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Cenomanian—Turonian ostracods from Gebel Nezzazat, southwestern Sinai, Egypt, with observations on $\partial^{13}C$ values and the Cenomanian/Turonian boundary.

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ABSTRACT — 96 surface samples from the Cenomanian—Turonian succession of Gebel Nezzazat, southwestern Sinai, Egypt were examined for ostracods. 45 species and varieties have been recognised with one new species *?Pterygocythere bisulcata* sp.nov. and four left in open nomenclature. Most species have been recorded in rocks of the same age in the Middle East and North Africa, and some from West Africa, Europe and South America suggesting biogeographic relationships between these regions. Three local ostracod zonal assemblages are established, two in the Cenomanian and one in the Turonian. The ostracods and associated foraminifera and megafossils, suggest a shallow marine environment, sometimes with restricted marine water and in part brackish. The Oceanic Anoxic Event of the Late Cenomanian is recognised on the evidence of $\partial^{13}C$ values; ostracod diversity has a negative relationship to $\partial^{13}C$ values.

INTRODUCTION

This study deals with the systematic examination of Cenomanian—Turonian ostracods from Gebel Nezzazat, southwestern Sinai (Fig. 1). The Cenomanian—Turonian marine exposure is represented herein by three lithostratigraphic units:

Wata Formation (Turonian)
Dolomitic limestone with shale, marl and sandstone intercalation (80m).

Abu Qada Formation (Late Cenomanian)
Shale, marl and limestone intercalation (35m).

Raha Formation (Early Cenomanian)
This is divided into the **Mellaha sand Member**, sandstone with some shale and limestone intercalation (35m), and the **Abu Had Member**, shale, marl and limestone intercalation (32m) overlying the Malha Formation of Early Cretaceous age.

The age determination of these formations is based on the foraminiferal and megafossil content (Shahin 1988). The present study is carried out to complete the picture of the Cenomanian—Turonian ostracods and to shed some light on their habitat and palaeogeographic distribution.

Few studies have been carried out on the Cenomanian—Turonian ostracods of Egypt. Bold (1964) described 33 species from the Cenomanian—Campanian of the Abu Roash area. Colin & El Dakkak (1975) studied the Cenomanian ostracods of Gebel Nezzazat and recorded only 5 species. Boukhary et al. (1977) recorded 10 species from the Cenomanian of northern Galala, Eastern Desert.

The systematics and terminology follow that of the Treatise (Moore, 1961). The abbreviations, L, H, W in the descriptions refer to length, height and width (in μm) respectively. All material is deposited in the Department of Geology, Faculty of Science, Mansoura University, Egypt under the catalogue number SHN.

SYSTEMATIC DESCRIPTIONS

Subclass: Ostracoda Latxreille, 1806
Order: Podocopida Müller, 1894
Suborder: Platycopina Sars, 1866
Family: Cytherellidae Sars, 1866
Genus: *Cytherella* Jones, 1849

Cytherella anteromarginata Babinot, 1980
(Pl. 1, figs 1, 2)

1980 *Cytherella anteromarginata* Babinot: Pl. 1, figs 1-5
Material. 5 carapaces; SHN 100
Horizon. Samples 16, 18, 31 (Cenomanian) and 90 (Late Turonian)
Dimensions. L 460, W 200, H 340
Remarks. This species was recorded from the Early Cenomanian of France (Babinot, 1980).

Cytherella cf. *eosulcata* Colin, 1973
(Pl. 1, figs 3, 4)

Material. 29 well preserved carapaces and 4 right valves; SHN 101
Horizon. Samples 16-31, 56 (Cenomanian) and 90 Late Turonian)
Dimensions. L 720, W 380, H 640
Remarks. *Cytherella eosulcata* was originally described from the Cenomanian of France (Colin, 1973). It was also recorded in the Late Turonian of France (Babinot, 1980). The Egyptian species differs from Colin's by having a thicker carapace and more pointed posterior end. It is distinguished from *Cytherella sulcata* Rosenfeld 1974 by the absence of the characteristic longitudinal sulcus in the right valve.

Cytherella gr. *ovata* (Roemer, 1840)
(Pl. 1, fig. 5)

1840 *Cytherina ovata* Roemer: 104, Pl. 16, Fig. 21
Material. 6 carapaces; SHN 102
Horizon. Samples 16, 18, Early Cenomanian

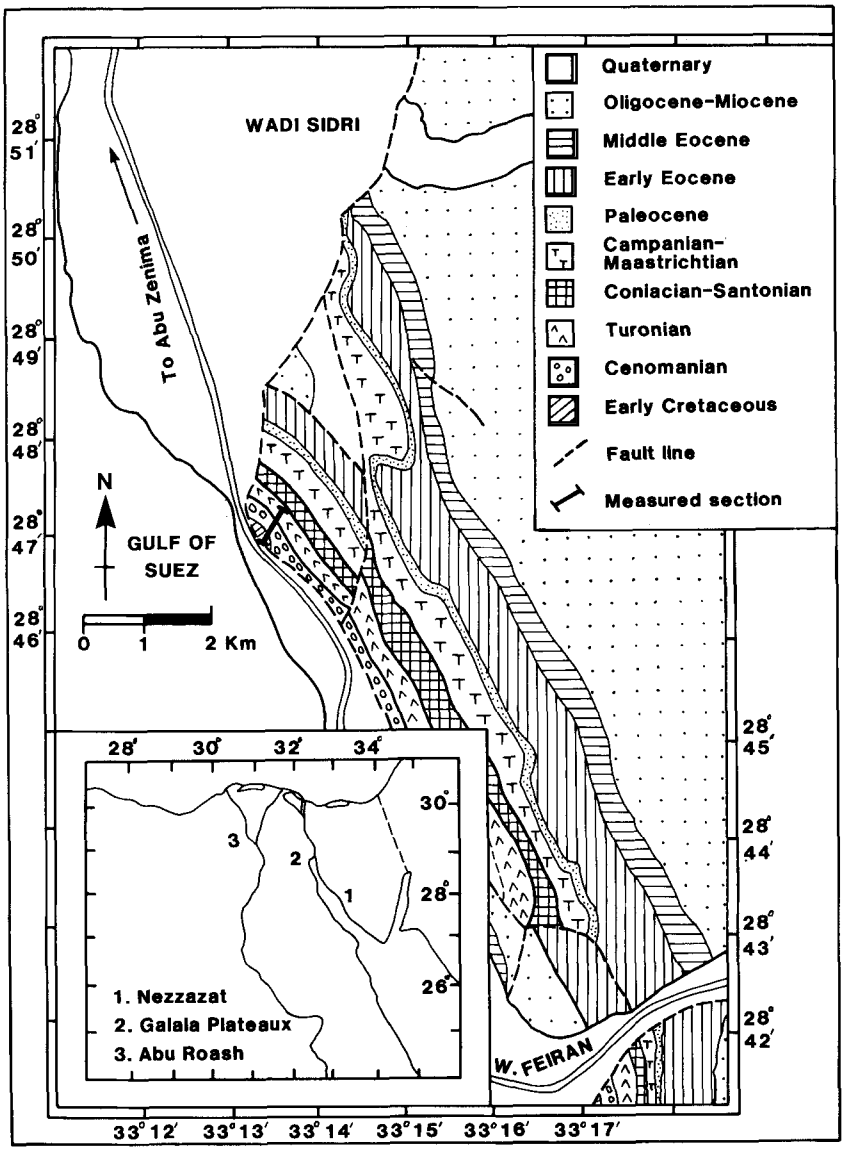


Fig.1.Geological map of Gebel Nezzazat area.

Dimensions. L 440, W 160, H 280
Remarks. This species was first recorded from the Senonian of Germany (Roemer, 1840) and has subsequently been recorded from the Late Cretaceous of many European localities. It is also reported from the Cenomanian—Turonian of Algeria (Bassoullet & Damotte, 1969) and Israel (Rosenfeld & Raab, 1974).

Cytherella cf. *parallela* (Reuss, 1845)
(Pl. 1, figs 6, 7)

1958 *Cytherella* cf. *parallela* (Reuss); Oertli: 1501, Pl. 1, figs 1-9
1974 *Cytherella* cf. *parallela* (Ruess); Rosenfeld & Raab: 3, Pl. 1, figs 1, 2
1980 *Cytherella* cf. *parallela* (Reuss); Babinot: Pl. 2, figs 4, 5
Material. 6 carapaces; SHN 103
Horizon. Samples 31, 47 (Cenomanian) and 90 (Late Turonian)
Dimensions. L 520, W 180, H 260
Remarks. This species was recorded from the Early Cretaceous and Cenomanian to Coniacian of France (Oertli, 1958 and Babinot, 1980) and the Cenomanian—Turonian of Algeria (Bassoullet & Damotte, 1969) and Israel (Rosenfeld & Raab, 1974).

Cytherella postangulata Babinot, 1980
(Pl. 1, figs . 8, 9)

1980 *Cytherella postangulata* Babinot: Pl. 2, figs 6-10
Material. 6 carapaces and some valves; SHN 104
Horizon. Samples 16, 22, 30 and 31, in the Cenomanian
Dimensions. L 560, W 240, H 340
Remarks. This species was recorded from the Cenomanian of France (Babinot, 1980).

Cytherella sulcata Rosenfeld, 1974
(Pl. 1, figs 10, 11)

1959 *Ostracod* U-10 Glintzboekel & Magné: 64, Pl. 3, fig. 31
1969 *Cytherella* U-10 (Glintzboekel & Magné); Grekoff: 233, Pl. 1, fig. 6
1973 *Cytherella* U-10 (Glintzboekel & Magné); Grosdidier: Pl. 1, fig.

