be rejoined (Stonely, 1990).

It should be noted that in the late Cretaceous, the main and great depression in the northeast Khuzestan continued from the east Iraq to the coastal Fars and occupied between them with median ridge separating two depressions from each other, and it is place of the growth of Rudists reef which have created the Tarbur Formation at the late Maastrichtian. But the Gurpi Formation containing planktonic foraminifera, is deposited inside the depressions.

The Tertiary sedimentary successions in Zagros could be divided into two distinct parts: 1- The Lower Tertiary successions, from the Paleocene to Early Miocene, 2- The Upper Tertiary successions, from Early Miocene to Pliocene and younger. In the Lower Tertiary, two sedimentary cycles could be identified: the Jahrom sedimentary cycle is dated Paleocene to Middle Eocene, which is the subject of this paper, and the Asmari sedimentary cycle is dated from Oligocene to Early Miocene. The upper Tertiary sedimentary successions represent a retrograde sedimentary facies, which is called the Fars cycle, and formed from Early Miocene to Pleistocene (Motiei, 1993).

In the type section, the Jahrom Formation is composed six rock units. This formation consists of thin nodular dolomitic limestones, medium to thick limestones and creamy to gray dolomites. The basal part of this formation contains a conglomerate horizon which is located on Sachun Formation, but in other regions, it is locally located on the formations of Kashkan, Tarbur and Pabdeh. Sometimes the carbonate rocks of Jahrom Formation are formed as an interfingering shape with radiolarian chert of Kashkan Formation in the depression. But the Jahrom Formation consists of thin to medium layer and massive limestones at the top which is located below the Asmari Formation with an Iron Conglomerate horizon.

In the studied area (the KuhSoukhteh), Jahrom Formation consists of a succession of thick layers and massive calcareous sedimentary rocks, thin and medium marls, and dolomits with intercalation of yellow medium bedded limestones. This formation has been studied by a large number of researchers such as James and Wynd (1965), Kalantari (1980), Rahaghi (1980), Khosrow Tehrani *et al.* (2005), Noor Mohammadi (2007), KhatibiMehr and Moalemi (2009), VaziriMoghadam *et al.* (2010) and Babazadeh and Pazooki (2015). The lower contact of Jahrom formation at the stratigraphic section with Pabdeh formation is faulted and upper boundary with Asmari formation is discontinuous. The purpose of this paper was to present the various rock units, to determine the types of microfacies and to identify the ancient sedimentary environment of studied area.

Geological setting

In terms of geographic expansion, Jahrom Formation is located in the interal and coastal Fars (Fig. 2). This formation has been reported in drilling fields of Darkhovin and Khorramshahr oilfields in Khuzestan. The Jahrom Formation could be equivalent with three Formations as Talezang, Shahbazan and KashkanFormations in the central and northeast of Lorestan. The thickness of the Jahrom Formation varies in different parts of Zagros due to unequal environmental conditions. In other areas of Zagros such as southwest of Lorestan and Khuzestan (Fig. 2). Pabdeh Formation will be replaced by the Jahrom Formation. In fact, the Jahrom Formation is outcroped in the central Zagros and high Zagros, such as the study area (Kuhsukhteh) with a latitude north 32 ° 00' 16 " and longitude eastern 50 ° 51'07" in southwest of Shahrekord (Fig. 3).

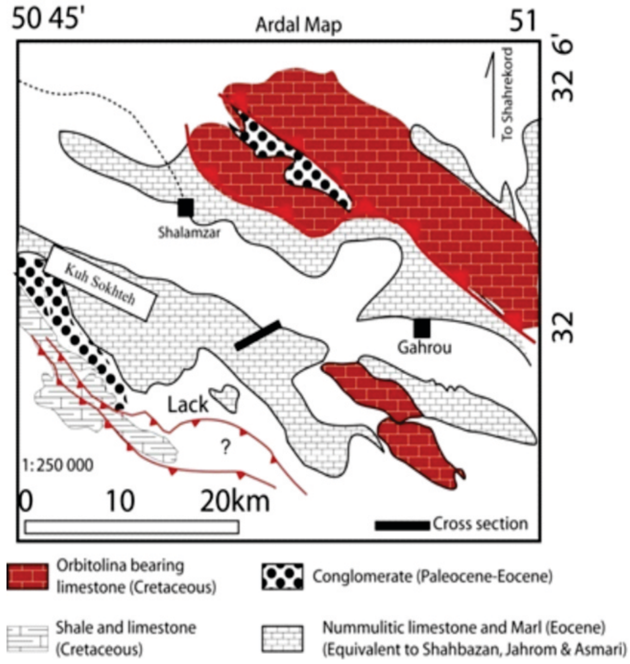

Fig. 3: Location of study area (Kuhsokhteh) on geological map of Ardal, 1:250,000.

