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*Full Length Research Paper*

# Microfacies and sedimentary environment of the Oligo-Miocene sequence (Asmari Formation) in Khuzestan sub- basin, Zagros Basin, southwest Iran

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**The Asmari Formation is a thick carbonate succession of the Oligo-Miocene in Zagros Basin. The Oligocene-Miocene Asmari Formation, Chidan area, is composed of limestone and calcareous marl. The Asmari Formation has a conformable contact with the overlying (Gachsaran Formation) and the underlying (Pabdeh Formation) units and is subdivided into three members. In order to interpret the facies and depositional environment of the Asmari Formation, two measured sections were studied in Chidan area for microfacies analyses. In this study, eight different microfacies types have been recognized on the petrographic studies, field observations, identification of larger foraminifera and facies studies of the Asmari Formation (Chidan section). These carbonate microfacies belonging to four major subenvironments: open marine (A), bar/shoal (B), lagoon (C) and tidal flat (D). The depositional environment of the Asmari Formation is interpreted as a shallow carbonate ramp. The most of the Asmari Formation in the study area was deposited in an inner ramp environment.**

**Keywords:** Asmari Formation, Chidan, Gachsaran, Pabdeh, Iran.

## INTRODUCTION

The Oligocene–Miocene Asmari Formation is famous as the most prolific oil producing sequences in the Zagoros Basin in the southwest of Iran. It has been recognised that some of the richest oil fields in the Middle East occur in the younger Cenozoic rocks of Iran and Iraq (Ala et al., 1980; Beydoun et al., 1992). The carbonate rocks of the Asmari Formation have been well studied (Lacassagne, 1963; Seyrafian, 2000; Vaziri- Moghadam et al., 2006). The Asmari Formation was deposited in the Oligocene-Miocene shallow marine environment of the Zagros foreland basin (Alavi, 2004) and is best developed in the Dezful embayment zone (a part of Khuzestan Province). Lithologically, the Asmari Formation consists of 314 m of limestone beds (Motiei, 1993). In the south of the Dezful embayment, its lithology changes to a mixed siliciclastic-carbonate deposit consisting of carbonate beds with several intervals of sandstone (Figure 1), sandy limestone and shale. This facies is attributed to the Ahwaz Sandstone Member (Motiei, 1993).

Most of the studies of the Asmari Formation in this basin are related to subsurface data, while this study is focused on an outcrop.

The main objectives of this research were focused on (1) a description of the facies and their distribution of the facies, (2) the palaeoenvironmental reconstruction of the Asmari Formation in Chidan area (SW Iran).

## METHODS AND MATERIALS

This paper is the first report on the Microfacies and depositional environments of the Asmari Formation at the Chidan area. Two sections of the Asmari Formation were measured bed by bed, and sedimentologically investigated. Fossils and facies characteristics were described in thin sections from 160 samples. Limestone classification followed the Dunham (1962) and Embry and Klovan (1972) nomenclature system. Samples were collected from an outcrop in the Khuzestan Province (Chidan area), which is representative of the entire

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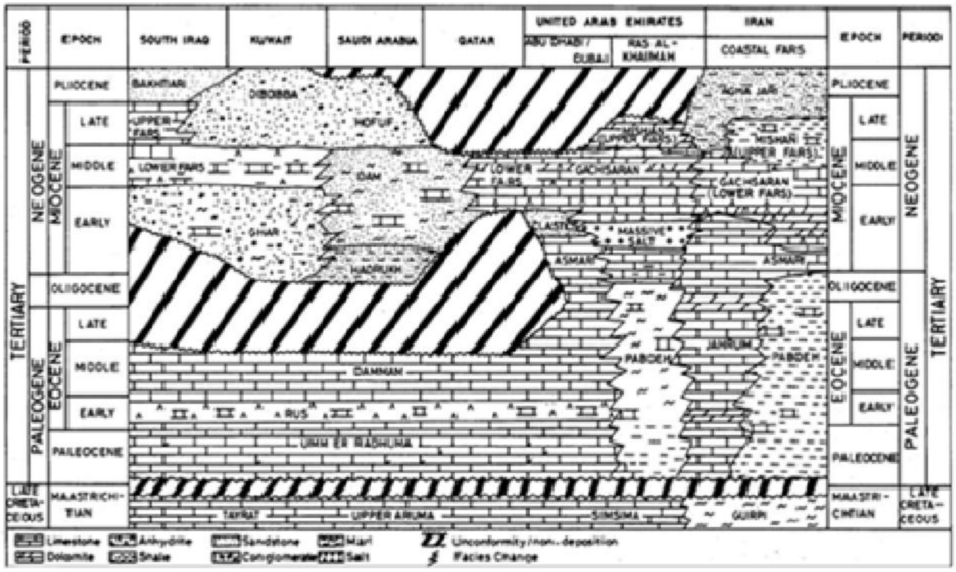