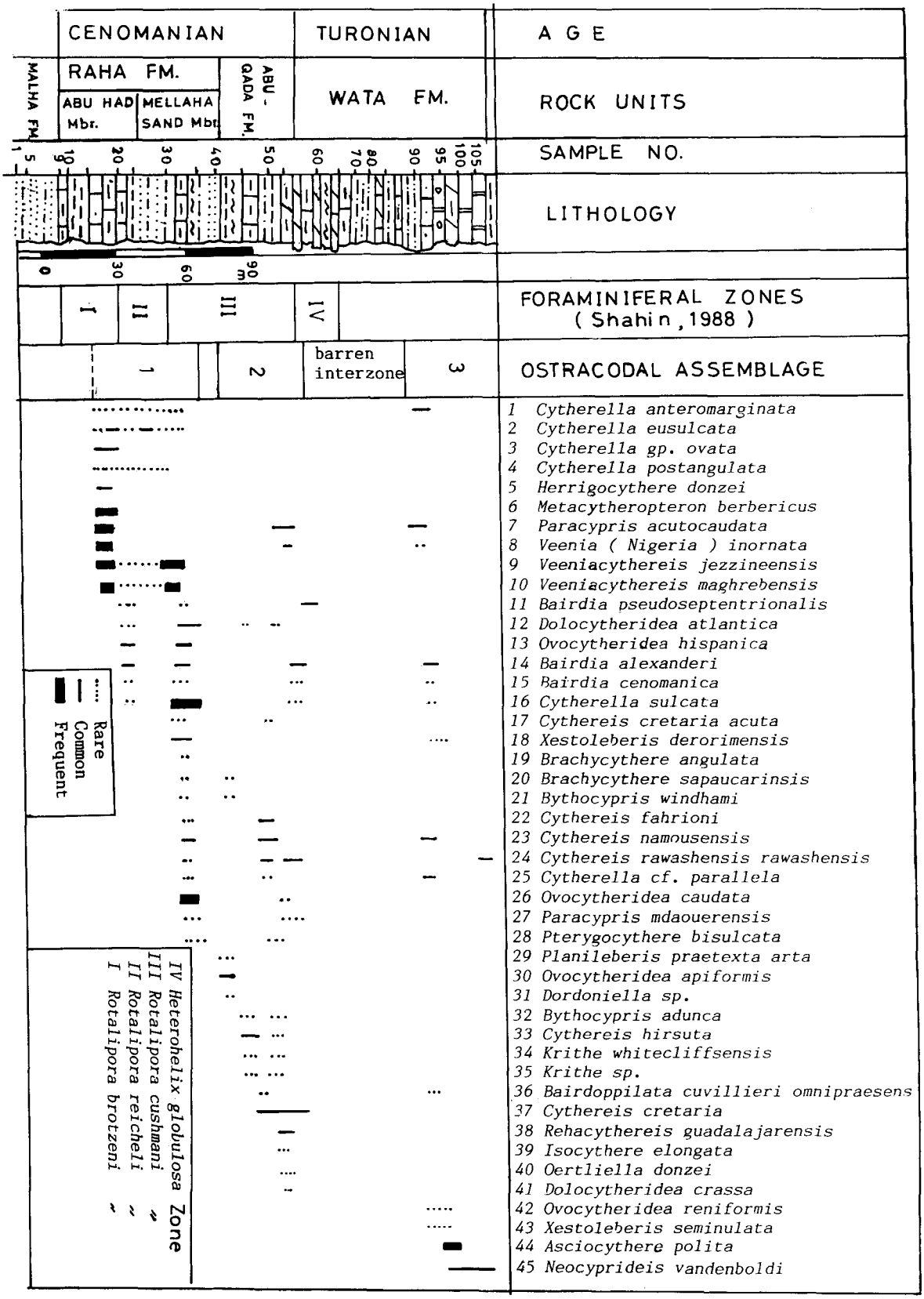


Fig.2. Ostracod range chart and lithostratigraphy of the Cenomanian—Turonian succession in Gebel Nezzazat.

2 a-c
1974 *Cytherella sulcata* Rosenfeld; Rosenfeld & Raab: 5, Pl. 1, figs 6-8; Pl. 4, figs 1-4
1981 *Cytherella sulcata* Rosenfeld; Bismuth *et al.*: 223, Pl. 6, figs 3-4
Material. 15 carapaces; SHN 105
Horizon. Samples 20-56 (Cenomanian) and 90 (Late Turonian)
Dimensions. L 480, W 220, H 300
Remarks. This species is characterized by the presence of a longitudinal sulcus on the right valve of the carapace. It was recorded from the Cenomanian of Israel (Rosenfeld & Raab, 1974), Tunisia (Glintzboekel & Magné, 1959, Grekoff, 1969 and Bismuth *et al.*, 1981) and Iran (Grosdidier, 1973).

Superfamily: Bairdiacea Sars, 1888
Family: Bairdiidae Sars, 1888
Genus: *Bairdia* McCoy, 1844
Bairdia cf. *alexanderi* Blake 1950
(Pl. 1, figs/. 12, 13)
Material. 7 carapaces; SHN 106
Horizon. Samples 20,.31, 56 (Cenomanian) and 90 (Late Turonian)
Dimensions. L 780, W 400, H 480
Remarks. *Bairdia alexanderi* was originally described by Blake (1950) from the Eocene of Alabama. It was also recorded by Swain (1981) from several Atlantic Coast wells. He stated that the Turonian stage in these wells is defined by *Globotruncana helvetica* (Smith *et al.*, 1976) and by *Bairdia alexanderi* Blake. The Egyptian species differs from Blake's specimen in having a less convex dorsal margin.

Bairdia cenomanica Babinot, 1970
(Pl. 1, figs 14, 15)
?1964 *Bairdia* sp.C Bold: 116, Pl. 13, fig. 10
1970 *Bairdia cenomanica* Babinot: 97, Pl. 1, figs 7, 8
1980 *Bairdia cenomanica* Babinot; Babinot: Pl. 3, figs 3-7
1985 *Bairdia* cf. *cenomanica* Babinot; Honigstein & Rosenfeld: 450, Pl. 2, figs/. 1, 2
Material. 9 carapaces; SHN 107
Horizon. Samples 20, 30, 31, 56 (Cenomanian) and 90 (Turonian)
Dimensions. L 540, W 320, H 320
Remarks. This species was recorded from the Early Cenomanian of France (Babinot, 1970, 1980), the Turonian of Spain (Reyment, 1984) and Israel (Honigstein & Rosenfeld, 1985). *Bairdia* sp.C Bold (1964) from the Turonian of Egypt is very similar to this species and could be considered synonymous.

Bairdia pseudoseptentrionalis (Mertens, 1956)
(Pl. 1, figs 16, 17)
1956 *Bairdoppilata pseudoseptentrionalis* Mertens: 182, Pl. 8, figs 7-10, Pl. 13, figs 89-90
1965 *Bairdia pseudoseptentrionalis* (Mertens); Kaye: 223, Pl. 2, figs 3-6
1971 *Bairdia pseudoseptentrionalis* (Mertens); Keen & Siddiqui: 63, Pl. 1, fig. 2
1980 *Bairdia pseudoseptentrionalis* (Mertens); Babinot: Pl. 3, figs 8-12
Material. 18 carapaces; SHN 108
Horizon. Samples 18, 56 (Cenomanian)
Dimensions. L 800, W 380, H 520
Remarks. This species was first described from the Cenomanian of northwest Germany by Mertens (1956) and subsequently recorded from the Albian of England (Kaye, 1965), the Cenomanian of North Ireland (Keen & Siddiqui, 1971) and France (Babinot, 1980).

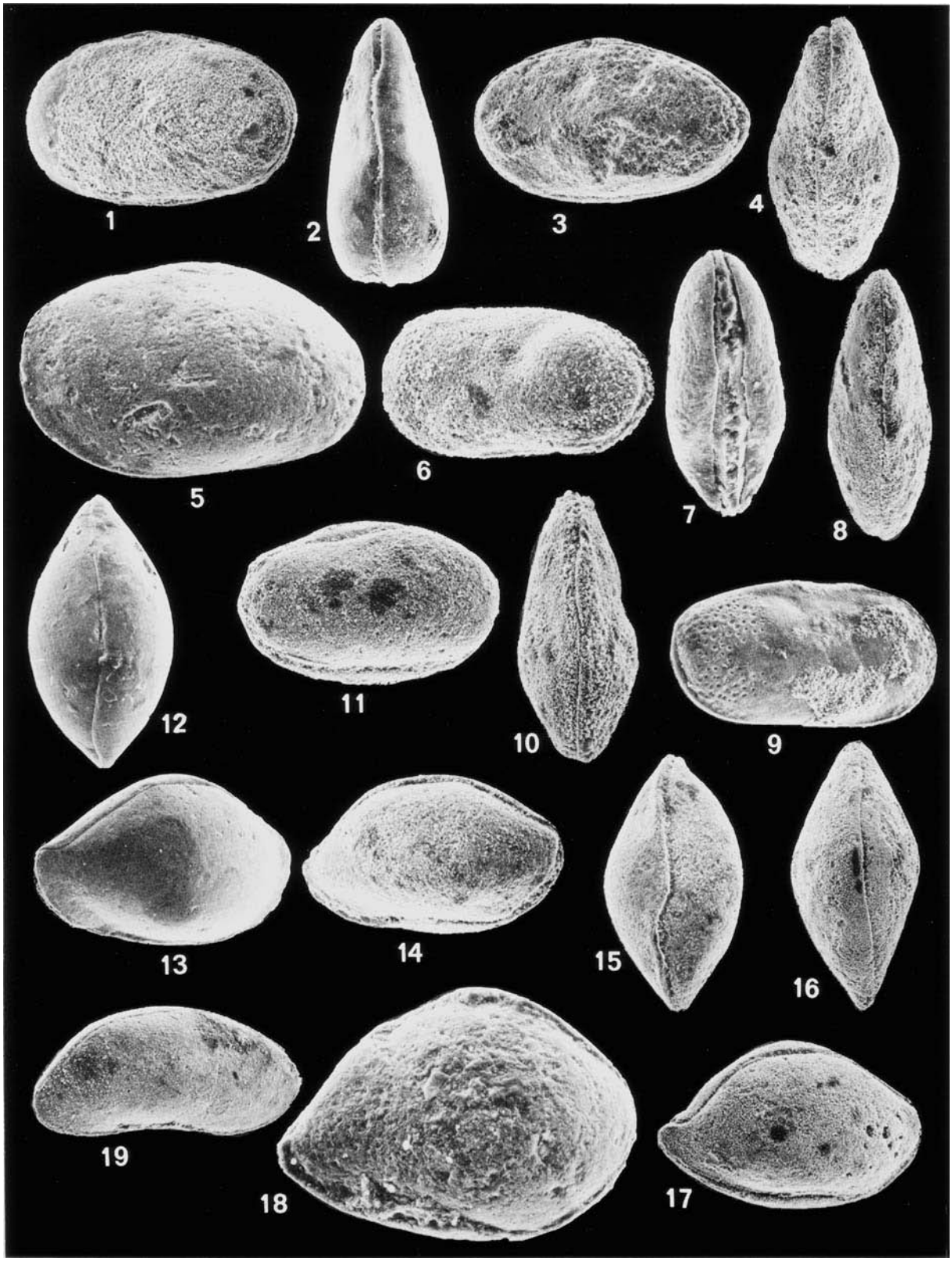
Genus: *Bairdoppilata* Coryell, Sample and Jenning, 1935
Bairdoppilata sp.
(Pl. 1, fig 18)
Diagnosis. This species is characterized by its punctate surface, strongly arched dorsal margin and slightly convex ventral margin
Material. 2 carapaces and 1 deformed valve; SHN 109
Horizon. Samples 46 (Cenomanian) and 90 (Late Turonian)
Dimensions. L 260, W 140, H 160
Remarks. This species is very similar to *Bairdoppilata* sp. of Crane (1965) recorded from the Late Cenomanian of the Gulf Coast area and to that of Breman (1976) recorded from the Early Turonian of central Spain.

