BIOFACIES AND SEQUENCE STRATIGRAPHY OF THE EOCENE SUCCESSION, AT HAMZEH-ALI AREA, NORTH-CENTRAL ZAGROS, IRAN

H.V. Moghaddam, A. Seyrafian, and P. Taraneh
Geology Department, Faculty of Sciences, University of Esfahan, Esfahan 81744, Iran

ABSTRACT: The predominant biofacies of Eocene deposits at the Hamzeh-Ali area in highlands of Zagros Mountains are: (1) planktonic foraminifera, (2) nummulitid-discocylinid-planktonic foraminifera (3) nummulitid-discocyclinid, (4) Alveolina-Nummulites, (5) Alveolina-Orbitolites-Somalina, and (6) Alveolina-miliolids-bioclasts.

Palaeoecology and sedimentary environments in association with the occurrence of foraminifera suggests an open shelf of carbonate platforms (with ineffective barrier) with emphasis on deep shelf and inner to outer shallow shelf of an open-marine environment during the Eocene.

Three depositional sequences were also recognized in the Eocene succession. Transgressive Systems Tracts are characterized by the occurrence of larger and flat perforated and planktonic forams. Abundance of imperforated forams and presence of smaller perforated forams are associated with Highstand Systems Tracts. Sequence boundaries are characterized by abrupt change in lithology and faunal succession.

INTRODUCTION

The Pabdeh and Jahrum Formations are part of the Lower Tertiary deposits (Paleocene-Lower Miocene) in the Zagros basin (Fig. 1). Deposition of the Jahrum and Pabdeh Formations was coincident with broad marine transgression during Paleocene through Eocene. The pelagic shale, marl and argillaceous carbonate of the Pabdeh Formation were deposited along the troughs, while the shallow marine carbonate of the Jahrum Formation was laid down over shallower areas of the Zagros basin (Wells 1967).

Lithologically, the Pabdeh Formation at the type section (E: 49° 13' 47", N: 32° 26' 50") consists of 798.3 meters, mainly argillaceous sediments. From base to top, thin-bedded argillaceous limestone (458.7 m.), thin bedded limestone with chert nodules (82.4 m.), intercalations of green shale and limestone (74.6 m.), and interlayering of blue and purple shale and argillaceous limestone (140.2 m.) is recorded, James and Wynd (1965), Setudehnia (1972) and Motiei (1993).

The Jahrum Formation at the type section (E: 28°, 25', 53'', E: 53°, 44', 47'') is composed of 467.5 m dolomite and dolomitic limestone. Upward, it consists of massive dolomite (35.5 m.), thin to medium bedded dolomite (162 m) and massive dolomitic limestone (270 m), James and Wynd (1965), Stocklin (1977), Darvishzadeh (1992). Microfauna of the Jahrum and Pabdeh Formations were studied by Adams and Bourgeois (1967), Kalantary (1968), Jalali (1971). The Jahrum Formation overlies evaporites of the Sachun, carbonates of the Tarbur, red beds of the Kashghan and also, shales of the Gurpi formations at the type section, south and north central, and north-southwest of the Zagros basin respectively.

