LOWER PALAEOGENE OSTRACODA, FROM THE SIRT BASIN OF LIBYA.

by

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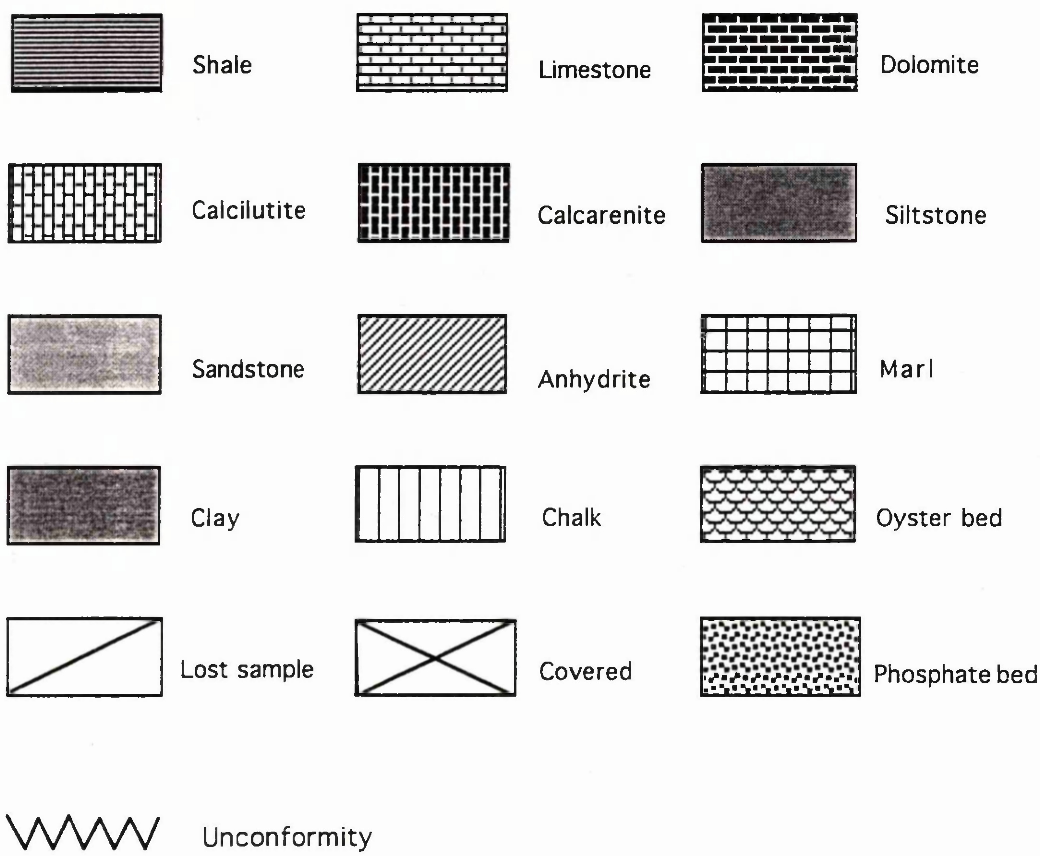

Key to Ostracod distribution

R → 1- 6 Valves

C → 6- 12 Valves

A → 12- 18 Valves

VA → > 18 Valves

Note: One carapace considered as two valves

All numbered specimens are housed in the Hunterian Museum Glasgow.

Synonyms of geographic locations:

Zelten= Zaltan, Agedabia= Ajdabiya, Surfa= Shurfa, Gelta= Qaltah.

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Summary

Ostracods have been studied from 5 wells from the Sirt Basin, two from trough areas, 3 from platform areas, together with 2 outcrop sections on the western edge of the basin. The El-Fogha section, previously studied by Barsotti (1963) was resampled.

122 species and subspecies belonging to 58 genera have been recorded; 35 new species and subspecies are proposed. 39 species have been previously recorded from west Africa, North Africa and the Middle East, 10 species are certainly contaminants and come from younger sediments, the remainder are left under open nomenclature; although some of these show similarities to earlier described faunas. Most of the species recorded in this study are widely distributed in the lower Palaeogene of west, north Africa and the Middle East.

The Palaeocene/Eocene boundary is marked by a large faunal turnover with the extinction of many typical Palaeocene ostracod species. The extinction of *Paracosta bensoni* has been used to define this boundary; studying the wells, the boundary is marked downhole by the sudden appearance of a rich ostracod fauna both in numbers of individual and in species. Four ostracod biozones have been recognised: early Eocene, late Palaeocene *Paracosta bensoni* zone, middle Palaeocene *Paracosta Paleomokattamensis* zone, and an early Palaeocene biozone.

Graphic correlation techniques have been used for correlating the wells. Filtered gamma ray logs has been used to establish a L. O. C (line of correlation) between platform well YY1-6 and trough well KK1-6. This technique has given a high resolution to solve the boundary problem between the Hagfa and Khalifa formation in well KK1-6. This approach, together with the ostracod biostratigraphy, indicates that the Hagfa Shale and Khalifa Formations include younger (i.e early Eocene) strata than previously thought.

The biofacies described by Bassiouni and Luger, (1990) have been recognised in the wells; these show a shallowing upwards sequence through the Palaeocene from outer shelf to near shore biofacies, with slight deepening at the start of the Eocene.

Cluster analysis has helped in recognising different ostracoda associations within Bassiouni and Luger's shallow marine Afro-Tethyan type biofacies in the outcrop sections.

The wide distribution of the Libyan fauna in North and west Africa, and the Middle East (Barsotti 1963, Reyment 1963, Berggren 1974 and Bassiouni and Luger 1990). The Trans-Saharan Seaway connecting Libya and North Africa with Nigeria via Mali and Niger had maximum flooding during the late Palaeocene transgression.

I declare that the contents of this thesis is my own work carried out in the Department of Geology and applied geology University of Glasgow from July 1993 to July 1996.

Amar Mohamed Gammudi.

Dr M. C. Keen.

CHAPTER ONE

INTRODUCTION

Introduction

Purpose of this study-

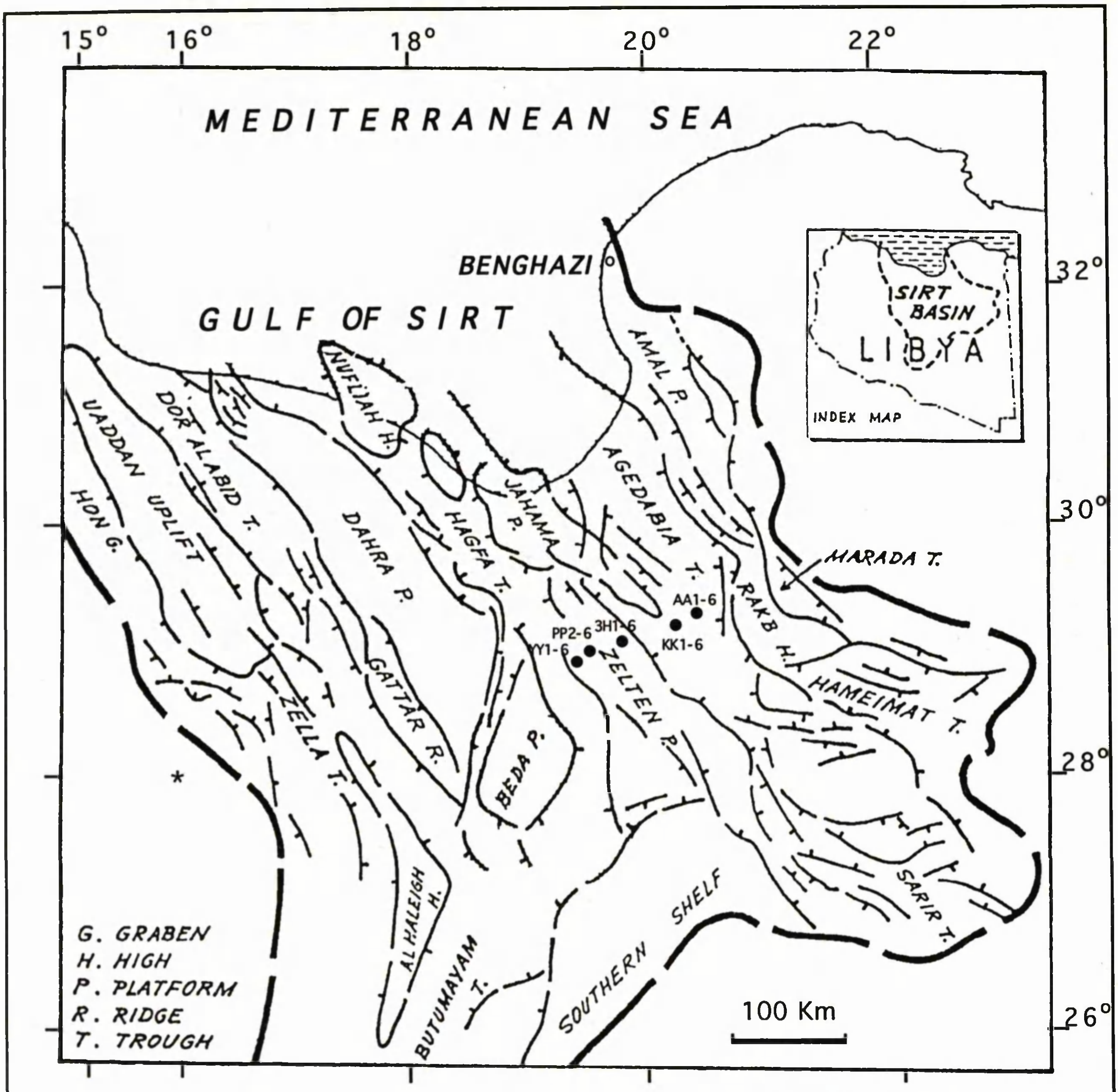
The main purpose of this study is a systematic account of lower Palaeogene ostracods and their application to biostratigraphy and Palaeoenvironmental and Palaeozoogeographic reconstructions. In order to achieve this, samples from wells and outcrops were studied. In the Sirt Basin, wells were chosen to compare a trough with a positive Platform area, while the outcrops are from the western margin of the basin allowing a comparison between the basin and much thinner sediments on the margin. The sections at El-Fogha and Heira were chosen because they show a complete section through the Palaeocene, the former being studied in the classic work of Barsotti (1963). Graphic correlation has been used to correlate the wells, using filtered gamma ray logs to establish a LOC (line of correlation) and biostratigraphic graphic correlation to supplement this LOC.

