International Research Journal of Geology and Mining (IRJGM) (2276-6618) Vol. 4(4) pp. 101-115,
July, 2014
DOI: http:/dx.doi.org/10.14303/irjgm.2014.022
Available online http://www.interesjournals.org/irjgm

Full Length Research Paper

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

Rokhsareh Yazdani

National Iranian Oil Company (NIOC), Iran

E-mail: rokhyazdani@gmail.com

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 Baisn 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 (Aquitania 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 deposite rich in bentic foraminifera (Vaziri-Moghaddam 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

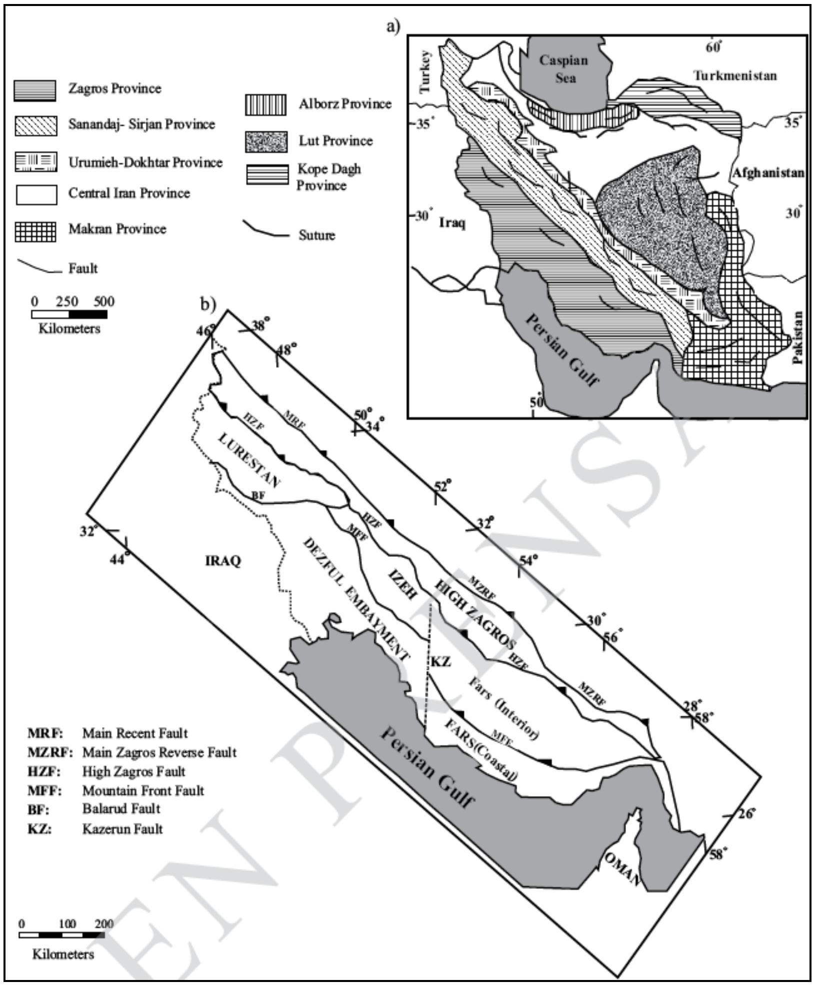

Figure1. a: General structural provinces of Iran (adapted from Heydari, 2008).
b: Six major tectonostratigraphic domains of the Zagros basin
(adabted from Motiei, 1993). The study area is located in Dezful Embayment.

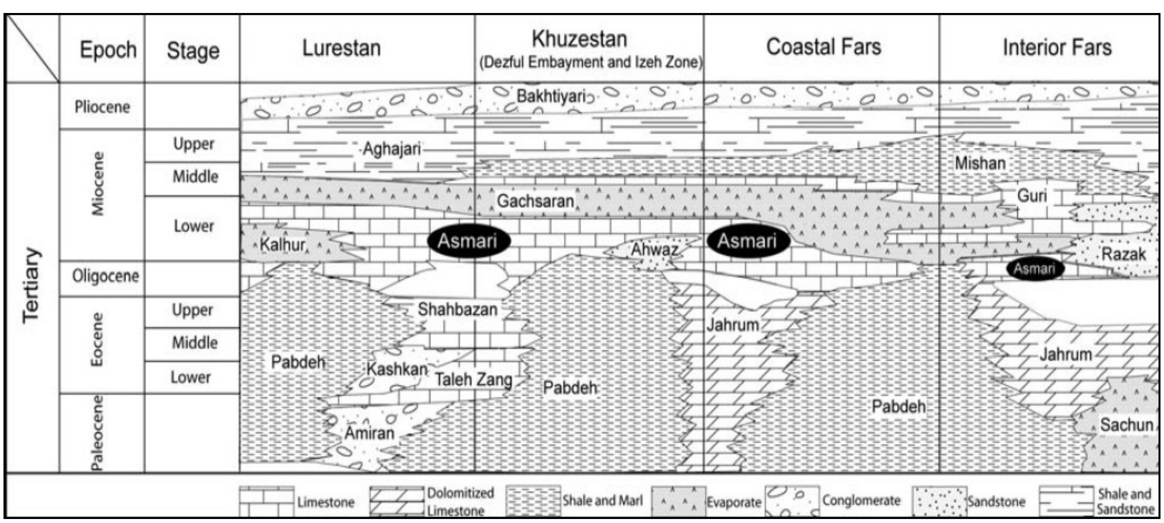

Figure2. Cenozoic stratigraphic correlation chart of the Iranian sector of the Zagros basin, adopted from James and Wynd (1965).

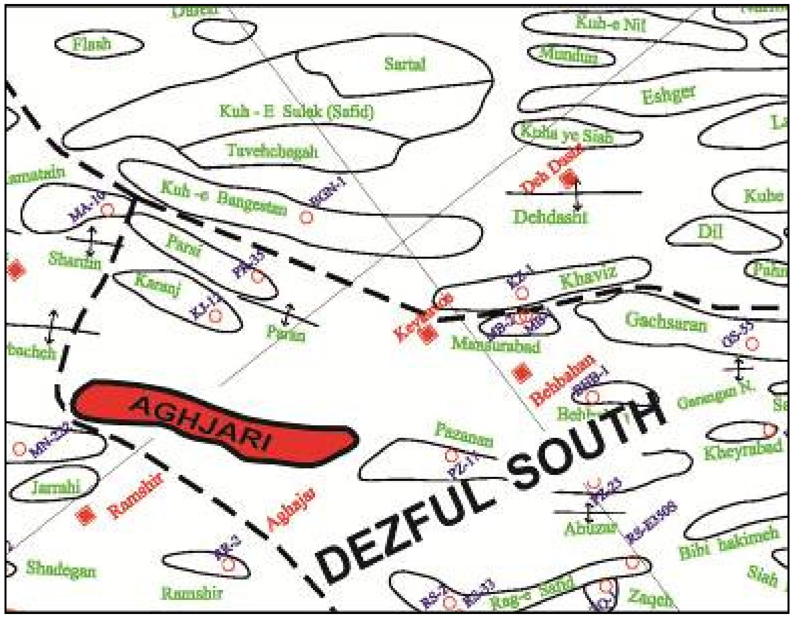

Figure3. Location of the study area at the Agha Jari oil field in southwest of Iran