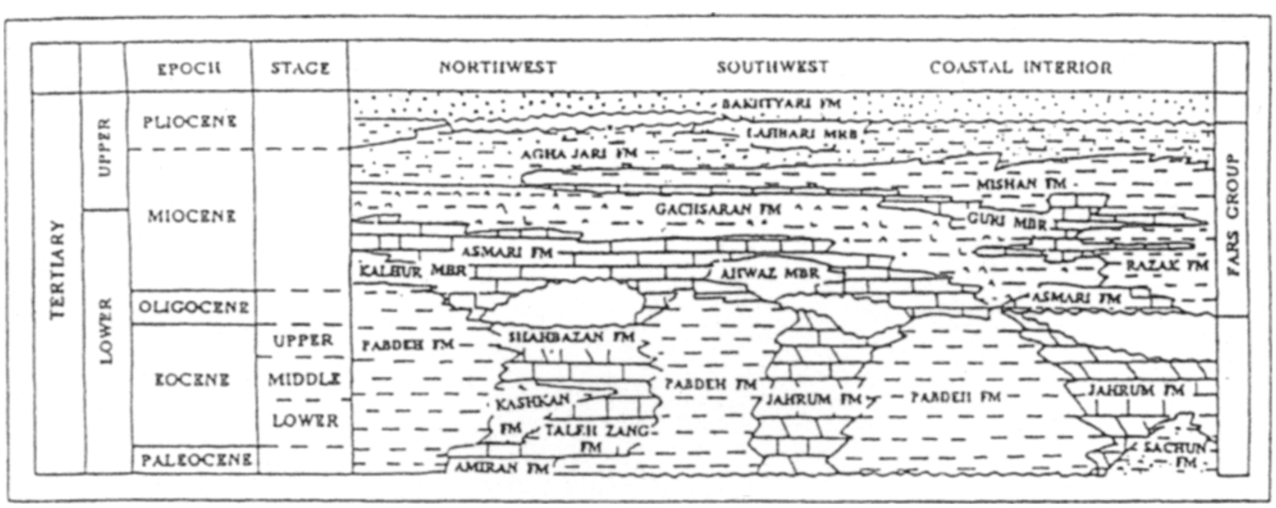

Figure 1. Correlation chart of the Tertiary of Southwest Iran (adopted from Ala 1982). Dots and circles - sandstones and conglomerates, dashes - mudrocks, rectangles limestones, parallelograms - dolomites, dashes and inverse V - evaporites, wavy line - unconformities.

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The Pabdeh Formation unconformably overlies the upper Cretaceous pelagic shales and marls of Gurpi Formation.

In the study area, no sharp boundary existed between the two formations. In another words, the lower outcrops of the Jahrum Formation interfingers with the most upper exposed layer of the Pabdeh Formation, both Eocene in age.

Most of the Pabdeh and Jahrum studies are mainly based on subsurface data derived from the oil field areas. Middle Eocene assilinid foraminifera from Iran (Mojab 1974) and petrofacies and depositional analysis of Eocene deposits (Seyrafian 1998) comprize the recent published works related to the Eocene outcrops in the north-central Zagros basin.

In this study, the exposed Eocene deposits (the upper-most part of the Pabdeh and lower part of the Jahrum Formations) in north-central Zagros basin, some distance from the oil field areas are examined.