Previous workers have considered the studied sequence in the wells to be Palaeocene in age on the basis of their stratigraphic position, and lower Palaeocene indicated by Planktonic foraminifera recovered from the lower part of the sediments. However the ostracods recorded here indicate younger sediments i.e Palaeocene-Lower Eocene.

Location and structure of the Sirt Basin-

The wells studied were drilled by the Esso Oil Company in concession 6 of the Sirt Basin, and penetrated a thick sequence of marine sediments of lower Palaeogene age, with a maximum thickness of 4980 ft (1518m). The two outcrop sections lying on the south west border of the Sirt Basin (see Fig. 1.1), the locations and intervals of material are as follows (table 1.1).

Well No	Interval	Latitude	Longitude
YY1- 6	6000-8360	29° 04' 55" N	19° 46' 09" E
PP2- 6	6540-7840	29° 07' 59" N	19° 50' 11" E
3H1- 6	7160-10040	29° 13' 24" N	20° 01' 27" E
KK1- 6	8500-13000	29° 18' 39" N	20° 26' 49" E



After MOUZUGHI & TALEB, 1981

Figure 1.1 Locations of the studied areas and tectonic elements of the Sirt Basin
(•) Location of the wells in concession six
(*) Locations of outcrops sections

AA1- 6	8320-13300	29° 21' 27" N	20° 33' 51" E
El-Fogha Depression	28.45 m	27° 47' 18" N	16° 22' 59" E
Heira composite	47.7m	27° 33' 57" N	16° 07' 63" E

Table 1.1 Geographic locations of wells and outcrops

Libya is situated in the central Mediterranean on the African shield (Fig 1.2). The east Sahara craton has a number of basins, such as Ghadamis, Murzuq, Al Kufrah and Sirt Basins. These Basins formed during a series of tectonic movements: Caledonian and Hercynian orogenies and late Cretaceous to middle Tertiary (Oligocene through to Miocene) and Recent times (Conant and Goudarzi, 1969). The first three basins are Palaeozoic Basins formed by Caledonian and Hercynian orogenies, the rock of these are mainly of continental sediments and shallow marine deposits.

A-Caledonian orogeny initiated in the middle Silurian, continued into Early Devonian (Lochkovian) lasting 25 million years, and affected the whole of Libya and neighbouring countries, such as northern Niger and northern Chad.

B-Hercynian orogeny commenced in the middle to Late Carboniferous and lasted into the Permian, although these are not yet proved (Bellini and Massa 1980). This phase has affected folding and faulting and caused major subsidence in Tripolitaina (north of Al Jifara). The tectonic evolution of Libya has been studied by several authors such as Goudarzi,(1967), Klitzsch, 1971, Goudarzi, (1980), Bellini and Massa (1980).

The Sirt Basin is an interesting basin in Libya, and displays a north south trending pattern, covering an area about 300,000Km^2. It has more than 12 giant oil fields. This basin was superimposed over Pan African plate and dated as late Cretaceous when the northern crest of the Tebesti-Sirt uplift collapsed forming a series of horsts and grabens (troughs) orientated Northwest-Southeast. The subsidence of the Sirt Basin continued from late Cretaceous to Palaeocene to as late as the middle Tertiary (Hea 1971; Selley, 1968, Burke and Dewey,1974 and Goudarzi,1980). These periods of

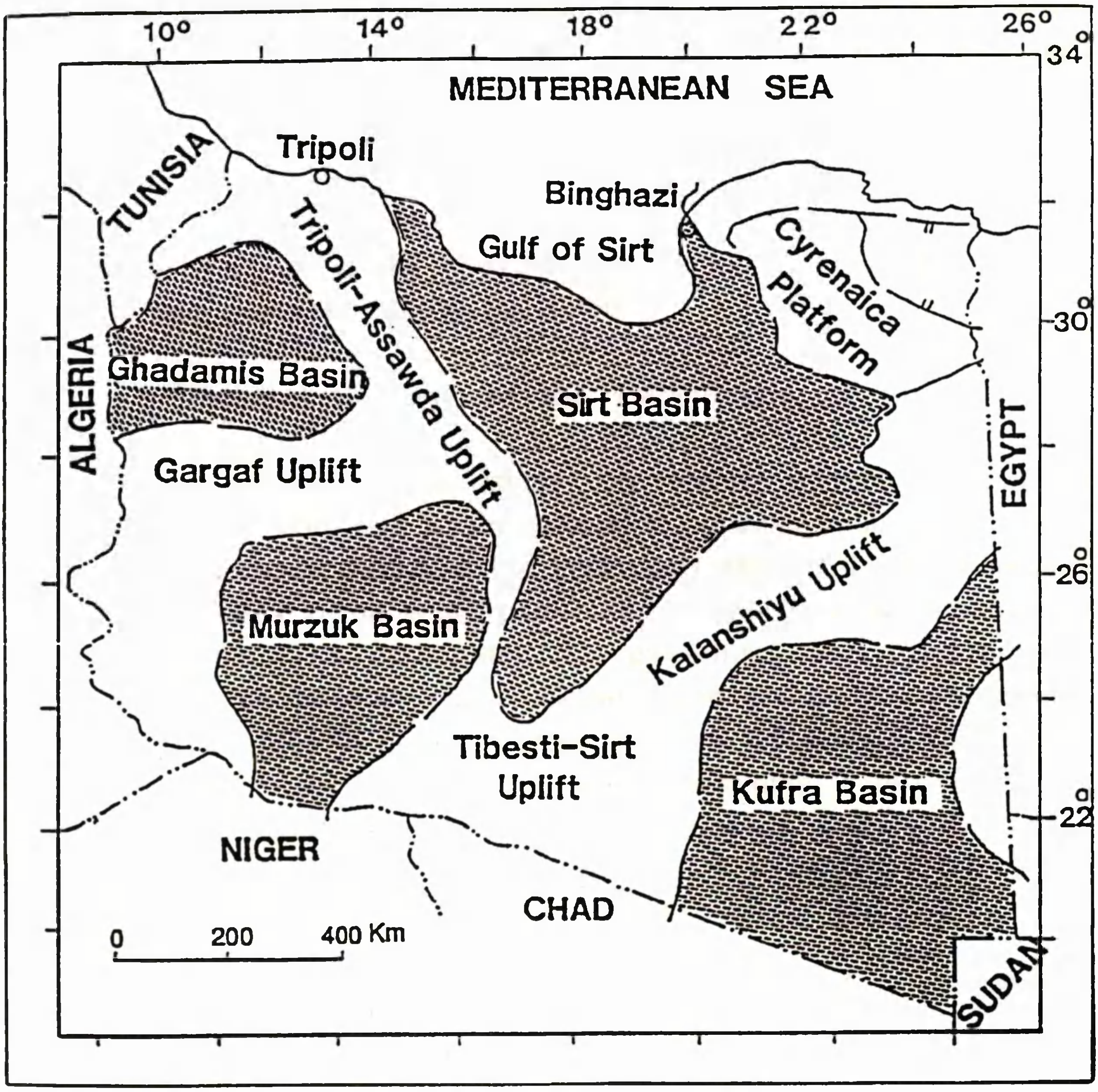


Figure 1. 2 Geological location of Libya and the basins distribution

rejuvenation of horsts and grabens yielded a maximum subsidence during Palaeocene and Eocene times as stated by Gumati and Kanes (1985), so that a thick sedimentary succession accumulated in deep troughs with a thickness of more than 20,000ft while the sediments thin over structural high areas and also southward towards the Tebesti-Sirt uplift. Large quantities of organic material, terrigenous clastic, and evaporites were deposited in the troughs while reefs and carbonate sediments accumulated on the flanks and over the crest of the horst.

General geology of the Palaeocene of Libya

The Palaeocene sequences are widely distributed in the subsurface of the Sirt Basin, where it consists mainly of open marine calcareous shales in the lower part and shelf sediments of carbonate rocks in the upper part in the eastern and western areas of the basin. The carbonates are calcilutites and calcarenites which may be pelletal, oolitic, skeletal and glauconite, while the shale is dark-grey to greenish grey, and very calcareous. Dolomites are tan-grey to brown-grey, often vuggy; anhydrite is also present. The vertical succession of the lower Palaeocene sediments is not homogeneous throughout the Sirt Basin due to structural complex pattern in the Basin, differentiated into positive (Platforms) and negative structures (troughs). This means that the vertical succession displays different facies in different locations, together with general facies changes laterally across the basin (Fig 1.3). In particular the Hagfa shale, Khalifa shale (lower unit) laterally changes into carbonate rocks eastwards in the basin.

The Palaeocene outcrops in the Sirt Basin existed in only a few sites along the southwest margin of the basin and in outcrops south of Jabal As Sawda along the Dur al Ghani, and west of the Al-Harug volcanic areas i.e. the El-Fogha and Heira areas. Field work was carrid out for the present study in the El-Fogha and Heira areas.