Genus: *Bythocypris* Brady, 1880
Bythocypris adunca Esker, 1958
(Pl. 2, fig 1)
1968 *Bythocypris adunca* Esker: 321, Pl. 2, figs 10-12; Pl. 4, fig. 4
1982 *Abyssocypris ? adunca* (Esker); Donze *et al.*: 281, Pl. 2, figs 3-4
Material. 3 carapaces and 2 valves; SHN 110
Horizon. Samples 43-46, 50 (Late Cenomanian)
Dimensions. L 520, W 220, H 160
Remarks. This species was originally described from the Danian of Tunisia (Esker, 1968). It is very similar to *Abyssocypris ? adunca* (Esker) described by Donze *et al.* (1982) from the Maastrichtian of Tunisia.

Bythocypris windhami Butler & Jones, 1957
(Pl. 1, fig. 19)

Explanation of Plate 1.

Figs 1, 2	*Cytherella anteromarginata* Babinot, sample 16, lateral view, x85 and dorsal view, x82 respectively.
Figs 3, 4	*Cytherella* cf. *eosulcata* Colin, samples 16, 18, lateral view, x73 and dorsal view, x60 respectively.
Fig. 5	*Cytherella* gr. *ovata* (Roemer), sample 16, lateral view, x112.
Figs 6, 7	*Cytherella parallela* (Reuss), sample 31, lateral view, x135 and dorsal view, x145 respectively.
Figs 8, 9	*Cytherella postangulata* Babinot, sample 16, lateral view, x87 and dorsal view, x87 respectively.
Figs 10, 11	*Cytherella sulcata* Rosenfeld, sample 20, lateral and dorsal views, x115, 90 respectively.
Figs 12, 13	*Bairdia* cf. *alexanderi* Blake, sample 56, lateral and dorsal views, x82, 47 respectively.
Figs 14, 15	*Bairdia cenomanica* Babinot, sample 31, lateral and dorsal views, x82, 73 respectively.
Figs 16, 17	*Bairdia pseudoseptentrionalis* (Mertens), sample 18, lateral and dorsal views, x 56, 55 respectively.
Fig. 18	*Bairdoppilata* sp. sample 46, x155.
Fig. 19	*Bythocypris windhami* Butler & Jones, sample 31, x66.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1957 *Bythocypris windhami* Butler & Jones: 12-13, Pl. 1, figs a-e
1965 *Bythocypris windhami* Butler & Jones; Crane: 197, Pl. 1, fig. 1
?1974 *Bythocypris* sp.1 Rosenfeld & Raab: 6, Pl. 1, figs 17-18
1984 *Bythocypris windhami* Butler & Jones; Honigstein: 10, Pl. 3, figs 1-3
Material. 3 carapaces; SHN 111
Horizon. Samples 31, 42, (Late Cenomanian)
Dimensions. L 680, W 260, H 320
Remarks. This species was first recorded from the Campanian of Louisiana (Butler and Jones, 1957). It was recorded from the Late Cenomanian of the Gulf Coast area (Crane, 1965), and the Coniacian to Campanian of Israel (Honigstein, 1984). *Bythocypris* sp.1 of Rosenfeld & Raab (1974) is similar to this species except for the prominent angular convexity of the dorsal margin of the former species.

Superfamily: Cypridacea Baird, 1845
Family: Paracyprididae Sars, 1923
Genus: *Paracypris* Sars, 1866
Paracypris acutocaudata Rosenfeld, 1974
(Pl. 2, fig. 2)

1974 *Paracypris acutocaudata* Rosenfeld: 8, Pl. 1, figs 22-24
?1985 *Paracypris* sp. Honigstein & Rosenfeld, 451, Pl. 2, fig. 11
Material. about 40 carapaces; SHN 112
Horizon. Samples 16-56 (Cenomanian), 57 and 90 (Turonian)
Dimensions. L 520, W 220, H 160
Remarks. This species was described from the Late Cenomanian of Israel (Rosenfeld and Raab, 1974). It was also reported from the Cenomanian of the western side of the Gulf of Suez, Egypt (Boukhary *et al.*, 1977). *Paracypris* sp. of Honigstein & Rosenfeld (1985) recorded from the Turonian of Israel is similar to this species. It is distinguished from *Paracypris siliqua* Jones & Hinde (1890) in having a concave ventral margin, and from *P. mdaourensis* Bassoullet & Damotte (1969) by having a more pointed posterior end and concave ventral margin.

Paracypris mdaouerensis Bassoullet & Damotte, 1969
(Pl. 2, figs 2, 3)

1969 *Paracypris mdaouerensis* Bassoullet & Damotte: 140, Pl. 2, fig. 10 a-d
1974 *Paracypris mdaouerensis* Bassoullet & Damotte; Rosenfeld & Raab: 7, Pl. 2, figs./ 29-31
1985 *Paracypris mdaouerensis* Bassoullet & Damotte; Lipson-Benitah *et al.*: 107, Fig. 4g
Material. 9 carapaces and some valves; SHN 113
Horizon. Samples 16-54, (Cenomanian)
Dimensions. L 460, W 240, H 240
Remarks. This species was first described from the Cenomanian and Turonian of Algeria by Bassoullet & Damotte (1969). It occurs in the Cenomanian and Early Turonian of Israel (Rosenfeld & Raab, 1974 and Lipson-Benitah *et al.*, 1985).

Superfamily: Cytheracea Baird, 1850
Family: Brachycytheridae Puri, 1954
Genus: *Brachycythere* Alexander, 1933
Brachycythere angulata Grekoff, 1951
(Pl. 2, fig. 5)

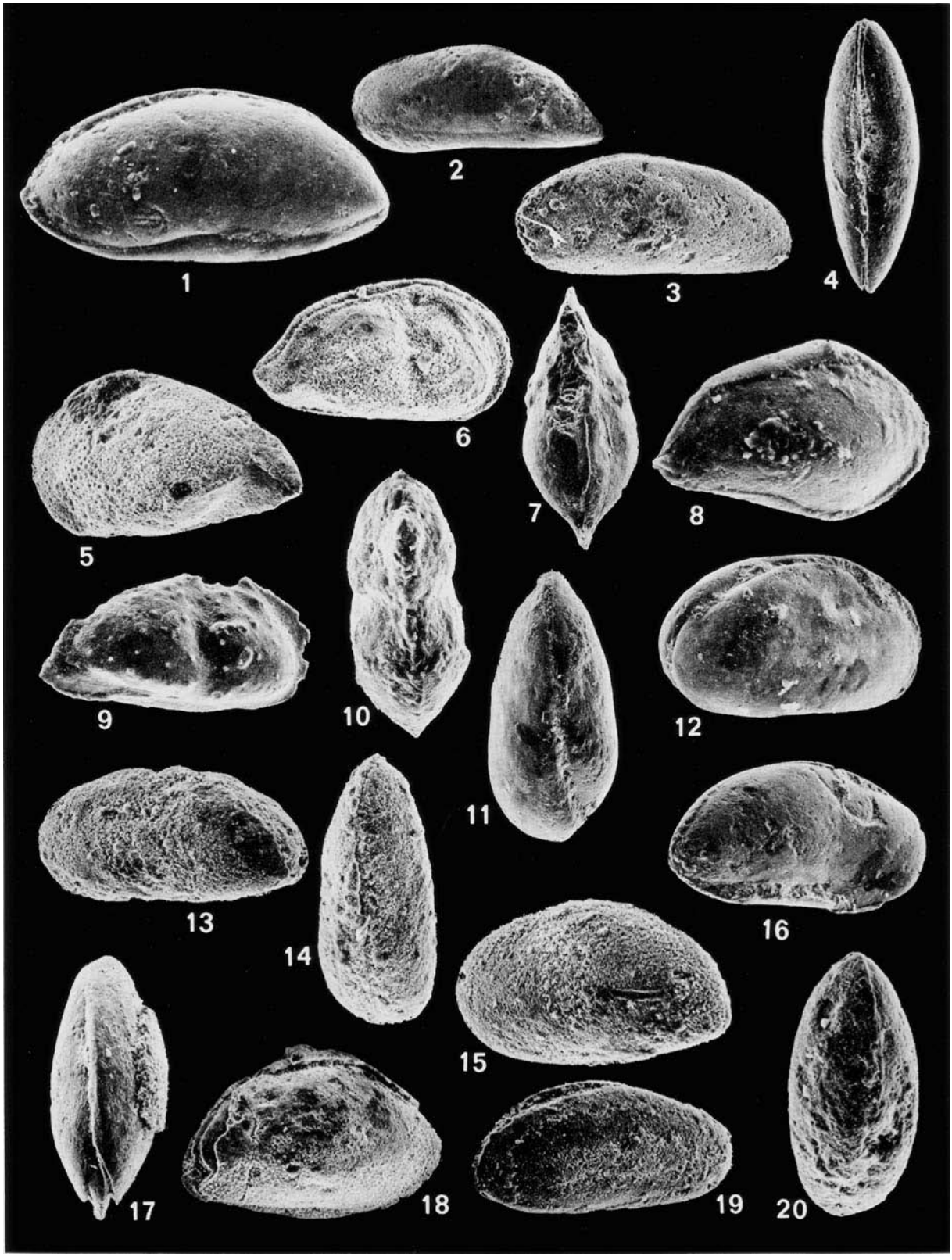
1951 *Brachycythere ledaforma angulata* Grekoff: 28, Pl. 2, figs 11-12
1964 *Brachycythere angulata* Grekoff; Bold:122, Pl. 13, Fig. 15
1984 *Brachycythere angulata* Grekoff; Honigstein: 16, Pl. 5, figs 1-7; Pl. 12, fig. 2
Material. 4 carapaces; SHN 114
Horizon. Samples 31, 50, (Cenomanian)
Dimensions. L 560, W 320, H 320
Remarks. This species was originally described from the Santonian of Cameroun by Grekoff (1951) and subsequently from the Coniacian—Santonian of Algeria (Grekoff, 1969), the Campanian of West Africa (Apostolescu, 1961), the Turonian of Egypt (Bold, 1964), the Santonian of Lebanon (Damotte & Saint-Marc, 1972) and the Senonian of Israel (Honigstein, 1984).

