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Ostracods and foraminifera from the Early - Middle Eocene of Qeren Sartaba, Jordan Valley

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ABSTRACT - 23 species of ostracods and 20 species and species groups of planktonic foraminifera from the 80m thick Qeren Sartabasection, central Jordan Valley, are described and illustrated. The material is determined by planktonic foraminiferal biostratigraphy to belong to the latest Early Eocene (upper part of Zone P9) and the early Middle Eocene (Zone Pl0). The palaeoecology is representative of a pelagic marine shelf, with periodic events of shallowing and hardground formation.

INTRODUCTION AND GEOLOGICAL SETTING

The Eocene section in the Qeren Sartaba region, central Jordan Valley, eastern Samaria (Fig.1) was mapped and described by Benjamini (1973). This marine sequence is characterized by chalk, chert and limestone lithologies. Shallow water limestones with larger foraminifera interfinger with more pelagic, chalky lithofacies in a complex pattern, but generally trending towards pelagic predominance southwards. Part of the palaeotopography of the Eocene substrate was derived from Cretaceous tectonics (Mimran, 1984), but much resulted from intra-Eocene folding and normal faulting. Two important angular unconformities, in the late Early Eocene and the mid-Middle Eocene part of the section, are tangible evidence of this structural activity. Biostratigraphic dating of the sedimentary and structural events was by planktonic foraminifera from the chalky facies, and this material has to date not been published.

The Sartaba Member of the Matred Formation (note: lithostratigraphic nomenclature in this area is tentative and unpublished, following broadly names used in the northern Negev, southern Israel) contains an important chalk horizon with a rich assemblage of planktonic foraminifera and ostracods, characteristic of the Early - Middle Eocene transition. The section described here is located at coordinates 1937/1668 (Israeli grid), a few hundred metres south of the archaeological site of Qeren Sartaba. An additional section, approximately one kilometre west of the Sartaba section at Δ 278 (coordinates 1925/1666). The location of these sections is shown in Fig.1. Samples from the chalky horizons were taken approximately every three metres.

The Sartaba Member at the Qeren Sartaba section is 80m thick, and consists of chalk and fine-grained limestone (Fig.2). The formation commences with the first chalk above the limestone Masua Member, and rapidly becomes a massive chalk, punctuated by some limestone hardgrounds. There is some limonite staining. At the interval from 50-65m, round nodules containing barite are present in the chalk. At 65m above the base, fine-grained limestone with chalky interbeds again predominates, and the section is truncated by an angular unconformity at 80m. At the location at Δ 278, the section is 11Om thick, with the additional section attributable to less truncation beneath the unconformity, as the lower subunits are identical with those of the Qeren Sartaba section.

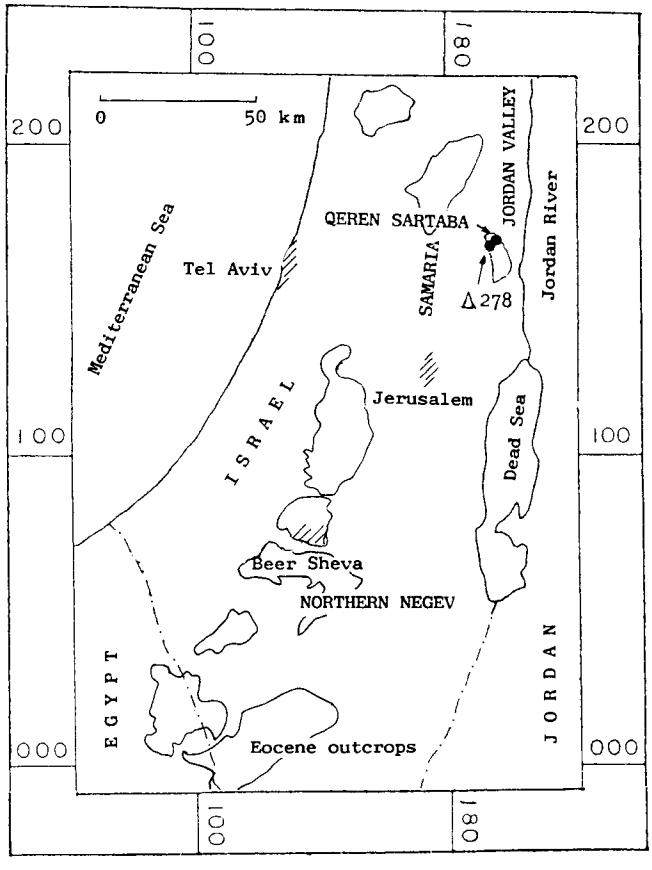


Figure 1. Location

Rare macrofossils in the chalk include small, branching (probably ahermatypic) hexacorals, a scaphopod, lucinid and cardiid bivalves, a cerithiid gastropod, and teeth of *Lamna*. Thin sections show the chalky facies to be a pelagic biomicrite, with abundant planktonic foraminifera and rare radiolarians. Phosphatic fragments are not uncommon. The limestone horizons