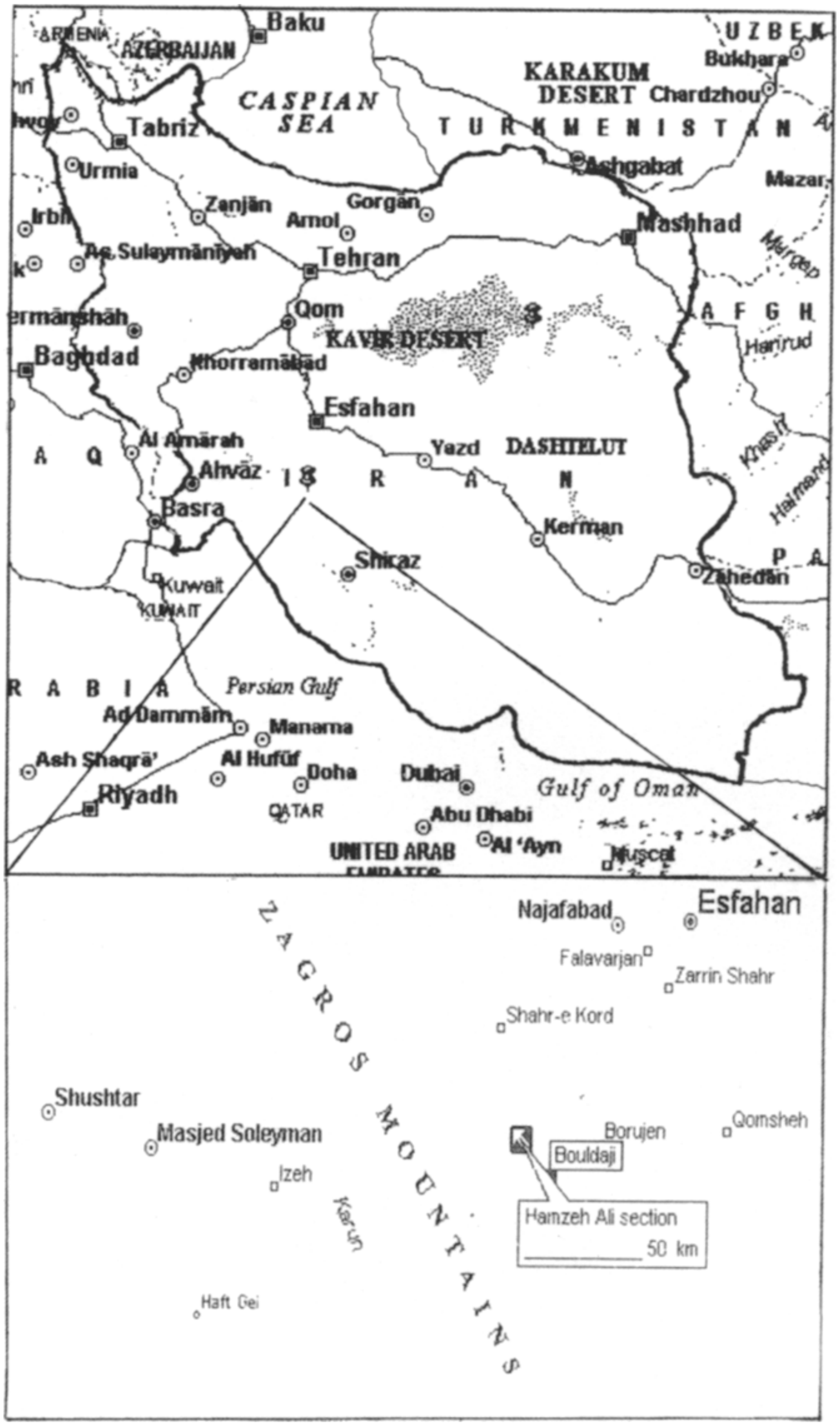

Figure 2. Locality map of the Hamzeh- Ali area.

The purpose of this study is based on the occurrence of foraminiferas and is: (a) to recognize the most dominant biofacies, (b) to model the environment of deposition and (c) to analyze stratigraphic sequence and system tracts.

STUDY AREA AND METHODOLOGY

The study area is located 10 km to the northwest of the Buldaji, in the north-central part of the high Zagros mountain (Fig. 2). Fieldwork was concentrated at the Hamzeh-Ali and neighboring mountains.

Sections were measured in detail along the southwestern flank of the Hamzeh-Ali mountain at N: 50° 56', E: 32° 00'. The thickness of the exposed Jahrum and Pabdeh formations in the study area is 255.5 meters. Samples were taken almost every 1.5 meters, and were based on outcrop facies changes. Approximately 130 thin sections were studied. A textural classification by Dunham (1965) was used.

BIOFACIES

Sedimentary environment interpretation is significantly dependent on biofacies studies. In this regard foraminifera are the most commonly occuring microfauna in Tertiary sediments and are valuable tools for this. Larger benthic foraminifera are mainly associated with shallow water environments. Several factors such as nutrient supplies, light penetration, salinity, substrate would strongly have controlled distribution of the benthic forams and in turn, the relationship of each biofacies types and faunal associations (Chaproniere 1975; Hottinger 1983 and 1997; Reiss and Hottinger 1984; Hallock and Glenn 1986). Thus, larger foraminifera are significantly paleoenviromental indicators (Frost and Longenheim 1974; Fermont 1982; Setiawan 1983). These are excellent tools to analyze environmental changes, for instance deepening and shallowing trends in lithologically uniform platform successions (Geel, 2000). In this study, six biofacies types based on the distribution of the foraminifera are recognized.

Biofacies Type 1: Planktonic Foraminifera

Globorotalid and globigerinid are the main faunal constituents. Textularids and small benthic forams are also