In north west Libya the Palaeocene outcrops existed over a large area of the Al-Hamada Al-Humra Platform (Jurdi and Lonfat, 1963 and Conant *et al*,1964).

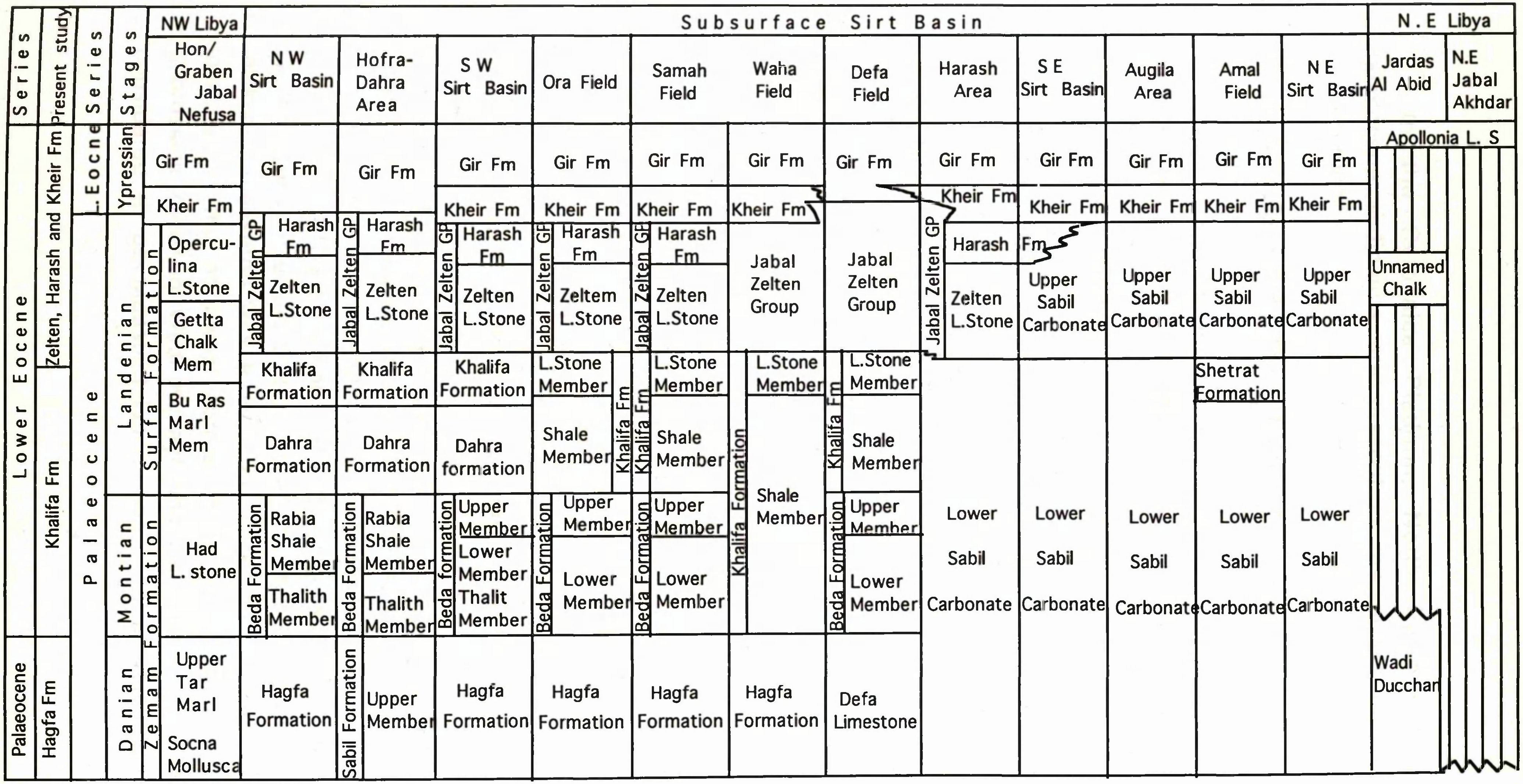


Figure 1.3 Correlation chart of lower Palaeogene in Libya

After (Barr and Weegar, 1972)

In the Cyrenaica Platform, North Eastern Libya, the Palaeocene sediments are present in few scattered areas and mostly eroded.

Previous studies of the Palaeocene of Libya

The description in this section are taken from previously published accounts. Some ostracods are listed, but these do not include the fauna described in this thesis, which are dealt with in separate section.

The Palaeocene outcrops in the south western Sirt Basin

Zemam Formation

This formation was described by Jordi and Lonfat (1963) as a sequences of shale, marl and limestone well exposed along the southwestern border of the Hon Graben. The type section was measured in an isolated hill near Wadi Tar 30 miles north west of Socna Oasis and divided into three members, in ascending order A- Lower Tar Marl , B- upper Tar Marl, C- Had limestone member.

A- Lower Tar Member-

Jordi and Lonfat (1963) studied this unit which consists of clay, marls and carbonate rocks. Their type section was measured at Wadi Tar. Barr and Weeger (1972) studied this member consisting mainly of thin bedded dark grey-greyish grey shale, gypsiferous; near the top of the member beds are light tan coloured moderately soft marls. The base of this unit is not exposed. Jordi & Lonfat (1963) measured 260 ft (79m) of section in the Wadi Tar area, so that the total estimated thickness ranges between 755-790 ft (230-241m) based on surface and subsurface data.
Woller (1984) studied this member in the sheet El-Foqha, the thickness measured was around 5m. It is well exposed in several localities in the northwest corner of the sheet area, and in the depression between Wadi Kunayr and Dor el Ghani. This unit is considered to be Maastrichtian in age. The microfauna is poorly

preserved and indicate a shallow near-shore environment with agglutinated foraminifera such as *Rheophax* sp, aff *R guineana* Petters, and *Ammobaculites* sp.

Southwards the Lower Tar member is replaced by the Bin Affin member which consists of carbonates and interbedded sandstone. The Bin Affin Schichten has been studied by Fürst (1964) and Woller (1984). At its type locality at Wadi Kunayer-Dor al Ghani it consists of sandstones interbedded with carbonates and clays with a maximum thickness of 100m. Woller (1978) considered it to be Maastrichtian in age. The Bin Affin are transgressive shallow marine deposits, possibly coastal, and overlie unconformably Devonian rocks.

The Lower Tar is present in the NW corner of the El-Fogha sheet, while the Bin Affin occurs in the south half of the sheet and is reported from the floor of the Heira depression.

B- Upper Tar member: (Danian)-

This was proposed by Jordi and Lonfat (1963) for a sequence of marl and carbonate rocks, yellowish in colour. It contains a Mollusc bed very rich in macrofauna at the base and referred to as (Socna mollusc bed), well developed in the Socna area, separating Upper Maastrichtian Lower Tat Marl and the Danian upper Tar Marl, this bed thinning northwards until completely disappears in the sheet area. The type section was measured at Wadi Tar, where it overlies the Bin Affin member in the area south of Jabal As Sawda. Fürst (1964) studied this member and designated the Dor al Ghani mergel as the type sequence, the type section was taken in the eastern part of Dor al Msid. This member is only exposed in the sheet area along the escarpment of Dur al Ghani, and in the lower part of the Qararat Heira.

Barr and Weeger (1972) studied the upper Tar Marl and recorded a thickness of 320 ft (98m) of similar lithology.

Woller (1984) gave more detailed studies of the upper Tar member in the sheet El-Foqha, recognising various types of dolomitic rocks, rarely mixed with quartz grains, with a total thickness in the sheet area of 5-10 m. This member is conformably overlain by the Had member; the boundary between these two is very obvious, with the underlying yellowish well stratified massive dolomites of the upper Tar overlain by grey dolomitic limestones of the Had member, although this contact is less clear towards the south because of weathering and lithological changes in the Had member. Few microfossils have been found; the foraminifera *Haplophragmoides* sp, *Cibicides simplex* Brotzen, *Cibicides* sp, *Anomalinoided* sp, *Gavelinella* cf *danica* Brotzen, *Miliolids* and some ostracods; from the recorded fauna the sediments were deposited in a neritic environment. Dolomitization could be an early diagenetic effect but some primary dolomites are formed in the intertidal and supratidal zones, so it may be primary. The age of this member is considered to be Danian on the basis of geological position.

C- Had member-

This member was studied by Jordi and Lonfat (1963) WIth a type section chosen in the Jufra area. Fürst (1964) also studied the same unit at Dor al Ghani. He described the lithology as greyish to brown hard dolomite, sandy in the upper part with interbedded marly rocks with a total thickness of 2-15 m and named the Scedida dolomite.

Barr and Weeger (1972), studied the Had limestone, consisting mainly of dolomitic limestone and dolomite with three thick intercalation layers of chalky marl with a thickness of 165 feet (50m).

Woller (1984), gave a detailed description of this member in the Sheet El-Foqha, from exposures at the escarpment of Dor al Ghani where it forms distinct morphological steps. It is also exposed in the northern half of the sheet area and is present in the Qararat Heira. Woller described this member as a homogeneous unit of grey-yellowish grey in the southern part of the area where it consists of massive dolomite and dolomitic limestone with chert nodules at the bottom with a thickness of 3-8 m. The contact with the overlying Bu Ras member is conformable and very distinct with a change from hard massive dolomites of the Had member to marly argillaceous rocks of the Bu Ras member. This member contains poorly preserved microfaunas, particularly foraminifera such as

Textularia sp, *Triloculina* sp, *Rotalia* sp, *Anomalinoides* sp, and fragments of ostracods. These do not help to determine the age of the sediments which are considered to be Montian because the fauna of overlying Bu Ras member is of upper Palaeocene age. The fauna indicates shallow intertidal palaeoenvironment conditions of medium energy. Dolomite may be primary, deposited in the upper intertidal to supratidal zone.