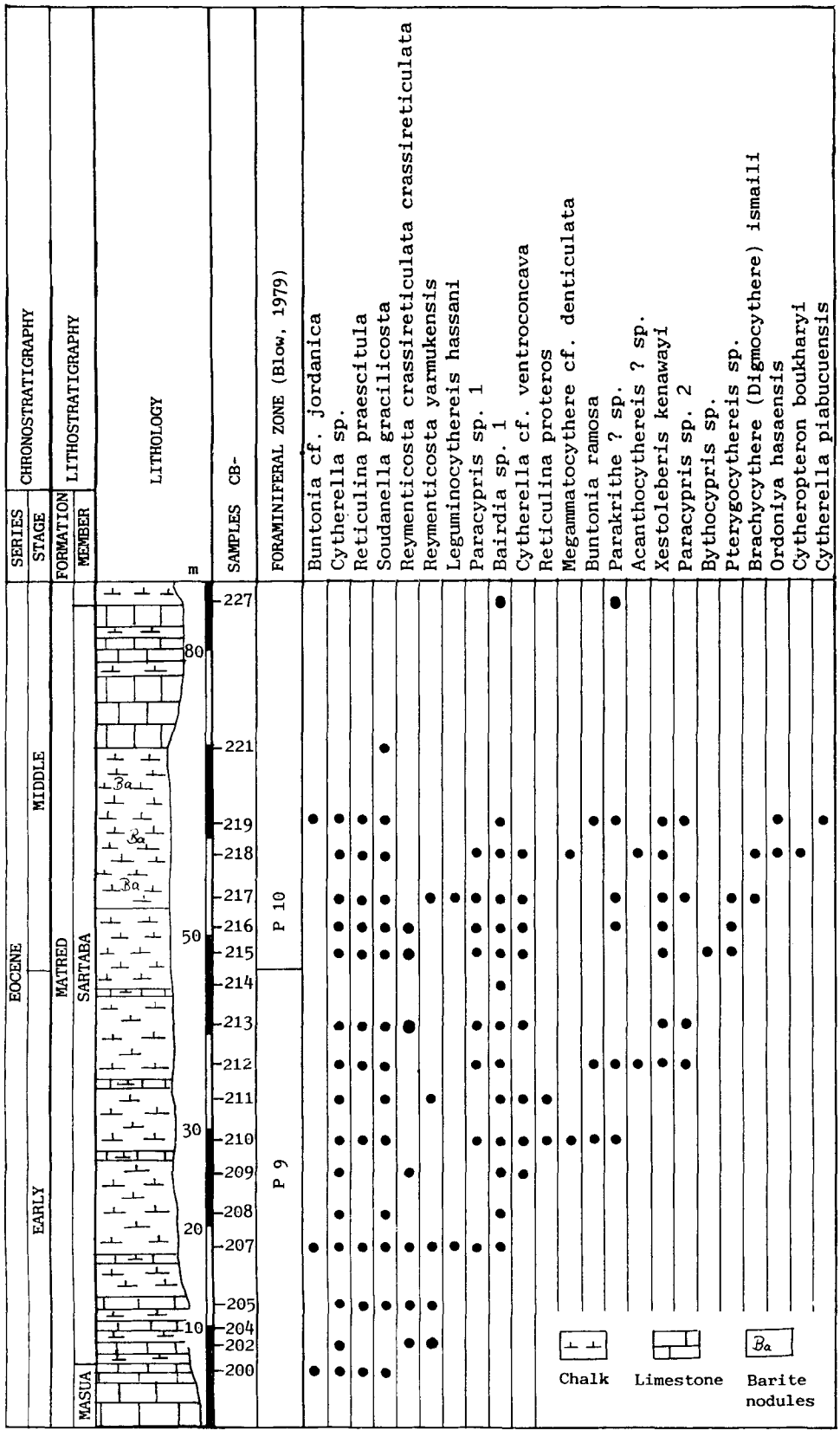


Fig. 2. Distribution chart of ostracods of the Early - Middle Eocene section at Qeren Sartaba, Jordan Valley.

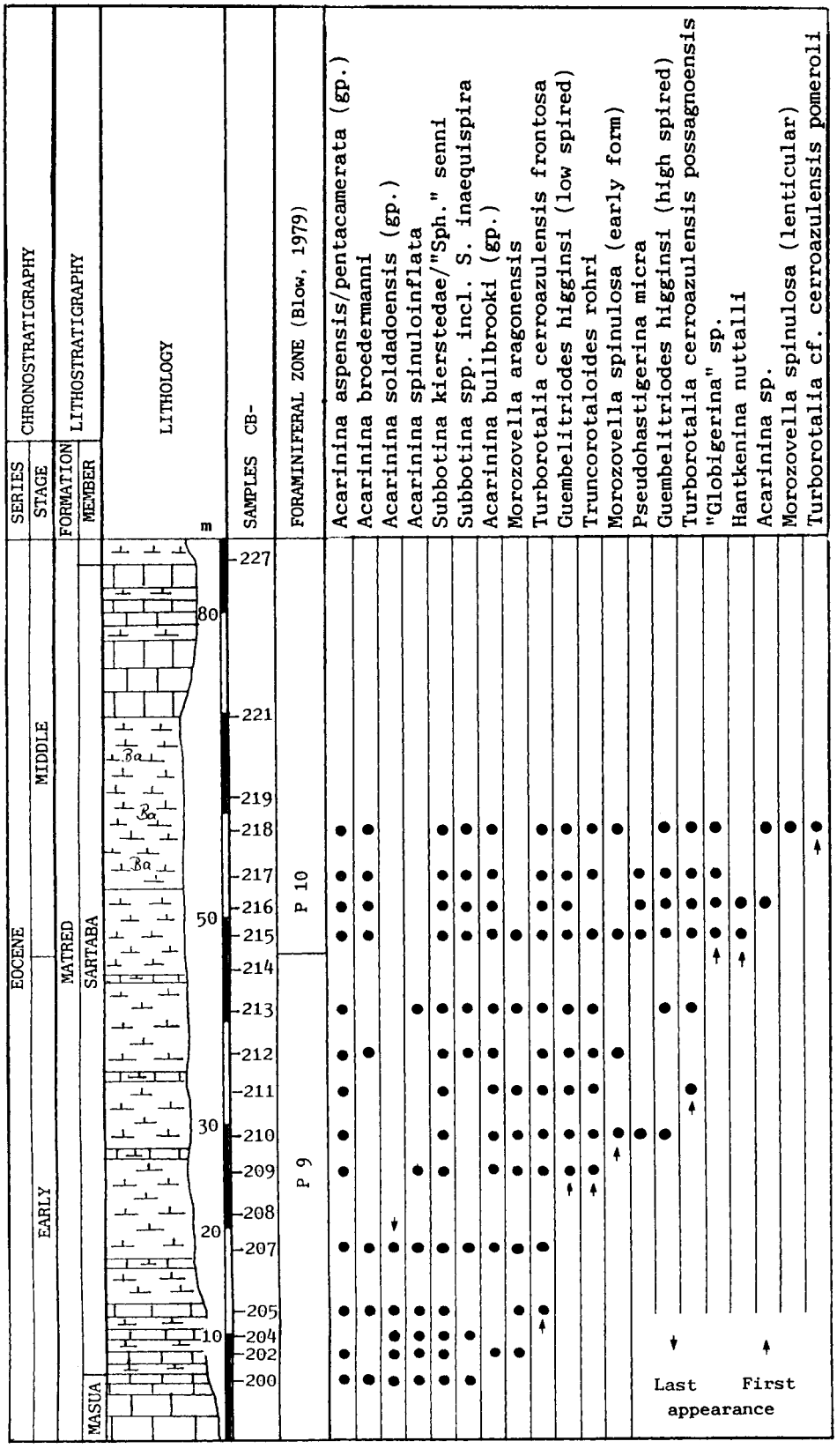


Fig. 3. Distribution chart of planktonic foraminifera of the Early - Middle Eocene section at Qeren Sartaba, Jordan Valley.

are mostly similar, but with more evidence of bioturbation and thus probably indurated hardgrounds of the chalky facies. *Ammobaculites* sp. is common in the hardgrounds. At location Δ 278, a hardground horizon at 35m is colonized by a nummulitic fauna, echinid and bryozoan debris, and rhodophyceans. This fauna was not recovered from hardgrounds at this level at the Sartaba section. The limestones at the top of the Sartaba Member contain, in addition to bioturbated pelagic material, transported fragments of rotaliid larger foraminifera, foretelling a significant shallowing trend. No clastics were found in thin sections.

The palaeoenvironmental interpretation based also on field and petrographic studies is a deep neritic, subphotic shelf dominated by pelagic facies, interrupted at intervals by hardground formation. At least one of these bears evidence locally of shallowing into the photic zone. Water depths of 50-1 50m, of normal salinity, and relatively warm temperatures are thus indicated.

In this paper we describe an ostracod and foraminiferal faunule found at the Qeren Sartaba section.