**Figure 1**. Lithostratigraphic chart of the Paleogene-Neogene sub-system in Iran and the adjacent areas (Alsharhan et al., 1995).

thickness of the Asmari Formation. Thin sections were stained to distinguish calcite and dolomite.

The foraminiferal assemblages of the Asmari Formation consist of various imperforate and perforate forms. This fauna is a good tool for biofacies analysis, recognition of paleoecology and biostratigraphy.

## Previous Studies

The Asmari Formation was named as a Cretaceous–Eocene interval by Busk and Mayo (1918); it was defined as an Oligocene Nummulitic limestone (Richardson 1924). Lees (1933) considered the age of the Asmari Formation as Oligocene – Miocene. He chose the type section in Tange gole torsh, located in southeast Masjed soleiman (SW Iran), and based on lithology features divided it into the following three members from base to top: the lower Asmari, middle Asmari and upper Asmari.

James and Wynd (1965) carried out the first study of the biostratigraphic properties of this formation. And reviewed by Adams and Burgeois (1967) in unpublished reports. Adams and Burgeois (1967) designed four assemblages of Asmari Formation indicating Oligo-Miocene age.

Recently published research on the Asmari Formation are: Seyrafian, 2000; Seyrafian et al., 1996; Seyrafian et al., 2003 and Vaziri Moghaddam et al., 2006.

## Paleogeographic History

The southwestern marginal active fold belt of Iran, the Zagros, is formed on the northeastern margin of the Arabian continental crust (Figure 2). The geological history of the Zagros belt is simply marked by relatively quiet sedimentation continuing from late Precambrian to Miocene time. The sedimentation was of platform-cover type in the Paleozoic, miogeosynclinal from the Middle Triassic to Miocene, and synorogenic with conglomerates in late Miocene-Pleistocene times (James and Wynd, 1965; Stocklin, 1968; Berberian, 1976). The belt was folded during Plio-Pleistocene orogenic movements.

The Zagros Paleogene succession can be divided into two cycles (Seyrafian, 2000). The first is the Jahrum cycle, dating from Paleocene to Oligocene times. This cycle comprises the deep Pabdeh Formation (containing of marl, shale and marly limestone) and shallow Jahrum Formation (dolomitic limestone and limestone). The second cycle is the Oligocene to early middle Miocene Asmari cycle. Overall, the Asmari Formation can be considered as a late transgression in the Zagros basin (Motiei, 1993).

## Asmari Formation (Oligocene- Early Miocene)

The formation in Khuzestan Province (Iran) consists of 340 m of thick, well-bedded limestones with shelly horizons. In the Ahwaz and Mansuri fields the basal third consists of calcareous sandstone and sandy limestone with minor shales, corresponding to the Ahwaz Member reported by James and Wynd (1965). Although the base of the Asmari Formation seems to be conformably overlying the Pabdeh Formation in the Fars Province, it is diachronous in Lurestan and Khuzestan Provinces. The reverse is true of the top of the formation, with a conformable contact with the overlying Gachsaran