Shurfah Formation

The Shurfah Formation were proposed by Jordi and Lonfat (1963) for a carbonate succession located in the Wadi Tar in the south eastern Hon Grabben (Al Jufrah area). He divided this succession into three members, in ascending order the Bu Ras marlstone, Gelta chalk and Operculina limestone. Fürst (1964) studied this formation and divided the sequences into two members, a lower member called Dur al Msid Tonstein and an upper member called the Operculinoides Schichten with type section South of Jabal as Sawda in eastern Dur al Msid. Barr and Weeger (1972) also studied this formation and followed the Jordi and Lonfat style of classification; some benthonic fauna were recovered indicating the carbonate succession was deposited in a shallow marine environment. Megrisi and Mamgan (1980) carried out studies of the Upper Cretaceous-Tertiary formations of North west Libya, in particular the Al Hamadah al Hamrah and Sirt Basin (North western Libya areas), and used the new term of "Ammur Member" instead of "Operculina limestone".

Woller (1984) gave more detailed studies to the formation in the Sheet El-Foqha also the formation has been divided into three members as follows in ascending order.

A- Bu Ras member-

This was proposed by Jordi and Lonfat (1963) for a carbonate sequence from the type locality Wadi Tar (Al Jufrah area). Fürst (1964) studied the same sequence, refering to it as the Dur al Msid Tonstein, consisting of grey-green silty, dolomitic clay-stone with fossiliferous beds of marls in the lower third; the type section was measured in the eastern part of Dur al Msid where there is a total thickness of 40m. Woller (1984) carried out detailed studies of the Bu Ras member in the Sheet El-Fogha. It forms the escarpment of Dur al Ghani where, together with the Qeltah member it forms an extensive plateau with the Had member of Zemam Formation at the base and the Ammur dolomites at the top. It is present in the southern part of the area of the sheet El-Foqha. The Bu Ras member varies in lithology north of latitude 27° 30′ it is mainly a brightly coloured argillaceous dolomite, locally brecciated at the top, while south of this latitude it is composed of dolomitic marls, argillaceous dolomitic limestone and dolomites which may be sandy near the top. It ranges in thickness from 6-16m in the Qararat Heira where a bed of gypsum one meter thick was recorded by Woller (1984); at the top a layer of brown massive gypsiferous sandy dolomite and gypsum concretions are present. in the southern part of the area, the top of this member is characterised by the present fragments of pelecypods, gastropods occurs in the thick brown bed of sandy dolomite.

The boundary with the Qaltah member in the northern part of the sheet area lies between a greyish-white argillaceous dolomite, brecciated in places, and grey massive dolomite which usually contains chert nodules although in the southern area (Qararat Heira) the top is usually taken at a massive bank of brown sand (Top Bu Ras member).

Woller states that there is no evidence of any unconformity between the Bu Ras and Qaltah members in which has been recorded sandstone and gypsum sediments considered to indicate a shallowing upward environment. The microfaunas in this member can be classified into two groups.

The first consists of agglutinated species and is found in the northern area. Species recorded are *Saccammina* sp , *Ammodiscus glabratus* (Cushman), *Glomospira charoides* (Jone et Parker) *Subtilina tenuis* (Chasman), *Ammobaaculites midwayensis* (Plummer) *Textularia midwayana* (Lalicker), etc. The second group is found in the Qararats and contains inner shelf assemblages with *Gaudryina africana* Le Roy, *Rotalia saxorum* d' orbigny, *Rotalia trochidifotrmis* (Lamark), *Pararotalia tuberculifera* (Reuss), and ostracods *Veenia (v) wariensis* Reyment, *Cytherella* sp, *Bairdoppilata magna* (Alexander) and *Quadracythere lagaghirboensis* (Apostolescu). On the basis of these faunas the Bu Ras member is considered to be late Palaeocene-Thanetian age.

B- Qaltah member-

This was first studied by Burollet (1960) and Jordi and Lonfat (1963) in the Al Jufrah area. Fürst (1964) carried out studies of this member although he did not recognise the Qaltah but its equivalent, the lower part of the Operculinoides Schichten (Fürst, 1964). Woller (1984) studied the Qaltah member in detail at its type section where it is composed of chalky limestone in the lower part with chert nodules, followed by intercalations of marly argillaceous limestone and pale coloured dolomite. The Qaltah member in the sheet area is well exposed in the escarpment of Dur al Ghani. The total thickness ranges from 16 to 28m. The contact with the Ammur member is not always obvious. For this reason Fürst (1964) combined both members into the Operculinoides Schichten, differentiated into upper and lower units: Argillaceous marls (Qaltah member) and mainly carbonates (Ammur member).

Barr and Weeger (1972) studied the Qaltah member, in Hon graben which consists of thick bedded to massive light grey to white soft chalk and chalky limestone with some harder limestone, marl and gypsum beds with a total thickness of 165 ft (50m). Woller (1984) studied this member and mentioned lithological changes eastwards in the upper part to grey green dolomitic marl, carbonate claystone with a deeper water fauna. These indicate late Palaeocene age: *Morozovella velascoensis* (Cushman) *Planorotalites* cf *pseudomenardii* (Bolli), *Planorotalites ebrenbergi* (Bolli), and *Subbotina* sp, as well as the ostracod species *Krithe* cf *peraticca* (Alexander), *Veenia (v) wariensis* Reyment *Veenia (v) ornatoreticulata* Reyment, *Cytherella meijeri* (Esker), *Bairdoppilata magan* (Alexander), *Quadracythere lagaghiroboensis* (Apotolescu), *Trachyleberis teiskotensis* (Apotolescu), *Cythereis teiskotensis* (Apostolescu), *Leguminocythereis teiskotensis* (Apostolescu), *Loxoconcha lagosensis* (Reyment), *Buntonia (B) pulvinata* (Apostolescu), *Isobuntonia harpa* (Apostolescu), *Paracypris* cf *jonesi* (Bonnema) and *Dahomey alata* (Apostolescu). Macrofossils are recorded in this member near the El-Foqha Oasis such as *Schizaster meslei* (Peron and Gauth), *Linthia desioi* Airagh, *Rostellaria apsidis* Bell. The environment of deposition of the Qaltah member was inner shelf slightly deeper eastwards indicated by the genera of larger forams *Ranikothalia*, *Lochartia*, and *Thalmannita*. The age of the sediments is Late Palaeocene based on the planktonic foraminifera *Planorotalites pseudomenardii* (p,4 zone sensu Blow, 1960). The slight deepening of the environment could be related to sea level changes during the Late Palaeocene.

C- Ammur member-

This member was proposed by Shakoor (in Megrisi and Mamgan 1980) to replace the term "Operculinoides limestone" (Burollet, 1960). The section was described in the eastern Hon graben, also studied by Jordi and Lonfat (1963) as the Operculinoides limestone and equal to the upper part unit of the Operculinoides Schichten of Fürst (1964). Woller (1984) studied this member and stated that it is lithologically homogeneous and consists of limestone and dolomites, slightly argillaceous, yellowish in colour with some massive thick bedded carbonate, with rare intercalation of marls, dolomitic marls and clays with gypsum. The total thickness ranges from 13-19m. The contact with the overlying Khayir member is conformable and the boundary is very distinct lithologically and morphologically between the upper most bank of organodetrital yellow dolomite or dolomitic limestone and several meters of soft argillaceous dolomite often with gypsum. This member is very rich in macro and microfauna, with as following foraminifera: *Rotalia saxrum* d;Orbigny, *Rotalia trochidiformis* Lamarck, *Pararotalia calcariformis* Schwager, *Cibicides beadnelli* Le Roy, *Cibicides burlingtonensis* Jennings, *Cibicides simplex* Brotzen, *nodosarella madrugaensis* Cushman et Bermudez. Ostracods were also recorded such as *Dahomey alata* Apostolescu, *Veenia* (*v) wariensis* Reyment, *Bairdoppilata magana* (Alexander). Macrofossils are present: *Linthia desioi* Airaghi, *Echinolampas moelehensis* Fourt, *Rostellaria* sp, *Osterea* *cochlearia* Lamark etc. The microfauna indicates that the sediments of the Ammur member were laid down on open lagoonal and inner shelf with a Tethyian foraminifera fauna of warm seas to shallow subtidal deposits. The fauna indicates a Late Palaeocene age

Bishima Formation

Kheir member-

This member has been described in the localities of Wadi Ammur, Wadi Tar and Wadi Zemam by Chiesa (1940), the type section taken at Wadi Ammur at coordinates 29° 18´ N, 16° 10´ E by Burollet (1960).

Burollet (1960) named and described the Kheir marl as a member of the Waddan Formation in the Jabal Waddan in the southern Hon Graben. The type section is in the Wadi Kheir and was measured by Jordi and Lonfat (1963), the total thickness varying from place to place: 35m in the area of Jabal Waddan, while to the west of jabal Harug it ranges is only 6-15 m.

Barr and Weeger (1972) recognised this unit in the subsurface Sirt Basin where it is widely distributed. They proposed it as a single Formation, the type section taken at well E1-59 with a total thickness of 270 ft (82m). This formation is conformably overlain by the Gir Formation and also conformably overlies the Upper Sabil carbonate; on the basis of planktonic foraminifera the age of this formation ranges from Upper Palaeocene-Lower Eocene, indicated by the foraminifera species *Globorotalia velascoensis* in the lower part and *G subbotinae* in the upper part. This suggests that the formation marks the boundary between the Palaeocene and Eocene.