Brachycythere sapaucariensis Krömmelbein, 1964
(Pl. 2, figs 6, 7)

1964 *Brachycythere sapaucariensis* Krömmelbein: 490, Pl. 44, figs 1-5
1981 *Brachycythere sapaucariensis* Krömmelbein; Bismuth *et al.*: 228, Pl. 6, figs 13-16
Material. 4 carapaces - SHN 115
Horizon. Samples 31, 42, in the Late Cenomanian
Dimensions. L 440, W 220, H 240
Remarks. This species was first described from the Early Turonian of Brazil by Krömmelbein (1964) and subsequently from the Coniacian of Gabon (Krömmelbein, 1966). Other occurrences of this species are in the Late Turonian of Tanzania (Bate & Bayliss, 1969), the Cenomanian—Turonian of western Africa (Grosdidier, 1979) and in the Cenomanian of Tunisia (Bismuth et *al.*, 1981).

Explanation of Plate 2.

Fig. 1	*Bythocypris adunca* Esker, sample 46, x135.
Fig. 2	*Paracypris acutocaudata* Rosenfeld, sample 18, x135.
Figs 3, 4	*Paracypris mdaouerensis* Bassoullet & Damotte, sample 31, lateral and dorsal views, x96, 70 repectively.
Fig. 5	*Brachycythere angulata* Grekoff, sample 31, x82.
Figs 6, 7	*Bracycythere sapaucariensis* Krömmelbein, sample 31, lateral and dorsal views, x102, 82 respectively.
Fig. 8	*Dordoniella* sp. sample 42, x185.
Figs 9, 10	*Pterygocythere bisulcata* sp. nov., Holotype samples 31, 34, lateral and dorsal views, x124, 135 respectively.
Figs 11, 12	*Asciocythere* cf. *polita* Damotte, sample 93, lateral and dorsal views, x73.
Figs 13, 14	*Dolocytheridea atlasica* Bassoullet & Damotte, sample 31, lateral and dorsal views, x98.
Fig. 15	*Dolocytheridea crassa* Damotte, sample 50, x140.
Fig. 16	*Ovocytheridea aptiformis* Reyment, sample 31, x70.
Figs 17, 18	*Ovocytheridea caudata* Bold, sample 30, lateral and dorsal views, x73, 65 respectively.
Figs 19, 20	*Ovocytheridea hispanica* Breman, sample 31, lateral and dorsal views, x73, 96 respectively.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Genus: *Dordoniella* Apostolescu, 1955
Dordoniella sp.
(Pl. 2, fig. 8)

Diagnosis. Concave ventral margin and pointed end
Material. 1 carapace - SHN 116
Horizon. Sample 42, Late Cenomanian
Dimensions. L 420, W 100, H 170
Remarks. This is similar to *D. insolita* Babinot (1980, Pl. 8, figs 9-14) but is distinguished from it by having a concave ventral margin and a more pointed posterior end. Due to its rarity, it is left in open nomenclature.

Subfamily: Pterygocythereidinae Puri, 1957
Genus: P*terygocythere* Hill, 1954
Pterygocythere bisulcata sp. nov.
(Pl. 2, figs 9, 10)

Derivation of name. From the sulcus present on each valve, just posterior to the eye spot.
Holotype. - SHN 117, Paratypes- SHN118.
Diagnosis. A species of *Pterygocythere* with triangular shape, compressed anterior and posterior ends, sulcus on both valves and posteroventral alar prolongation.
Description. Carapace triangular, elongate; dorsal margin curved, ventral margin straight, anterior margin rounded with thin margin, posterior margin pointed and caudate, eye spot pronounced, surface slightly tuberculate with sulcus posterior to the eye spot, posteroventral alar prolongation pronounced, maximum width between the central and the posterolateral areas, dorsal view arrow-like.
Material. 6 carapaces, samples 31-50; SHN 118
Type Locality and Horizon. Sample 31, Late Cenomanian, Gebel Nezzazat.
Dimensions. L 460, W 260, H 240
Remarks. This species is similar to *Pterygocythere* sp. of Honigstein (1984) from the Santonian of Israel, but is distinguished from it in having a sulcus on both valves.

Family: Cytherideididae Sars, 1925
Subfamily: Cytherideidinae Sars, 1925
Genus: Asciocyth*ere* Swain, 1952
Asciocythere cf. *polita* Damotte, 1962
(Pl. 2, figs 11, 12)

Material. 16 carapaces; SHN 119
Horizon. Sample 93, (Late Turonian)
Dimensions. L 500, W 280, H 320
Remarks. *Asciocythere polita* was described from the Turonian of France by Damotte (1962) and recorded from the Cenomanian—Turonian of central Spain (Breman, 1976) and the Turonian of France (Babinot, 1980). This species is similar to that of Damotte but differs in having a concave ventral margin and less pointed posterior end. It is also similar to *Ovocytheridea reniformis* Bold in outline and smooth surface. Bold (1964) stated that some species of the genus *Asciocythere* could belong to *Ovocytheridea*. The two genera differ in the structure of the median hinge element.

Genus: *Dolocytheridea* Triebel, 1936
Dolocytheridea atlasica Bassoullet & Damottte, 1969
(Pl. 2, figs 13, 14)

1969 *Dolocytheridea atlasica* Bassoullet & Damotte: 139, Pl. 2, fig. 9 a-d
1974 *Dolocytheridea atlasica* Bassoullet & Damotte; Rosenfeld & Raab: 11, Pl. 2, figs 12-13
Material. 11 carapaces and some valves; SHN 120
Horizon. It occurs sporadically in samples 18-51, (Cenomanian)
Dimensions. L 260, W 220, H 200
Remarks. This was described from the Cenomanian—Turonian of Algeria (Bassoullet and Damotte, 1969) and from the Cenomanian of Israel (Rosenfeld & Raab, 1974).

Dolocytheridea crassa Damotte, 1971
(Pl 2, fig. 15)