The tectonostratigraphic structure of Shahrekord is consists of three zones: northeast, central, and southwest position. They are including north-east Zayandeh-rud Zone (Z1), central high Zagros Zone (Z2), and southwest Karun Zone (Z3) from East to West. The second zone, which is part of the high Zagros, is located between the Trust faults of Saman-FereidounShahr Fault (F1) and Bazouft fault (F3) and is divided into two smaller sub-zones (Z 2a)and (Z 2b) by the main Zagros thrust fault (F2). The study area is located in Z 2b sub-zones and in Chaharmahal-Bakhtiari province (Fig. 4).

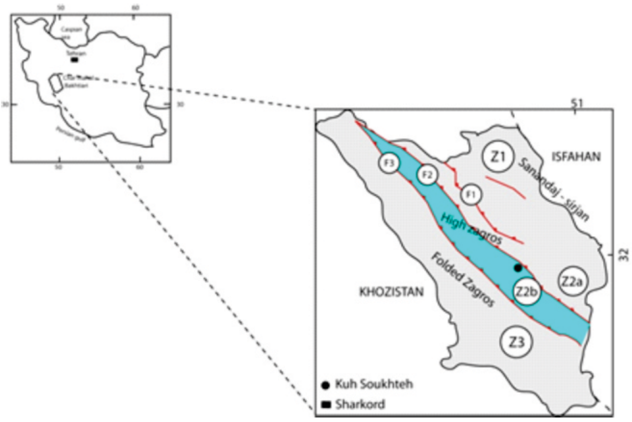

Fig. 4: Location of the study area (KuhSokhteh) in the central high Zagros zone (Z2b) on Shahrekord map.

Materials and Method

About 80 rock samples, 157 m thick, were collected from the sedimentary facies of Jahrom Formation in KuhSokhteh. The microscopic analysis of samples was carried out in the Geological Lab of Payame Noor University. Thin-section study was performed using light microscopy. The limestones were classified according to depositional texture (Dunham, 1962). The determination of carbonate facies is based on petrographically studies to define the depositional environments of the concerned formation and the terminology of Buxton and Pedley (1989) and Flügel (2004). Stratigraphic column and sedimentary model are drawn with Adobe Illustrator software.

Lithostratigraphy

In general, the lithology of Jahrom Formation in the study area can be divided into three parts: 1. Argillaceous limestones 2- Marls 3- Dolomitic Limestones. According to lithological characters, thickness and structural rocks, about 9 lithological units have been identified. These units are following from bottom to top (Fig. 5):

Unit 1: The thickness of this unit is reached to 45 meters and extended from horizon (bed) 1 to horizon (bed) 21 in stratigraphical column. This unit consists of a sedimentary succession that including soft and fine grain argillaceous limestone, thin dolomitic layers and intercalition of dense to medium layer limestones. The microfacies of this unit vary from mudstone and dolostoneto wackestone.

Unit 2: This unit is introduced here immediately overlies the Unit 1. It is 15 meters thick and exposed along the columnar section from bed 22 to bed 34 in stratigraphical column. This unit is mainly consisted of thin layers of marl and argillaceous limestone.

Unit 3: This unit consists of some 22 meters of fairly well thin bedded to massive limestones. It is extended from layer 35 to layer 45. The carbonate facies varies from grainstone to wackestone.

Unit 4: This unit is consisted of a thin layers of clay and marls that continued to the top of section by a thin layer of dolomite. The thickness of this unit is reached to 10 meters and extended from layer 46 to layer 49.

Unit 5: This unit is 14 m thick and extended from layer 50 to layer 57 in the stratigraphical column. It is mainly composed thick bedded to massive limestones. The carbonate facies represents grainstone to bioclasticwackestone.

Unit 6: This unit is 9 meters in thickness and composed of green marls and yellow argillaceous limestones. It is exposed to the interval between bed 58 to bed 63. The carbonate facies of this unit is mudstone.

Unit 7: This unit is 9 m thick and extended from layer 64 to layer 67 in the stratigraphical column. It is composed of gray to cream medium to thick bedded of limestones. The carbonate facies assigns to bioclastic wackestone and grainstone.