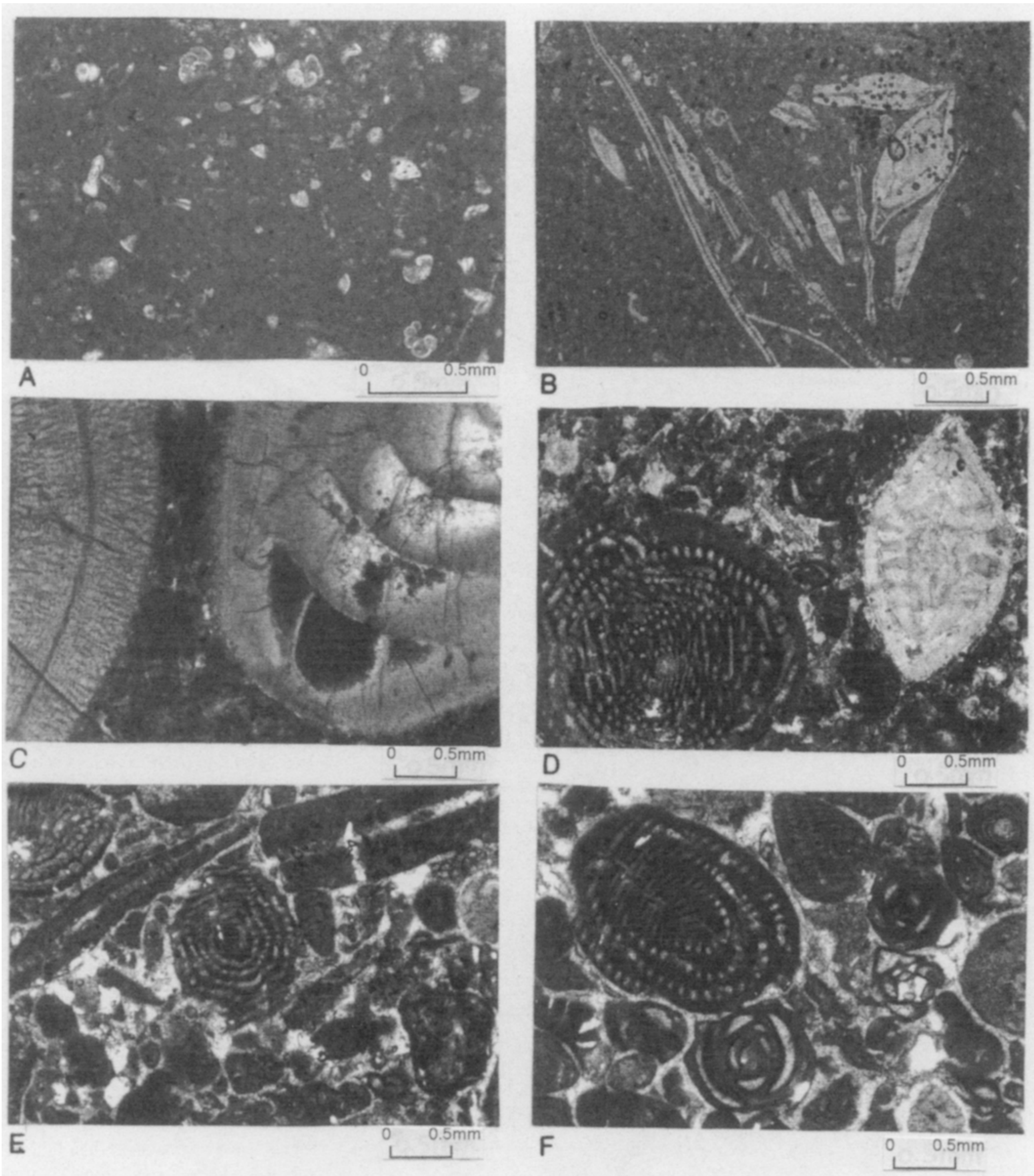

Figure 3. General view of biofacies.A: Planktonic foraminifera (BF.1). X 31.B: nummulitid-discocyclinid-planktonic forams (BF. 2). X 20.C: nummulitid-discocyclinid (BF. 3). X 20.D: Alveolina-Nummulites (BF. 4). X 20.E: Alveolina-Opertorbitolites-Somalina (BF. 5). X 20.F: Alveolina-Miliolids-bioclasts (BF. 6). X.20.

associated as accessory constituents. Mudstone to wackestone is the most predominate textural rock type (Fig. 3A).

Biofacies Type 2: Nummulitid-Discocyclinid-Planktonic Foraminifera

Benthic and pelagic forams are the principle constituents, associated with wackestone to rarely packstone. Benthic foraminifers include large and flat nummulitid (Nummulites, Assilina and Operculina) and discocyclinid (Discocyclina, Asterocyclina and Actinocyclina).