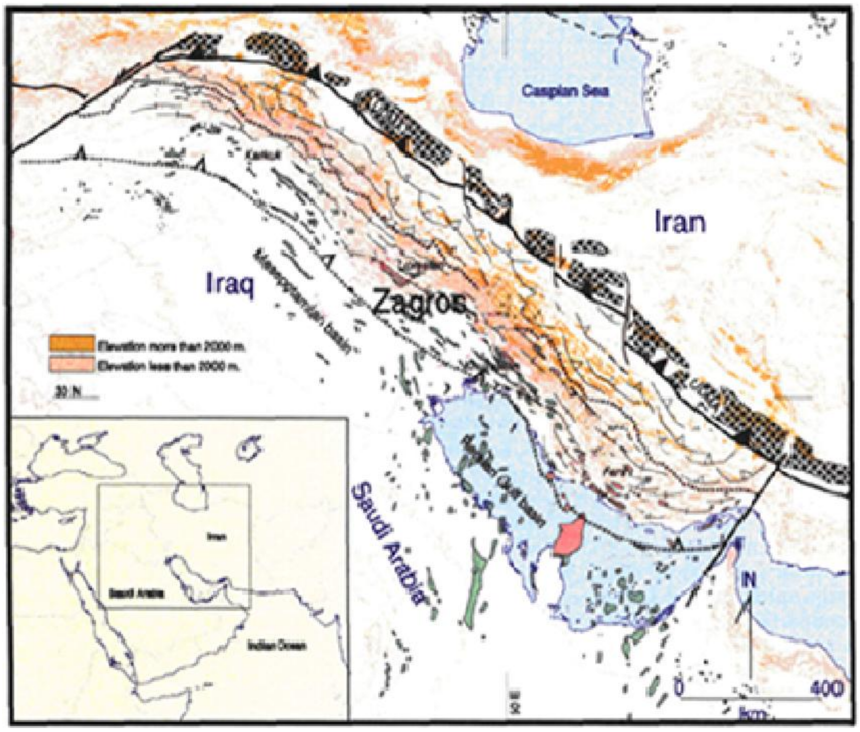


**Figure 2**. The position of folded Zagros belt (Alavi, 2004)

Formation in the latter two regions but a diachronous relationship in the Fars Province. In southeastern Iran the Asmari grades into the marls of the uppermost part of the Pabdeh Formation, as revealed by wells drilled on Qeshm Island (SE Iran).

The lower part of the formation has been dated as Chattian-Rupelian by Eames et al. (1962) and the middle and upper parts as early Miocene. The Oligocene to earliest Miocene Asmari limestones have also been encountered in the subsurface in the offshore northern Emirates and in an outcrop on Jabal Hafit (Abu Dhabi) close to the Oman Mountains (Alsharhan et al., 1995).

## Geological Setting

The Zagros Mountains are situated within the NE part of the southern Neotethys ocean.

Geographically the Zagros Mountains belong to the Alpine-Himalayan chain, but clearly do not fit into models for the Alps or Himalayas (Takin, 1972). Some of these difficulties were discussed by Stocklin (1968), who concluded that Iran had a peculiar type of Alpine tectonics.

The study area is located in Khuzestan province, 152 km from Ahwaz and east of Baghemalk (Figure 3). It is measured in detail at N 48° 33´ 48´´, E 49° 59´ 50´´ at surface.

○In this area, the Asmari Formation is consists of 340 m of thick and cream thin- medium-bedded limestones and calcareous marl that the upper part of Asmari Formation are divided into two parts by coral limestone (Figure 4).

## DISCUSSION AND RESULTS

### Microfacies types and facies interpretation

Eight microfacies were defined from the Asmari Formation (Chidan area at Baghemalek, SW Iran), which were grouped into four facies associations representing subenvironments.

### Tidal flat Facies

### D: Limemudstone

The microfacies mainly consists of micrite, lacking lamination and with rare bioturbation. In some parts, moulds of evaporates are observed. In some thin sections quartz grains are visible (Figure 5a). Similar present-day conditions are seen in hot and dry carbonate platforms with high evaporation, such as the Persian Gulf (Tucker and Wright, 1990).

Observations indicate that this microfacies is deposited in an upper tidal flat to supratidal environment.

