Biostratigraphy and Facies Distribution of The Asmari Formation in Aghajari Well # 66, Zagros Basin, SW Iran

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ABSTRACT

This investigation is concentrated on biostratigraphy, facies distribution, palaeoecology and palaeoenvironment of the Asmari Formation with 276m in thickness on oil field of Aghajari (well #66) with an anticlinal structure, in the fold–thrust zone of the Zagros Basin in southwest of Iran. According to the lithology properties, four lithostratigraphic units were recognized, dolomitic limestone, sandy limestone, dolomitic and marly limestone are predominant. The Asmari carbonate system was dominated by foraminifera and corallinacean assemblage. 24 genera, 15 species were encountered in the studied area and 4 assemblage zones have been recognized. Based on distribution of the larger foraminifera, the Asmari Formation is Late Oligocene (Rupelian - Chattian) -Early Miocene (Aquitanian and Burdigalian) in age. Based on petrographical studies of 320 thin sections, 12 carbonate microfacies were identified within the Asmari Formation. These microfacies belong to inner ramp, shoal and middle ramp environments. As a result of this study, the Asmari Formation deposited in tropical waters and oligotrophic to slightly mesotrophic conditions. Our itemized analysis of microfacies and paleoecology display that the Asmari Formation deposited on a carbonate shelf dominated by heterozoan and subordinately, photozoan skeletal assemblage.

Keywords: Biostratigraphy, Asmari Formation, Aghajari well, Oligocene- Miocene, Benthic, Foraminifera.

INTRODUCTION

The Oligocene – Lower Miocene marine carbonates of the Asmari Formation is famous as a limestone rich in large Foraminifera which retains excellent reservoir characteristics over most of the Dezful Embayment (Motiei, 1993). Its reservoir quality is generally enhanced by a prominent system of fractures which occurs near the tops of the high-relief anticlines (Fig.1) (Hull and Warman 1970; Mequillan 1973, 1974, 1985). The Asmari Formation was deposited in the flanking shelves of the Zagros foredeep and is composed of light-coloured and shallow marine limestone during late Oligocene through early Miocene (Ziegler, 2001; Motiei, 1993). At the type section in Tang-e-Gel-e Tursh on the southwest flank of the Kuh-e Asmari, the Asmari Formation consists of 314 m of limestone, dolomitic limestone and argillaceous limestones (Motiei, 1993). It comprise predominantly of inner and middle ramp carbonate deposits rich in benthic foraminifera (Vaziri-Moghadam et al., 2006; Alavi, 2004). Planktonic foraminifera of deeper environment deposit are also locally present (Seyrafian, 2000). The members of sandstone and anhydrite also occur within the Asmari Formation. Kalhur member evaporate and ahwaz sandstone member deposits in Lurestan province and in southwest Dezful Embayment, respectively.

In the most places of the Zagros Basin, included Lurestan, Khuzestan and some parts of the Coastal Fars and Interior Fars provinces the Asmari Formation lies conformably on the deeper facies of the Pabdeh Formation (Paleocene–Oligocene). The Asmari in most places is unconformity capped by the thick evaporates...
Figure 1. a: General structural provinces of Iran (adapted from Heydari, 2008). b: Six major tectonostratigraphic domains of the Zagros basin (adapted from Motiei, 1993). The study area is located in Dezful Embayment.

Figure 2. Cenozoic stratigraphic correlation chart of the Iranian sector of the Zagros basin, adopted from James and Wynd (1965).
and marls of the Gachsaran Formation which forms an effective seal. Toward the northeast and eastern parts of the Zagros basin it is overlain by the marls, silt and sand beds of Razak Formation (Fig. 2) (Motiei, 1993).

The lower boundary of Asmari Formation varies from Rupelian to Aquitanian. For instance, toward the coastal Fars area, it is mainly Rupelian in age; in the Dezful Embayment, it ranges from Rupelian to chattian in age (Motiei 1993). The upper boundary of the Asmari Formation is almost Burdigalian in age, but toward the coastal and interior Fars, it is chattian in age.