Unit 8: This unit is 18 meters in thickness and extended from bed 68 to bed 74 in columnar section. It is composed of marls and argillaceous limestones. In terms of carbonate facies, it is assigned to the mudstone.

Unit 9: This unit is continued from layer 78 to layer 80 and reached to 15 meters in thickness. It is consisted of yellow medium bedded limestones with intercalation of dolomite and marls. The carbonate facies is referred to bioclasticwackestone. According to lithological similarities, units 1, 3, 9, units 5, 7, as well as units 2, 4, 6, 8 are similar and repeated in the stratigraphic column.

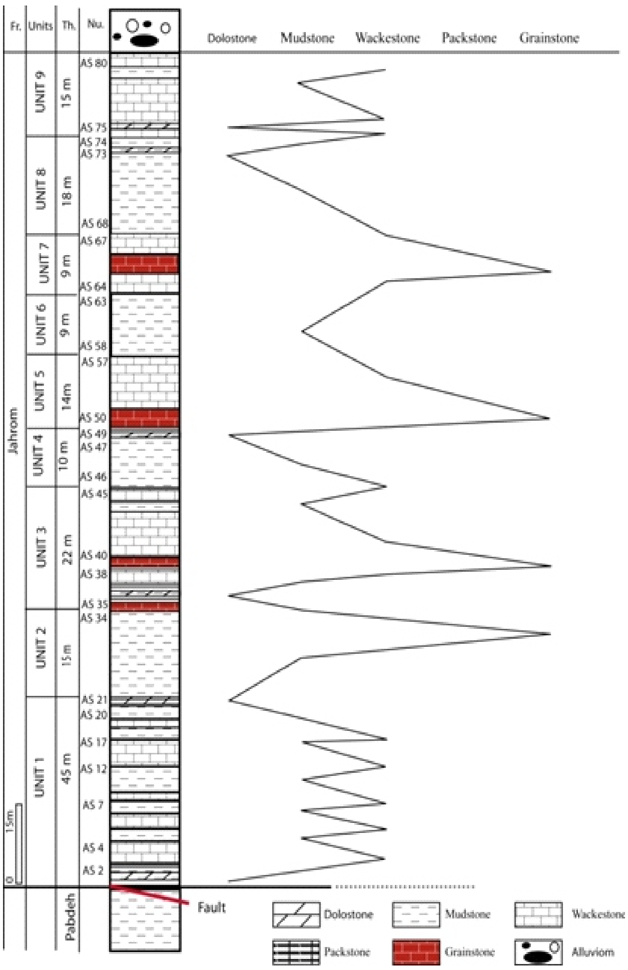

Fig. 5 - Stratigraphic column shows different types of lithology and sedimentary facies in KuhSokhteh.

Microfacies and sedimentary environment interpretation

The eight facies including Mudstone, Dolostone/ Dolomitic limestone, Interaclasticwackestone, Miliolid ¬ pellet wackestone, Orbitolites- miliolid ¬ pellet wackestone, Bioclasticgrainstone, hyaline- procellaneous foraminifera wakestone and hyaline foraminifera wakestone have been identified and introduced from littoral zone to fore shoal (continental slope).

Littoral-

1-Mudstone Facies

This facies consists of argillaceous limestone with micritic facies. No fossils observed in this facies but the small miliolid is very rare. The micritization processes are controlled by biological and chemical factors and take place in shallow- and deep-marine as well as in terrestrial and lacustrine environments

Interpretations: The littoral zone is usually composed of thin layer marls, stratified argillaceous limestone (mudstone) and fine grained siltstones. These rocks contain thin shells of invertebrates' fossils, ostracods, small procellaneous foraminiferasuch as small miliolid and hyaline perforate foraminifera such as small Rotalia. This situation shows the low energy in tidal flat environment. As a result of a gradual transition from the littoral to the lagoon, the facies changes from mudstone to wackestone.

2 - Dolostone / dolomitic limestone Facies

As a result of the dolomitization in dolomitic facies, the fossils fragments such as miliolid (porcellaneous foraminifera) and bivalves will be faded and disappeared so that it is almost impossible to identify them. The existence of vuggy porosities also is abundant in dolostone. The dolomites are small and rhomboidal shape.

Interpretations: the succession of sedimentary rocks such as dolostone, dolomitic wackestone, and dolomudstone are usually formed in the low-energy environment of littoral zone. The dolomitization represents the diagenetic process in sedimentary environments. The vuggy porosity in the dolostones is occurred in the upper part of the intertidal environment and indicated shallowing upward.