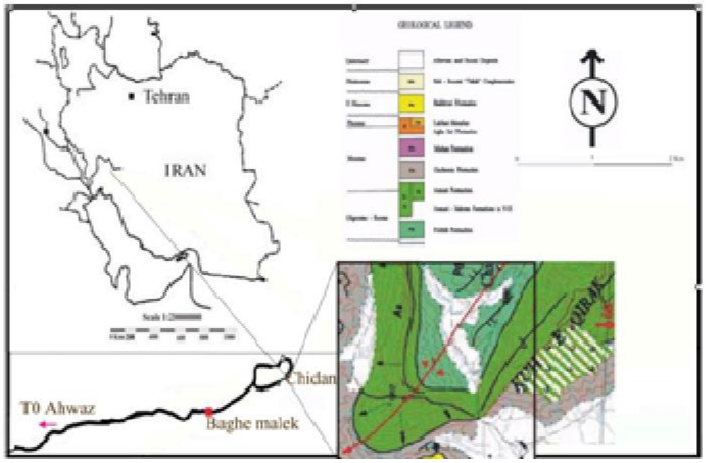


**Figure 3**. Location and geological map of the study area.

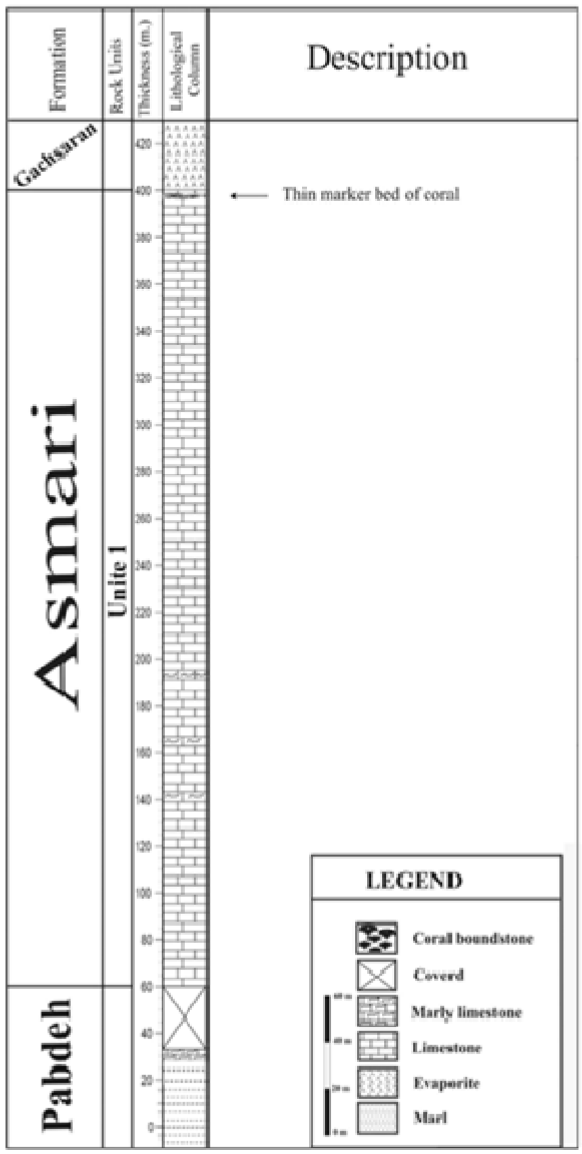


**Figure 4.** Lithostratigraphic profile of the Asmari Formation in the Chidan area.

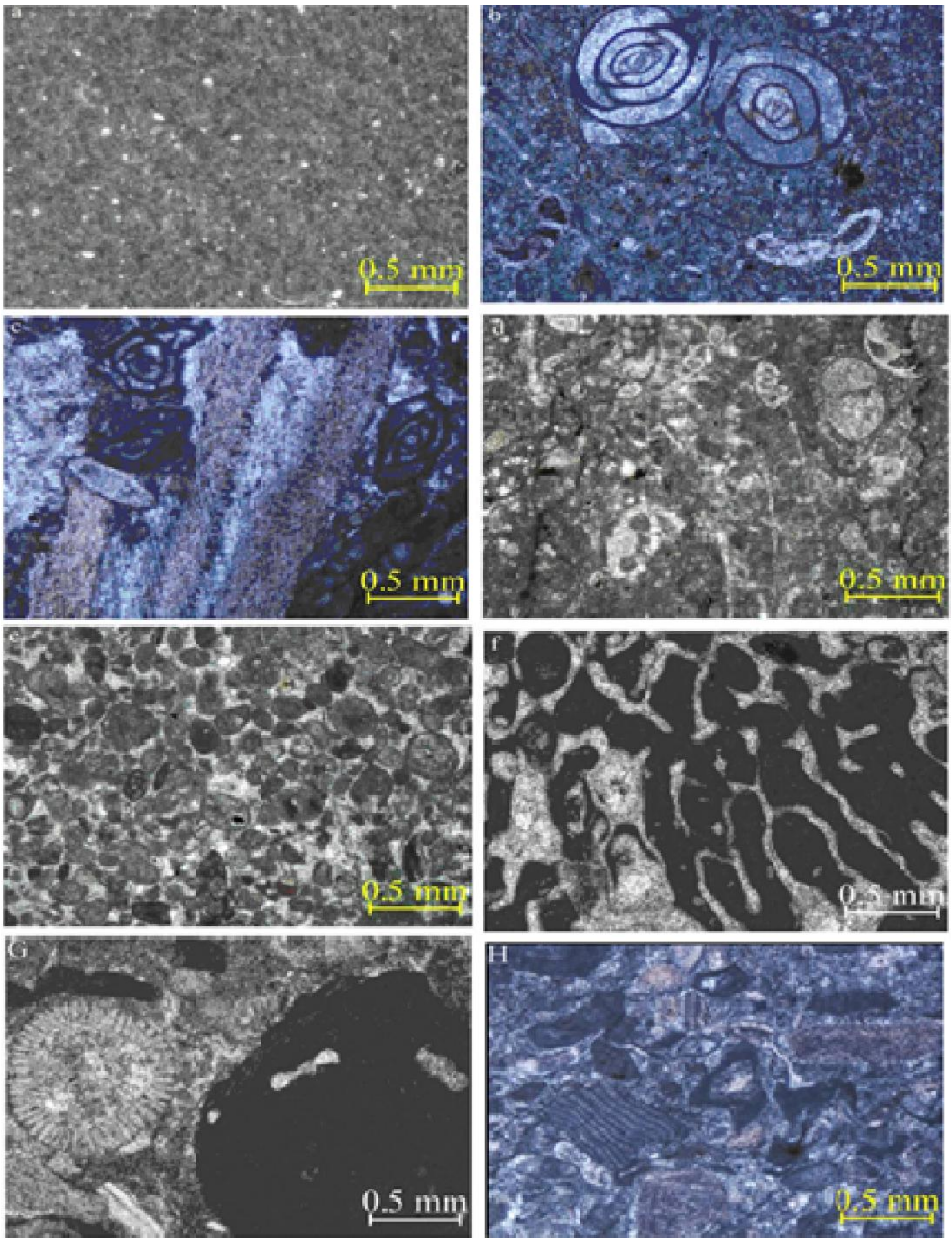


**Figure 5.** Microfacies types in the Chidan area. a: limemudstone, microfacies D. b: Miliolid/ Discorbis Wackestone, microfacies C1. c: Bioclast / Miliolid Packstone, microfacies C2. d: Bioclast/ Rotalia Wackestone, microfacies C3. e: Bioclast / Peloidal / Miliolid Grainstone, microfacies C4. f: Coral Boundstone, microfacies B2. g: Bioclast / Corallinacea Wackestone, microfacies B1. h: Intraclast / Miliolid / Bioclast Packstone – Wackestone, microfacies A.

## Lagoon Facies

### C1: Miliolid/ Discorbis Wackestone

The main feature of the microfacies is a relatively large amount of shell fragments in the matrix, mainly comprising Discorbis shells. Also, other shell fragments (bivalves, echinoderms) and miliolids can be seen (Figure 5b). This microfacies is associated with the lagoon of an internal ramp (Flügel, 2004).

