Upper Eocene larger foraminifera from the Dammam Formation in the border region of United Arab Emirates and Oman

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ABSTRACT: An Upper Eocene diagnostic larger foraminiferal assemblage is described and illustrated from carbonates of the uppermost Dammam Formation, on the western side of the Northern Oman Mountains, along the United Arab Emirates and Oman borders. This assemblage comprises Fabiania cassisi (Oppenheim, 1896), Silvestriella tetraedra (Gümbel, 1870), Pellatispira madaraszi Hantken, 1876, Nummulites fabiani (Prever, 1905), N. ptukhiani Kacharava, 1969 and N. retiatus (Roveida, 1959). The presence of Nummulites ptukhiani and N. fabricii within the same horizon of Pellatispira madaraszi places both species in the Priabonian stage, confirming a Late Eocene age for the uppermost part of the Dammam Formation. The studied carbonates were deposited in an inner shelf environment, which may be related to the eustatic fall of sea level at the end of the Late Eocene.

INTRODUCTION

The Dammam Formation and the partly equivalent Seeb Limestone Formation were deposited in a shallow marine environment (Racey, 1994). The Eocene part of the Dammam Formation consists of fossiliferous shallow-marine carbonates and covers a large part of the eastern Arabian Peninsula. Upper Eocene sequences along the United Arab Emirates and Oman border, (text-fig.1) have been studied previously by Hunting (1979), Cherif and El-Deeb (1984), Hamdan and Bahr (1992), Anan et al. (1992), Racey (1994), White (1994), Jones and Racey (1994), Anan (1995), Whittle et al. (1996) and Abdelghany (2002).

The first lithostratigraphic and chronostratigraphic subdivision of the Paleogene strata in the Al-Ain area, southeastern United Arab Emirates was erected by Hunting (1979), who defined eleven coded rock units (text-fig.2) and assigned ages to these rock units based mainly on the micropaleontologic data of Terratase (1973).

In their study of the Eocene of the Al-Ain area, Cherif and El-Deeb (1984) introduced the Hafit, Senaiya and Al Jaww formations (text-fig.2) and subdivided them into members similar to the lithostratigraphic units described by Hunting (1979). The Eocene-Oligocene sequence in the Jabal Hafit area was later divided into three formations and eight members (text-fig.2) based on lithology, defined planktonic foraminifera and Nummulites (Hamdan and Bahr, 1992). They defined the Rus Formation (Lower Eocene), comprising the Hilli and Wadi Tarabat members; the Dammam Formation (Middle to Upper Eocene), comprising the Middle Eocene Wadi Al Nahyan Member and Ain Al-Faydah Member (on the eastern limb of Jabal Hafit anticline only), and the Mazyad Member (Upper Eocene); and the Asmari Formation (Lower to Middle Oligocene) consisting of the Muwaiji, Mutaredh and Zakher members (text-fig.2).

Anan et al. (1992) identified twelve planktonic foraminiferal zones (P9-P21) at Jabal Hafit spanning the late Early Eocene to Oligocene.

Cherif et al. (1992) recognized four bathymetrically significant types of shallow and deep inner neritic; middle and outer neritic of calcareous algae, bryozoaa and foraminiferal assemblages represented in the Eocene and Oligocene sequences at Jabal Hafit. This study enabled Cherif et al. (1992) to establish a bathymetric curve for the studied sections which fits with their results and this can be also correlated with the Eustatic curve of Haq et al. (1987) for global changes in sea levels.

Anan (1995) recorded Cribrohanthenina inflata (Howe) in the Mazyad Member of the uppermost part of the Dammam Formation from the northwestern limb of Jabal Malaqaq antcline (text-fig.1). Whittle et al. (1996) described the Dammam Formation in Jabal Hafit as representing a continuous sequence from the Early Eocene Rus Formation to the Oligocene Asmari Formation.

The present study aims dates and illustrates Upper Eocene larger foraminifera from the uppermost part of the Dammam Formation in Jabal Qatar, Jabal Malaqaq, Jabal Hafit and the western limb of Jabal Buhays in the Al Faiyah Range Mountains. This interval consists of a thick, well exposed sequence of rhythmically alternating limestone and marl beds that is rich in smaller and larger foraminifera, and therefore well suited for the present micropaleontologic study.