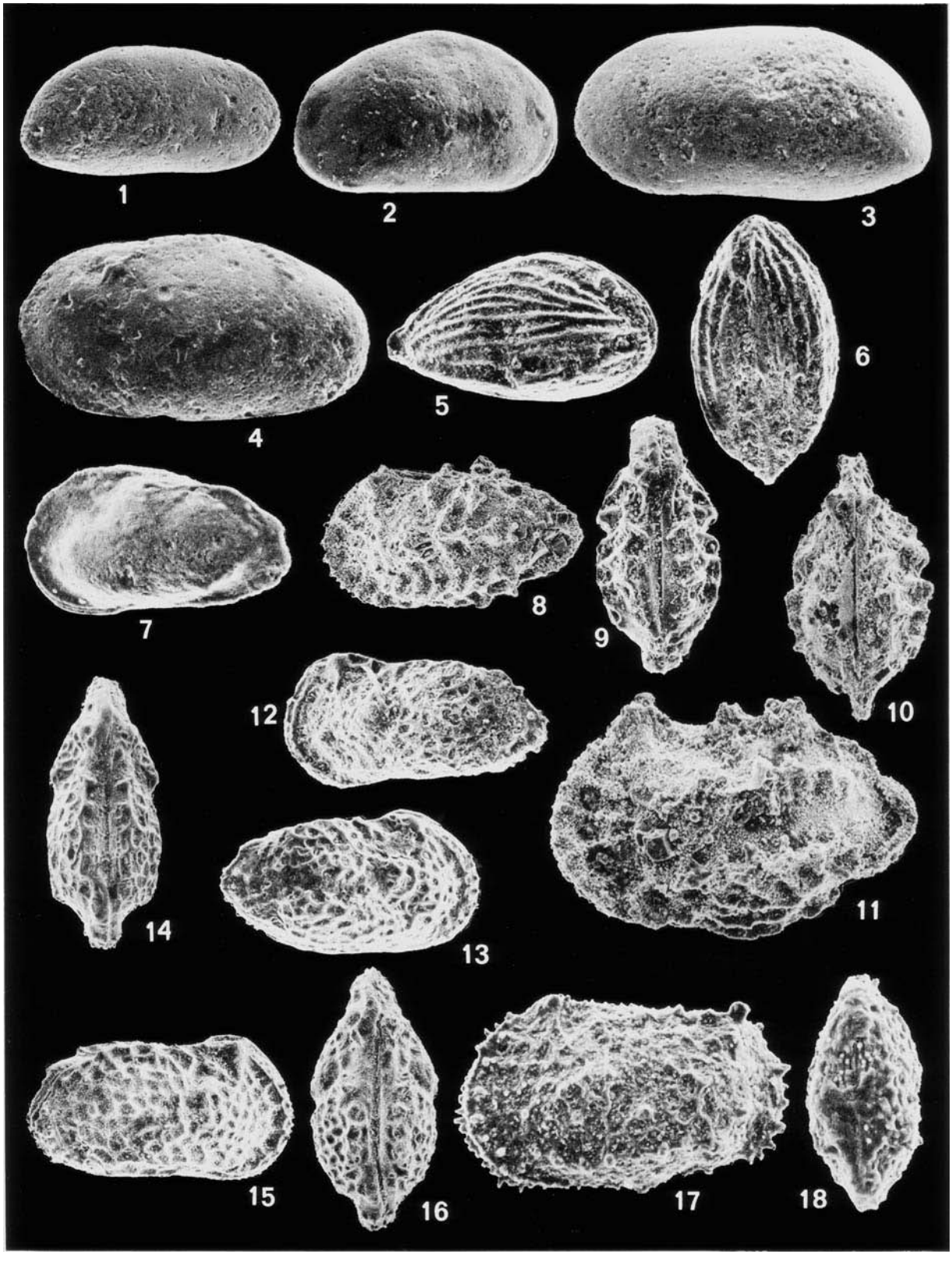
1971 *Dolocytheridea crassa* Damotte: 4, Pl. 1, fig. 2 a-c
1976 *Dolocytheridea crassa* Damotte; Breman: 99, Pl. IV, fig. 10a; Pl. XIII, fig. 36
1980 *Dolocytheridea crassa* Damotte; Babinot: Pl. 5, figs 7-13
Material. 4 carapaces - SHN 121
Horizon. Sample 50, Late Cenomanian
Dimensions. L 340, W 140, H 180
Remarks. This species was described from the Cenomanian of France (Damotte, 1971 and Babinot, 1980) and the Early Turonian of Spain (Breman, 1976).

Genus: *Ovocytheridea* Grekoff, 1951
Ovocytheridea apiformis Reyment, 1960
(Pl. 2, fig. 16)

1960 *Ovocytheridea apiformis* Reyment: 79, Pl. 2, fig. 5; Pl. 3, fig. 4 a-c; Pl. 5, fig. 5; Pl. 14, figs 2-3
1964 *Ovocytheridea apiformis* Reyment; Bold: 117, Pl. 14, fig. 3
Material. 3 carapaces; SHN 122

Explanation of Plate 3.

Fig. 1	*Ovocytheridea reniformis* Bold, sample 90, x 110.
Fig. 2	*Neocyprideis vandenboldi* Gerry & Rosenfeld, sample 93, lateral views, x120.
Fig. 3	*Krithe whitecliffsensis* Crane, sample 46, x135.
Fig. 4	*Krithe* sp., sample 43, lateral view, x65.
Figs 5, 6	*Metacytheropteron berbericus* (Bassoullet & Damotte), sample 16, lateral and dorsal views, x110, 115 respectively.
Fig. 7	*Veenia (Nigeria) inornata* Bertels, sample 55, x142.
Figs 8, 9	*Veeniacythereis jezzineensis* (Bischoff), sample 16, lateral and dorsal views, x58, 73 respectively.
Figs 10, 11	*Veeniacythereis maghrebensis* (Bassoullet & Damotte), sample 30, lateral and dorsal views, x65, 100 respectively.
Fig. 12	*Cythereis namousensis* Bassoullet & Damotte, sample 31, x89.
Figs 13, 14	*Cythereis rawashensis rawashensis* Bold, sample 46, lateral and dorsal views, x65, 55 respectively.
Figs 15, 16	*Cythereis fahrioni* Bischoff, sample 31, lateral and dorsal views, x55.
Figs 17, 18	*Cythereis* cf. *hirsuta* Damotte & Grosdidier, sample 43, lateral and dorsal views, x110, 113 respectively.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Horizon. Sample 42, (Late Cenomanian)
Dimensions. L 680, W 240, H 360
Remarks. Reyment (1960) described this species from the Santonian of Nigeria. It is also found in the Santonian of Senegal (Apostolescu, 1961) and the Turonian of Egypt (Bold, 1964)

Ovocytheridea caudata Bold, 1964
(Pl. 2, figs 17, 18)
1964 *Ovocytheridea caudata* Bold: 119, Pl. 14, fig. 4 a,b
1985 *Ovocytheridea caudata* Bold; Honigstein & Rosenfeld: 453, Pl. 3, figs 3-4
Material. 15 complete carapaces and some deformed ones; SHN 123
Horizon. Samples 30, 31, 50 (Cenomanian)
Dimensions. L 680, W 280, H 440
Remarks. This species is recorded from the Turonian of Egypt (Bold, 1964), Spain (Swain, 1978) and Israel (Honigstein & Rosenfeld, 1985).

Ovocytheridea hispanica Breman, 1976
(Pl. 2, figs 19, 20)
1976 *Ovocytheridea hispanica* Breman: 99, Pl. 4, fig. 11; Pl. 5, fig. 11 a-f
Material. 6 carapaces; SHN 124
Horizon. Samples 18, 30, 31, (Early Cenomanian)
Dimensions. L 600, W 220, H 320
Remarks. Breman (1976) described this species from the Early Turonian of central Spain. It is similar to *Ovocytheridea caudata* Bold and *O. apiformis* Reyment in the *Paracypris*-like shape, but the greatest height of this species is located more posteriorly. These three species may be related.

Ovocytheridea reniformis Bold, 1964
(Pl. 3, fig. 1)
1964 *Ovocytheridea reniformis* Bold: 118, Pl. 14, fig. 1 a-f
1981 *Ovocytheridea* aff. *reniformis* Bold; Bismuth *et al.*: 229,. Pl. 6, fig. 8
1985 *Ovocytheridea reniformis* Bold; Honigstein & Rosenfeld: 452, Pl. 3, figs 1-2
Material. 5 carapaces and 2 valves; SHN 125
Horizon. Samples 90, 94, 95, (Late Turonian)
Dimensions. L 420, W 160, H 200
Remarks. Bold (1964) described this species from the Turonian to Early Campanian of Egypt. It is also reported from the Turonian of Israel (Rosenfeld & Raab, 1974 and Honigstein & Rosenfeld, 1985) and Tunisia (Bismuth et al. 1981).

Genus: Ne*ocyprideis* Apostolescu, 1956

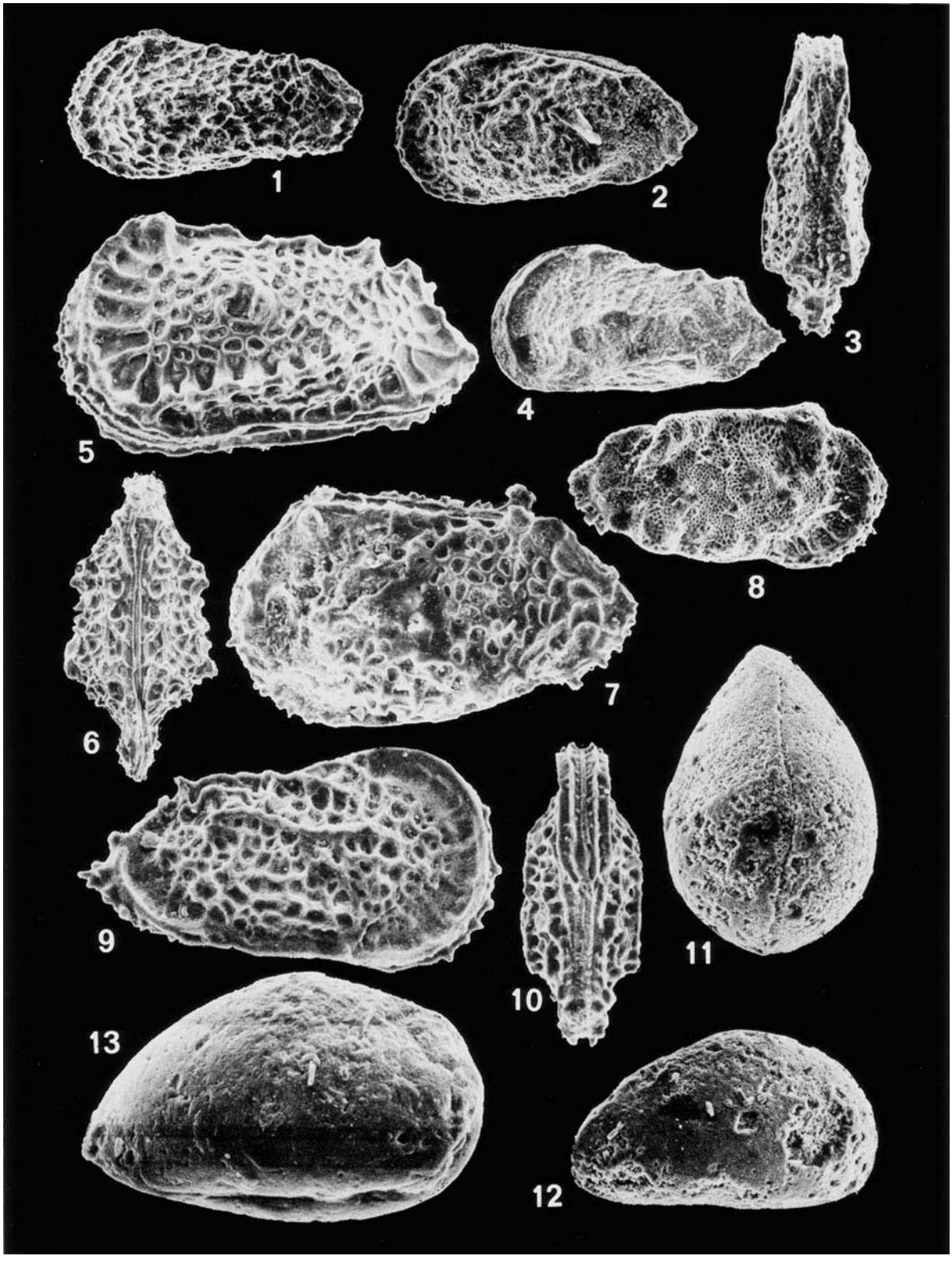
Neocyprideis vandenboldi Gerry & Rosenfeld, 1973
(Pl. 3, fig. 2)
1964 *Fabanella ?* sp. A Bold: 120, Pl. 14, fig. 5 a-d
1973 *Neocyprideis vandenboldi* Gerry & Rosenfeld: 103-104, Pl. 1, figs 1-9; Pl. 2, figs 1-6
1985 *Neocyprideis vandenboldi* Gerry & Rosenfeld; Lipson-Benitah *et al.*: Fig. 4h
Material. 12 carapaces and 7 valves; SHN 126
Horizon. Samples 93, 100, 104, (Late Turonian)
Dimensions. L 600, W 340, H 380
Remarks. This species is recorded from the Late Cenomanian and Early Turonian of Israel (Gerry & Rosenfeld, 1973; Rosenfeld & Raab, 1974; Lipson-Benitah et *al.* 1985). *Fabanella ?* sp. A described by Bold (1964) from the Cenomanian of Egypt is very similar and is considered synonymous with it. This species differs from *Neocyprideis flexeri* Honigstein & Rosenfeld in having a more rounded anterior end and a more convex dorsal margin.