### C2: Bioclast / Miliolid Packstone

Porcelaneous foraminifera (Figure 5c) are the main constituents of this microfacies. Echinoderms and bivalves debris are present in small quantities. The existence of porcelaneous foraminifera and microfacies type packstone is related to a low-energy lagoon environment (Flügel, 2004).

### C3: Bioclast / Rotalia Wackestone

The main constituent microfacies are Rotalia, echinoderms and bivalves debris (Figure 5d). Biodiversity is low. The microfacies has been associated with a lagoon of the internal ramp (Buxton and Pedley, 1989)

### C4: Bioclast / Peloidal / Miliolid Grainstone

Peloid and foraminifera such as miliolids (Figure 5e) are the main constituents. Echinoderms debris and intraclast contents are low. Miliolids live in shallow saline to hypersaline waters (Gell, 2000). Considering the available allochemes, grainstone texture, intraclasts and low foraminifera diversity, this microfacies is associated with an inner ramp and a relatively limited environment with high-energy.

## Barrier Facies

### B2: Coral Boundstone

This microfacies is formed by the growth of coral networks (Figure 5f). Echinoderms debris, miliolids and rarely Miogypsinoides can be seen. The skeleton space of coral is mainly filled by sparite and rarely micrite. This facies is formed in patch reefs and represents the mid - ramp environment (Buxton and Pedley, 1989).