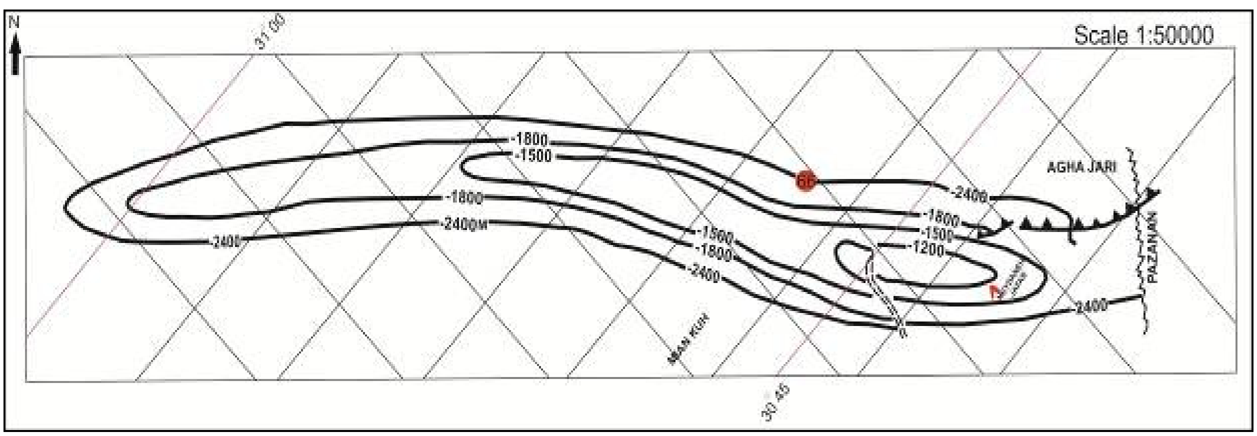

Figure4. Location of the wells number 66 from the Agha Jari oil field

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., (2009),Sooltanian et al., (2011) and Rahmani et al., (2012).

Researches concerning the sedimentary and facies analysis and depositional environment of the Asmari Formation are Seyrafian and Hamedani (2003), Vaziri-Moghaddam et al., (2006), Amirshahkarami et al.,2007a, 2007b), Fakhari et al., (2008), Mossadegh et al., (2009), Vaziri-Moghaddam et al., (2010), Sadeghi et al., and (2010), Allahkarampour Dill et al., (2010), Vaziri-Moghaddam et al., (2011), Rahmani et al., (2009), Saleh and Seyrafian (2013), Sahraeyan et al., (2014).

Diagenesis of the Asmari Formation has been recently received more attention (Aqrawi et al., 2006; Ehrenberg et al., 2006; Al-Aasm et al., 2009).

This research present a comprehensive biostratigraphic criteria based on newly strontium isotope stratigraphy and biozones (Laursen et al., 2009) and strontium isotope data (b) to recognize the most dominant biofacies and their distribution on the Oligo-Miocene carbonate platform on the study area,(c) to model the palaeoenvironment of deposition and (d) lithology properties in the wells #66 at Aghajari oil Field.

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 (Falcon 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 Baisn in southwest of Iran (Fig. 3). This oil Field is about 90 Km southeast of the Ahwaz city. This study 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 foraminiferal 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 dolomitic, marly and evaporate are predominant. Lithologically, the asmari formation at this study consists of 276 meters, mainly limestone sediments. From base to tope, dolomitic limestone with dolomite andstone (63 m), dolomit limestone with thin-bedded marl, dolomite sandstone and limit distribution (64 m), dolomit limestone and dolomite andstone (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 foraminiferal 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 tratigraphic column. The foraminifera in this assemblage are: Archaias kirkukensis, Archaias sp., Elphidium sp., Miogypsina sp., Miogypsinoides sp., Asterigerina sp., Dendritina sp., Rotalia viennoti, Peneroplis farsensis, Peneroplis sp., Peneroplis evolutus, Valvulinid sp., Discorbis sp., Austrotrillina howchini, Austrotrillina sp., Spirolina sp., Rotalia sp., miliolids, Heterostegina costata, Lepidocyclina sp., Nephrolepidina sp., Amphistegina sp., Eulepidinan sp., 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).

Table1. Biozonation of the Asmari Formation, after Adams and Bourgeois 1967).

Assemblage zone	Age
B. melo–M. iranica	Burdigalian
Elphidium sp.14–*Miogypsina*	Late Aquitanian
A. asmaricus–A. hensoni	Early Aquitanian
Eulepidina–Nephrolepidina–Nummulites	Oligocene

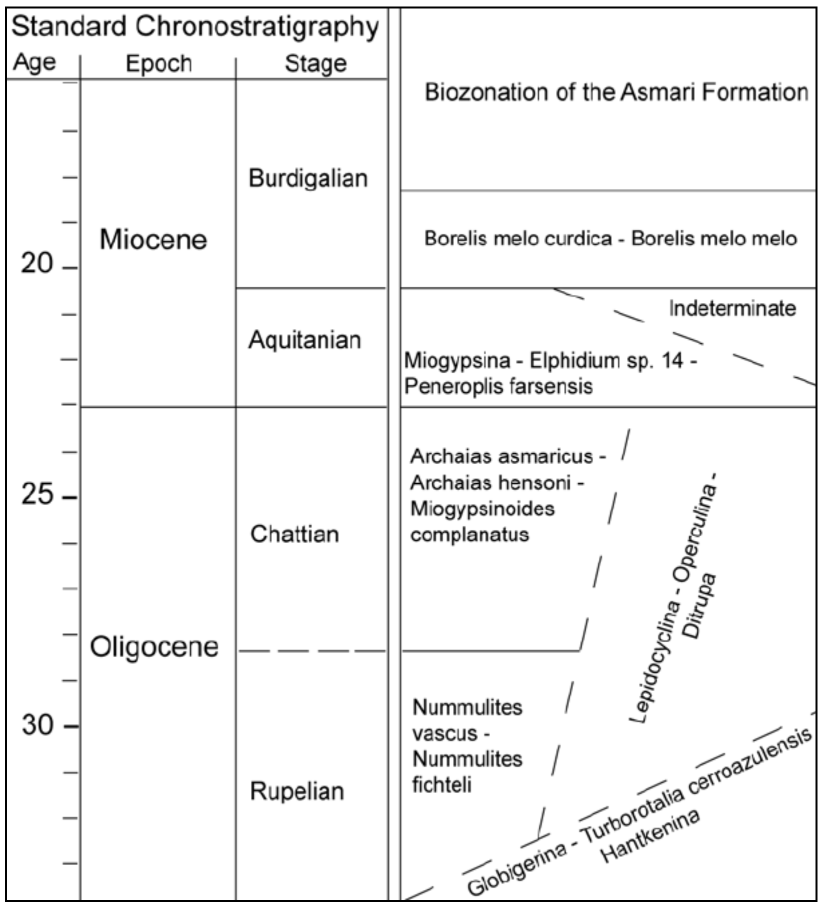

Figure5. Biozonation of the Asmari Formation, after Laursen al. (2009).