MATERIAL AND STUDY LOCATIONS

Four stratigraphic sections representing the Upper Eocene part of the Dammam Formation were measured and sampled in the area along the border between the United Arab Emirates and Oman (text-figs.1, 3 and plate 7). Stratigraphic section (A), located 24km northeast of Al-Ain city, is 194m thick and forms a limb of the Jabal Qatar syncline at latitude 24°19′30″N and longitude 55°54′00″E.
TEXT-FIGURE 1
Location map of the study area and the measured sections.
The poorly-exposed basal beds consist of a thick marl sequence containing thin (0.5m thick) erosion-resistant layers of limestone. These are followed by a one-metre limestone bed rich in larger foraminifera and then another thick succession of marl capped by another thin limestone. 

Stratigraphic section (B), was measured on the northwestern limb of the Jabal Malaqet anticline, about 22km east of Al-Ain city, at latitude 24°9'24"N and longitude 55°56'47"E. It is estimated to be 94m thick, although the base is unexposed. It consists of yellow, gypsiferous marls alternating with brown, nummulitic limestone beds near the top of the section.

Stratigraphic section (C) is 64m thick and was examined from a site near the hinge zone of the Hafit anticline, south of the city of Al-Ain. The base of the section is located at latitude 24°08'57"N and longitude 55°44'47"E. The lowermost part of this section consists of hard, thick-bedded, bioturbated, nummulitic limestones. These are followed by a thick sequence of intercalated limestones and marls topped by another hard, thick bedded nummulitic limestone.

Stratigraphic section (D) is 18m thick and located on the lower slopes of the western side of Jabal Buhays, in the Al Faiyah Range Mountains. It consists of a pale green, highly fractured marl with calcite veins at its base. This is followed by a thick sequence of limestone, which is highly fossiliferous and very rich in larger foraminifera especially *Nummulites* spp.

### Lithostratigraphy

<table>
<thead>
<tr>
<th>Epochs</th>
<th>Iran</th>
<th>Oman</th>
<th>Saudi Arabia, Qatar, Kuwait and South Iraq</th>
<th>Oman</th>
<th>Abu Dhabi</th>
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<td>No.</td>
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<td>23</td>
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<td>49</td>
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**TEXT-FIGURE 2**

Lithostratigraphic correlation chart of Abu Dhabi (UAE), and neighbouring countries (based on Hamdan and Bahr, 1992).
TEXT-FIGURE 3

Lithostratigraphy of the studied sections showing the distribution of the identified foraminiferal species (Based on Abdalgany, 2002).

<table>
<thead>
<tr>
<th>Location of the Studied Sections</th>
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<tbody>
<tr>
<td>Age</td>
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<td>Samples Number</td>
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<table>
<thead>
<tr>
<th>Lithology</th>
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<tbody>
<tr>
<td>Turborotalia cosmolamis</td>
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<tr>
<td>Cribroalveolina inflata</td>
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<tr>
<td>Ellobiogirotheca seminivulata</td>
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<tr>
<td>Febnius cariss</td>
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<tr>
<td>Silvestrellina tetraedra</td>
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<td>Pollampopina muraturi</td>
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<td>Nummulites parvianus</td>
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<td>N. fubinii</td>
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<td>N. reestra</td>
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<td>N. gantieri</td>
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<tr>
<td>Discocolia pratti</td>
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<td>Aversicolina ceriasta</td>
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<tr>
<td>A. pentagonuloides</td>
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<td>A. soladiensis</td>
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*Table showing the distribution of foraminiferal species across different sections.*
Eocene larger foraminifera, while the upper part has age-diagnostic larger benthonic fauna of Middle-Late Eocene age. In the UAE (offshore Abu Dhabi) the Dammam Formation has been dated to the Middle to Late Eocene. In the present study area it consists of three members, from base to top as follows: the Wadi Al Nahyan and Ain Al Faydah members, both of Middle Eocene age, and the Mazyad Member of Late Eocene age as in (text-fig. 2).