### B1: Bioclast / Corallinacea Wackestone

The main components of this microfacies included fragments of corallinaceans, bryozoans, bivalves, echinoderms and benthic foraminifera (Miogypsinoides, Rotalia, Discorbis). The matrix consists mainly of micrite. Red algae are discoidal. Patch reef corals are also observed (Figure 5g). The microfacies is equivalent to microfacies 5 reported by Buxton and Pedley (1989) and is associated with a mid - ramp environment.

## Open marine Facies

### A: Intraclast / Miliolid / Bioclast Packstone - Wackestone

The bioclastic content of this microfacies is mainly composed of algal crust debris (Figure 5h), echinoderms, bivalves and foraminifera (miliolids and lesser numbers of Miogypsinoides, Rotalia, Discorbis); intraclasts are also seen.

The microfacies texture is grain supported. Considering the diversity of existing allochemes, evidence of bioclastic smashing and disturbance, and the presence of micrite, this microfacies is attributed to an environment that was sometimes high energy (causing smashing and disruption of allochem) and sometimes low energy (leading to the micrite carbonate between allochemes) (Flügel, 2004). These are typical conditions of the mid -ramp.

## Sedimentary environment in the studied section

After studying the thin sections and identifying the microfacies, a facies profile was constructed (Figure 6).

The lack of reworked sediment and lack of falling and sliding facies indicates a gentle slope depositional environment during deposition and shows that Asmari Formation was deposited in a shallow carbonate platform with a gentle slope.

Deposition of the Asmari Formation in the study area started with microfacies related to the middle ramp environment and transgressed to beach facies as water depth decreased. Accordingly, the Asmari Formation in the Chidan area was mainly determined by the internal ramp characteristics. In other words, most of the Asmari Formation sedimentary rocks in the study area were deposited on the inner ramp.

Considering the type of carbonate sediments produced and the main locations of sediment accumulation in the study section, a reconstructed sedimentary model is