OSTRACODS

(A. Honigstein & A. Rosenfeld)

Eocene ostracods from Israel have not yet been described. However, Middle and Late Eocene ostracods from Jordan and Egypt were reported by Bassiouni (1969a, 1969b, 1969c, 1969d, 1971a, 1971b), Khalifa & Cronin (1978), Cronin & Khalifa (1979), Boukhary *et al.* (1982b) and Bassiouni *et al.* (1982). Palaeocene to Early Eocene ostracods were described from Tunisia (Esker, 1968; Donze *et al.*, 1982), Libya (Salahi, 1966), Egypt (Boukhary *et al.*, 1982a; Bassiouni & Luger, 1990) and Saudi Arabia (Al-Furaih, 1983). A Ph.D. thesis on Eocene ostracods from Egypt is currently being carried out by Ismail A. under the superivision of J. Szczechura, Institute of Paleobiology, Polish Academy of Sciences, Warszaw. Information from this thesis was also used for comparison with our material.

Common to abundant ostracod faunas were found in the Sartaba Member at Qeren Sartaba in nearly all samples of the lower and middle part of the Sartaba Member (CB200 -219). Richest in ostracods are the samples CB 215 - 218 from the middle part of the section. The ostracods are figured on Pls 1-2, and their distribution is given on Fig.2.

TAXONOMY

All the examined and described ostracods are deposited in the collection of the Geological Survey of Israel. The abbreviations l, h, w in this chapter refer to length, height and width of the representative types and M, F to male and female specimens, respectively.

Genus *Bairdia* M'Coy, 1844

Bairdia sp. 1
(Pl. 1, fig. 2)

1978 *Bairdia* sp. 1, Khalifa & Cronin: 174, pl.1, fig.9.

Material. About 140 carapaces and valves from the whole section.

Dimensions (mm).	l	h	w
	1.25	0.80	0.64
	1.10	0.70	0.60
	1.08	0.68	0.59

Remarks. A typical species of the genus *Bairdia*, reported also from the Middle Eocene of Egypt (Khalifa & Cronin, 1978). The surface of the carapace is entirely covered with small and dense pits. The eye-spot is oval and weakly developed. The valves are denticulated antero- and posteroventrally. Our specimens resemble in these features the figured type of *Bairdia ilaroensis* Reyment & Reyment, 1959 in Bassiouni & Luger (1990, p.780, pl.1, fig.15; Maastrichtian - Early Eocene of Egypt).

Genus *Cytherella* Jones, 1849

Cytherella cf. *ventroconcava* Neale & Singh, 1985
(Pl. 1, fig. 1)

cf. 1985 *Cytherella ventroconcava* Neale & Singh: 364, pl.41, figs 10-12.

Material. 45 carapaces and valves mostly from the middle part of the Sartaba Member.

Dimensions (mm).	l	h	w
	0.82	0.47	0.38
	0.85	0.51	0.44
	0.82	0.47	0.36

Remarks. Our specimens with their concave ventral margin are very similar to those of Neal & Singh (1985; Middle Eocene of Assam, India), but are definitely larger.

Cytherella piacabucuensis Neufville, 1973
(Pl. 1, fig. 3)

1973 *Cytherella piacabucuensis* Neufville: 137, pl.1, figs 3a-d.
?1978 *Cytherella* sp.1, Khalifa & Cronin: 173, pl.1, fig.1.
1990 *Cytherella piacabucuensis* Neufville, Bassiouni & Luger: 777, pl.1. figs 7-8, 10-11.

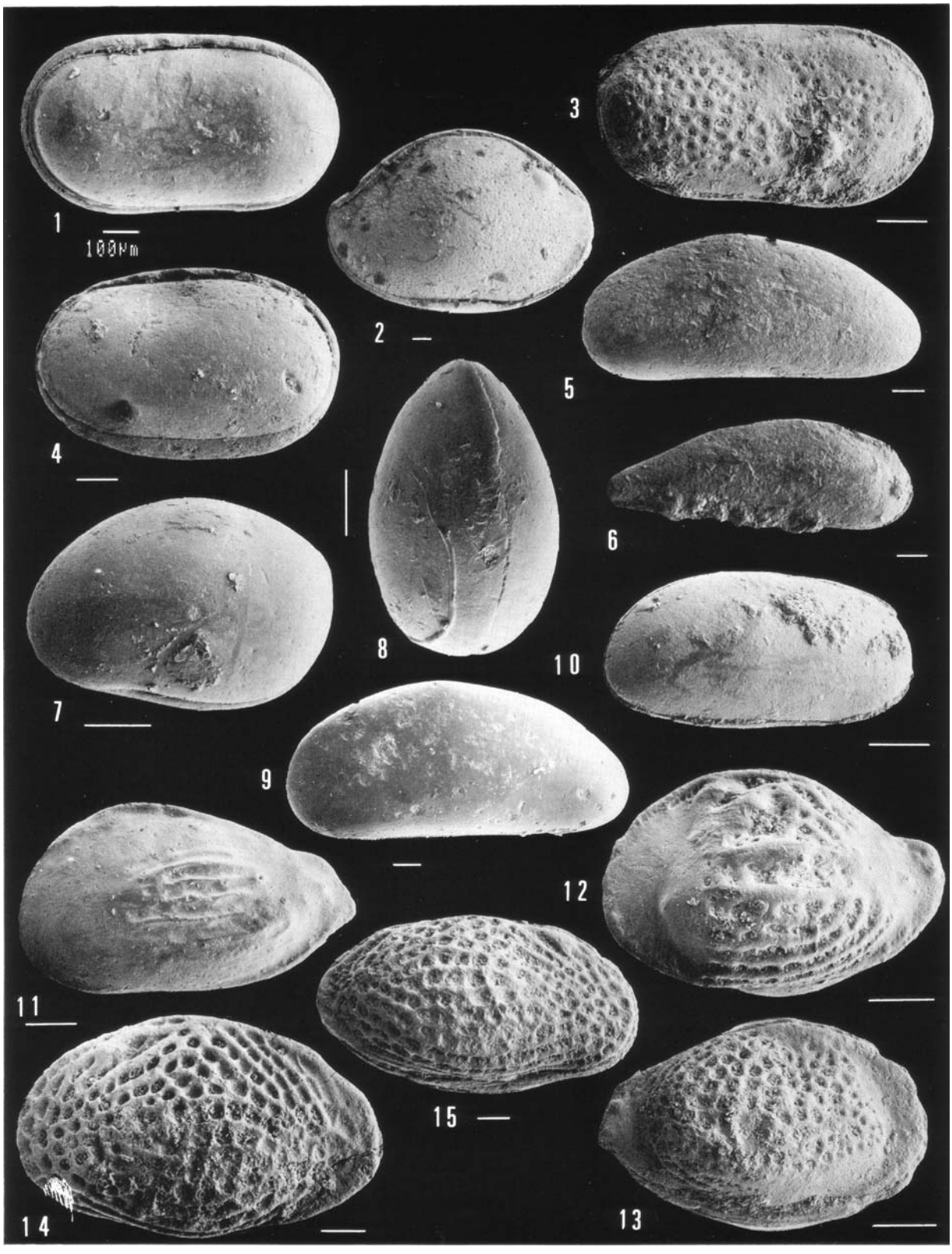
Material. Two carapaces from the sample CB 219.