Globigerinids and globorotalids are the most abundant planktonic fauna. Textularids and echinid debris are present as minor constituents (Fig. 3B).

Biofacies Type 3: Nummulitid-Discocyclinid

Large and flat nummulitid and discocyclinid fauna are dominant in the packstone. Small benthic and planktonic foraminifera are rare or absent. Molluscs and echinoderm debris comprise the minority of the assemblage (Fig. 3C).

Biofacies Type 4: Alveolina-Nummulites

Small and medium sized Nummulites spp. and various sized Alveolina spp. are the major components in the packstone. Miliolids, Orbotolites, Somalina (imperforate), Lockhartia, Discocyclina and Assilina (perforates), are present as an accessory fauna (Fig. 3D).

Biofacies 5: Alveolina-Orbitolites-Somalina

Alveolina (high diversity), Orbitolites and Somalina are the predominant fauna in the packstone to grainstone. Miliolids, Opertorbitolites (imperforates) and Lockhartia (perforates) and fragments of porcelaneous foraminifers are the minor constituents of the assemblage (Fig. 3E).

Biofacies 6: Alveolina-Miliolids-Bioclasts

Two porcelaneous imperforate benthic foraminifera, Alveolina ssp. and miliolids are the main fauna associated with the packstones and grainstones. Test fragments of porcelaneous foraminifera are the dominant bioclasts. Among the larger forams, the smaller-sized perforate Lockhartia and dasycladacean algal debris as minor contituents are present (Fig. 3F).

DEPOSITIONAL SETTING

In this section palaeoecology, sedimentary environments and the distribution of foraminifera occurring in the Eocene deposits of the study area are discussed. Also, related palaeoecology and sedimentary environments are analized. This discussion is based on the work of Hottinger (1973, 1977, 1983, 1997), Brasier (1975a,b), Ghose (1977), Luterbacher (1984), Esamo and Barbieri (1999) and Geel (2000). The faunal distribution (Fig. 4) includes the rimmed and open-shelf platform models of Geel (2000). The explanation of faunal associations are related to biofacies type introduced in the previous section.