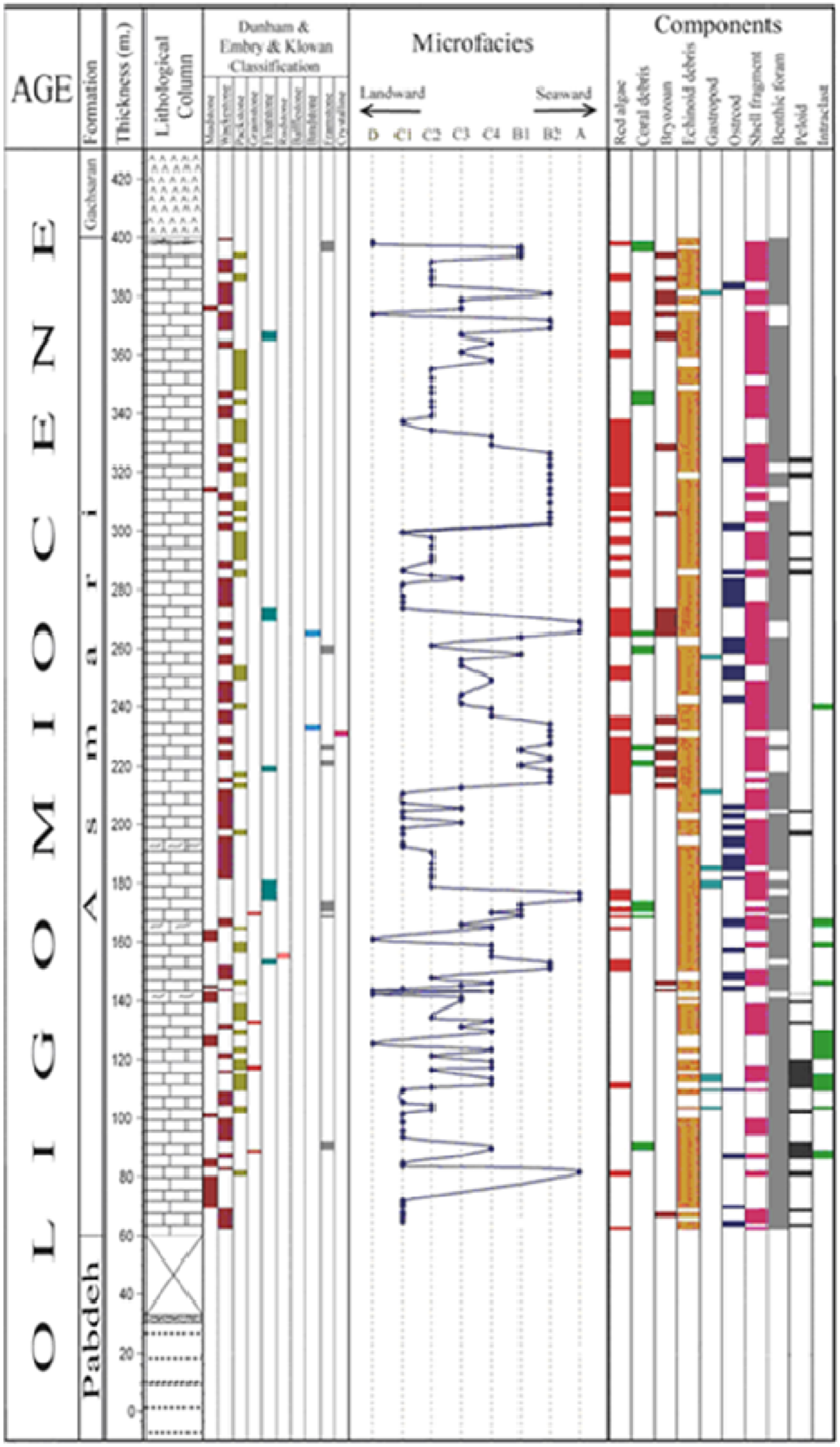


**Figure 6.** Facies variation and biodiversity in the Chidan area.

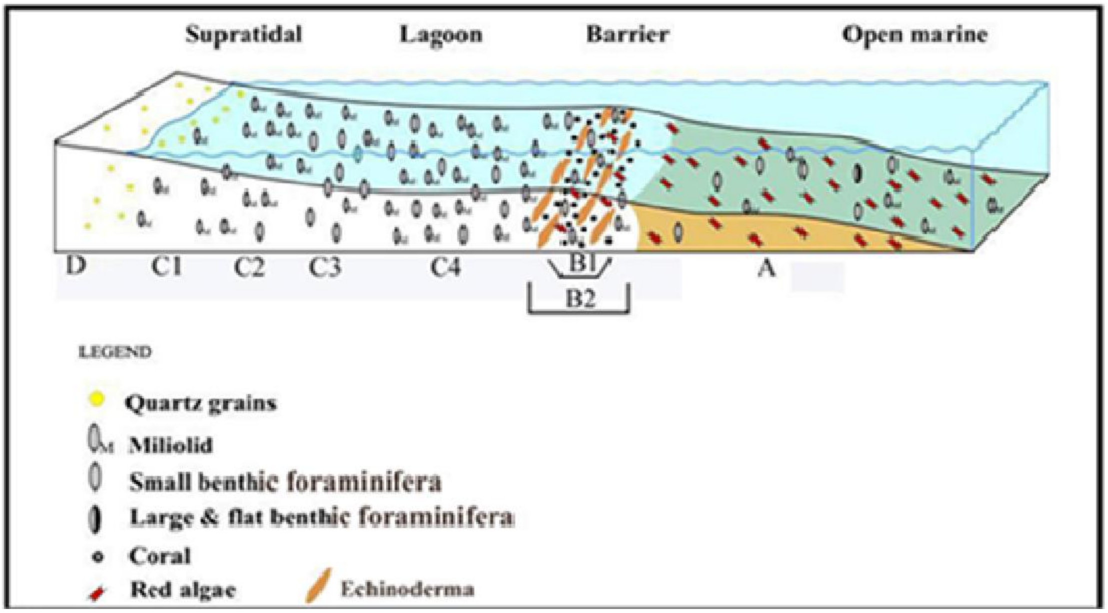


**Figure 7.** Sedimentary model of the Asmari Formation, Chidan (Baghmalek) area

provided in Figure 7.

## CONCLUSIONS

The Asmari Formation in the study area is composed of limestone, and also the upper part of Asmari Formation is divided into two sections by limestone containing coral.

Thin section observation of the Asmari Formation (Chidan section) have allowed identification of eight carbonate microfacies belong to four subenvironments.

The depositional environment of the Asmari Formation is interpreted as a shallow carbonate platform with a low slope. The most part of the Asmari Formation in the Chidan area was deposited in an inner ramp environment.

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