Dimensions (mm).	l	h	w
	0.61	0.32	0.24

Remarks. *Cytherella piacabucuensis* Neufville, 1973 was hitherto described in our region from Egypt (Bassiouni & Luger,

Explanation of Plate 1

Fig.1. *Cytherella* cf. *ventroconcava* Neale & Singh, left valve, CB 213.
Fig.2. *Bairdia* sp. 1, right valve, CB 210.
Fig.3. *Cytherella piacabucuensis* Neufville, right valve, CB 219.
Fig.4. *Cytherella* sp., left valve, CB 200.
Fig.5. *Paracypris* sp. 1, left valve, CB 217.
Fig.6. *Paracypris* sp. 2, right valve, CB 212.
Fig.7. *Xestoleberis kenawayi* Khalifa & Cronin, left valve, CB 217.
Fig.8. *Xestoleberis kenawayi* Khalifa & Cronin, dorsal view, CB 215.
Fig.9. *Bythocypris sp.*, left valve, CB 215.
Fig.10. *Parakrithe? sp.*, right valve, CB 212.
Fig.11. *Soudanella gracilicosta* Bassiouni, left valve, CB 211.
Fig.12. *Buntonia ramosa* Bassiouni, left valve, CB 219.
Fig.13. *Buntonia* cf. *jordanica* Bassiouni, right valve, CB 200.
Fig.14. *Leguminocythereis hassani* Khalifa & Cronin, left valve, CB 207.
Fig.15. *Leguminocythereis hassani* Khalifa & Cronin, right valve, CB 217.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1990; Middle Paleocene - Early Eocene; Khalifa & Cronin, 1978; Middle Eocene; Ismail A. and Szczechura, pers. comm., 1989; Middle Eocene).

Cytherella sp.
(Pl. 1, fig. 4)

Material. About 130 carapaces and valves throughout the whole section.

Dimensions (mm).	l	h	w
	0.71	0.45	0.35
	0.81	0.51	0.37

Remarks. These common species of *Cytherella* exhibit no diagnostic features.

Genus *Paracypris* Sars, 1866

Paracypris sp.1
(Pl. 1, fig. 5)

Material. 35 carapaces from the whole section.

Dimensions (mm).	I	h	w
	0.94	0.40	0.38
	0.81	0.34	0.33
	0.90	0.39	0.40

Remarks. *Paracypris* sp. 1 possesses a rounded posterior end.

Paracypris sp.2
(Pl. 1, fig. 6)

Material. 6 carapaces from the middle part of the section

Dimensions (mm).	l	h	w
	0.90	0.26	0.26

Remarks. The posterior end of this species is pointed, terminating ventrally and differs mainly herein from *Paracypris* sp.1.

Genus *Bythocypris* Brady, 1880

Bythocypris sp l.
(Pl. 1, fig. 9)

Material. 2 carapaces from the middle part of the section

Dimensions (mm).	l	h	w
	1.20	0.50	0.45

Remarks. A very large species of *Bythocypris* with rounded posterior and anterior ends.

Genus *Parakrithe* Bold, 1958

Parakrithe? sp.
(Pl. 1, fig. 10)

Material. 15 carapaces from the middle and upper parts of the section.

Dimensions (mm).	l	h	w
	0.51	0.28	0.21
	0.51	0.25	0.22
	0.54	0.25	0.23

Remarks. The generic position of these specimens as species of *Parakrithe* must remain open, until single valves will be found and their marginal pore canals can be examined. The broadly rounded posterior end is characteristic for the small carapaces of *Parakrithe*? sp. Similar types of *Parakrithe* are also commonly found in Late Paleocene - Middle Eocene strata of Egypt (Cronin & Khalifa, 1979; Bassiouni & Luger, 1990; Ismail A. and Szczechura, pers. comm., 1989).

Genus *Xestoleberis* Sars, 1866

Xestoleberis kenawayi Khalifa & Cronin, 1978
(Pl. 1, figs 7-8)

1978 *Xestoleberis kenawayi* Khalifa & Cronin: 181, pl. 1, figs 7-8

Material. About 180 valves and carapaces from the middle part of the section, abundant in samples CB 215 - CB 218.

Dimensions (mm).	l	h	w
	0.44	0.32	0.30
	0.45	0.30	0.32
	0.42	0.30	0.31

Remarks. This small form of *Xestoleberis* possesses a rounded anterior end, pointed ventrally, and shows an angular posterodorsal margin. The posterior margin is only slightly rounded to truncated. *Xestoleberis kenawayi was* described originally from the Middle Eocene sediments of Egypt (Khalifa & Cronin, 1978). It differs from other Middle Eocene species of this genus mainly by its less rounded posterior end (X. *subglubosa* (Bosquet), 1852 in Boukhary *et al.*, 1982b, pl.2, fig.11; and in Bassiouni et *al.*, 1984, p.186, pl.2, fig.8). Our specimens *are* also very similar to X. *kiseibaensis* Bassiouni & Luger, 1990 (p.848, pl.25, figs 8-12; Maastrichtian - Early Eocene of Egypt), but exhibits a less convex dorsal margin.

Genus *Soudanella* Apostolescu, 1961

Soudanella gracilicosta Bassiouni, 1969
(Pl. 1, fig. 11)