3-Interaclastic wackestone

The matrix of this facies is micritic limestone. The Intraclast (up to 50%) and peloid (10-20%) are the most abundant components. Miliolid smaller foraminifera and other subordinate bioclasts account for 5-20%. They are broken Because of the displacement.

The intraclasts are irregularly shaped of carbonate fragment that formed by syndepositional erosion. The carbonate fragment is consisted of lithified or semi-lithified sediment and derived from the erosion of nearby contemporaneous sediment. Therefore, the intraclasts are fragments of carbonate sediment, usually fine-grained, that was deposited and then later ripped up by strong currents to be redeposited with other carbonate sediment.

Interpretations: the word intraclast implies that the ripping up took place within the environment of carbonate deposition, after the depositional of the sediment. Then intraclast could be taken place in shallow water under high energy conditions.

Lagoon

4-Miliolid – pellet wackestone

This type is dominated by pellet and smaller miliolids. This facies is characterized by the presence of micritic limestone and porcellaneous foraminifera. The peloids are structure less subrounded micritic grains. The subordinate alveolinids, echinoid and bivalve fragments are present.

Interpretations: The association of pellet and miliolids are common on shallow-marine carbonate platforms in lagoonal settings and hint to restricted environment.

5-Orbitolites-miliolid-pellet Wackestone

This facies is similar to the previous facies except that there is orbitolites. The main component is pellet smaller, miliolids and orbitolites. The subordinate components are agglutinated foraminifera (Coskinolina) and small rotalids. Fragmentation is low to absent in sample comprising wackestone.

Interpretations: The occurrence of Orbitolites represents a shallow water lagoonal environment in protected shelf (Hottinger 1983, Gietl 1998). This facies is supported by the miliolids and micritic pellets and showing a lateral paleoenvironmental relationship with the miliolid-pellet wackestone facies. It is assigned to relatively shallower water than alveolinids facies in tropical environment.

Back shoal

6-Bioclastic (Hyaline-Porcellaneous foraminifera) wackestone

This microfacies has micritic matrix. The bioclasts such as procellaneous and hyaline shells are the most abundant components but the other components are subordinate.

Interpretations :

Since the imperforate and perforate foraminifera thrive in different environments therefore this facies reflects the imperforate foraminifera are transported from back shoal to the shoal front. The co-occurrence of normal marine (perforate foraminifera) and platform interior (imperforate foraminifera) biota in this facies indicates that sedimentation took place in a open shelf platform and suggests that low relief as shoal (Romero *et al*., 2002, Rasser *et al*., 2005). This facies deposited in offshore environment and reported from an inner ramp of Lower Inn Valley (Nebelsick *et al*., 2001).

7- Hyaline foraminifera wackestone

The components are dominated by rotalids, predominantly Rotalia. Additional components are agglutinated foraminifera and echinoid fragments. Miliolids are very rare and orbitolites are absent.

Interpretations:

The rotaliids are very frequent in inner neritic facies rich in terrigenous mud but rarely found in clean carbonates . The co-occurrence of rotalids and agglutinated foraminifera represents an open environment and an open sea connection therefore this facies is formed in back shoal.

Shoal

8-Bioclastic grainstone

The main bioclasts as benthic foraminifera and bivalve fragments are present in the sparitic cement. The occurrence of rounded rotalids as Medocia in sparitic cements indicates that sedimentation took place in shallow water at low relief as shoal environment.

Interpretations:

The grainstone textural rock type is interpreted as results of a high-energy environment. Therefore the micritic calcite is washed and removed from the environment. Usually rounded bioclasts are forming bioclastic shoal and generally found in more energetic environments than Alveolina (Rasser *et al*., 2005).

Discussion

In the transition zone from the littoral to lagoon, mudstones, dolo-mudstone and dolo-wackestones are occurred. These facies represents a shallow subtidal environment. Episodic high-energy storm events washed peloids onto the lagoonal environment and led to formation pellet-foraminiferal wackestone.

The porcelaneous foraminifera are mainly improved in tropical carbonate platform within the upper part of the photic zone (Reiss and Hottinger, 1984; Hohenegger *et al*., 2000). These foraminifera constitute thick carbonate succession and localized in lagoonal or back relief setting (Hottinger, 1983). The miliolids indicate a preference for warm, shallow water and tolerance between 18 to 36% fluctuations in salinity.

The foraminifera with porcellaneous and hyaline shells are found in two separate sedimentary environments. The co-occurrence of porcellaneous and hyaline foraminifera represents low relief with the connection between the front and behind relief or that porcellaneous foraminifera were transported from the shallow environment through the flow of water and removed to deeper areas (Hohenger *et al*., 1999).