The Asmari carbonates have been the subject of detailed study ever since the first petroleum reservoir was discovered at Masjid-e Suleiman in SW Iran in 1908 (Busk and Mayo, 1918; Adams, 1969; Wells, 1967). Lees (1933) was the first to carry out a systematic investigation of the Asmari Formation.

Primary and geological investigation of the Asmari Formation started with the work of Busk and Mayo (1918), Richardson (1924), Lees and Richardson (1940) and Thomas (1948). Later, the Asmari Formation studied by Wynd (1965), James and Wynd (1965), Adams and Bourgeois (1967), Jalali (1987), Kalantari (1986) and Motiei (1993) to review and improve the previous works and define the Asmari Formation throughout the Zagros basin.

Recent works concerning the biostratigraphy of the Asmari Formation are Seyrafian et al., (1996), Seyrafian and Mojikhalifeh (2005), Hakimzadeh and Seyrafian (2008), Amirshahkarami (2008) Sadeghi et al.,
Aghajari oil Field (well number 66) (Fig. 4). Involves 1 well section of the Asmari Formation from the about 90 Km southeast of the Ahwaz city. This study involves the Zagros basin in southwest of Iran (Fig. 3). This oil Field is with an anticlinal structure, in the fold–thrust zone of the Dezful Embayment zone (fig. 1).

Regional setting

The Zagros region is located to the southwest of Iran. It can be divided in to a number of zones (Lurestan, Izeh, Dezful Embayment, Fars and Hight Zagros), which differ according to their structural style and sedimentary history (Falco 1974; Berberian and King 1981; Motiei 1993). The Zagros basin was associated to the Gonwdwana supercontinent during the Paleozoic. It was a site of passive margin and convergent orogeny in Mesozoic and Cenozoic, respectively (Motiei, 1993; Bahroudi and Koyi, 2004; Heydari, 2008). The study area is located at the Dezful Embayment zone (fig. 1).

This study was concentrated on oil field of Aghajari with an anticlinal structure, in the fold–thrust zone of the Zagros Basin in southwest of Iran (Fig. 3). This oil Field is about 90 Km southeast of the Ahwaz city. This city involves 1 well section of the Asmari Formation from the Aghajari oil Field (well number 66) (Fig. 4).

MATERIAL AND METHODS

Approximately 320 thin sections of the cores with the total thickness of 276 meters were assembled for microscopic studies to identify the distribution of foraminifera and biostratigraphical characteristics of each section. The most samples contain well preserved and abundant benthic foraminifera. The foraminifer assemblages of the Asmari Formation consist of various imperforate and perforate forms. This fauna is a good tool for biofacies analysis, recognition of the paleoecology and biostratigraphy. The studied well is not reached the lower boundary of Asmari formation. Therefore, the lower contact of the Asmari Formation with the Pabdeh Formation (Paleocene–Oligocene) cannot be discussed. The upper contact is overlain by the Gachsaran Formation (Miocene). The microfacies investigation of thin sections is based on constituents' analysis (Flugel, 2004).

In this study four lithostratigraphic units were recognized that dolomit sandstone, sandy limestone dolomitit, marly and evaporate are predominant. Lithologically, the asmari formation at this study consists of 276 meters, mainly limestone sediments. From base to tope, dolomitit limestone with dolomite andstone (63 m), dolomitit limestone with thin-bedded marl, dolomite sandstone and limit distribution (64 m), dolomitit limestone and dolomite sandstone (68 m), high diversity of limestone and sandstone and interlayering of anhydrite and marl (81 m) is recorded (Wynd, 1965). Evaporates of Gachsaran Formation overlies the Asmari.

Biostratigraphy

The biostratigraphic data of the Asmari Formation was established by Wynd (1965) and reviewed by Adams and Bourgeois (1967) (Table 1). Ehrenberg et al., (2007) applied the method of strontium isotope stratigraphy to date the Asmari Formation in some localities in the southwest of Iran. The defined assemblage zones at the study area accommodated the biozonation of the Upper Oligocene-Lower Miocene sediments by Laursen et al., 2009 (Fig. 5).