Woller (1984) studied this unit in the sheet El-Foqha which forms the majority of the eastern part of the Sarir Al-Qattusah. The sediments are mostly weakly lithified, and composed of grey-green dolomitic marl, and pseudonodular light-grey to light-yellowish grey argillaceous dolomite. The total thickness recorded in the northeastern sheet area where the top and bottom of the member is very clear ranges from 14-18m. This member conformably overlies the Ammur member and is conformably underlain by the Wadi Zakim member. The fossils recorded in the Kheir member are foraminifera such as *Ammobaculites expansus* Plummer, *Ammobaculites* sp, *Textularia* cf *midwayana* Lalicker, *Spiroloculina esnaensis* Le Roy, *Rotalia saxorum* d' Orbigny, *R trochideformis* Lamarck, *Elphidiella africana* Le Roy, *Cibicidina mariae* Jones, *Cibicides simples* Brotzen, *Alabamina wilcoxensis* Toulmin etc.

One species of gastropod *Proconulus* cf *giganteus* Lam, has been recorded which indicates an Eocene age. Foraminifera indicate that this member ranges from Upper Palaeocene-Ypresian in age, and the sediments were laid down in shallow marine conditions.

Subsurface Palaeocene in the Sirt Basin

Hagfa shale-

Desio (1935) carried out studies of this formation in the El-Foqha depression and described the El-Fogha Series to include the Hiera and Ruega Formations; the whole sequences was dated as Lower and Middle Eocene. Brown (1958) studied the Hagfa Formation in the Heira depression where the type section was observed in a well exposed section of 40m thickness located 35 Km south west of El-Foqha Oasis. The section consists of dark shales, mainly dark green to black, becoming brown to yellowish in the upper part, with intercalation of limestones which are generally whitish, chalky, and highly fossiliferous. This location has been studied here (see chapter 3).

Barr and Weeger (1972) proposed the name Hagfa Shale for the subsurface of the Sirt Basin, the type section being in the well Y1-59 where the maximum thickness recorded was 1023 ft (312m), mainly of shales with rare interbedded limestones. The shale is grey and grey-brown, grey-green, and black in colour; it is soft to medium hard, calcareous, highly fossiliferous, and fissile; it is slightly silty in the lower part. The limestone beds present in the upper part of the Formation are fine grained grey to brown hard, dense, fossiliferous, rarely glauconitic. They are equivalent to the subsurface Upper Satal Formation in the area around Dahra and Hofra in the northwestern Sirt Basin. This formation is widely distribution in the subsurface of the central and western Sirt Basin. The thickness varies from place to place and it is occasionally absent over regional highs. This formation changes laterally to a more calcareous facies, changing into a carbonate sequences eastwards (Defa limestone in the Defa Field and Lower Sabil Carbonate in the east of the Basin). The Hagfa shale has a very rich microfauna, in particular planktonic foraminifera in the Lower part. The following species were recorded *Globoconusa daubjergensis*, *Globorotalia compressa*, *Globogerina pseudobulloides,* and *G triloculinoides* which indicate a Danian age. The sediments were deposited in deeper to open marine environments. The formation is conformably overlain by the Beda Formation in the type section area and conformable overlain by the Khalifa Formation in places such as the Waha field; it overlies the Kalash limestone of Maastrichtian age.

Khalifa Formation-

Barr and Weeger (1972) studied this formation in the subsurface of the Sirt Basin with the type section in well AA1-59 of the Oasis oil company. The total thickness is 529 ft (161m), divivded into two units. The upper unit consists of argillaceous limestone 196 ft (60m) thick, mainly of argillaceous dark-grey moderately indurated cacilutite, with some intercalations of grey calcareous shale. The lower unit consists mainly of shales 333 feet (102m) thick, dark grey to black, fissile, slightly pyritic, with occasional thin calcareous layers. The shale unit changes laterally into the carbonate facies of the Defa Formation in the areas of Samah, Ora field, NW and SW of the basin. In these areas the Khalifa Fomation is very thin and the only the upper unit is present. The Khalifa Formation conformably overlies the Beda, Dahra, and Hagfa Formations, the contact is usually graditional but this contact with the Hagfa Shale in certain areas are not clear. It is conformably overlain by the Upper Palaeocene Zelten Formation,

marked by a sharp change from the light coloured chalky limestone of the Zelten Formation to the darker more argillaceous Khalifa Formation. This contact forms noticeable sharp shift of sp curve on the electric log.
Abundant microfaunas were recorded from this Formation; the upper part has assemblages of benthonic foraminifera including miliolids which indicate shallow marine environment, while the shale sequences contain planktonic species of a more open marine environment. They are considered to be Upper Palaeocene (Landenian) in age.

Zaltan Formation-

This formation was proposed by Barr and Weeger (1972) for subsurface carbonate rocks present in the central and western Sirt Basin, while in the south central part of the basin it is difficult to differentiate it from the Harash Formation. The type section is recorded from well AA1-59 where the maximum thickness is 334 ft (102m). This formation consists mainly of limestone with minor amounts of shale. The sediments are variable in colour. In the type section it consists mostly of cream, tan, and grey coloured, argillaceous, chalky, fossiliferous calcilutite, with some calcarenite as well as thin beds of grey green, very soft fissile pyritic shale. In other areas it consists of tan-brown, very fossillferous, arenaceous, glauconitic, vuggy calcilutite and calcarenite with minor amounts of white to brown finely crystalline to medium crystalline, hard dense dolomite. This changes into a sequence of anhydritic dolomite facies in some wells such as B1-13. In the south central Sirt Basin it is difficult to differentiated the Zelten Formation from the Harash Formation. The upper and lower contacts are conformably this overlies the Khalifa Formation and is underlain by the Harash Formation. In the Harash area this formation conformably overlies the Lower Sabil Carbonate. No faunas or floras have been recorded.

Harash Formation-

This Formation was proposed by Barr and Weeger (1972) for a widely distributed formation found in the subsurface of the central and western Sirt Basin. The type section was chosen at well AA1-59 of the Oasis oil company. The maximum thickness in the type section was 288 ft (88m), while the thickness ranges from a few feet to over 500 ft. The section consists mainly of soft chalky, white brown argillaceous calcilutite and muddy calcarenite with thin interbedded grey to green, calcareous, fissile shale. The lower part of the formation becomes almostly shaley. The Harash formation conformably overlies the Zelten limestone or Upper Sabil Carbonate and is often conformably overlain by the Kheir Formation or more rarely the Eocene Gir Formation. The faunas recorded include *Operculina*, Bryozoa and Algae. These do not indicate any precise age or palaeoenvironmental condition, but the authors considered it to be Upper Landenian on the basis of stratigraphic position.

Kheir Formation-

This formation outcrops in the Wadi Ammur, with the type section measured by Burollet (1960) at coordinates 29° 18′ N and 16° 10′ E in the Southern Hon Graben. Barr and Weeger (1972) observed this succession in many wells of the Sirt Basin so that they proposed it as a new formation in the subsurface of the Sirt Basin. The type section was proposed in the well E1-59 where it has a maximum thickness of 274 ft (84m) mainly of shale with some clays, marl, and limestone. The shale is grey to dark grey and green in colour, fissile and calcareous. The clay is grey, soft, calcareous to very calcareous. The marl is grey, soft, and argillaceous, while the limestones are grey calcilutites and fossiliferous. This formation has a variable lithology with shale, marl, and limestone. The surface outcrops consist mainly of yellow to greenish gypsiferous marls. These sequences are conformably bounded by the Gir Formation on the top and the Upper Sabil carbonate at the base in the section.

The Kheir Formation ranges in age from late Palaeocene to Lower Eocene as indicated by Planktonic foraminifera *Globorotalia velascoensis*, from the lower part and *Globorotalia subbotinae* from the upper part. These indicate a late Palaeocene-lower Eocene age.

Beda Formation-

This Formation were proposed by Barr and Weeger (1972) in the subsurface western part of the Sirt Basin. The type section is located in well BBB1-59 of the Oasis oil company of Libya. The lithology is variable, based on its location in the basin. In the south-west it consists mainly of interbedded limestone, dolomite, and calcareous shale, the main rock types including argillaceous calcilutites with skeletal fragment and oolitic calcarenites, oolites commonly occurs in the upper part and dasycladacean algae is abundant in the lower part. In most of the south western of the basin the formation is divided into upper and lower members, while in the north western part of the basin it becomes more shaley and is divided into a lower Thalith member and the Rabia shale member. The thickness ranges from a few feet, to 800 feet while in the type section it is 45 ft (14m) thick. The Beda Formation conformably overlies the Hagfa shale. In the Defa area this formation conformably overlies the Defa limestone, and in the Hofra, Dahra and Bahi areas it conformably overlies the upper Satal Formation. Its lower boundary coincides with the top of the ?Danian stage.

Dahra Formation-

This formation also proposed by Barr & Weeger (1972) in the subsurface western Sirt Basin. The type section is recorded in well F1-32, with a total thickness of 310 ft (95m). The lithology consists mainly of white to light-grey, chalky, calcarenites and calcilutites, rarely argillaceous with pyrite. Tan to brown microcrystalline dolomite, thin interbeded dark shale, as well as minor amounts of anhydrite are present at the top of the formation. In the south western part of the basin the lower part of the formation changes into interbedded shale and argillaceous calcilutites. This formation in only present in the western part of the basin. The Dahra Formation is conformably overlain by the Khalifa Formation, while in its type section the Dahra Formation conformably overlies the Rabia Shale. In the central part of the basin it changes laterally into the shale sequences of the lower part of the Khalifa Formation.

Sabil carbonates

This carbonate sequence is present in the eastern Sirt Basin and divided into two formations.