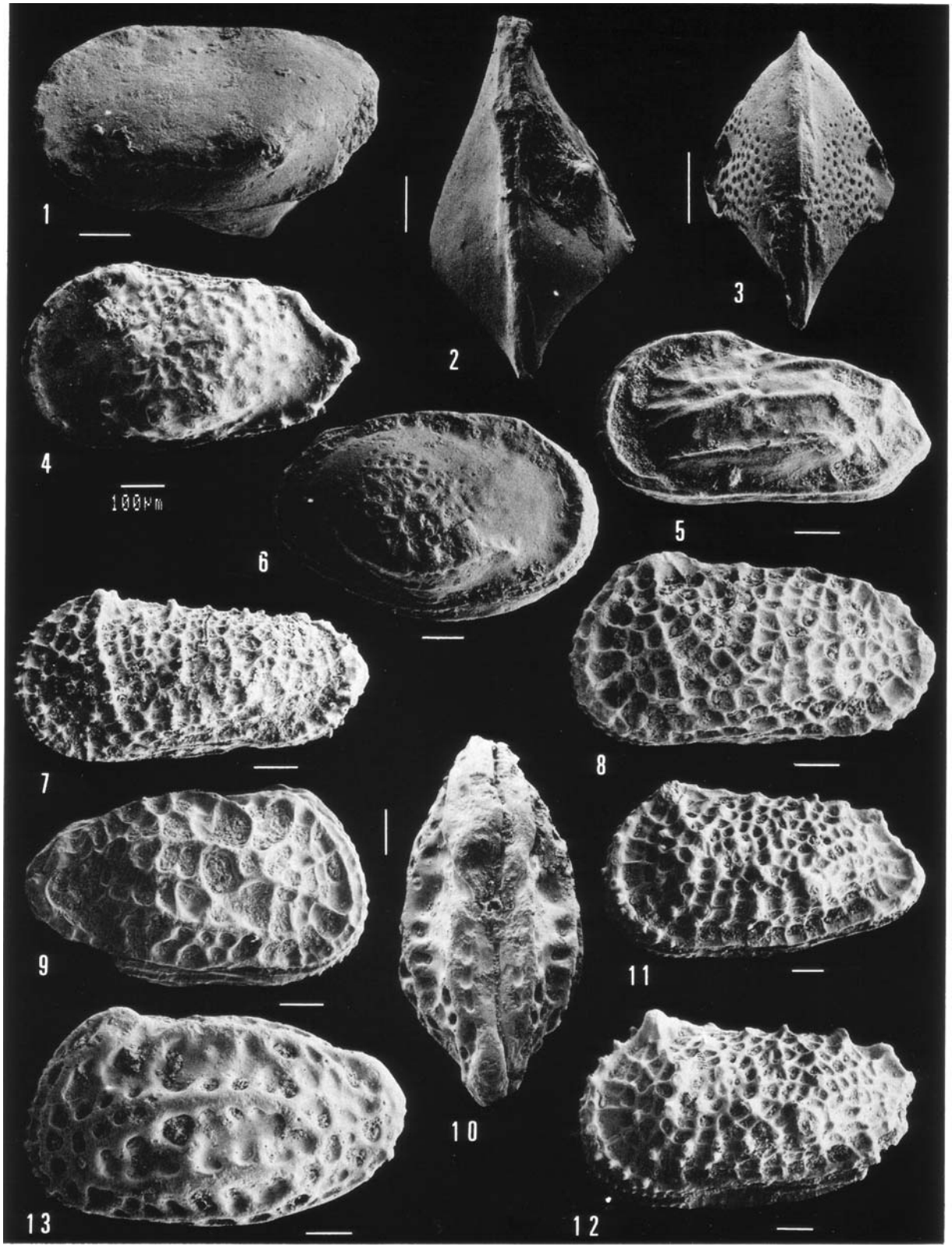
1969 *Soudanella gracilicosta* Bassiouni (1969a): 210, pl.24, figs 9-10; pl.25, figs 5-8.

Material. 55 carapaces and valves throughout the section.

Dimensions (mm).	l	h	w	
	0.65	0.37	0.32	F
	0.64	0.36	0.32	F

Explanation of Plate 2

Fig. 1. *Pterygocythereis* sp., left valve, CB 217.
Fig. 2. *Pterygocythereis* sp., dorsal view, CB 217.
Fig. 3. *Cytheropteron boukharyi* Khalifa & Cronin, dorsal view, CB 218.
Fig. 4. *Acanthocythereis?* sp., left valve, CB 218.
Fig. 5. *Ordoniya hasaensis* (Bassiouni), left valve, CB 219.
Fig. 6. *Brachycythere (Digmocythere) ismaili* Bassiouni, right valve, CB 217].
Fig. 7. *Reticulina proteros* Bassiouni, left valve, CB 211.
Fig. 8. *Reticulina praescitula* Bassiouni, left~valve, CB 207.
Fig. 9. *Reymenticosta crassireticulata crassireticulata* (Bassiouni), right valve, CB 215.
Fig.10. *Reymenticosta crassireticulata crassireticulata* (Bassiouni), dorsal view, CB 205.
Fig.11. *Megommatocythere* cf. *denticulata* (Esker), left valve, CB 210.
Fig.12. *Megommatocythere* cf. *denticulata* (Esker), left valve, CB 210.
Fig.13. *Reymenticosta yarmukensis* (Bassiouni), left valve, CB 207.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	0.66	0.34	0.26	M

Remarks. Our specimens with their 4-5 ribs in the central area are identical with the type species, described from the Middle-Late Eocene of Jordan (Bassiouni, 1969a). This species exhibits in other sections in Israel a relatively broad stratigraphic range, but is most common here in this Early - Middle Eocene transition interval.

Genus *Buntonia* Howe, 1965

Buntonia ramosa Bassiouni, 1969
(Pl. 1, fig. 12)

1969 *Buntonia ramosa* Bassiouni (1969a): 207, pl.24, figs 1-4

Material. 5 carapaces from the middle part of the section.

Dimensions (mm).	l	h	w	
	0.51	0.33	0.33	F
	0.55	0.34	0.28	M
	0.50	0.31	0.30	F

Remarks. *Buntonia ramosa* occurs in Israel in a similar stratigraphic level as in Jordan (Bassiouni, 1969a; Middle Eocene).

Buntonia cf. *jordanica* Bassiouni, 1969
(Pl. 1, fig. 13)

cf. 1969 *Buntonia jordanica* Bassiouni (1969a): 206, pl.24, figs 5-6); pl.25, figs 1-4

Material. 4 carapaces from the lower and middle part of the section.

Dimensions (mm).	l	h	w	
	0.59	0.30	0.24	M
	0.53	0.30	0.29	F

Remarks. The specimens of *Buntonia* cf. *jordanica* from the Sartaba section are very similar to the type material from Jordan (Bassiouni, 1 969a, Middle Eocene), but are smaller and less regularly reticulated.

Genus *Leguminocythereis* Howe, 1936

Leguminocythereis hassani Khalifa & Cronin, 1978
(Pl.1, figs 14-15)

1978 *Leguminocythereis hassani* Khalifa & Cronin: 178, pl.2, figs 1-2.

Material. 5 carapaces and 1 left valve from the lower and middle part of the Sartaba section

Dimensions (mm).	l	h	w	
	0.81	0.48	0.42	F
	0.76	0.48	0.43	F
	0.92	0.50	0.49	M

Remarks. *Leguminocythereis hassani* with a distinct sexual dimorphism is relatively rare in the Sartaba section, but occurs also in Middle Eocene beds of Egypt (Khalifa & Cronin, 1978).

Genus *Pterygocythereis* Blake, 1933

Pterygocythereis sp.
(Pl. 2, figs 1-2)

Material. 8 carapaces from the middle part of the section.

Dimensions (mm).	l	h	w
	0.63	0.34	0.39
	0.66	0.36	0.34
	0.66	0.35	0.38

Remarks. Our specimens are badly preserved, but show a very faint reticulation. A dorsomedian sulcus exists, the ventral ala is pointed at $^2/_3$ length of the carapace. The posterior end is pointed subdorsally.

Genus *Cytheropteron* Sars, 1866

Cytheropteron boukharyi Khalifa & Cronin, 1978
(Pl. 2, fig. 3)

Material. 1 carapace from sample CB 218.