Based on biostratigraphic study, 24 foraminifer genera and 15 species were encountered and their distributions plotted. From base to top, 4 foraminifer assemblages were determined in the study section (fig. 6).

Assemblage 1: Lepidocyclina- Operculina-Ditrupa assemblage zone.

This zone is present at the lowermost part of Asmari Formation and extending a thickness of 44 m in the stratigraphic column. The foraminifera in this assemblage are: Archaias kirkukensis, Archaias sp., Elphidium sp., Miogypsina sp., Miogypsinoidea sp., Asterigerina sp., Dendritina sp., Rotalia viennoti, Peneroplis farsensis, Peneroplis sp., Peneroplis evolutus, Valvulinid sp., Discorbis sp., Austrotrillinia howchini, Austrotrillinia sp., Spiroline sp., Rotalia sp., miliolids, Heterostegina costata, Lepidocyclina sp., Nephrolepidina sp., Amphistegina sp., Eulepidinae, Archaias hensoni and Meandropsina anahensis.

The assemblage corresponds to the Lepidocyclina-Operculina-Ditrupa assemblage zone of Laursen et al., (2009) attributed to Rupelian-Chatian age. Based on the content of large foraminifers, this fauna represents Eulepidina-Nephrolepidina-Nummulites assemblage zone of Adams and Bourgeois (1967).
Assemblage 2: Archaias asmaricus- Miogypsinoide spp. assemblage zone.


The faunal assemblage of this zone corresponds to Archaias asmaricus- Miogypsinoide spp. assemblage zone of Laursen et al.,(2009) and indicates Chattian age. This assemblage zone includes Miogypsinoide-Archaias-Valvulinid sp.1 biozone of Adams and Bourgeois (1967).


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**Table 1. Biozonation of the Asmari Formation, after Adams and Bourgeois 1967).**

<table>
<thead>
<tr>
<th>Assemblage zone</th>
<th>Age</th>
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<tbody>
<tr>
<td>B. melo – M. iranica</td>
<td>Burdigalian</td>
</tr>
<tr>
<td>Elphidium sp.14 – Miogypsinia</td>
<td>Late Aquitanian</td>
</tr>
<tr>
<td>A. asmaricus – A. hensoni</td>
<td>Early Aquitanian</td>
</tr>
<tr>
<td>Eulepidina – Nephrolepidina – Nummulites</td>
<td>Oligocene</td>
</tr>
</tbody>
</table>

**Figure 5. Biozonation of the Asmari Formation, after Laursen al. (2009).**
Figure 6. Lithology and biostratigraphy column of the Asmari Formation at the Agha Jari oil field, well # 66 (Zagros Basin, SW Iran)
This assemblage with thickness 34 m, comprise of Peneroplis farsensis, Miogypsina sp., Peneroplis evolutus, Discorbis sp., Elphidium sp., miliolids, Valvulinid sp.


Assemblage 4: Borelis melo group-Meandropsina iranica assemblage zone.

This assemblage with thickness 142 m, comprise of Borelis sp., Meandropsina anahensis, Dendritina sp., Meandropsina sp., Valvulinid sp., Elphidium sp., Rotalia sp., Rotalia viennoti, miliolids, Peneroplis farsensis, Peneroplis sp., Archaias kirkukensis, Peneroplis evolutus, Discorbis sp., Archaias sp.

This assemblage is found in the upper part of Asmari Formation. Due to absence of Borelis melo and Meandropsina iranica (Index fossils), this accumulation beginning its occurrence where Archaias kirkukensis and Miogipsinooides sp. are disappeared. These microfauna correspond to Borelis melo-Meandropsina iranica biozone of Adams and Bourgeois (1967) and indicate Burdigalian age. Biostratigraphical characters in the well#66 from Aghjari oil Field (Fig. 6) indicates to the following explanations:

Due to reach to OWC, drilling in the well number 66 is incomplete and the cores of the Asmari Formation contact with the underlying Pabdeh Formation (Paleocene-Oligocene) are not available. Therefore fauna analysis of the lowermost subsurface layers of the Asmari Formation cannot be discussed. The upper contact of the Asmari Formation with Gachsaran Formation is conformity in the well section 66.