Lower Sabil Carbonates- (Lower to Middle Palaeocene).

The lower Sabil carbonate were proposed by Barr & Weeger (1972) as a new formation in the subsurface of the eastern Sirt Basin. The type section was taken in well C1-12 of the Mobil Oil Company, with a total thickness of 1328 ft (405m). The lithology consists of dolomite, with a few limestones and occasionally chalk, and anhydrite. The dolomites are tan to brown in colour, fine crystalline occasionally sucrosic, medium hard, rarely fossiliferous. The limestone at the top and the base of the formation is a calcilutite, white to tan in colour, highly fossiliferous. The anhydrite occurs in association with dolomite, In the east of the type area it consists mainly of dolomite, with a high percent of gypsum. This formation conformably overlies the upper Cretaceous Kalash Formation and is conformably overlain by the Sheterat Formation. This is equivalent to the shale and carbonate sequences of the Western Sirt Basin.

Upper Sabil Carbonates- (Upper Palaeocene).

This was proposed by Barr and Weeger (1972) in the subsurface eastern Sirt Basin, the type section recorded in well C1-12 with a total thickness of 785 ft (240m). This sequence consists mainly of limestone with rarely dolomite and some chalk. The limestone is light in colour, ranging from pink to white, grey and tan. They are mainly calcilutites, often dolomitic or chalky, fossiliferous, soft to slightly hard and dense. They occasionally contain, cherts and pyrite. The dolomite is light to medium brown, fine to medium crystalline, moderately hard, while the chalk is soft and white to pink in colour. The upper Sabil Formation is conformably overlain by the kheir Formation, and conformably overlies the Sheterat Formation. In the area where the Shetrat Formation is missing the upper Sabil Carbonate lies directly on the lower Sabil Formation.

Sheterat Formation-

This was proposed by Barr and Weeger (1972) in the subsurface of the eastern Sirt Basin. The type section in well C1-12, with a total thickness of 145 ft (44m). The lithology consists of light grey to tan fossiliferous calcilutites, and some chalk with interbedded grey green, to brown, pyritic, fossiliferous, fissile to blocky, calcareous shale. This formation is conformably underlain by Lower Sabil carbonate and conformably overlain by Upper Sabil carbonate. This formation disappears in the eastern concession 59, east of the Gailo oil field and thins to 26 ft in the Amal field.

Satal Formation-

This formation was proposed by Barr and Weegar (1972) in the subsurface Dahra and Hofra areas of the north west Sirt Basin. The type section is recorded in well B2-32. It ranges from Maastrichtian-Danian. with a total thickness of 1029 ft (314m). This formation is divided into two members, a lower Palaeocene Upper member and a Maastrichtian Lower member. The contact between these members is marked by a change into chalky and less dolomitic sediments of upper Satal. This member is characterised by light grey to white, moderately indurated fine grained calcarenites in association with calcilutites. In the higher shelf area this becomes dolomitized and contains beds of anhydrite, shale are present along Platform margins where they interfinger with calcilutites. Abundant pellets are present and benthonic foraminifers such as *miliolids* and rare molluscs, echinoderms, algae and corals. The top of the upper member is distinguished by the presence of dense, grey, Pelecypod calcilutites. The contact with the overlying Thalith member of the Beda Formation is generally sharp and conformable. The Lower Satal consists of calcilutite, white chalky, poorly indurated, containing lager benthonic foraminifera. This formation conformably overlies the

Sirt Shale and unconformably overlies the quartzite of Hofra Formation.

The Palaeocene outcrops in the Cyrenaica Platform North Eastern Libya.

The early Tertiary of eastern Libya, the Cyrenaica Paltform, is composed of mainly marine sediments. The Al Uwayliah Formation (Palaeocene age) is recorded in two sites, the first located 6 Km east of Al Uwayliah village where the type section has been measured, and the second at Jardas al Jarari. In other areas such as Marsa El Hilal and Jardas Al Abid the whole of the Palaeocene has been eroded, with the Apollonia and Darnah Formations of Eocene age unconformably overlying the Maastrichtian (Wadi Ducchan Formation). The Palaeocene was described by Barr (1968b) in a small quarry composed of whitish chalk and greenish marls with a thickness of 6m located 6 Km east of Al Uwayliah village and considered to be the type section of the Al Uwayliah Formation.

More detailed studies have been carried out in the Cyrenaica Platform by Röhlich (1974) for the Al Bayda sheet, N1 34-15. In the type section area the following planktonic Foraminifera were recognised by Hanzlikova *Globorotalia velascoensis* (Cushman), *Globorotalia angulata* (White), *Globorotalia pseudomenardii* (Bolli), *Globorotalia* ex gr *uncinata* (Bolli), *Globigerina* (*Subbotina*) *triloculinoides* (Plummer), *Globigerina* ex gr *inaequispira Subbotina*. These indicate a Landenian age. The second locality is better exposured with thin to medium beds of whitish chalky limestone and greenish marls with a total thickness of about 20m, it is unconformably overlain by the Darnah Formation (Eocene age). Hanzlikova, identified Planktonic Foraminifera which indicate a Lower Palaeocene (Danian) age. These are *Globorotalia perclara* Loeblich et Tappan, *Globigerina* ex gr *spirlis* Bolli, *Globigerina* cf *daubjergensis* Bronnimann, *Guembelitria cretcea* Cushman, *Anomalinoides burlingtonensis* Jennigs etc. Microfossils recorded above suggest that this was laid down in a deeper marine environment.

Eliagoubi (1980) studied the type section of the Al Uwaylia Formation and dated it as Landenian on the basis of planktonic foraminifera *Globorotalia angulata* and *Globorotalia Pseudomenardii.*

The geology of the studied areas

Heira Section-

The Heira depression is one of a series of roughly circular depressions found in the region around El-Fogha (Fig 1.4). The geology of the Heira depression has previously been described by Brown (Internal report Esso oil company 1958) and Woller(1984). These depressions are named "Gararat" = depressions in Arabic; they are believed to have been formed in a semi-arid climate by weathering of rocks during more humid periods followed by eolian erosion in dry periods. Their location does not appear to be related to any geological structures such as gentle doming (Woller, 1984). The Heira depression was chosen for study because it is the largest exposing a succession from the late Cretaceous through to the early Eocene (Woller 1984). It was hoped to use this as a reference section to be correlated with subsurface sequences in the Sirt Basin. Unfortunately once in the field it was difficult to relate the sections given by Woller (1984) to the section observed. The sections measured have been related to prominent ledges seen in the depression formed by harder rocks (Fig. 1.5). The base of the section was taken at the lowest point where rocks could be observed, which were believed to be Upper Tar. However subsequent analysis leads to the belief that the measured section actually commenced in the Bu Ras member. The section began in black to dark-grey shales which were not described by Woller (1984); the first hard layer, an echinoid-rich dolomitic limestone is taken to be the lowest part of the Qaltah member. It is interesting that Brown (1958 internal report Esso) described the Heira Shale at Heira, which includes shales similar to the ones at the base of the section measured here. The Heira Shale of Brown is mostly equivalent to the Shurfa Formation of Woller(1984).