Assemblage 2: Archaias asmaricus- Miogypsinoides spp. assemblage zone.

This assemblage with The thickness 90 m, consists of Archaias kirkukensis, Archaias sp., Elphidium sp., Miogypsina sp., Dendritina sp., Rotalia viennoti, Peneroplis farsensis, Peneroplis sp., Peneroplis evolutus, Valvulinid sp., Discorbis sp., Austrotrillina howchini, Austrotrillina sp., Spirolina sp., Rotalia sp., miliolids, Heterostegina costata, Lepidocyclina sp., Nephrolepidina sp., Amphistegina sp., Eulepidinan sp., Archaias hensoni., Meandropsina sp., Archaias operculiniformis, Borelis sp., Spirolina cylindracea, Borelis pygmaea and Meandropsina anahensis.

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

Assemblage 3: Miogypsina-Elphidium sp14. Peneroplis farsensis assemblage zone.

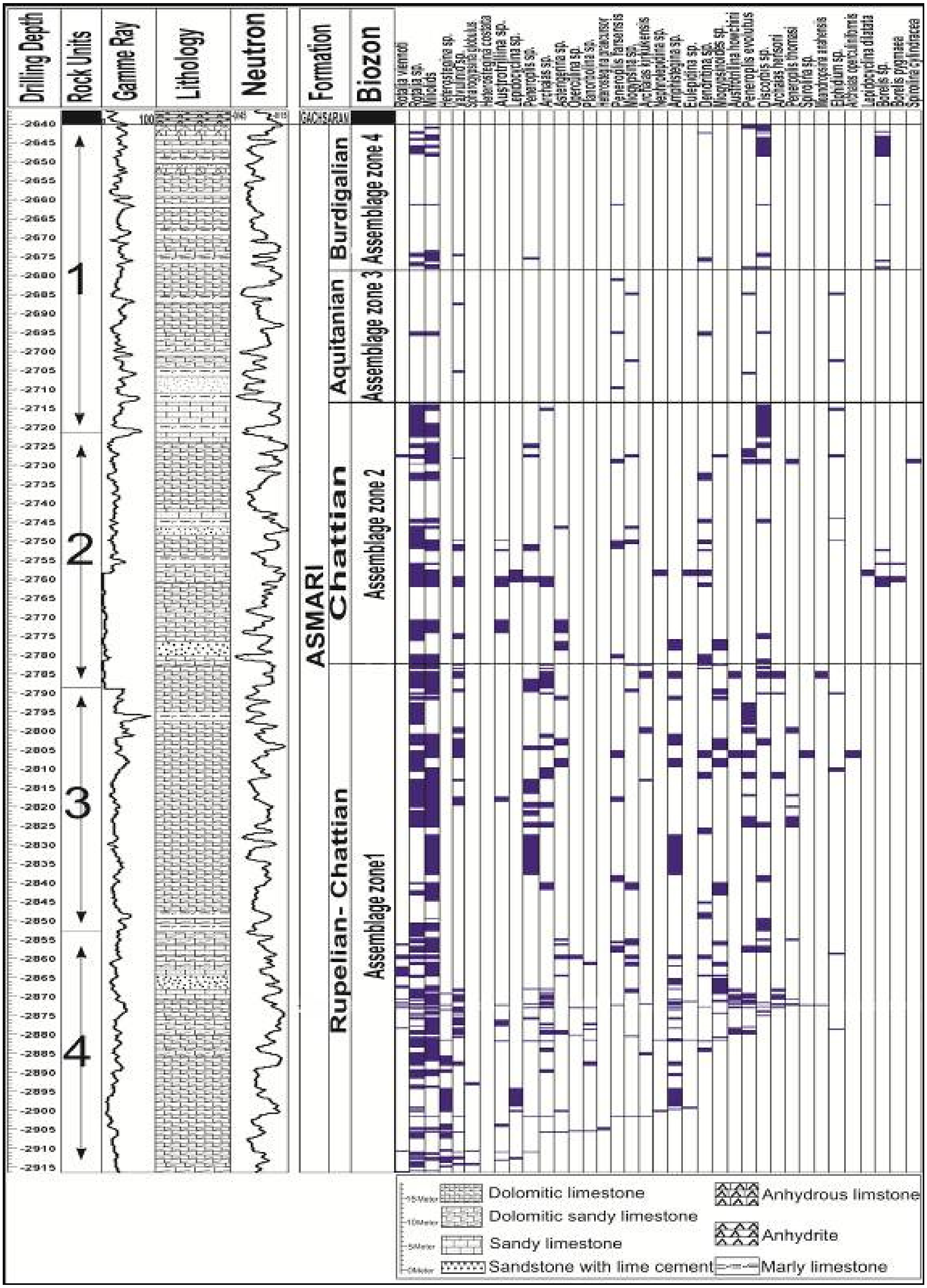

Figure6. Lithology and biostratigraphy column of the Asmari Formation at the Agha Jari oil field, well # 66 (Zagros Basin, SW Iran)

This assemblage with thickness 34 m, comprise of Peneroplis farsensis, Miogypsina sp., Peneropolis evolutus, Discorbis sp., Elphidium sp., miliolids, Valvulinid sp.

The assemblage corresponds to the Miogypsina-Elphidium sp. Peneroplis farsensis assemblage zone of Laursen et al., (2009) attributed to Aquitanian age. Based on the content of foraminifers, this fauna represents Miogypsina-Elphidium sp14. assemblage zone of Adams and Bourgeois (1967).

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, Peneropolis 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 Miogipsinoides sp. are disappeared. These microfauna correspond to Borelismelo curdica - Borelis melo melo assemblage zone of Laursen et al., (2009) and Borelis melo-Meandopsina iranica biozone of Adams and Bourgeois (1967) and indicate Burdigalian age. Biostratigraphical characterizes 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 sedimentologycal 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 precence of a large number of imperforate benthic foraminifer tests suggests that this facies was deposited in an inner ramp setting and points to nutrient-rich with slightly hypersaline and warm euphotic 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 benthic foraminiferas 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.