The Mazyad Member of the Damam Formation in the UAE–Oman border area is the topic of this contribution. The base of the Mazyad Member is unexposed in any of the studied stratigraphic sections. The top of the member is characterized by hard, thin-bedded, bioclastic nummulitic limestones, rich in larger foraminifera (plate 7). The exposed thicknesses of the Mazyad Member in the studied sections are as follows: 194m thick in the Jabal Qatar section, 94m thick in the Jabal Malaqet section, 64m thick in the Jabal Hafit section and 18m thick at the base of slope of the western limb of Jabal Buhays Anticline, in the Al Faiyah Range Mountains. The Mazyad Member is recognized for the first time at Jabal Buhays. The biostratigraphic distribution of the identified smaller and larger foraminifera the studied sections is shown in (text-fig.3).

**Faunal Content of the Dammam Formation**

Marl layers in the studied sections are rich in planktonic foraminifera whereas the limestones are rich in larger foraminifera. The *Nummulites fabianii* group is important for defining the Middle/Upper Eocene boundary in the Tethyan province. The evolutionary lineage of this group according to (Herb and Hekel, 1973; 1975; Schaub, 1981; Racey, 1995; Papazzoni, 1998; and Papazzoni and Sirotti, 1995) comprises from (older to younger) *Nummulites ptukhiani*, *N. fabianii*, *N. retiatus*. The present investigations indicates that *N. ptukhiani* co-occurs with *N. fabianii* and that *N. fabianii* extends stratigraphically above *N. retiatus*. We also, note that the rest size of *N. ptukhiani* is larger than that of *N. fabianii*, whereas the size of the protoconch of *N. ptukhiani* overlaps with that of *N. fabianii* (table 1 and text-fig. 4).

The **DISCUSSION**

**Geological age of the Dammam Formation**

Most previous workers have assigned the Damam Formation to the Early to Middle Eocene (Powers et al., 1966; Powers, 1968; and Boukhary, 1985). But some have said it extends into the Upper Eocene.
El-Nakhal (1988) assigned a Middle-Late Eocene age to the Dammam Formation on the basis of the occurrence of Early Eocene planktonic foraminifera in the lower part of the Umm er Radhuma Formation from some wells of the Rub al-Kali described by Hasson (1985), and the estimates of sedimentation rates for shallow water carbonates for the area. The extension of the Dammam into the Late Eocene was confirmed by the presence of Late Eocene planktonic and benthonic foraminifera in the western Desert of Iraq (Al–Hashimi 1980).

As reported by Cherif and El Deeb (1984), Anan et al. (1992), Anan (1995) and Abdelghany (2002), the Upper Eocene Mazyad Member consists of an open marine highly fossiliferous marl alternating with thin-bedded limestone. It is dated as early to middle Late Eocene (Priabonian) on the basis of the *Globigerinatheka semiinvoluta*, *P15* and *Turborotalia cunialensis/Cribrohantkenina inflata* Concurrent Range Zone, P16 (text-fig.6).

**Paleoenvironments**

Larger foraminifera occur in warm waters within the photic zone (Bearington-Penney and Racey, 2004). Hohenegger et al. (1999) reported larger foraminifera living in the upper 50m in front of the fringing reef northwest of Sesoko Island, Japan and recent nummulites species living between 20 and 70m depth of the water. A pronounced eustatic sea level fall occurred at the close of Chron C13r (mid) to Chron C13r (late) (the end of Zone P17, *T. cerroazulensis*) (Haq et al. 1987, Keller et al. 1987). This occurred at about 34.0-33.8 Ma, i.e. latest Eocene (Berggren et al., 1995). This global regression may have been expressed in the study area by sea level fluctuations partly associated with tectonic disturbances (uplifting and subsidence or responsible for the mountains building). A drop in sea level is consistent with this research, reflecting the deposition of shallow marine limestones rich in echinoids, calcareous algae, miliolids and nummulitids (plates 2-7). This conclusion is in accordance with Cherif et al. (1992) who interpreted a hiatus between the Priabonian and the Lower Oligocene at Jabal Hafit.