The skeletal grains, lack of lime mud and the presence of sparry calcite cement in grainstone is also indicative of a high-energy environment. This facies is apparently characterized a bioclastic shoal due to the presence of rounded bioclasts and sparry cements. The rotalids also are found in shallow and turbulent aquatic environments in the middle ramp and their presence shows the upper part of the upper part of photic zone (Geel, 2000; Bassi *et al*., 2007).

Eventually, these facies are occurred in a carbonate platform of the ramp type and formed from the coastal plain (littoral) to shallow environments in the middle ramp, respectively (Fig. 6).

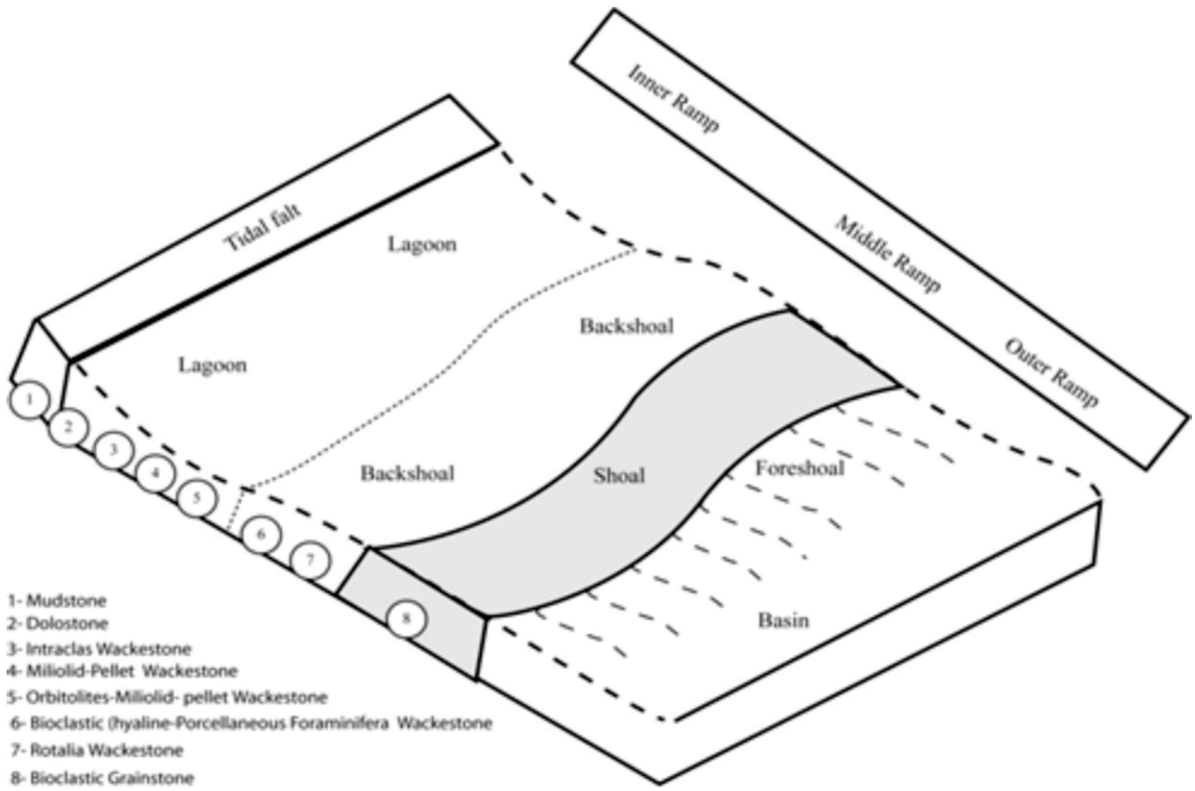

Figure 6: Sedimentary model showing the expansion of main facies of the Kuhsokhteh stratigraphic section.

Conclusion

According to lithological characters, thickness and structural rock, about 9 lithological units have been introduced in the studies area (Kuhsokhteh). They are subdivided into three parts as argillaceous limestones, marls and dolomitic limestones. About eight microscopic microfacies have been identified in the carbonate platform and they are indicated a gradual deepening arrangement from littoral, lagoon, shoal and continental slope to the open sea. No resedimented facies and true reefal structures found in the Jahrom Formation.

Based on variation of benthic foraminifer's diversity and vertical transition of facies, the sedimentation of the Jahrom Formation was carried out in a carbonate ramp environment from the inner ramp to middle ramp.

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