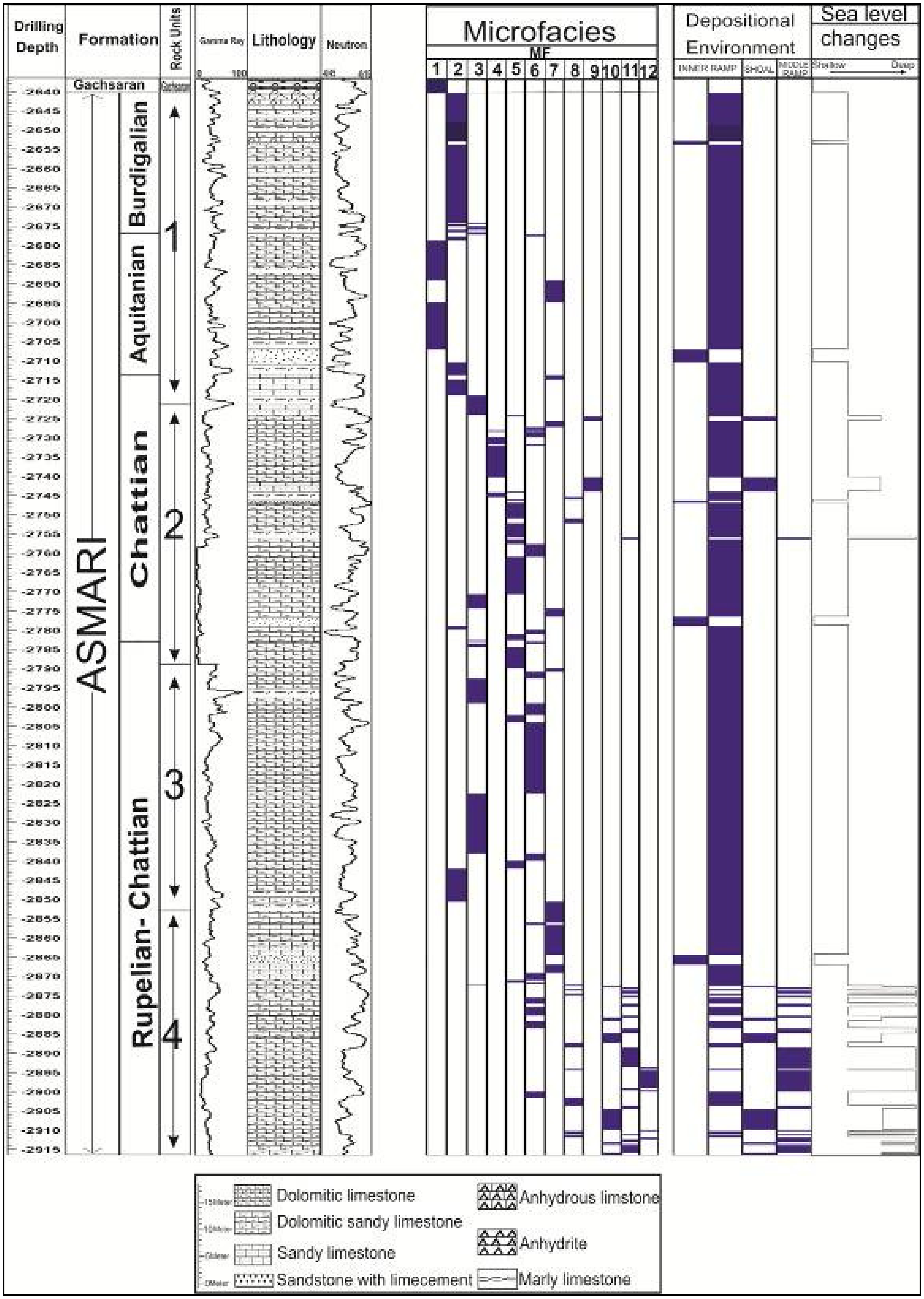

Figure7. Vertical Distribution of microfacies of the Asmari Formation at the Agha Jari oil field, well # 66 (Zagros Basin, SW Iran)

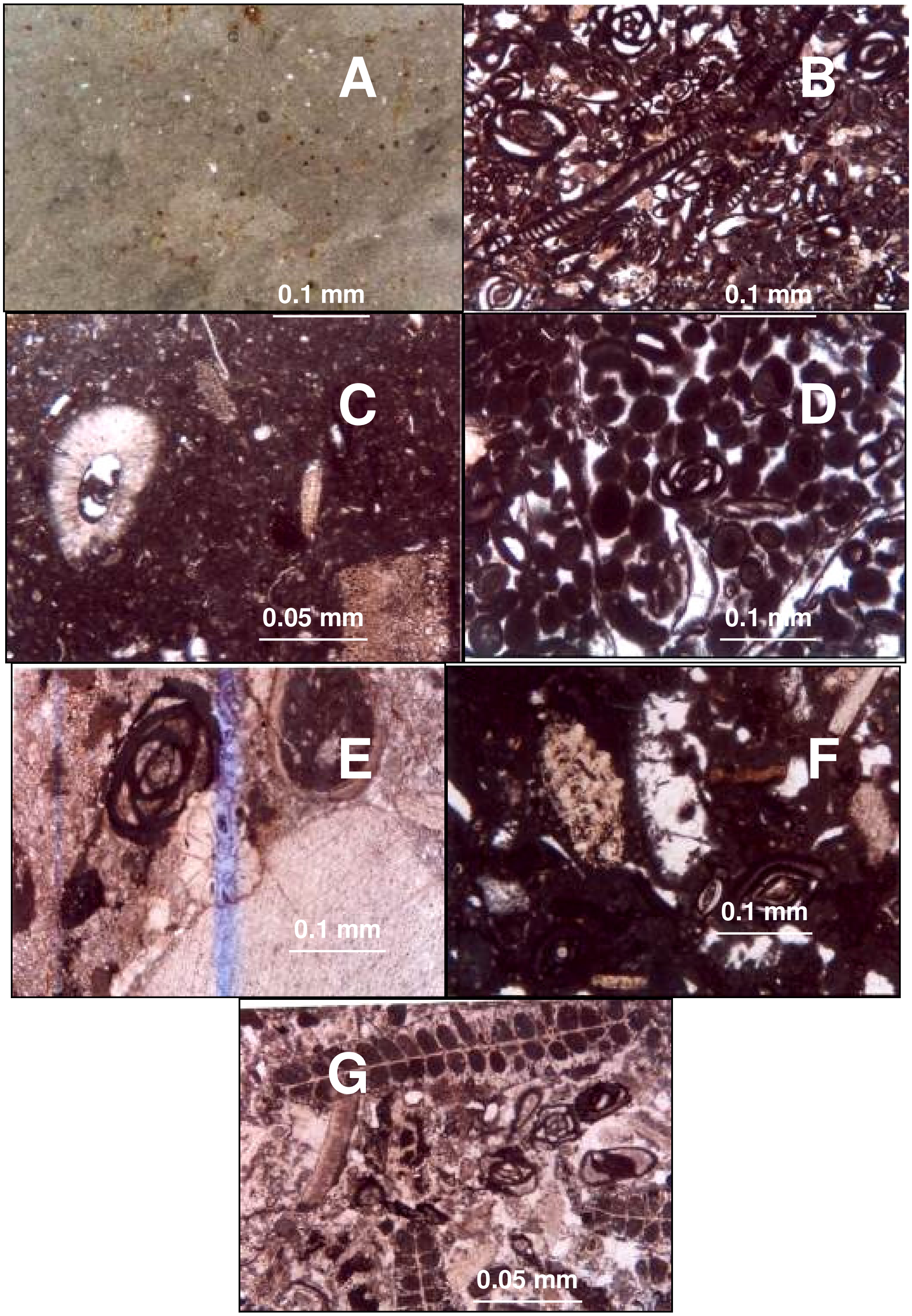

Plate 1. Microfacies types of Asmari Formation,
A-MF1: Quartz Mudstone.
B-MF2: Peneroplis, Miliolid Wackestone-Packstone.
C-MF3: Bioclastic wackestone-packstone.
D-MF4: Miliolid, ooid Packstone-Grainstone.
E-MF5: Bioclast, Miogypsina, Miliolid Wackestone-Packstone.
F-MF6: Echinoid, Miliolid, Rotalia 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).