Subfamily Krithinae Mandelstam in Bubikan, 1958
Genus: *Krithe* Brady, Crosskey & Robertson, 1874
Krithe whitecxliffensis Crane 1965
(Pl. 3, fig. 3)
1965 *Krithe whitecliffsensis* Crane: 204, Pl. 2, fig. 9 a-c
Material. 5 carapaces and a few valves; SHN 127
Horizon. Samples 43-50, (Late Cenomanian)
Dimensions. L 420, W 160, H 200
Remarks. *K. whitecliffensis* was described from the Late Cretaceous of the Gulf Coast area by Crane (1965).
Krithe sp.
(Pl. 3, fig. 4)
Material. 5 carapaces and some valves; SHN 128
Horizon. Samples 43-50; (Late Cenomanian)
Dimensions. L 560, W 200, H 280
Remarks. This species is differentiated from *K. whitecliffsensis* Crane by having a straight to slightly convex ventral margin and a less truncated posterior end. They are very similar, and as they are recorded from the same horizon, they may belong to one species.

Family Cytheruridae Müller, 1894
Genus *Metacytheropteron* Oertli, 1957
Metacytheropteron berbericus (Bassoullet & Damotte, 1969)
(Pl. 3, figs 5, 6)
1969 *Cytheropteron berbericus* Bassoullet & Damotte: 137-138, Pl. 2, fig. 7 a-d
1981 *Metacytheropteron berbericus* (Bassoullet & Damotte); Bismuth *et al.*: 225, Pl. 8, figs 7-8
1988 *Metacytheropteron berbericus* (Bassoullet & Damotte);

Explanation of Plate 4.

Fig. 1	*Cythereis cretaria* Bold, sample 46, x70.
Fig. 2	*Cythereis cretaria acuta* Honigstein, sample 47, x104.
Figs 3, 4	*Planileberis praetexta arta* (Damotte), sample 31, lateral and dorsal views, x73.
Figs 5, 6	*Rehacythereis guadalajarensis* Breman, sample 51, lateral and dorsal views, x96, 48 respectively.
Fig. 7	*Oertliella* cf. *donzei* Weaver, sample 53, x82.
Fig. 8	*Herrigocythere* cf. *donzei* (Weaver), sample 16, x110.
Figs 9, 10	*Isocythere elongata* Weaver, sample 51, lateral and dorsal views, x145, 108 respectively.
Figs 11, 12	*Xestoleberis ? X. derorimensis* Rosenfeld, sample 30, lateral and dorsal views, x130, 124 respectively.
Fig. 13	*Xestoleberis seminulata* Crane, sample 90, x200.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Athersuch: Pl. 1, figs 12-13
Material. 18 carapaces; SHN 129
Horizon. Samples 16, 18, (Early Cenomanian)
Dimensions. L 400, W 240, H 220
Remarks. Bassoullet & Damotte (1969) described this species from the late Cenomanian of Algeria. It is reported from the Cenomanian of Israel (Rosenfeld & Raab, 1974) and of Gebel Nezzazat, Sinai (Colin & El Dakkak, 1975). It is also recorded from the Late Varconian to Late Cenomanian of Tunisia (Bismuth *et al.*, 1981) and the Cenomanian of Oman (Athersuch, 1988).

Family: Trachyleberididae Sylvester-Bradley, 1948
Subfamily: Trachyleberidinae Sylvester-Bradley, 1948
Genus: *Veenia* Butler & Jones, 1959
Veenia (Nigeria) inornata Bertels, 1975
(Pl. 3, fig. 7)
1975 *Veenia (Nigeria) inornata* Bertels: 110, Pl. 4, fig. 3
Material. 6 carapaces; SHN 130
Horizon. Samples 55 (Cenomanian) and 90 (Late Turonian)
Dimensions. L 320, W 140, H 180
Remarks. Bertels (1975) described this species from the Maastrichtian of Argentina. It is characterized by its almost smooth surface. *Cythereis africana* Bate & Bayliss (1969) from the Albian of Tanzania is similar differing in having more prominent dorsal and ventral ribs.

Genus: *Veeniacythereis* Gründel, 1914
Veeniacythereis jezzineensis (Bischoff, 1963)
(Pl. 3, figs 8, 9)
1963 *Cythereis jezzineensis* Bischoff: 42, Pl. 16, figs 128-130
1974 *Veeniacythereis jezzineensis* (Bischoff); Rosenfeld & Raab: 21, Pl. 3, figs 28, 29
1981 *Veeniacythereis jezzineensis* (Bischoff); Al Abdul Razzak & Grosdidier: 177, Pl. 1, fig. 2
1983 *Veeniacythereis jezzineensis* (Bischoff); Rosenfeld & Raab: 59-65, Pl. 1
1988 *Veeniacythereis jezzineensis* (Bischoff); Athersuch: Pl. 3, figs 9, 10
Material. 28 carapaces; SHN 131
Horizon. Samples 16, 30, (Early Cenomanian)
Dimensions. L 380, W 320, H 320
Remarks. *Cythereis jezzineensis* was described by Bischoff (1963) from the Albian to Cenomanian of Lebanon. It also occurs in the Cenomanian of Jordan (Koch, 1968), Iran (Grosdidier, 1973), Israel (Rosenfeld & Raab, 1974, 1983), Kuwait (Al Abdul Razzak & Grosdidier, 1981) and Oman (Athersuch, 1988).

Veeniacythereis maghrebensis (Bassoullet & Damotte, 1969)
(Pl. 3, figs 10, 11)
1969 *Cythereis maghrebensis* Bassoullet & Damotte: 133-134, Pl. 1, fig. 1 a-c
1981 *Veeniacythereis maghrebensis* (Bassoullet & Damotte); Bismuth *et al.*: 232, Pl. 10 figs 1-2
1981 *Veeniacythereis maghrebensis* (Bassoullet & Damotte; Al Abdul Razzak & Grosdidier: 182, Pl. 1, fig. 3
1983 *Veeniacythereis maghrebensis* (Bassoullet & Damotte); Rosenfeld & Raab: 59-65, Pl. 2
1988 *Veeniacythereis maghrebensis* (Bassoullet & Damotte); Athersuch: Pl. 3, figs 7, 8
Material. 4 carapaces; SHN 132
Horizon. Samples 16, 30, (Early Cenomanian)
Dimensions. L 740, W 420, H 400
Remarks. *Cythereis maghrebensis* was described by Bassoullet & Damotte (1969) from the Late Cenomanian of Algeria and subsequently recorded from the Cenomanian of the western side of the Gulf of Suez, Egypt (Boukhary *et al.*, 1977), Kuwait (Al Abdul Razzak & Grosdidier, 1981), Tunisia (Bismuth et *al.*, 1981) and Oman (Athersuch, 1988). Some of the *Veeniacythereis jessineensis* (Bischoff) described by Rosenfeld & Raab (1974) from the Cenomanian of Israel (Pl. 2, fig. 30) seem to be *V. maghrebensis* (Bassoullet & Damotte).

Veeniacythereis jezzineensis closely resembles *V. maghrebensis* except for the extent of development of the main ridges on the surface of the carapace (see the description of Bischoff, 1963 and Bassoullet & Damotte, 1969 of both species).

Genus: *Cythereis* Jones, 1894
Cythereis cretaria Bold, 1964
Cythereis cretaria cretaria Bold 1964
(Pl. 4, fig. 1)
1964 *Cythereis cretaria* Bold: 126-127, Pl. 15, figs 3-4
1984 *Cythereis cretaria* Bold; Honigstein: 19, Pl. 6, figs 15-16, Pl. 7, figs 1-5
Material. 5 carapaces; SHN 133
Horizon. Sample 46, 47, (Late Cenomanian)
Dimensions. L 620, W 260, H 320
Remarks. Bold (1964) described this species from the Campanian of Egypt. It also occurs in the Coniacian—Santonian of Israel (Honigstein, 1984).