Microfacies Analysis

Based on sedimentological features and skeletal and non-skeletal components, 12 carbonate facies and 1 terrigenous facies are recognized (fig. 7, plate. 1 and 2). The general environmental interpretations of the microfacies are discussed in the following paragraphs.

MF 1. Quartz Mudstone
This microfacies is composed of dense lime mudstones, absent fauna and also include detrital quartz grains. This facies occurs in middle and upper parts of the Asmari Formation (PLATE 1, A).

Interpretation: Lime mudstone, quartz grains and no evidence of subaerial exposure, was deposited in near-shore, very shallow, low-energy restricted settings seaward of tidal flat. This facies refer to hypersaline situations within a shelf lagoon (Amirshahkarami et al., 2007a, 2010; Taheri et al., 2008, 2010; Rahmani et al., 2009; Vaziri-Moghaddam et al., 2010; Saleh and Seyrafian 2013; Sooltanian et al., 2011; Sahraeyan et al., 2014).

MF 2. Peneroplis, Miliolid Wackestone-Packstone
Two porcelaneous imperforate bentic foraminifera, Peneroplis and miliolids are main component associated with wackestone and packstone. Fragments of echinoid, mollusca, bryozoan, dasyclacean alga, ostracod and other foraminifera such as discorbis, valvulinid, archaias, elphidium and dendritina are also present (PLATE 1, B).

Interpretation: The presence of a large number of imperforate bentic foraminifer tests suggests that this facies was deposited in an inner ramp setting and points to nutrient-rich with slightly hypersaline and warm euyptic condition (Geel 2000; Romero et al., 2002; Corda and Brandano 2003; Bassi el al. 2007; Vaziri-Moghaddam et al., 2011). A similar microfacies were reported from shelf lagoon environment of the Oligo-Miocene, Zagros Basin, Iran (Vaziri-Moghaddam et al., 2006, 2010; Taheri 2010; Amirshahkarami et al., 2007a-b, 2010; Rahmani et al., 2009, 2012; Saleh and Seyrafian 2013) and Miocene sediments of the central, Iran (Okhravi R and Amini A, 1998).

MF 3. Bioclastic wackestone-packstone
This facies comprised of echinoid, mollusca, bryozoans and corallinacean. Additional components are miliolids, and dendritina (PLATE 1, C).

Interpretation: Due to predominance of mud-rich texture with miliolids and the presence of a low-diversity foraminiferal arrangement, a restricted platform, very shallow lagoon with quiet water conditions is suggested for deposition of this microfacies (Geel 2000; Amirshahkarami et al., 2010; Sooltanian et al., 2011; Rahmani et al., 2009, 2012; Sahraeyan et al., 2014).

MF 4. Miliolid, ooid Packstone-Grainstone
This facies is composed of imperforate foraminifera (miliolids) and ooids. Other common constituents include mollusca, corallinacean, coprolite, ooid and bentic foraminifers such as Peneroplis, dendritina discorbis (PLATE 1, D).

Interpretation: This facies was deposited in restricted circulation condition in a protected lagoon environment. The abundance of ooids, miliolids and the moderate diversity of fauna support this interpretation. The oligotypic fauna (such as miliolids) and the presence of a low-variety foraminiferal association signify a very shallow subtidal environment with low to moderate energy (Ghobeishavi et al.,2009; Rahmani et al., 2010; Sooltanian et al.,2011; Sahraeyan et al.,2014) and low water turbulence (Geel, 2000) as well as high salinity.
Figure 7. Vertical Distribution of microfacies of the Asmari Formation at the Agha Jari oil field, well # 66 (Zagros Basin, SW Iran)
Plate 1. Microfacies types of Asmari Formation,
A-MF1: Quartz Mudstone.
B-MF2: Peneroplis, Miliolid Wackestone-Packstone.
C-MF3: Bioclastic wackestone-packstone.
D-MF4: Miliolid, ooid Packstone-Grainstone.
E-MF5: Bioclast, Miogypsina, Miliolid Wackestone-Packstone.
F-MF6: Echinoid, Miliolid, Rotalia Packstone-Grainstone.
G-MF7: Quartz, Miliolid, Bryozoan, Mollusca Packstone.
Furthermore, an abundance of ooids with a low diversity of fossils suggests deposition in a restricted shallow subtidal water and slow sedimentation rate (Wanas 2008; Flugel, 1982; Wilson 1975).