**CONCLUSION**

Larger foraminifera recovered from the uppermost part of the Dammam Formation in the United Arab Emirates-Oman border area include assemblages of *Fabiania cassis*, *Silvestriella tetraedra*, *Pellatispira madaraszi*, *Nummulites fabianii*, *N. ptukhiani*, *N. retiatus*, *N. garnieri*, *Discocyclina pratti*, *Asterocyclina asterisca*, *A. pentagonalis* and *A. soladensis*. Most of these species are reported in these strata for the first time especially at Jabal Qatar and the western limb of Jabal Buhays in the Al Faiyah Range Mountains.

These occurrences indicate deposition in warm shallow marine inner shelf environments. Similar conclusions have been reported by Cherif et al.(1992), Anan (1995) Abdelghany (2002) in the United Arab Emirates and by Racey (1992, 1994, 1995, 2001), White (1994), Jones and Racey (1994) and Bearington-Penney and Racey (2004) in Oman. The expansion of shallow-water depositional settings indicated by these occurrences reflect the eustatic sea-level fall at the end of *Turborotalia cerroazulensis*, Zone P17, i.e. about 33.8Ma (Berggren et al. 1995).
TEXT-Figure 5
Correlation between the study area and other localities (based on Al-Hashimi, 1980).

TEXT-Figure 6
Stratigraphic ranges of the Late Eocene foraminiferal index species according to different authors: Globigerinatheka semiinvoluta (— —), Cerbrosphaerina inflata (— — —), Turborotalia cuminensis (—— —) and T. cerroazulensis (— — — —).
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1-2 Turborotalia cunialensis (Toumarkine and Bolli, 1970), Jabal Qatar section, sample 8; 1 dorsal view, x107; 2, ventral view, x98, (from Abdelghany, 2002).

3-6 Cribrhoantkenina inflata (Howe, 1928), Jabal Qatar section, sample 8; 3-5, apertural views; 3, x79; 4, x114; 5, x107; 6, dorsal view, x74, (from Abdelghany, 2002).

7 Globigerinatheka semiinvoluta (Keijzer, 1945), Jabal Hafit section, eastern limb, sample 5, x60 (from Anan et al., 1992).

PLATE 1
PLATE 2

1-3 Fabiania cassis (Oppenheim, 1896).
4-8 Silvestriella tetraedra (Gümbel, 1870).
9-18 Pellatispira madaraszi Hantken, 1876.
1-5 Nummulites fabianii (Prever, 1905); external view, (A-Form).
6-10 Nummulites fabianii (Prever, 1905); equatorial section, (A-Form).
11-12 Nummulites fabianii (Prever, 1905); axial section, (A-Form).
3-4 Nummulites ptukhiani Z. D. KACHARAVA, 1969; 3-equatorial view; 4-axial view, (B-Form).
5-6 Nummulites ptukhiani Z. D. KACHARAVA, 1969; equatorial section, (A-Form).
7-8 Nummulites ptukhiani Z. D. KACHARAVA, 1969; axial section, (A-Form).
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REFERENCES


PLATE 5

1-8 Nummulites retiatus (ROVEDA, 1959); external view.
9-10 Nummulites retiatus (ROVEDA, 1959); equatorial section (B-Form).
11-12 Nummulites retiatus (ROVEDA, 1959); equatorial section, (A-Form).
13-14 Nummulites garnieri De la Harpe in Boussae, 1911; external view.


PLATE 6

1-2 Discocyclina pratti (MICHELIN); 1-equatorial section; 2- axial section.
3-4 Asterocyclina asterisca (GUPPY); external view.
5, 6 Asterocyclina pentagonalis (SCHAFFHAUT); external views.
7 Asterocyclina soladensis CAUDRI, 1975; external view.


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PLATE 7

Field photographs showing the stratigraphic relations and characters of the Dammam Formation in the study area.

1- Interlayer larger foraminiferal limestone and marl of the Dammam Formation, Jabal Qatar.
2-4 Interlayer larger foraminiferal limestone and marl of the Dammam Formation, Jabal Malaqet.
5-6 Interlayer larger foraminiferal limestone and marl of the Dammam Formation, Jabal Haft.
7- Interlayer larger foraminiferal limestone and marl of the Dammam Formation, western limb of Jabal Buways Anticline, Al Faiyah Range Mountains.