Cythereis cretaria acuta Honigstein, 1984
(Pl. 4, fig. 2)
1984 *Cythereis cretaria acuta* Honigstein: 19, Pl. 7, figs 8-10
Material. 2 carapaces; SHN 134
Horizon. Sample 47, (Late Cenomanian)
Dimensions. L 420, W 160, H 240
Remarks. Honigstein (1984) distinguished this subspecies from *Cythereis cretaria cretaria* Bold by its acute middle part of the posterior end. He recorded this species from the Santonian of Israel. The specimen described herein is similar to Honigstein's except for the nearly smooth posterolateral area.

Cythereis fahrioni Bischoff, 1963
(Pl. 2, figs 15, 16)
1963 *Cythereis fahrioni* Bischoff: 31-33, Pl. 12, figs 90-93, fig. 94
1981 *Cythereis* cf. *fahrioni* Bischoff; Bismuth *et al.*: 231, Pl. 9, figs 6-8
1988 *Cythereis* cf. *fahrioni* Bischoff; Athersuch: Pl. 3, figs 5, 6
Material. 4 carapaces; SHN 135
Horizon. Samples 31, 47, the Late Cenomanian
Dimensions. L 860, W 380, H 480
Remarks. Bischoff (1963) described this species from the Albian of Lebanon. Bismuth *et al.* (1981) and Athersuch (1988) recorded *C. cf. fahrioni from* the Albian—Cenomanian of Tunisia and Albian of Oman respectively, which are here considered to be true members of the species.

Cythereis cf. *hirsuta* Damotte & Grosdidier, 1963
(Pl. 3, figs 17, 18)

Material. 3 carapaces; SHN 136
Horizon. Samples 43, 50, (Late Cenomanian)
Dimensions. L 640, W 250, H 410
Remarks. *Cythereis hirsuta* was described from the Early Cenomanian of France by Damotte & Grosdidier (1963). These Egyptian specimens differ from the holotype of Damotte & Grosdidier in having a more rounded and spiney posterior end and a less spiney lateral surface.

Cythereis namousensis Bassoullet & Damotte, 1969
(Pl. 3, fig. 12)

1969 *Cythereis namousensis* Bassoullet & Damotte: 134-135, Pl. 1, fig. 3 a-d
1981 *Cythereis namousensis* Bassoullet & Damotte; Bismuth *et al.*: 232, Pl. 9, figs 9-10
Material. 6 carapaces and 1 valve; SHN 137
Horizon. Samples 31, 47, (Late Cenomanian)
Dimensions. L 580, W 260, H 300
Remarks. Bassoullet & Damotte (1969) described this species from the Cenomanian of Algeria. It is also recorded from the Cenomanian of Israel (Rosenfeld & Raab, 1974), Egypt (Boukhary *et al.*, 1977), and Tunisia (Bismuth *et al.*, 1981).

Cythereis rawashensis rawashensis Bold, 1964
(Pl. 3, figs 13, 14)

1964 *Cythereis rawashensis rawashensis* Bold: 124, Pl. 15, fig 1 a,b
Material. 18 carapaces; SHN 138
Horizon. Samples 31-51 (Cenomanian) and 96-107 (Late Turonian)
Dimensions. L 680, W 320, H 360
Remarks. This species was described from the Turonian of the Abu Roash area, Egypt by Bold (1964).

Genus: *Planileberis* Deroo, 1966
Planileberis praetexta arta (Damotte, 1962)
(Pl. 4, figs 3, 4)

1962 *Cythereis praetexta arta* Damotte: 9, Pl. 3, fig 14 a-d
1976 *Rehacythereis praetexta arta* (Damotte); Breman: 113, Pl. 9, fig 18 a,b
Material. 3 carapaces; SHN 139
Horizon. Samples 31, 33, (Late Cenomanian)
Dimensions. L 480, W 180, H 280
Remarks. Damotte (1971) described this subspecies from the Cenomanian of France. It is characterized by a compressed form, the less pronounced longitudinal ribs, and faint reticulation, suggesting the genus Planileberis Deroo.

Genus: *Rehacythereis* Gründel, 1973
Rehacythereis guadalajarensis Breman, 1976
(Pl. 4, figs 5, 6)

1976 *Rehacythereis guadalajarensis* Breman: 112, Pl. 9, fig 17 a-c
Material. 5 carapaces; SHN 140
Horizon. Samples 49-53, (Late Cenomanian)
Dimensions. L 740, W 400, H 380
Remarks. Breman (1976) described this species from the Early Turonian of Spain. It is similar to *Oertliella supra* Babinot (1980) described from the Coniacian—Santonian of France in the form and deep reticulation, but is distinguished from it in its less spiney posterior end.

Genus: *Oertliella* Pokorney, 1964
Oertliella donzei Weaver, 1982
(Pl. 4, fig. 7)

1982 *Oertliella donzei* Weaver: 74, Pl. 15, figs 6-11, text fig. 14
1988 *Oertliella donzei* Weaver; Jarvis *et al.*: Fig. 19 (f)
Material. 6 carapaces; SHN 141
Horizon. Samples 49-53, (Late Turonian)
Dimensions. L 600, W 320, H 320
Remarks. This species was recorded from the Early and Middle Cenomanian of England (Weaver, 1982, and Jarvis, *et al.*, 1988). It can be distinguished from *Oertliella?* cf. *Rasbaalbekensis* Damotte & Saint Marc figured by Honigstein (1985) in having more prominent spines and a subcentral node. *Acanthocythereis denticulata* Esker figured by Donze *et al.* (1982) is similar, but differs by having fewer posteroventral spines and a thinner anterior margin.

Genus: *Herrigocythere* Gründel 1973
Herrigocythere cf. *donzei* (Weaver, 1982)
(Pl. 4, fig. 8)

Material. 1 carapace; SHN 142
Horizon. Sample 16, (Early Turonian)
Dimensions. L 400, H 200
Remarks. This is similar to *H. donzei* (Weaver) from the Middle and Late Cenomanian of England (Jarvis *et al.*, 1988) but differs by having fewer anterior marginal spines .

Genus: *Isocythere* Triebel, 1940
Isocythereis elongata Weaver, 1982
(Pl. 4, figs 9, 10)

1982 *Isocythereis elongata* Weaver: 72, Pl. 14, figs 9-11
1988 *Isocythereis elongata* Weaver; Jarvis *et al.*: Fig. 19 (d)
Material. 5 carapaces; SHN 143
Horizon. Samples 49, 51 and 53, (Late Cenomanian)
Dimensions. L 320, W 160, H 200
Remarks. This species was described from the Late Cenomanian of England (Weaver, 1982 and Jarvis *et al.*, 1988). *Isocythereis* sp. of Breman (1976) is similar except for the denticulate ventroanterior margin. It is also distinguished from *Isocythereis fissicostis* Triebel (1949) by its spiney anterior and posterior margins.

Family: Xestoleberididae Sars, 1928
Genus: *Xestoleberis* Sars, 1966
Xestoleberis ?X. derorimensis Rosenfeld, 1974
(Pl. 4, figs 11, 12)

1974 *Xestoleberis ? Xestoleberis derorimensis* Rosenfeld: in Rosenfeld & Raab, 22, Pl. 2, figs 34-37
1985 *Xestoleberis ? Xestoleberis derorimensis* Rosenfeld; Honigstein & Rosenfeld: 452, Pl. 2, figs 4-7.
Material. 6 carapaces; SHN 144
Horizon. Samples 30 (Cenomanian) and 90 and 95, (Late Turonian)
Dimensions. L 340, W 240, H 220
Remarks. This species is recorded from the Late Cenomanian of Israel (Rosenfeld & Raab, 1974; Lipson-Benitah *et al.* 1985 and Honigstein & Rosenfeld, 1985).

Xestoleberis seminulata Crane, 1965
(Pl. 4, fig. 13)

1965 *Xestoleberis seminulata* Crane: 234, Pl. 9, fig. 5
Material. 1 carapace and 3 valves; SHN 145

Horizon. Samples 90-95, (Late Turonian)
Dimensions. L 360, W 240, H 200
Remarks. This species was described from the Late Cretaceous of the Gulf Coast area (Crane, 1965). It is differentiated from *Xestoleberis ovata* Bonnema by having an elongate carapace and straight ventral margin and from *X. ? X. derorimensis* Rosenfeld in having a less tumid posterior end.

BIOSTRATIGRAPHY

The stratigraphic ranges of the species described here are shown in Fig. 2.

The Cenomanian—Turonian succession of Gebel Nezzazat has already been subdivided into biostratigraphic zones on the basis of foraminiferal and macrofossil content (Shahin, 1988). Three ostracod assemblages can be distinguished from oldest to youngest as follows:

1. *Cytherella—Veeniacythereis—Metacytheropteron* Assemblage

The lower part of this unit is characterized by the dominance of *Cytherella* spp., *Veeniacythereis* spp., *Herrigocythere* cf. *donzei* and *Bairdia* spp. This assemblage declines or even disappears in the middle part of the unit, reappearing towards the top. *Brachycythere* spp., *Dolocytheridea atlasica* and *Paracypris acutocaudata* occur sporadically within this unit, and extend upwards into the next unit.

Most of this association is present in the Cenomanian of many parts of the world. It is equivalent to the *Rotalipora brotzeni* and *R. reicheli* Zones, of Early Cenomanian age (Shahin, 1988).

The presence of *Cytherella* and *Veeniacythereis* indicates open marine, moderately deep neritic conditions (Morkhoven, 1963), which are confirmed by the presence of *Rotalipora* and *Thomasinella*. *Dolocytheridea* spp. and *Ovocytheridea* spp. together with a few *Xestoleberis derorimensis* occur sporadically within this unit, perhaps suggesting littoral or even brackish water conditions at some horizons.