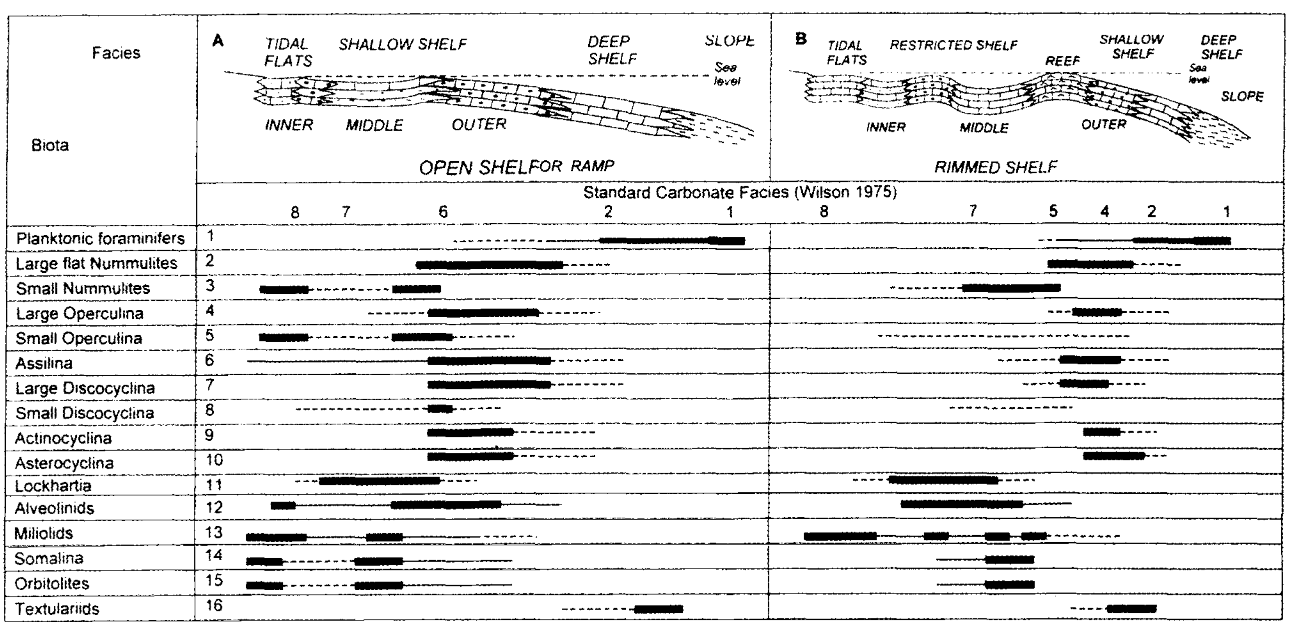

Figure 4. Environmental distribution of the most significant Eocene foraminifers on an open (A) and on a rimmed (B) shelf (modified from Geel 2000).

Planktonic foraminifera are open marine water indicators. A lack of large forams (e.g. nummulitid and discocyclinid in biofacies type 1 suggests a deeper water setting of the lower slope to basin where more than 200 meters of water prevailed. This biofacies coincides with facies belts 1, 2 and 3 of Wilson (1975) in slope and the deep shelf of an open or rimmed shelf platform of Geel (2000). The sloping platform without a rimmed has been termed a ramp (Ahr 1973).

The faunal association of biofacies type 2, nummulitid-discocyclinid- planktonic forams suggests deposition in the upper to middle portions of deeper shelf, in both rimmed and open shelf ramp environment (facies belts 2 and 3 of Wilson 1975). Wide-spired Assilina and Operculina are soft bottom dwellers and lived on one of their sides. Large Nummulites and Discocyclina are open marine indicators. Thin form Discocyclina, Nummulites, Pllatispira, Spiroclypeous, Asterocyclina and Actinocyclina are reported as a deeper Eocene fore-slope fauna and Nummulites-Rotalia-Operculina assemblage as a shallower Eocene fore-slope (Setiawan 1983).

The assemblage of biofacies type-3 reflects fore-reef shallow rimmed or a deeper outer open shelf with a depth of 50 to 80 meters.

Lense-shaped Nummulites in association with Alveolina, rare miliolids and Discocyclinia occur in biofacies type-4 and reflects a low energy soft bottom interior platform, 50-90 meters in depth. A restricted rimmed shelf or an open marine outer or inner shelf is suggested for biofacies type-4.

The association of Alveolina and Orbitolites reflects a shallow to moderately agitated environment of deposition. Orbitolites is mostly found in carbonate facies free of terrigenous and mud occurring in well-washed back-reef environments. The occurrence of a large number of porcelaneous imperforates points to a somewhat hypersaline setting. Thus middle part of restricted rimmed shelf or a shallow inner to outer open shelf is proposed for deposition of biofacies type-5.

Miliolids live in water of low turbulence. The abundance of miliolids suggests a restricted lagoon and relatively rich nutrient back-reef environments. Alveolinids will tolerate shallow water (with less than 15 meters of water depth) clearly suggestive protected areas in the back-reef or inter-reefal sand near and below wave base. Therefore, the middle part of the restricted rimmed shelf or inner to shallow part of an outer open shelf is suggested for deposition of biofacies type-6. In summary, an open shelf of carbonate platform (with an ineffective barrier) is proposed for depositional setting of the Eocene deposits of the study area.

Globigerinids, globorotalids and smaller benthic forams lived in deeper parts of the platform (slope to basin) BF. 1. The association of planktonic and benthic larger forams occurs in upper to middle parts of the deep shelf. Large and flat nummulitid and discocyclinid are abundant and diverse (BF. 2). Also, diverse perforate forams (nummulitid and discocyclinid) are present in deeper parts of the outer shelf (BF. 3). Shallow parts of outer shelf or inner shelf is characterized by the occurrence of small-sized perforate (Nummulites) and imperforate (Alveolina) forams (BF. 4).

Finally, the imperforate foraminifera (Alveolina, Orbitolites, Somalina and miliolids) are the dominant fauna of the inner, middle and shallow parts of the outer shelf (BF. 5,6).