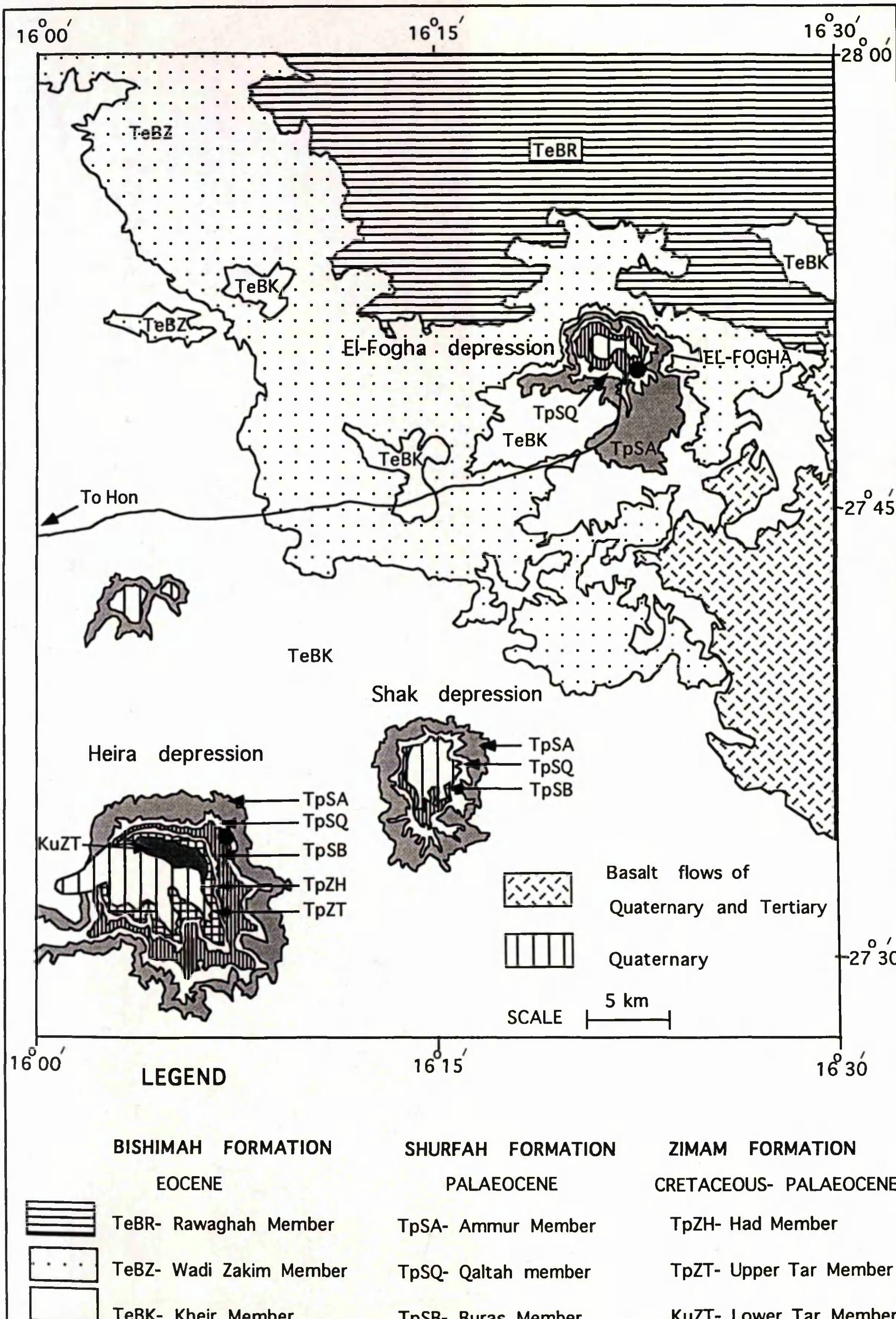


Figure 1.4 (●) Location of the studied outcrops

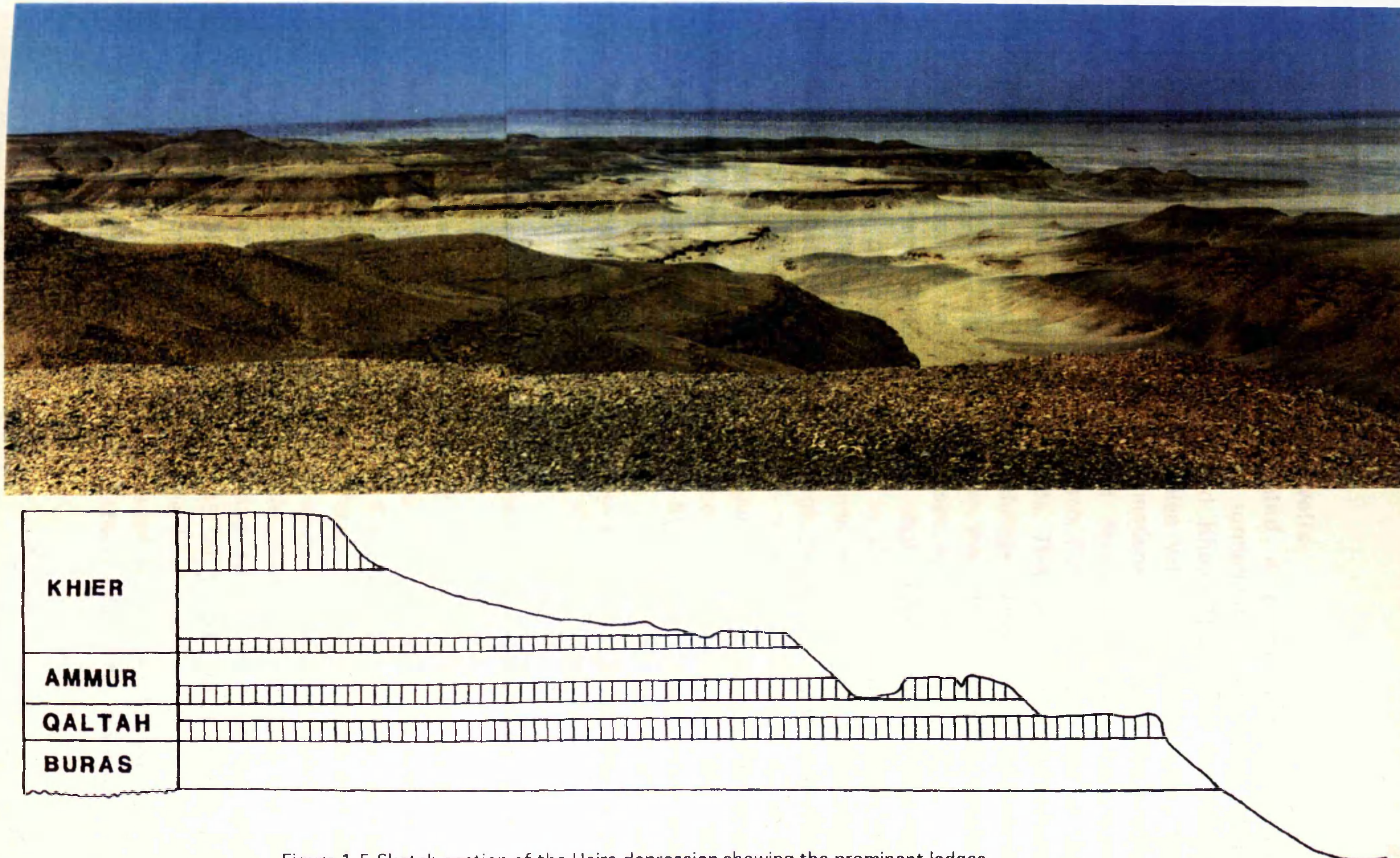


Figure 1.5 Sketch section of the Heira depression showing the prominent ledges

The geology in the studied wells-

The studied wells penetrated a succession of Lower Palaeogene including the following formations in ascending order: Hagfa, Khalifa, Zelten, Harash and Kheir. These are exclusively marine deposits, predominantly shales with some carbonates. The shales of the Hagfa and Kheir Formations and part of the Khalifa Formation, have a rich ostracod fauna, while the carbonate succession of the Zelten and Harash Formations and part of the Khalifa Formation have less ostracods. This sequence is not uniform throughout the basin and facies change eastwards to westwards across the basin due to tectonics in the basin. For more detailed lithological description of the wells see appendix 1.

The Hagfa Formation shows slight differences in thickness between the platform and through in the subsurface section (Fig 1.6), the Khalifa and Zelten formations show a sharp difference in thickness between platform and trough, while the Harash and Kheir Formations have slight differences in thickness. From this it can be concluded that normal faulting took place around Palaeocene/Eocene boundary, i.e after deposition of the Hagfa Formation. This fault was very active during the lower Eocene with great subsidence occurring in the trough during the deposition of the Khalifa and Zelten Formations. This fault appears to have been less active during deposition of the Harash and Kheir formations.

Previous studies of Palaeocene ostracods of Libya

The Palaeocene ostracods of Libya have been studied by several authors. The fauna shows a strong relationship with West Africa, North Africa and the Middle East. 23 species was recorded by Barsotti (1963), from the upper Palaeocene of El-Fogha and well A1-85 of the Sirt Basin. 13 of these species have been found in this study. Salahi (1966) studied material from well C3-6 of the Sirt Basin, he described sixty species and subspecies from the upper Cretaceous-Oligocene sediments; 45 of these are new but not formally described. 23 of these have been found in this study. El Sogher (1991 M.S) studied the ostracod fauna from the Raguba oil field (upper Cretaceous-lower Palaeocene), 73 species and

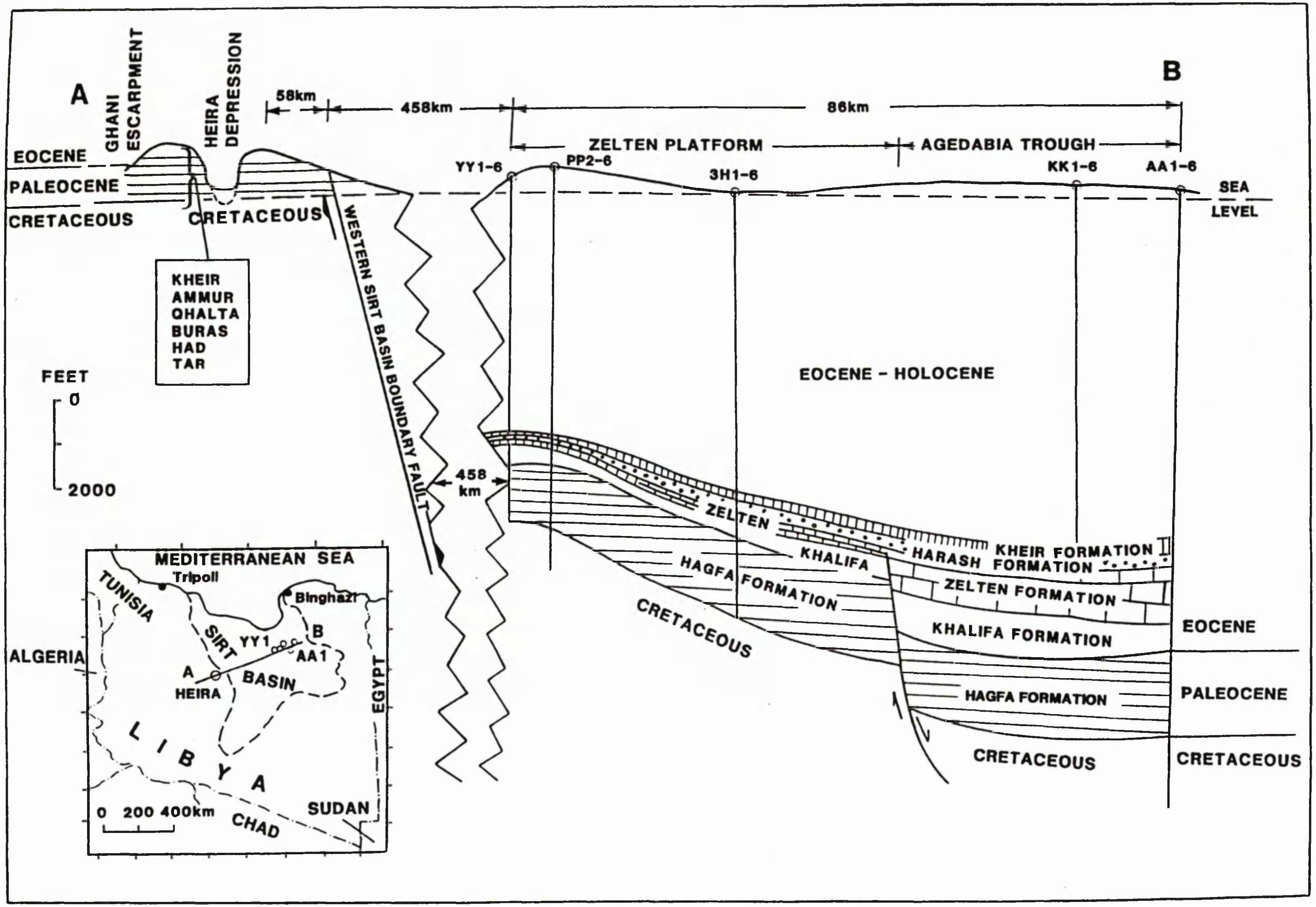


Fig 1.6 Cross section showing the relationship between the wells in the Sirt Basin and outcrop sections