MF5. Bioclast, Miogypsina, Miliolid Wackestone-Packstone

This facies is composed mainly of miliolids, miogypsina and corallinacean. Bentic foraminifera such as Peneroplis, dendritina, archaias, borelis, valvulinid, austrotrillina, small rotalia, amphistegina, lepidocyclina, spirolina and bioclast fragments of ostracod, echinoid, 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 - Grainstone

Bentic foraminiferas and bioclasts such as miliolids, rotalia and echinoid are the most abundant fauna. In addition, large fragments of bryozoan, mollusca, coral, corallinacean, austrotrillina, archaias, amphistegina, peneroplis, miogypsinoides, 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 foraminifers 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, archaias, peneroplis, miogypsina, amphistegina, valvulinid, rotalia, dendritina, elphidium, discorbis, 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 fauas are austrotrillina, corallinacean and coral in the packstone. Echinoid, mollusca, bryozoan, miliolids, peneroplis, small rotalia, amphistegina, valvulinid, archaias, discorbis, dendritina and borelis 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 (abundant 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. Bioclast coral Floatstone

This microfacies is predominantly composed of coral colonies and echinoid 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

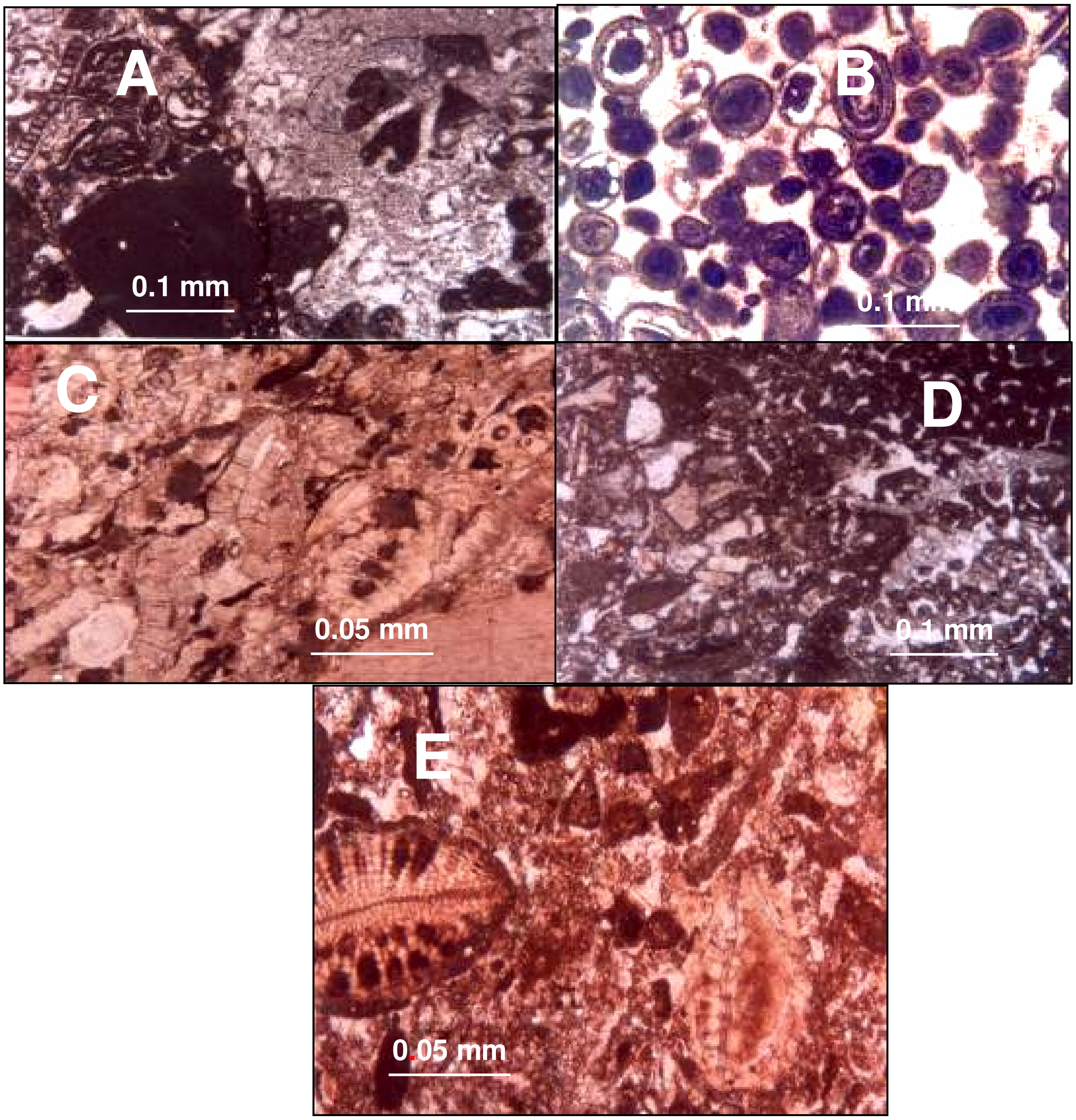

Plate 2. Microfacies types of Asmari Formation,
A-MF9: Austrotrillina, Corallinacean, Coral Packstone.
B-MF10: Bioclastic ooid packstone-grainstone.
C-MF11: Bioclastic rotalia grainstone.
D-MF12: Bioclast coral Floatstone.
E-MF13: Nummulitide Lepidocyclinide Bioclastic Packstone Grainstone.

et al., 1991; Longman 1981; Flügel, 1982, Melim and Scholl 1995; Pedley 1996; Pomar 2001a; Taheri, 2010).