SEQUENCE STRATIGRAPHY

This paper assumes that a depositional sequence is a relatively conformable succession of genetically related strata bounded by unconformities or their relative conformities (Vail et al. 1977; Mitchum 1977; Van Wagoner et al. 1988). We also accept that the smallest sequence stratigraghic unit is the parasequence, which is equivalent to the ubiquitous fifth-order (10^4-10^5 year duration), shallowing-upward, depositional cycles seen throughout the sedimentary record (Sarg 1988; Van Wagoner et al. 1988). We also recognized that sequence can be subdivided into system tracts (Transgressive Systems Tracts, Highstand Systems Tracts, Lowstand Systems Tracts), which are genetically related intervals of strata that are interpreted to have formed during specific increments of a eustatic sea-level cycle. We defined the system tracts by their position within a sequence, the types of bounding surfaces, and internal stratal geometries (Van Wagoner et al. 1988; Sarg 1988). Friedman and Sanders (2000) focused special attention on issues of terminology and concepts of sequence and seismic stratigraphy and provided historical context on sequences, parasequences, mesosequences, systems, system tracts and facies tracts.

DEPOSITIONAL SEQUENCE

Three depositional sequences were recognized in Eocene succession at the study area (Fig. 5). Deepening trends considered as Transgressive Systems Tracts (TST), shallowing trends as Highstand Systems Tracts (HST), and maximum flooding surface (mfs) interpreted as a change from deepening to shallowing in depositional setting were all identified. The sudden superposition of transgressive beds upon prograding ones is thought to represent a sequence boundary (SB).

Sequence 1

The basal part of sequence 1 (TST) is characterized by marly limestone and yellow to pale green marls 30 m. in thickness. Planktonic and smaller benthic forams are present in the marls. Perforate forams (large and flat nummulitid and discocyclinid) and planktonic forams are common in the marly limestone.

The upper part of the sequence (HST), is composed of white to cream marly limestone and limestone, 37.5 m in thickness.