2. *Cythereis* spp. Assemblage

Most of the characteristic species of the previous assemblage disappear, although some of them (*Paracypris acutocaudata* Rosenfeld, *Bairdia* spp., *Dolocytheridea atlasica* Bassoullet & Damotte and some *Cytherella*) extend within this unit. It is characterized by the dominance of *Cythereis* spp. and other trachyleberidids. The interval between samples 34 and 42 is devoid of ostracods, probably due to an anoxic event. The genera found below this barren interzone reappear above it where other important genera make their first appearance (see the range chart, Fig. 2).

This association is partly equivalent to the *Rotalipora cushmani* Zone and the lower part of the *Heterohelix globulosa* Zone of Late Cenomanian and earliest Turonian age respectively (Shahin, 1988).

Most of the aforementioned species abruptly disappear a few metres above the Cenomanian—Turonian boundary. However, some of them are long ranging and reappear in the Turonian. This disappearance is probably due to another anoxic event associated with the Cenomanian—Turonian boundary.

The abundance of *Cythereis* and related genera and *Paracypris* indicates open, relatively deep neritic condidions (cf. Morkhoven, 1963). However the presence of *Ovocytheridea* spp. again refers to shallow to restricted marine environments at least where it is present. These alternating marine conditions were also deduced from the foraminiferal and megafossil content (Shahin, 1988).

3. *Asciocythere polita—Neocyprideis vandenboldi* Assemblage

Following the barren interzone, some species start to appear and extend upwards while others, which first appeared in the Cenomanian, are also reported (Fig. 2). This interval is equivalent to the *Coilopoceras* sp. Assemblage Zone of the Late Turonian (Shahin, 1988).

The sporadic occurrence of the brackish water *Neocyprideis*, *Asciocythere* and *Xestoleberis* together with a few deeper neritic genera *Cythereis*, *Cytherella*, *Bairdia* and *Bairdoppilata* indicate alternation of neritic, open marine and brackish environments. The top of this zone suggests brackish water conditions.

PALEOGEOGRAPHICAL DISTRIBUTION

During the Cenomanian a similar ostracod assemblage characterized a vast palaeogeographical province. This assemblage includes *Metacytheropteron berbericus*, *Veeniacythereis jessineensis*, *V. maghrebensis* and *Cythereis namousensis*. These are recorded from the Cenomanian of Libya, Tunisia, Algeria, Morocco, Israel, Lebanon, Iraq, Kuwait, Oman and Iran. Other elements of the fauna are present in France and Spain to the north, and Senegal and Tanzania to the south. *Cytherella* gr. *ovata*, *Cytherella sulcata* and *Cytherella parallela* are recorded from the Cenomanian of France, Spain, England, North Africa and Israel.

The Turonian assemblage, including Brachycythere sapaucariensis and similar forms, is known from the Early Turonian of Brazil, Tanzania, Gabon, Nigeria and Tunisia. *Asciocythere polita*, *Ovocytheridea reniformis* and *Bairdia cenomanica* are recorded from the Turonian of France, Spain, Tunisia and Israel.

The Cenomanian—Turonian ostracods recorded here link the area with Europe, North and West Africa, the southern shelf of Tethys, South America and the Middle East. At that time Tethys covered much of the aforementioned regions where shallow to slightly deep marine sediments were deposited including similar ostracod assemblages. This is due mainly to the similarity of environmental conditions, and the ability of the fauna to be distributed throughout the Tethyan province. This also supports the idea of a trans-Saharan seaway and direct connection betweeen South America and West Africa (Furon, 1935 and Chancellor, 1982 repecitively).

OSTRACOD DIVERSITY AND OXYGENATION LEVELS

Oxygen supply is an important ecological factor, and any reduction would lead to a reduction in the number of individuals. It is tentatively suggested therefore that a reduced ostracod fauna is the result of very low oxygen levels in the bottom water. When the ostracod diversity is plotted stratigraphically (Fig. 3), it is clear that there are repeated declines in the diversity of both platycopids and podocopids within the succesion.

A fluctuation of ostracod diversity coinciding with $\partial^{13}C$ values of normal marine salinity is clearly seen within the lower part of the Cenomanian. This change in diversity is partly explained by the sedimentological variation in the Raha Formation from shale to sand to limestone bands. The increased diversity may reflect a higher proportion of sand-sized bioclasts in the sediment.

The peak of $\partial^{13}C$, accompanied by a drop in the diversity of ostracods, is clearly observed at the base of the Abu Qada Formation (Fig. 3). This major increase in $\partial^{13}C$ values refers in part to high productivity caused by incoming nutrients associated with the Cenomanian transgression. This increased surface productivity leads to the development of a marked oxygen-minimum zone in the underlying water column because oxygen is utilized during the breakdown of organic matter as it sinks downwards from the surface water (Jenkyns, 1980 and Summerhayes, 1987). Hume *et al.* (1920) stated that the dark

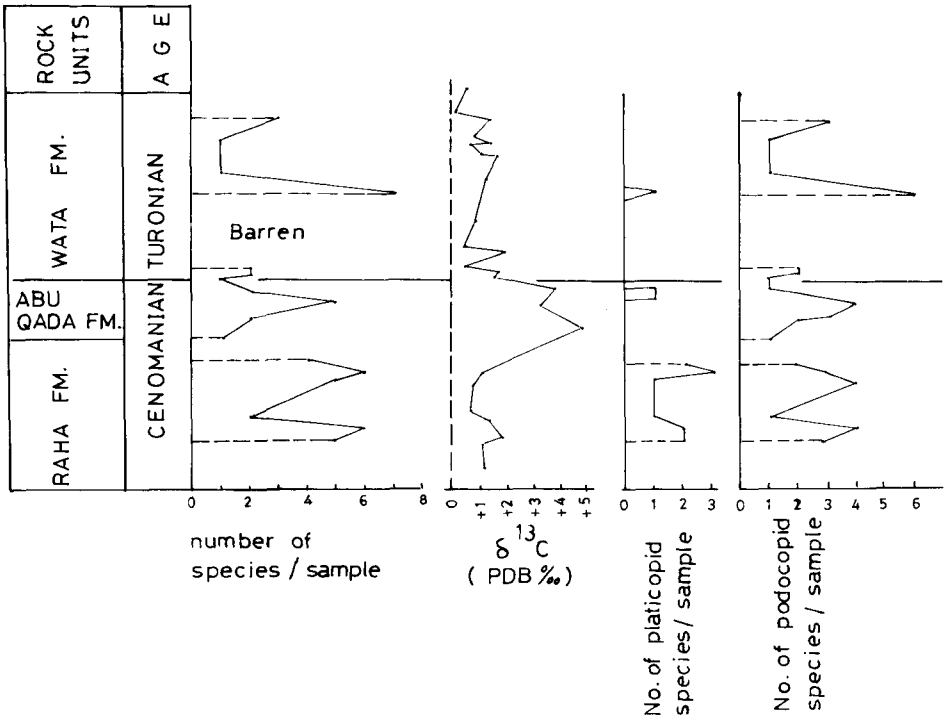

Fig.3. Ostracod diversity and $\partial^{13}C$ stratigraphy within the studied Cenomanian—Turonian succession.

stained sediments in the Cenomanian of Gebel Nezzazat may be due to the occurrence of some forms of hydrocarbon in a highly weathered state. Fischer & Arthur (1977) stated that in the case of a high rate of sedimentation and preservation of organic carbon in marine sediments, the rate of $\partial^{13}C$ values increases in the oceanic reservoir and consequently in the biogenic calcite. Therefore, the high $\partial^{13}C$ values in the Abu Qada Formation may be due to high productivity and the presence of organic carbon. Therefore, the accompanying drop in ostracod diversity below the Cenomanian—Turonian boundary is readily explained by bottom water oxygen level falling below the minimum respiratory requirements of individual species (Oceanic Anoxic Event), causing the disappearance or even extinction of many typical Cenomanian species (cf. Weaver, 1981). The complete disappearance of the Cenomanian foraminiferal forms *Thomasinella* and *Rotalipora* in the earliest Turonian of G. Nezzazat is the most obvious feature around the Cenomanian—Turonian boundary (Shahin, 1988). Hart (1980) recorded that anoxic events, for example that of the Late Cenomanian—Early Turonian, coincide with levels of maximum faunal change. The unfavourable palaeoceanographic conditions seem to be the main reason for the observed fauna changes around this boundary. However, an increase of ostracod diversity in this anoxic interval, is also noticed a few metres below the boundary, and may be due to the tolerance of some platycopid and podocopid species to low oxygen levels.

The $\partial^{13}C$ values again decrease just above the Cenomanian—Turonian boundary that lies within a region of already decreasing $\partial^{13}C$ values. This decrease is accompanied by a continued drop in ostracod diversity (the podocopids are the only ostracods present). This is followed by a slight increase in the podocopids a few metres above the boundary, accompanied by an obvious increase in the planktonic foraminifera (*Heterohelix globulosa* Abundance Zone) (Shahin, 1988).

Arthur *et al.* (1987) stated that the earliest Turonian was a period of peak transgression, caused by a worldwide high stand of sea level. The large increase in the shelf sea areas caused by the transgression led to enhanced production of warm saline water, which sank to form bottom-water masses. This caused an increase in the rates of oceanic turnover because in the Cretaceous, oceanic circulation was salinity driven (Brass *et al.* 1982), and this triggered the anoxic event. This peak transgression led to the annihilation of most ostracod species (the barren interzone). Some of the ostracod species found in the Cenomanian reappear in the Late Turonian and other new species appear. It is clear that most of the ostracods are podocopids, corresponding to normal $\partial^{13}C$ values of normal marine salinity, accompanied only by very low numbers of small size benthonic forams. The increase of ostracod diversity in sample 90 partly reflects a high proportion of sand-sized bioclasts.

The presence of some hydrocarbons, the high positive $\partial^{13}C$ values, the sudden faunal change and the drop in ostracod diversity at the Cenomanian—Turonian boundary refer to an oceanic anoxic event at that time. This event may have caused a sequence of extinctions during the Late Cenomanian and the Early Turonian.

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