Dimensions (mm).	I	h	w
	0.45	0.22	0.30

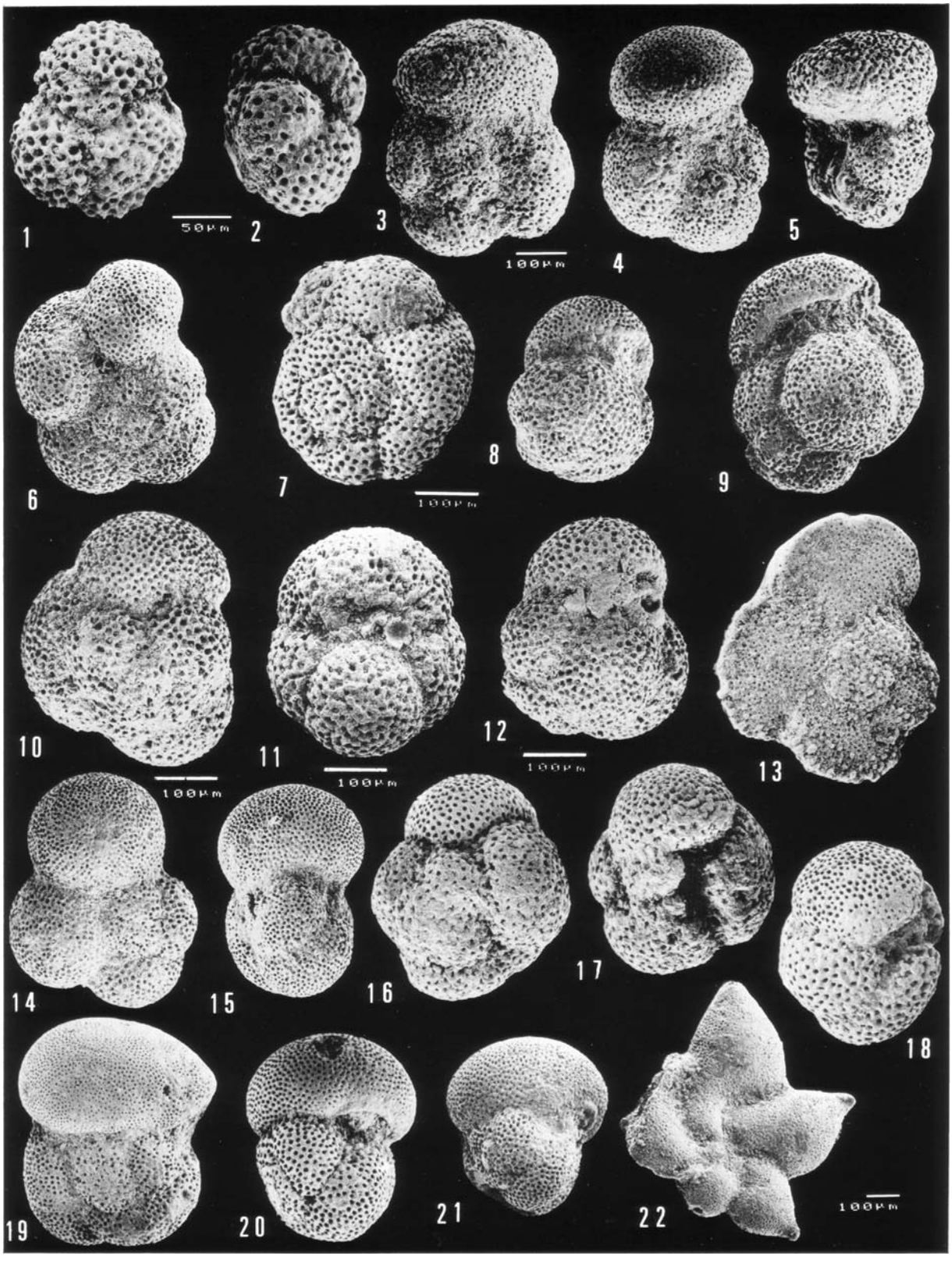
Remarks. The carapace of this species is finely punctated. Our single specimen is smaller than the type-species, described by Khalifa & Cronin (1978) from the Middle Eocene of Egypt.

Genus *Acanthocythereis* Howe, 1963

Explanation of Plate 3

If not otherwise indicated, the scale on Fig. 3 implies for all Figures.

Fig. 1. *Acarinina* sp., spiral view, CB 218 (scale = 50 microns).
Fig. 2. *Acarinina* sp., axial view, CB 218 (scale = 50 microns).
Fig. 3. *Truncorotaloides rohri* Broennimann & Bermudez, spiral view, CB 218 (scale = 100 microns).
Fig. 4. *Truncorotaloides rohri* Broennimann & Bermudez, umbilical view, CB 218.
Fig. 5. *Truncorotaloides rohri* Broennimann & Bermudez, axial view, CB 218.
Fig. 6. *Acarinina aspensis* (Colom), spiral view, CB 218.
Fig. 7. *Acarinina broedermanni* (Cushman & Bermudez), spiral view, CB 212.
Fig. 8. *Guembelitriodes higginsi* (Bolli) (low spired), axial view, CB 218.
Fig. 9. *Guembelitriodes higginsi* (Bolli) (high spired), axial view, CB 218.
Fig.10. *"Globigerina" sp.* spiral view, CB 218.
Fig. 11. *"Globigerina"* sp., umbilical view, CB 218.
Fig. 12. *"Globigerina"* sp., axial view, CB 218.
Fig. 13. *Morozovella spinulosa* (Cushman) (early form) spiral view, CB 215.
Fig. 14. *Subbotina inaequispira* (Subbotina), spiral view, CB 218.
Fig. 15. *Subbotina inaequispira* (Subbotina), axial view, CB 218.
Fig. 16. *Subbotina kierstedae Fleisher "Sphaeroidinellopsis" senni* (Beckmann), spiral view, CB 211.
Fig. 17. *Subbotina kierstedae Fleisher "Sphaeroidinellopsis" senni* (Beckmann), umbilical view, CB 211.
Fig. 18. *Subbotina kierstedae Fleisher" Sphaeroidinellopsis" senni* (Beckmann), axial view, CB 211.
Fig. 19. *Turbotalia cerroazulensis possagnoensis* (Toumarkine & Bolli), spiral view, CB 218.
Fig. 20. *Turborotalia cerroazulensis possagnoensis* (Toumarkine & Bolli), axial view, CB 211.
Fig. 21. *Turborotalia* cf. *cerroazulensis pomeroli* (Toumarkine & Bolli), axial view, CB 218.
Fig. 22. *Hantkenina nuttalli* Toumarkine, lateral view, CB 215.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Acanthocythereis? sp.
(Pl. 2, fig. 4)

Material. 3 carapaces from CB 212 and CB 218.

Dimensions (mm).	l	h	w
	0.80	0.42	0.33
	0.80	0.42	0.37

Remarks. The rare occurrence of this species in the Sartaba section and the lack of information of its internal features do not allow its final definition as a probably new species of the genus *Acanthocythereis*. The specimens are finely reticulated, mostly in their central area, and possess low tubercles. The anterior and posterior areas are smooth. A ventral rib is composed of a chain of small nodes.

Genus *Brachycythere* Alexander, 1933
Subgenus *Digmocythere* Mandelstam, 1958

Brachycythere (Digmocythere) ismaili Bassiouni, 1971
(PI. 2, fig. 6)

1971 *Brachycythere (Digmocythere) ismaili* Bassiouni (1971a): 170, pl.7, figs 5-6.
1974 *Brachycythere (Digmocythere) ismaili* Bassiouni, Bassiouni *et al.*: 184, pl.2, figs 1a-c.