MF 5. Bioclast, Miogypsina, Miliolid Wackestone-Packstone
This facies is composed mainly of miliolids, miogypsina and corallinacean. Bentic foraminifera such as Peneroplis, dendritina, archaia, borelis, valvulinid, austrotrillina, small rotalia, amphistegina, lepidocyclina, spirorina and bioclast fragments of ostracod, echnoid, mollusca, bryozoan, dasyclacean alga, Peloid and coral are associated as accessory constituents. Matrix is too changing to packstone - grainstone in some sections (PLATE 1, E).

MF 6. Echinoid, Miliolid, Rotalia Packstone - Grainsone
Bentic foraminiferas and bioclasts such as miliolids, rotalia and echinod are the most abundant fauna. In addition, large fragments of bryozoan, mollusca, coral, corallinacean, austrotrillina, archaia, amphistegina, peneroplis, miogypsinoide, heterostegina and nephrolepidina occur in minor amounts and distributed regularly among the other components (PLATE 1, F). Interpretation: Both MF6 and MF7 represent variable proportion of benthic foraminifera but differ from each other by their grain composition. The co-occurrence of Porcelaneous foraminifera (miliolids, Peneroplis, Archaias) and hyaline foraminifera (rotalia, heterostegina and lepidocyclinidae) indicate warm, euphotic and shallow water, with low to moderate energy conditions in a semirestricted and open lagoon depositional setting (Vaziri-Moghaddam et al., 2011; Taheri et al., 2008; Amirshahkarami et al., 2010; Rahmani et al., 2010; Seyrafian et al., 2011; Saleh and Seyrafian 2013; Sahraeyan et al., 2014).

A similar facies with imperforate foraminifers and perforate foraminifera was reported from the inner ramp of the Oligo-Miocene sediments of the Miocene sediments of the central Apennines (Corda and Brandano 2003) and from Early Oligocene deposits of the Lower Inn Valley (Nebelsick et al., 2001).

MF 7. Quartz, Miliolid, Bryozoan, Mollusca Packstone
The major components of this facies are miliolids, bryozoan, mollusca. This group is presented by bioclast fragments and bentic foraminiferas such as coral, corallinacean, dasyclacean alga, echinoid, archaia, peneroplis, miogypsina, amphistegina, valvulinid, rotalia, dendritina, elphidium, discorsib, operculin and also some detrital quartz grains. Matrix is variable to grainstone (PLATE 1, G).
Interpretation: These deposits comprise different textures ranging from packstone to grainstone. The supremacy of oligotypic fauna (miliolids), heterotrophs (bryozoans) and high-diversity foraminiferal association indicate deposition in a low-moderate energy, warm euphotic and semirestricted lagoonal setting with relatively good connection with the open marine. Mixed protected environment bioclasts (such as miliolids) and open marine bioclasts (such as perforate foraminifera, bryozoan and mollusca) confirm this interpretation (Geel, 2000; Romero et al., 2002; Taheri et al., 2008; Sooltanian et al., 2011; Sahraeyan et al., 2014).