MF 12. Nummulitide Lepidocyclinide Bioclastic Packstone Grainstone

The predominant grain types are corallinacean and larg perforate foraminifera consists of lepidocyclina and heterostegina. The minor constituents are echinoid, mollusca, bryozoan, dasyclacean alga and larg foraminifera such as rotalia, amphistegina, operculin, Spiroclypeus, spaerogypsina (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

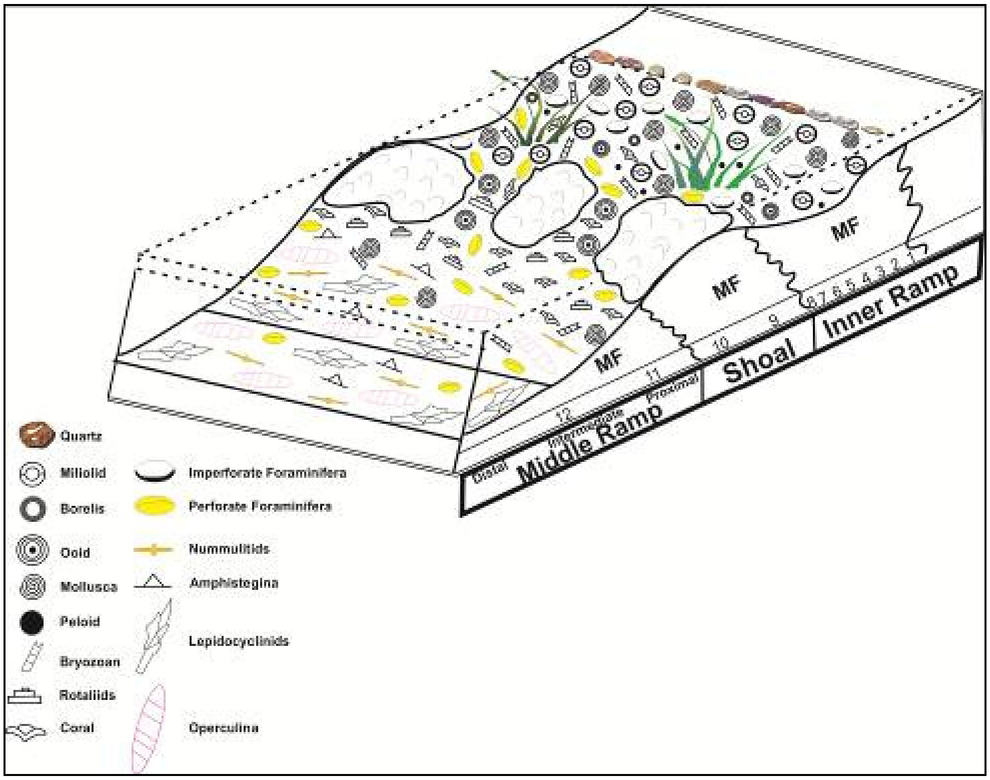

Figure8. Depositional model for the platform carbonates of the Asmari Formation at the Agha Jari oil field, well # 66 (Zagros Basin, SW Iran)

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; Hoheneger 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, hyposaline 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 corallinacean. The proximal middle ramp dominated by corallinacean 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, oligothrophy and normal salinity (Leutenegger, 1984; Romero et al., 2002). In this study area, 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.

ACKNOWLEDGEMENTS

Many thanks to Professor Hossein Vaziri Moghaddam and Dr. Ali Seyrafian from the University of Isfahan for their advice and support. Thanks to A. Rahmani and A. Ghabeishavi for their constructive comments that improved the manuscript. I would also like to thank the University of Isfahan for providing financial support and National Iranian South Oil Company for fieldwork logistics.

REFERENCES

Adams TD (1969). The Asmari Formation of Lurestan and Khuzestan provinces. Geological and Exploration Division. Iranian Oil Operating Company Report 1154 (unpublished).

Adams TD. Bourgeois F (1967). Asmari biostratigraphy. Geol Explor Div IOOC Rep. 1024. Tehran (unpublished).

Alavi M (2004). Regional stratigraphy of the Zagros Fold-Thrust Belt of Iran its proforeland evolution. Am. J. Sci. 304: 1535-1541.

Alavi M (2007). Structures of the Zagros fold-thrust belt in Iran. Am. J. Sci. 307: 1064–1095.

Allahkarampour Dill, Seyrafian A, Vaziri-Moghaddam H (2010). The Asmari Formation, north of the Gachsaran (Dill anticline, southwest Iran): facies analysis, depositional environments and sequence stratigraphy. Carbonates and Evaporites. 25(2): 145-160.

Amirshahkarami M (2008). Distribution of miogypsinoides in the Zagros Basin, in southwest Iran. Historical Biology. 20: 175-184.

Amirshahkarami M, Vaziri-Moghaddam H, Taheri A (2007a). Paleoenvironmental model and sequence stratigraphy of the Asmari Formation in southwest Iran. Historical Biology. 19(2):173-183.

Amirshahkarami M, Vaziri-Moghaddam H, Taheri A (2007b). Sedimentary facies and sequence stratigraphy of the Asmari Formation at Chaman_Bolbol (Zagros Basin, Iran). J. Asian Earth Sci. 29: 947-959.

Amirshahkarami M, Ghabeishavi A, Rahmani A (2010). Biostratigraphy and paleoenvironment of the larger benthic foraminifera in wells sections of the Asmari Formation from the Rag-e-Safid oil field (Zagros Basin, southwest Iran). Stratigraphy and Sedimentology Researches. 40(3): 63-84.

Aqrawi AAM, Keramati M, Ehrenberg SN, Pickard A, Moallemi A, Svana T, Darke G, Dickson JAD, Oxtoby NH (2006). The origin of dolomite in the Asmari Formation (Oligocene-Lower Miocene), Dezful embayment, SW Iran. J. Pet. Geol. 29(4):381-402.

Bahroudi A, Koyi HA (2004). Tectono-sedimentary framework of the Gachsaran Formation in the Zagros foreland basin. Marine and Pet. Geol. 21(10):1295–1310.

Barattolo F, Bassi D, Romero R (2007). Upper Eocene larger foraminiferal-coralline algal facies from the Klokova Mountain (south continental Greece). Facies. 53: 361–375.

Bassi D, Hottinger L, Nebelsick H (2007). Larger foraminifera from the Upper Oligocene of the Venetian area, Northeast Italy. Palaeontology. 50(4): 845–868.

Berberian M, King GCP (1981). Towards a paleogeography and tectonic evolution of Iran. Can. J. Earth Sci. 18:210 - 265.

Beavington-Penney SJ, Racey A (2004). Ecology of extant nummulitids and other larger benthic foraminifera: applications in paleoenvironmental analysis. Earth Sci. Rev. 67: 219–265.

Brandano M, Corda L (2002). Nutrients See level and tectonic: Constrain for the faciesarchitecture of Miocene carbonate ramp in central Italy. Blackwell science. 4: 257-262.

Brandano M, Frezza V, Tomassetti L, Cuffaro M (2009). Heterozoan carbonates in oligotrophic tropical waters: The Attard member of the Lower Coralline Limestone Formation (Upper Oligocene). Malta: Palaeogeography, Palaeoclimatology, Palaeoecology. 274: 54–63.

Betzler C, Brachert T, Nebelsick JH (1997). The warm temperate carbonate province: facies, zonations and delimitations. Courier orschungsinstitut Senckenberg. 201: 83–100.

Buxton MWN, Pedley HM (1989). A standardized model for Tethyan tertiary carbonate ramps. J Geol Soc. Lond. 146: 746–748.

Burchette TP, Wright VP (1992). Carbonate ramp depositional systems. Sed Geol. 79: 3–57.