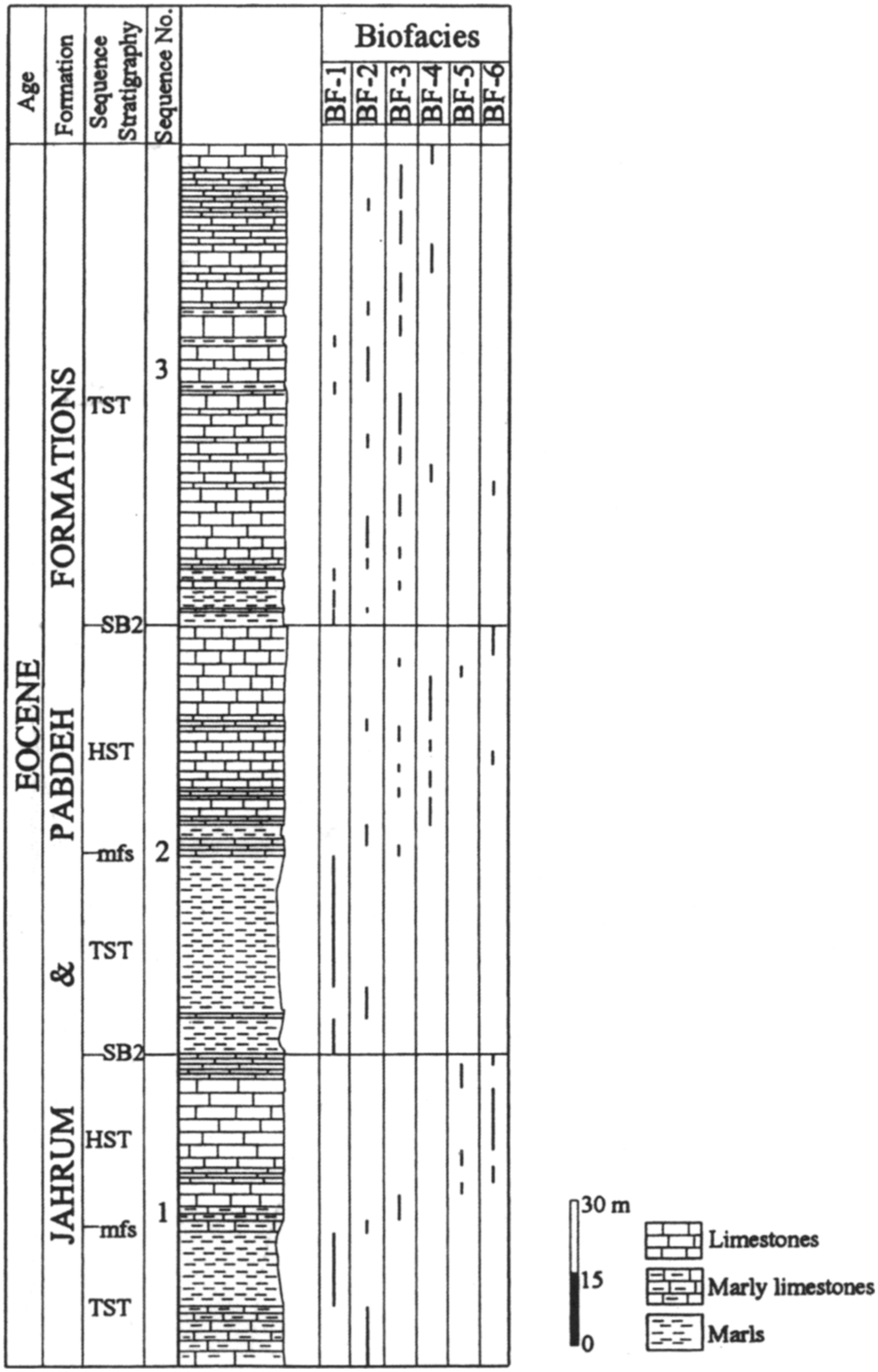

Figure 5. The distribution of biofacies and sequence stratigraphical interpretation of the Eocene sediments at Hamzeh-Ali area. TST: Transgressive Systems Tracts; HST: Highstand Systems Tracts; mfs: maximum flooding surface; SB2: Sequence boundaries (they are marked by abrupt lithological and faunal changes).

Perforate forams (BF. 2,3) are common in the lower part, while imperforate forams (Alveolina, miliolids, Orbitolites) are numerous in the upper part.

No nummulitids and discocyclinids were observed in the upper part of the HST. Wackestone, packstone and grainstone are the predominant sedimentary textures.

Sequence 2

The basal part of sequence 2 (TST) is composed of pale green pelagic marls, 43 m in thickness. Globorotalids and globigerinids are common in this interval. The upper part of the sequence 2 (HST) is characterized by marly to cream calcareous wackestone to grainstone, 48.5 m in thickness.

Perforate forams (large and flat nummulitid and discocyclinid) concentrated within the lower section and imperforate forams (Alveolinida, Somalina, ...) mostly occurr in the upper section of the HST. This, in turn, may reflect the occurrence of small scale parasequences within the HST of sequence 2 (Fig. 5). A vertical upward change through the parasequence is also recognized. As limestones with perforate forams decrease in thickness, a progradational stacking pattern maybe indicated.

Sequence 3

The basal part of sequence 3 (TST) is characterized by marl and marly limestone, wackestone to packstone, 85m in thickness. Upward, planktonic forams are followed by larger flat perforate forams.

The TST is characterized by its retrogradational character. TST geometry is defined by type 1b of Hunt and Tucker, et al. (1993).

The HST of sequence 3 either was not fully developed at the study area (Hamzeh-Ali. mountain), or could have been eroded by the overlying sequence (Asmari Formation).

Primarily fieldwork reveals the HST represented by inner and middle part of shallow shelf facies, with miliolids, alveolinids and Somalina may be present in other parts of the Zagros basin.

CONCLUSION

During deposition of the Eocene deposits in the Hamzeh-Ali area six biofacies are recognized as follows: planktonic foraminifera, nummulitid-discocyclinid-planktonic foraminifera, nummulitid-discocyclinid, Alveolina-Nummulites, Alveolina-Orbitolites-Somalina and Alveolina-miliolids-bioclasts.

Transgressive System Tracts are associated with planktonic, smaller benthic and large perforated foraminifera that are present in marls, marly limestone and limestones. Highstand Systems Tracts are characterized by predominantly imperforated foraminifera. An occurrence of a vertical upward increase in imperforated forams in each parasequences is observed in the HST. An abrupt change in lithogical and faunal association is present at the sequence boundaries.

As a result, an open shelf of carbonate platform is recognized for deposition of the Eocene succession at the study area.

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