MF 8. Austrotrillina, Corallinacean,Coral Packstone
The most abundant faunas are austrotrillina, corallinacean and coral in the packstone. Echinoid, mollusca, bryozoan, miliolids, peneroplis, small rotalia, amphistegina, valvulinid, archaia, discorsib, dendritina and borel are present as an accessory fauna (PLATE 2, A).
Interpretation: This facies represent deposition an open lagoon environment, adjacent to the platform margin with a good water circulation. This interpretation is supported by abundance of typical open marine skeletal fauna including corallinacean and coral. Nebelsick et al., 2001, Vaziri-Moghaddam et al., 2006, Taheri et al., 2008 and Saleh and Seyrafian 2013 considered similar facies representative of a shelf lagoon.

MF 9. Bioclastic ooid packstone-grainstone
Main characteristic of this microfacies is ooids which are highly rounded and sorted. Other common constituents comprise miliolids, dendritina, peneroplis and austrotrillina as accessory constituents. Texture varies from pack-stone to grainstone (PLATE 2, B).

MF 10. Bioclastic rotalia grainstone
The major ingredients are corallinacean and rotalia. Accessory bioclasts contain Echinoid and Mollusca. Inorganic fragments are quartz (PLATE 2, C).
Interpretation: The high textural maturity and the predominant sparite matrix of MF10 and MF11 indicate high energy waters with much movement and reworking of bioclasts and the production of ooids (abundent constituents of warm-water carbonates). The sediments would have been deposited in a shoal and Sub marine mobilesandy bars setting which separating the open marine from more restricted marine environment (Wilson, 1975; Flügel, 2004; Vaziri-Moghaddam et al., 2010; Rahmani et al., 2012; Sahraeyan et al., 2014).

MF 11. Bioclastic coral Floastone
This microfacies is predominantly composed of coral colonies and echnoid fragments. Additional components are bryozoan, corallinacean, mollusca, and small benthic foraminifers (rotalia, heterostegina, valvulinid, amphistegina). Grains are poorly sorted. In some samples rotalia and coral are abundant (PLATE 2, D).
Interpretation: The presence of varied and stenohalyn fauna including corallinacean, coral and benthic foraminifera refer to upper part of acarbonate slope environment in oligotrophic situation (Wilson 1975; Riding...
Plate 2. Microfacies types of Asmari Formation,
B-MF10: Bioclastic ooid packstone-grainstone.
C-MF11: Bioclastic rotalia grainstone.
D-MF12: Bioclast coral Floatstone.

The predominant grain types are corallinacean and large perforate foraminifera consists of lepidocyclina and heterostegina. The minor constituents are echinoid, mollusca, bryozoan, dasyclacean alga and large foraminifera such as rotalia, amphistegina, operculin, Spiroclipeus, spaeorgypsina (PLATE 2, E).


The predominant grain types are corallinacean and large perforate foraminifera consists of lepidocyclina and heterostegina. The minor constituents are echinoid, mollusca, bryozoan, dasyclacean alga and large foraminifera such as rotalia, amphistegina, operculin, Spiroclipeus, spaeorgypsina (PLATE 2, E).

Interpretation: The high diversity of plentiful hyaline, lamellar, perforate large and flat foraminifera such as nummulitids and lepidocyclinids and presence of typical open marine skeletal fauna including echinoid and corallinacean point to low-medium energy, normal salinity and oligophotic zone in a shallow open marine setting (Romero et al., 2002; Leutenegger 1984) or distal middle shelf (Pedley 1996; Brandano and Corda, 2002, Corda and Brandano, 2003; Bassi et al., 2007). Present larger foraminifera are in fact restricted to the photic zone, since all of them house symbiotic algae. They also require
defending themselves from very high degrees of illumination causing damage by ultraviolet light. Lepidocyclinidae and Nummulitidae with transparent and hyaline walls protect themselves in deeper water from UV-light by producing large and flat walls (Geel, 2000; Beavington and Racey, 2004; Nebelsick et al., 2005; Bassi et al., 2007; Barattolo et al., 2007; Sooltanian et al., 2011; Sahraeyan et al., 2014).

This flattened test shapes suggest that this microfacies was deposited in the lower photic zone in the distal middle ramp (Hottinger, 1980, 1983; Hohenegger, 1996; Hallock 1999; Reiss and Hottinger, 1984; Leutenegger, 1984, Beavington-Penney and Racy, 2004; Allahkarampour Dill et al., 2010; Vaziri-Moghaddam et al., 2011; Saleh and Seyrafian, 2013).