Material. 2 carapaces from the middle part of the section.

Dimensions (mm).	l	h	w	
	0.77	0.50	0.42	F

Remarks. This species shows a prominent ventrolateral convexed ventral rib. The central zone is coarsely pitted. A distinct rim is developed anteriorly and dorsally. B. *(D). ismaili* was reported from Egypt from Middle Eocene (Bassiouni *et al.*, 1984) and Late Eocene sediments (Bassiouni, 1971a).

Genus *Ordoniya* Al-Sheikhly, 1985

Ordoniya hasaensis (Bassiouni), 1971
(Pl. 2, fig. 5)

1971 *Hazelina hasaensis* Bassiouni (1971b): 33, pl.5, figs 5-6.

Material. 3 carapaces from the upper part of the Sartaba Member.

Dimensions (mm).	l	h	w
	0.80	0.40	0.32
	0.80	0.41	0.32

Remarks. The size, shape and rib pattern of our specimens agree well with the type-species and justify its definition as *Ordoniya hasaensis*. The range of this species, originally described from the Late Paleocene - Early Eocene of Jordan (Bassiouni, 1971b) is here extended to the early Middle Eocene. This species is found in Egypt in Early Eocene sediments (Ismail A. and Szczechura, pers. comm., 1989).

Genus *Reticulina* Bassiouni, 1969

Reticulina proteros Bassiouni, 1969
(Pl. 2, fig. 7)

1969 *Carinocythereis (Reticulina) scitula proteros* Bassiouni (1 969b): 11, pl.1, fig.8; pl.2, Figs 6, 7.
1982 *Reticulina proteros* Bassiouni, *Donze et al.*: 287, pl.5, figs 7-8
1990 *Reticulina proteros* Bassiouni, Bassiouni & Luger: 836, pl.20, figs 16-21.

Material. 2 carapaces from the upper part of the Sartaba Member

Dimensions (mm).	l	h	w	
	0.85	0.38	0.31	M
	0.38	0.40	0.40	F

Remarks. *Reticulina* with fine reticulation. Many small spines occur on the junction of reticulation ribs. A transversal oblique distinct ridge, mainly built by tubercles, starts from the very prominent eye spot and continues towards the ventral margin. *Reticulina proteros* was hitherto recorded only from Late Paleocene - Early Eocene sediments of Jordan (Bassiouni, 1 969b), Egypt (Bassiouni & Luger, 1990) and Tunisia (Donze *et al.*, 1982). The figured specimens from Tunisia are less spinous than our material.

Reticulina praescitula Bassiouni, 1969
(Pl. 2, fig. 8)

1969 *Carinocythereis (Reticulina) scitula praescitula* Bassiouni (1 969b): 13, pl.2, fig.5.
1969 *Carinocythereis (Reticulina) scitula* ssp., Bassiouni (1969c): 398, pl.26, fig.4.

Material. 80 carapaces and valves from most of the samples of the section.

Dimensions (mm).	l	h	w	
	0.83	0.48	0.40	F
	0.85	0.45	0.40	F
	0.85	0.41	0.34	M

Remarks. *Reticulina praescitula is* similar to *R. proteros,* but differs from it by its less spinous ornamentation, less prominent eye-spot, coarser reticulation and the more developed longitudinal riblets. This species was found in Middle Eocene strata of Jordan (Bassiouni, 1969b) and Egypt (Bassiouni, 1969c; Ismail A. & Szczechura, pers. comm., 1989).

Genus *Reymenticosta* Bassiouni & Luger, 1990

Reymenticosta crassireticulata crassireticulata (Bassiouni), 1969
(Pl. 2, figs 9-10)

1969 *Costa crassireticulata* Bassiouni (1969b): 403, pl.28, figs 2-5.
1979 *Costa bassiounii* Cronin & Khalifa: 402, pl.2, figs *16-18.*
1982 *Costa crassireticulata* Bassiouni, Boukhari *et al.* (1982b): 57, pl.2, figs 6a-b.

Material. 22 carapaces and 3 valves from the lower and middle part of the section.

Dimensions (mm).	l	h	w
	0.80	0.43	0.43
	0.72	0.43	0.36

Remarks. *Costa crassireticulata crassireticuiata* (see Bassiouni *et al.*, 1984) is included hereby in the genus *Reymenticosta* Bassiouni & Luger, 1990 because of its more oval, *Veenia* like outline. This species is also found in the Middle Eocene of Jordan (Bassiouni, 1969b) and Egypt (Cronin & Khalifa, 1979; Boukhary *et al.*, 1982b). The juveniles show a denser reticulation pattern in the anterior area than in the adult forms.

Reymenticosta yarmukensis (Bassiouni), 1969
(Pl. 2, fig. 13)
Costa? yarmukensis Bassiouni (1969c), p.7, pl.2, figs 1-2

Material. 30 carapaces and valves from the lower and middle part

of the section.

Dimensions (mm).	l	h	w
	0.90	0.50	0.48
	0.92	0.48	0.49
	0.90	0.45	0.43
	0.83	0.48	0.45

Remarks. *Reymenticosta yarmukensis* (Bassiouni, 1969c; Middle Eocene of Jordan) is similar to *R. crassireticulata crassireticulata* (Bassiouni, 1969b), but differs from the latter mainly by its broader ribs and coarser reticulation.

Genus *Megommatocythere* Colin & Oertli, 1982 (in Donze et al., 1982)

Megommatocythere cf. *denticulata* (Esker), 1968
(Pl.2, figs 11-12)

cf. 1966 *Acanthocythereis* sp., Salahi: 22, pl.5, fig.27.
cf. 1968 *Acanthocythereis denticulata* Esker: 328, pl.2, figs 6-7; pl.4, fig.1.
cf. *1982 Acanthocythereis? denticulata* Esker, Donze *et al.:293*, pl.11, figs 1-4.
cf. 1990 *Megommatocythere denticulata* (Esker), Bassiouni & Luger: 825, pl.17, fig.7.

Material. 3 carapaces from the middle part of the section.

Dimensions (mm).	l	h	w
	0.87	0.48	0.48
	0.88	0.49	0.49

Remarks. The type species of *Megommatocythere denticulata* from the Paleocene of Tunisia (Esker, 1968), as well as the figured specimen of Salahi (1966) from the Early Eocene of Libya are more spinous than our specimens. Specimens of this species with less prominent and fewer tubercles are reported from the Late Maastrichtian - Paleocene of Tunisia (Donze *et al.*, 1982) and the Paleocene of Egypt (Bassiouni & Luger, 1990) and agree rather well with our material. However, all hitherto described species are definitely larger than *M.* cf. *denticulata*.