Busk HG, Mayo HT (1918). Some notes on the geology of the Persian Oilfields. J Inst Petrol Technol. 5: 5–26.

Buxton MWN, Pedley HM. (1989) A standardised model for Tethyan Tertiary carbonates ramps. J Geol Soc. Lond. 146: 746–748.

Corda L, Brandano M (2003). Aphotic zone carbonate production on a Miocene ramp, Central Apennines, Italy. Sed Geol. 161: 55–70.

Ehrenberg SN, Eberli GP, Keramati M, Moallemi SA (2006). Porosity and permeability relationships in interlayered limestone-dolomite reservoir. AAPG Bull. 90(1): 91-114.

Ehrenberg SN, Pickard NAH, Laursen GV, Monibi S, Mossadegh ZK, Svana TA, Aqrawi AAM, McArthur JM, Thirlwall MF (2007). Strontium isotope stratigraphy of the Asmari Formation (Oligocene–Lower Miocene), SW Iran. J. Pet. Geol. 30:107–128.

Falcon NL (1974). Southern Iran, Zagros Mountains. In: SPENCER, A, Editor. Mesozoic – Cenozoic orogenic belts. Geological Society of London Special Publication. 41: 99 – 211.

Fakhari MD, Axen GJ, Horton BK, Hassanzadeh J, Amini A (2008). Revised age of proximal deposits in the Zagros foreland basin and implications for Cenozoic evolution of the High Zagros.Tectonophysics. 451: 170–185.

Flügel E (1982). Microfacies analysis of limestones. Berlin - Heidelberg, New York, Springer. 633.

Flügel E (2004). Microfacies of carbonate rocks; analysis, interpretation and application. Berlin. Springer-Verlag. 976.

Geel T (2000). Recognition of stratigraphic sequence in carbonate platform and slope: empirical models based on microfacies analysis of Paloogene deposits in southeastern Spain. Palaeogeog. Palaeoclimatol. Palaeoecol. 155: 211–238.

Hakimzadeh S, Seyrafian A (2008). Late Oligocene-Early Miocene benthic foraminhfera and biostratigraphy of the Asmari Formation, south Yasuj, north-central Zagros basin, Iran. Carbonates and Evaporites. 23(1): 1-10.

Hallock P (1999). Symbiont bearing foraminifera. In: Sen Gupta BK. Editor. Modern Foraminifera. Dordrecht: Kluwer Academic.

Hallock P (1984). Distribution of selected species of living algal symbiont, bearing foraminifera on two Pacific coral reefs. J Foramin Res. 9: 61–69.

Hallock P (1988). Diversification in algal symbiont-bearing foraminifera: a response to oligotrophy? Rev Paleobiol Spec. 2: 789–797.

Heydari E (2008). Tectonics versus eustatic control on supersequences of the Zagros Mountains of Iran. Tectonophysics. 451: 56-70.

Hottinger L (1980). Répartition comparée des grands foraminifères de la mer Rouge et de l'Océan Indien. Annali dell'Università di Ferrara. 6: 35–51.

Hottinger L (1983). Processes determining the distribution of larger foraminifera in space and time. In: Meulenkamp JE. Editor. Reconstruction of marine paleoenvironments. Utrecht Micropaleontological Bulletin. 30: 239–253.

Holzmann M, Hohenegger J, Hallock P, Piller WE, Pawlowski J (2001). Molecular phylogeny of large miliolid foraminifera. Soritacea hrenberg Marine Micropaleontology. 43: 57–74.

Hull CE, Warman HR (1970). Asmari oil fields of Iran. In: Halbouty, MT. Editor. Geology of giant petroleum fields. AAPG Memoir. 14: 428-437.

Jalali MR (1987). Stratigraphy of Zagros Basin: National Iranian Oil Company, Exploration and Production Division Report. 1249. 1072.

James GA, Wynd JG (1965). Stratigraphic nomenclature of Iranian oil consortium agreement area. AAPG Bull. 49: 1282-2245.

Kalantary A (1986). Microfacies of carbonate rocks of Iran. National Iranian Oil Company, Geological Laboratory Publication, Tehran, Vol. 11. P. 520.

Laursen GV, Monibi S, Allan TL, Pickard NAH, Hosseiney A,Vincent B, Hamon Y, Van Buchem FSH, Moallemi A, Driullion G (2009). The Asmari Formation revisited: Changed stratigraphic allocation and new biozonation. First international petroleum conference and exhibition, Shiraz, Iran.

Lee JJ (1990). Fine structure of the rhodophycean Porphyridium purpureum in situ in Peneroplis pertusus (Forskal) and P acicularis (Batsch) and in axenic culture. Journal of Foraminiferal Research. 20(2): 162–169.

Lees GM (1933). The reservoir rocks of Persian oil fields. AAPG Bull. 17 (3): 229 - 240.

Lees GM, Richardson FDF (1940). The geology of the oil field belt of SW Iran and Iraq. Geology Magazine. 76(3): 227-252.

Leutenegger S (1984). Symbiosis in benthic foraminifera, specificity and host adaptations. J Foram Res. 14: 16–35.

Longman MW (1981). A process approach to recognizing facies of reef complex, in Toomey DF. Editor. European Fossil Reef Models. Society of Economic Paleontologists and Mineralogists. Special Publication. 30: 9–40.

Mossadegh ZK, Haig DR, Allan T, Adabi MH, Sadeghi A (2009). Salinity changes during Late Oligocene to Early Miocene Asmari Formation deposition, Zagros Mountains, Iran. Palaeogeography, Palaeoclimatology, Palaeoecology. 272: 17-36.

Melim LA, Scholle PA (1995). The forereef facies of the Permian Capitan formation. The role of sediment supply versus sea-level changes. J Sediment Res. 65: 107–119.

Motiei H (1993). Stratigraphy of Zagros. In: Treatise of Geology of Iran. No. 1. Ministry of Mine and Metals. Geol Surv Iran Publ. p. 497 (in Persian).

Murray JW (1991). Ecology and palaeoecology of benthic foraminifera. New York, Wiley and Sons. p. 397.

Nebelsick JH, Stingl TV, Rasser M (2001). Autochthonous Facies and Allochthonous Debris Flows compared: Early Oligocene carbonate facies patterns of the lower Inn valley (Tyrol, Austria). Facies. 44: 31–46.

Nebelsick JH, Rasswer M, Bassi D (2005). Facies dynamic in Eocene to Oligocene Circumalpine carbonates. Facies. 51: 197–216.

Okhravi R, Amini A (1998). An example of mixed carbonate-pyroclastic sedimentation (Miocene, Central Basin Iran). Sediment Geol. 118: 37-57.

Pedley M (1996). Miocene reef facies of Pelagian region (Central Mediterranean region). In: Franseen EK, Esteben M, Ward WC, Rouchy JM. Editor. Models for carbonate stratigraphy from Miocene Reef complexes of Mediterranean Regions. SEPM Concept Sediment Paleontol. 5: 247–259.