**Sedimentary Environment**

The Asmari Formation was deposited on a carbonate shelf (Read 1982; Tucker 1985; Tucker and Wright 1990) dominated by large bentic foraminifera, coralline algae and subordinately, echinoids, bryozoans, colonial corals. Basis of stratigraphy, sedimentology, distribution of foraminifera and vertical facies relationships, three depositional environments are identified in the oligo-Miocene succession in the study section. These include inner shelf/ lagoon, shoal and middle shelf (Burchette and Wright 1992) (Fig. 8). The paleolatitudinal reconstructions (Alavi, 2007) and skeletal grains suggest that carbonate sedimentation of Asmari Formation took place in tropical waters under oligotrophic to slightly mesotrophic conditions.

The inner shelf ramp biotic accumulation represents a wider spectrum of marginal marine deposits indicating of restricted lagoon and open lagoon. The faunal variety of the protected lagoon setting (MF 1, 2, 3 and 4) is low and normal marine fauna are lacking. The epiphytic foraminiferal fauna (Archaias, Peneroplis, Borelis) (Brandano et al., 2009) were the best accommodated fauna to the paleoenvironmental conditions such as low turbidity, highlight intensity, low-substrate stability and points to meso-to-oligotrophic settings at shallow depths (Hallock 1984, 1988; Reiss and Hottinger 1984; Buxton and Pedley 1989; Romero et al., 2002; Barattolo et al., 2007). Today, porcelaneous larger foraminifera prosper in tropical carbonate platforms within the upper part of the photic zone. In addition, miliolids are indications of very shallow, hypersaline to hypersaline and restricted environments (Murray, 1991) and reflect decreased circulation and likely reduced oxygen contents or euryhaline conditions.
Open lagoon shallow subtidal environments are characterized by imperforate foraminifera with the plentifulness of perforate foraminifera such as Amphistegina and rotalia (MF 5, 6). This biotic association suggests that sedimentation occurred under shallower, more disturbed inner ramp conditions and commenced from tropical and subtropical shallow water (MF 7, 8) (Lee, 1990; Betzler et al., 1997; Holzmann et al., 2001; Brandano et al., 2009).

The sorting and grainy texture suggests a high energy environment for MF 9, 10. The sediments would have been deposited in a shoal environment which separating the open marine from more restricted marine environment (Flugel, 2004).

The middle shelf association consists of large perforate foraminifera (nummulitids, lepidocyclinids, Amphistegina, Operculina) and fragments of echinoid and corallineal. The proximal middle ramp dominated by corallineal and small perforates foraminifera (MF11). The whole tests of perforate foraminifera are the dominant microfauna of the intermediate to distal middle ramp (MF12). Mainly, the lower part of the upper photic zone is controlled by perforate hyaline foraminifera that points to low hydrodynamic energy, lower limit of the photic zone, oligotrophy and normal salinity (Leutenegger, 1984; Romero et al., 2002). In this study area, there are no evidences of the outer shelf environment because this setting is characterized by fine-grained, well-bedded and laterally continuous deposits marked by abundance planktonic foraminiferal content.

CONCLUSION

The Asmari Formation at the Agha Jari oil field well # 66, Zagros Basin, SW Iran, Supply 24 foraminifer genera and 15 species. The fauna is controlled by hyaline perforated and porcellaneous taxa. Based principally on the occurrence of the larger benthic foraminifera, 4 assemblage biozones are recognized that are attributed to the Rupelian- Burdigalian.

The study area is subdivided into 12 microfacies that are distinguished on the basis of their depositional textures, petrographic analysis and fauna. In addition, three major depositional environments were recognized in the Asmari Formation that corresponds to the inner/lagoon, shoals and middle shelf settings. The biotic accumulations of the Asmari Formation are interpreted as a carbonate ramp that took place in tropical waters and oligotrophic to slightly mesotrophic conditions.

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