PLANKTONIC FORAMINIFERA

(C. Benjamini)

Well-preserved microfaunas were recovered from samples CB 207 - 218, from the middle chalky part of the unit. Chalk from between the limestone interbeds contained recrystallized material from which only benthic foraminifera were recovered. Nomenclature of the planktonic foraminifera follows that of Benjamini (1980), for similar intervals in the northern Negev, and generally, usage in Toumarkine & Luterbacher (1985). Fig.3 shows the distrubution of the planktonic foraminifera in the chalky lithofacies of the Sartaba Member. Some of the species are illustrated on Pl 3.

The following species are common at Qeren Sartaba. Only a brief discussion of special features is here presented. These are included to clarify our biostratigraphic conclusions.

Acarinina aspensis (Colom)/*pentacamerata* (Subbotina) [P1.3, fig.6].

Benjamini (1980) ranged these two forms together. In the Qeren Sartaba material. The *A. aspensis* morphotype is clearly dominant.

Acarinina broedermanni (Cushamn & Bermudez) [P1.3, fig.7].

Acarinina bullbrooki (Bolli) (gp.) [not illustrated].

Several morphotypes are included here, including *A. matthewsae* Blow.

Acarinina soldadoensis (Broennimann) (gp.) [not illustrated]

The last members of this group are found in the lower samples of the interval.

Acarinina spinuloinflata (Bandy) [not illustrated].

Acarinina sp. [P1.3, figs 1-2].

This very small form superficially resembles *A. spinuloinflata,* but the aperture is nearly in a globigerinid position and it is very spinose. It may be more closely related to *A. broedermanni*. It was also found in the Negev.

"Globigerina": sp. [P1.3, figs 10-12]

The affinity of this species is highly problematic. It has a subspherical test, and unlike *"Sphaeroidinellopsis" senni,* has a clearly defined, rather high early trochospire. In that respect its closest affinities are to some *Globigerinatheka,* but does not have an embrancing final chamber or bulla. The spire, test shape, and position of the single aperture strongly suggest affinity with *Globigerinatheka index* (Finlay) (gp.). It cannot be placed there as it lacks the requirements of that genus, but seems to be ancestral to that group.

Guembelitriodes higginsi (Bolli) (high spired) [P1.3, fig.9].

Guembelitriodes higginsi (Bolli) (low spired) [P1.3, fig.8].

Benjamini (1980) demonstrated an evolutionary succession from a *Subbotina* ancestor through a low spired morphotype to the high spire of the end member. Other authors prefer to derive *G. higginsi* from *Globigerina lozanoi* Colom (cf. Toumarkine & Luterbacher, 1985).

Hantkenina nuttalli Toumarkine [P1.3, fig.22].

Morozovella aragonensis (Nuttall) [not illustrated].

Morozovella spinulosa (Cushman) (early form, close to *A. bullbrook;* [P1.3, fig.13].

These are the transitional forms from *A. bullbrook* to *M. spinulosa*. We do not differentiate *M. crassata densa* (Cushman).

Morozovella spinulosa (Cushman) (biconvex) [not illustrated].

Pseudohastigerina micra (Cole) [not illustrated].

Subbotina kierstedae (Fleisher) *I"Sphaeroidinellopsis" senni* (Beckmann) [P1.3, fig.16-18].

The forms present at Qeren Sartaba still have a fairly open umbilicus and do not have the sphaeroidal form of the "S." *senni* end member. The crust is well developed and the form is not a *Subbotina.*

Subbotina inaequispira (Subbotina) [P1.3, figs14-15].

Many variants belonging to the S. *inaequispira* -

"Hastigerina" cf. *bolivinaria "Turborotalia" griffinae* plexus are found at Sartaba.

Truncorotaloides rohri Broennimann & Bermudez [P1.3, figs.3-5].

Turborotalia cerroazulensis frontosa (Subbotina) [not illustrated].

Turborotalia cerroazulensis possagnoensis (Toumarkine & Bolli) [P1.3, figs 19-20].

Turborotalia cf. *cerroazulensis pomeroli* (Toumarkine & Bolli)[P1.3, fig.21].

BIOSTRATIGRAPHIC CORRELATION

The Sartaba Member of the Matred Formation at Qeren Sartaba spans the Early - Middle Eocene transition. The lower chalk interval of the Sartaba Member may be correlated, therefore, to the Horsha Formation and the base of the Matred Formation (s.s.) of the northern Negev, according to the biostratigraphic scheme of Benjamini (1980). The relevant standard zonal schemes are as follows:

1. The *Sphaeroidinellopsis senni* Zone (latest Early Eocene). Benjamini (1980) erected the *Sphaeroidinellopsis senni* Zone for the upper part of Zone P9 (Blow, 1979) - *pentacamerata* zone (Krasheninnikov, 1965), subsequent to the extinction of *Planorotalites palmerae*. The top of the range of the *Acarinina soldadoensis* group extends into this zone, while the first appearance datum of *Turborotalia cerroazulensis frontosa* is near its base. Samples CB 200 - 214 of the Qeren Sartaba section belong to this zone. Many authors (see discussion in Blow, 1979 and in Toumarkine & Luterbacher, 1985) consider the upper part of this zone to belong to the Middle Eocene, as many Middle Eocene forms develop during this interval, but the presence of *Hantkenina nuttalli* in the Sartaba section, and in the northern Negev in the same interval, clearly defines only the overlying zone as the base of the Middle Eocene.
2. The *Hantkenina nuttalli* Zone (earliest Middle Eocene; Bolli, 1957, subsequently renamed, see discussion in Toumarkine & Luterbacher, 1985). This is the zone P10 of Blow (1979). The nominate species defines the base of the Middle Eocene. This zone extends to the first appearance of *Globigerinatheka subconglobata subconglobata*. The latter does not appear in the Qeren Sartaba material, but is common in the northern Negev in somewhat younger strata. We therefore conclude that samples CB 215 - 218 of the Qeren Sartaba section belong to the *H. nuttalli* Zone. The uppermost sample contains a form close to *Turborotalia cerroazulensis pomeroli*, indicating proximity to the overlying zone.

CONCLUSIONS

All 23 ostracod species, which occur in the Sartaba section, are known from the literature and are described from the Middle East, defining an Early - Middle Eocene age for these strata. Eight of them belong mostly to smooth and stratigraphically not important species and are left in open nomenclature. The Sartaba Member of the Matred Formation at Qeren Sartaba cannot be subdivided by means of ostracods. *Reticulina praescitula, Bairdia* sp.1, *Cytherella* cf. *ventroconcava, Xestoleberis kenawayi* and *Soudanella gracilicosta* are the most common ostracod species in this section.

The sometimes abundant occurrence of euryhaline inner to outer shelf specimens of *Xestoleberis kenawayi* in the middle part of the section points to a shallowing event within an otherwise normal marine outer shelf environment during the deposition of most of the section. The planktonic foraminifera present at Qeren Sartaba clearly place this section across the Early - Middle Eocene transition, based on the first appearance of *Hantkenina nuttalli*. The upprmost horizons which could be clearly dated are placed at the top of Zone P10. Benthic foraminifera of Midwayan aspect place water depths at outer shelf, 50 - 150m deep. Hardground horizons and sporadic larger benthic foraminifera indicate periodic shallowing to within the shallower parts of this range.

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