Pomar L (2001a). Types of carbonate platforms, a genetic approach.Basin Research. 13: 313-334.

Rahmani A, Vaziri-Moghaddam H, Taheri A, Ghabeishavi A (2009). A model for the paleoenvironmental distribution of larger foraminifera of Oligocene–Miocene carbonates rocks at Khaviz Anticline, Zagros Basin, SW Iran. Historical Biology. 21: 215-227.

Rahmani Z, Vaziri-Moghaddam H, Taheri A (2010). Facies distribution and palaeoecology of the Guri member of the Mishan Formation in Lar area Fars Province SW Iran. Iranian Journal of Science and Technology. Transaction A. 34(A3).

Rahmani A, Taheri A, Vaziri-Moghaddam H, Ghabeishavi A (2012). Biostratigraphy of the Asmari Formation at Khaviz and Bangestan Anticlines, Zagros Basin SW Iran. Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen. 263(1): 1-16.

Reiss Z, Hottinger L (1984). The Gulf of Aqaba: Ecological Micropaleontology. Berline. Springer. P. 354.

Read JF (1982). Carbonate margins of passive (extensional) continental margins. types, characteristics and evolution. Tectonophysics. 81: 195–212.

Richardson P K (1924). The geology and oil measures of southwest Persia. Journal of the Institute of Petroleum Technology. 10: 256 - 283.

Riding R, Martin TM, Braga TC (1991). Coral-stromatolite reef framework, Upper Miocene. Almeria. Spain Sedimentology. 38(5): 799–818.

Romero J, Caus E, Rossel J (2002). A model for the paleoenvironmental distribution of larger foraminifera based on late Middle Eocene deposits on the margin of the south Pyrenean basin (NE Spain). Palaeogeogr. Palaeoclimatol. Palaeoecol. 179: 43–56.

Sadeghi R, Vaziri-Moghaddam H, Taheri A (2009). Biostratigraphy and Palaeoecology of the Oligo-Miocene succession in Fars and

Khuzestan areas (Zagros Basin, SW Iran). Historical Biology. 21(1-2): 17–31.
Sadeghi R, Vaziri-Moghaddam H, Taheri A (2010). Microfacies and sedimentary environment of the Oligocene sequence (Asmari Formation) in Fars sub-basin (Zagros Mountains, southwest Iran). Facies. 57(3): 431-446.
Sahraeyan M, Bahrami M, Arzaghi S (2014). Facies analysis and depositional environments of the Oligocene–Miocene Asmari Formation
(Zagros Basin, SW Iran). Geoscience Frontiers. 5 (1): 103–112.
Saleh, Z, Seyrafian A (2013). Facies and Depositional Sequences of the Asmari Formation, Shajabil Anticline (North of the Izeh Zone, Zagros Basin, Iran). Acta Geologica Sinica - English Edition. 87 (6): 1520–1532.
Seyrafian A (2000). Microfacies and depositional environments of the Asmari Formation at Dehdez area (A correlation across Central Zagros Basin). Carbonate and Evaporite. 15: 22–48.
Seyrafian A, Vaziri-Moghaddam H, Torabi H (1996). Biostratigraphy of the Asmari Formation, Burujen area, Iran. J Sci. 7(1): 31-48.
Seyrafian A, Hamedani A (2003). Microfacies and paleoenvironmental interpretations of the lower Asmari Formation (Oligocene), north-central Zagros basin, Iran. Neues Jahrbuch fur Geologie und Palaontologie, Monatshefte. 3: 164-174.
Seyrafian A, Mojikhalifeh AR (2005). Biostratigraphy of the Late Paleogene-Early Neogene succession (north-cental border of the Persian Gulf). Carbonates and Evaporites. 20(1): 91-97.
Seyrafian A, Vaziri-Moghaddam H, Arzani n, Taheri A (2011). Facies analysis of the Asmari Formation in central and north-central Zagros basin (SW Iran) Biostratigraphy, paleoecology and diagenesis. Revista Mexicana de Ciencias Geológicas 28 núm. 3. 2011: 439-458.
Sooltanian N, Seyrafian A, Vaziri-Moghaddam H (2011). Biostratigraphy and Paleo-ecological implication in microfacies of the Asmari Formation (Oligocene), Naura anticline (Interior Fars of the Zagros Basin, Iran). Carbonates and Evaporites. 26(2): 167-180.
Tucker ME (1985). Shallow marine carbonate facies and facies models. In: Brenchley PJ Williams BPJ (eds) Sedimentology, recent development and applied aspects: Geo So London Spe. Pub. 18: 139–161.
Tucker ME, Wright VP (1990). Carbonate sedimentology. Blackwell Sci. Publ Oxford. Pp425.
Taheri A (2010). Paleoenvironmental model and sequence stratigraphy for the Oligo-Miocene foraminiferal limestone in east of Dogonbadan. Stratigraphy and Sedimentology Researches. 40(3): 15-30
Taheri A, Vaziri-Moghaddam H, Seyrafian A (2008). Relationships between foraminiferal assemblages and depositional sequences in Jahrum Formation, Ardal area (Zagros Basin, SW Iran). Historical Biology. 20: 191-201.
Thomas AN (1948). The Asmari limestone of southwest Iran. Anglo - Iranian Oil Company Report, P. 706 (unpublished).
Vaziri – Moghaddam H, Kimiagari M, Taheri A (2006). Depositional environment and sequence stratigraphy of the Oligocene - Miocene Asmari Formation in SW Iran. Facies. 52: 41-51.
Vaziri-Moghaddam H, Seyrafian A, Taheri A, Motiei H (2010). Oligocene-Miocene ramp system (Asmari Formation) in the NW of the Zagros basin, Iran. Microfacies, paleoenvironmental and depositional sequence. Revista Mexicana de Ciencias Geológicas. 27(1): 56-71.
Vaziri-Moghaddam H, Kalanat B, Taheri A (2011). Sequence stratigraphy and depositional environment of the Oligocene deposits at Firozabad section, southwest of Iran based on microfacies analysis. Jgeope. 1 (1): 71-82
Wanas HA (2008). Cenomanian rocks in the Peninsula, Northeast Egypt, Facies analysis and sequence stratigraphy. J Afr. Earth Sci. 5: 125-138.
Wilson JL (1975). Carbonate Facies in Geological History. Berlin-Heidelberg. New york: Springer. Pp471.
Wells AJ (1967). Iranian Oil Offshore Company Report 1108. Unpublished Lithofacies and geological history of lower tertiary sediments in southwest Iran.
Wynd J (1965). Biofacies of Iranian Oil Consortium Agreement Area. Iranian Oil Operating Company. Report 1082. Unpublished.
Ziegler MA (2001). Late Permian to Holocene paleofacies evolution of the Arabian plate and its hydrocarbon occurrences. Geo Arabia. 6(3): 445–504.

How to cite this article: Yazdani R. (2014). Biostratigraphy and Facies Distribution of The Asmari Formation in Aghajari Well # 66, Zagros Basin, SW Iran. Int. Res. J. Geo. Min. 4(4): 101-115