subspecies were described 29 of these are in common with the present study. Keen *et al* (1994), studied Tertiary ostracods from North Africa and the Middle east including material from the Sirt Basin. Outside the Sirt Basin Palaeocene ostracods have been described by El-Waer (1992) from offshore N.W Libya; this work is principally on Middle-Upper Eocene, but 18 species were recorded from the Palaeocene of which only 3 are present in this study.

Whatley and Arias (1993) described Palaeogene ostracods from the Tripoli Basin, offshore Libya; these were again principally from the Eocene, with only 3 species recorded from the Palaeocene, none of which are recorded here, although 2 species from the Eocene have been found in this study.

More studies have been published on the neighbouring countries Tunisia , Niger and Egypt (chapter 6).

CHAPTER TWO

SYSTEMATIC DESCRIPTIONS

Systematic Description

All numbered specimens are housed in the Hunterian Museum Glasgow; Catalogue No- GLAHM 100867-101000, 106001-106333.

Subclass Ostracoda Latreille, 1806
Order Podocopida Müller, 1894
Suborder Platycopa Sars, 1866
Family Cytherellidae Sars, 1866
Genus *Cytherella* Jones, 1849
Type species: *Cytherina ovata* Roemer, 1840
Cytherella sorrensis El Sogher, 1991
pl. 1, figs. 6-10

1991 *Cytherella sorrensis* El Sogher,p. 44, pl. 2, figs. 1-8.

Material- 479 carapaces, 17 valves and 25 juvenile; 209 carapace and 3 valves well YY1-6; 110 carapaces, 2 valves well PP1-6; 102 carapaces, 4 valves and 24 juveniles Well 3H1-6; 1 carapace and 1 juvenile well KK1-6; 34 carapaces well AA1-6; 13 carapaces and 3 valves from the Heira; 10 carapaces and 5 valves from El-Fogha; GLAHM 100872-876.

Diagnosis- A species of *Cytherella* with distinct depression in the central dorsal area; broadly rounded anterior margin; obliquely rounded posterior margin; with weak rim in the postero ventral area.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100875	647	448	1.44	295
Female carapace;GLAHM 100876	645	436	1.48	314
Male carapace; GLAHM 100873	620	403	1.54	289
Female carapace; GLAHM 100872	626	398	1.57	261
Male carapace; GLAHM 100874	700			293

Remarks- This was originally described from the Waha and Heira Formations (Maastrichtian-Danian) of the Sirt Basin Libya (El Sogher 1991). Some specimens recorded in this study are finely punctate rather than entirely smooth as described by El Sogher.

Occurrence- Occurs in the Maastrichtian-Palaeocene Sirt basin.

Cytherella hateibensis El Sogher, 1991
pl. 1, figs. 11,12 & pl.2, figs. 1-3

1991 *Cytherella hateibensis* El Sogher, p. 41, pl. 1, figs. 6-8, 15.

Material- 162 carapaces and 1 juvenile; 40 carapaces well YY1-6; 30 carapaces well PP1-6; 28 carapaces well PP2-6; 54 carapaces and 1 juvenile well KK1-6; 9 carapaces well AA1-6; 1 carapace from Heira; GLAHM 100877-881.

Diagnosis- A species of *Cytherella* with distinct anterior rim on the left valve extending from antero-dorsal area along the ventral margin and ending at a point on the posterior margin.

Dimension of figured specimens (in μm)

	Length	Height	L/H	width
Female carapace; GLAHM 100877	645	387	1.66	242
Male carapace; GLAHM 100878	666	373	1.71	242
Female carapace; GLAHM 100879	634	379	1.67	244
Male carapace; GLAHM 100881	696	397	1.75	246
Female carapace; GLAHM 100880	682			248

Remarks- This species was originally described from the Waha and Heira Formations of the Sirt Basin Libya El Sogher (1991 M.S). The figured species differs in lateral outline from the original material due to sexual dimorphism; the material recorded here consists of females while the material previously recorded are males.

Occurrence- Occurs in the Maastrichtian-Palaeocene of the Sirt Basin.

Cytherella mohamedi sp nov
pl. 2, figs. 4-9

Material- 43 carapaces and 1 juvenile; 18 carapaces well YY1-6; 12 carapaces and 1 juvenile well PP2-6; 10 carapaces well 3H1-6; 3 carapaces well KK1-6; GLAHM 100882-887.

Derivation of Name- In honour of my Father Mohamed Gammudi.

Diagnosis- A species of *Cytherella* with distinct marginal rim around anterior, ventral and postero-ventral areas; anterior margin evenly rounded; ventral margin. concave; dorsal margin centrally concave.

Holotype- Male left carapace; pl.2, fig. 4, GLAHM 100882.

Paratype- Female right carapace; pl.2, fig. 5, GLAHM 100883.

Type Locality- well 3H1-6 at depth of 8420ft.

Type Horizon- Hagfa Formation (upper Palaeocene).

Description- Carapace subrectangular in lateral outline; anterior margin evenly rounded; posterior margin obliquely rounded; dorsal margin sinuous and slightly concave at third length from anterior; ventral margin sinuous and strongly concave in the middle; maximum height at quarter length from anterior; maximum length at mid height; right carapace larger than left and overlapping all around; carapace surface smooth; sexual dimorphism distinct; females higher than males. Internal features not known.

Dimension of figured specimens (in μm)

	Length	Height	L/H	width
Male carapace; GLAHM 100882	756	400	1.89	288
Female carapace; GLAHM 885	748	400	1.87	271
Female carapace; GLAHM 100883	753	401	1.87	254
Female carapace; GLAHM 100884	670	374	1.79	263
Female carapace; GLAHM 100887	676			245
Female carapace; GLAHM 100886	633			236

Remarks- This shows some similarities in lateral outline to *Platella kellettae* Munsey, figured and illustrated by Van Den Bold (1957) from the Palaeocene of Trinidad, but the latter differs in having a subtruncated posterior margin. Van Den Bold's specimens appear to be smooth because of poor preservation, however the original species described by Munsey (1953) displayed coarser reticulation.

Occurrences- Upper Palaeocene.

Cytherella zaltanensis sp nov
pl. 2, figs. 10-14 & pl.3, figs. 6,7

Material- 13 carapaces; 5 carapaces well YY1-6; 7 carapaces well PP2-6; 1 carapace well 3H1-6; GLAHM 100888-892, 100898, 899.

Derivation of the name- After Jabal Zaltan.

Diagnosis- The whole carapace is punctate with slots concentrically arranged in anterior and central areas of carapace; posteriorly coarsely punctate; the shape and position of the central muscle scare can be seen externally.

Holotype- Female carapace; pl.2, fig.14, GLAHM 100892.

Paratype- Male carapace; pl.2, fig.10, GLAHM 100888.

Type locality- well PP2-6, holotype at depth of 7580 ft and paratype at depth of 7620 ft.

Type horizon- Hagfa Formation (late Palaeocene).

Description- Carapace subrectangular in lateral view; anterior margin broadly and evenly rounded; posterior margin broadly rounded; dorsal margin almostly straight; ventral margin convex in centre; right valve larger than left, overlapping whole carapace except along postero-dorsal area; maximum height at anterior third; maximum length at mid height; in dorsal view tapered anterior rounded posterior, Maximum thickness near posterior; The surface of the carapace is ornamented with concentric slots (elongate coarse punctae). Internal features not known, sexual dimorphism obvious but not pronounced; the male is more elongate and the female has a more evenly rounded posterior margin.

Dimension of figured specimens (in μm)

	Length	Height	L/H	width
Male carapace; GLAHM 100888	678	357	1.90	256
Female carapace; GLAHM 100892	647	343	1.88	246
Male carapace; GLAHM 100891	618	312	1.98	198
Female carapace; GLAHM 100890	607	320	1.89	232
Male carapace; GLAHM 100899	612			238
Male carapace; GLAHM 100898	615			268
Juvenile carapace; GLAHM 100889	548	273	2.13	193

Remarks- *Cytherella meijeri* Esker, 1968 from the Palaeocene of Tunisia has some similarities to this species, but differs in outline and ornamentation. The coarse punctae differ in being restricted to one half of the valve in *C meijeri;* Both Esker (1968) and Donze *et al* (1982) state that the ornament is present in the anterior half, yet in both cases the authors illustrate specimens where it appears to be present only at the posterior. (Esker, pl. 1, figs 4-5; Donze *et al* Pl. 1, fig. 1). The female illustrated by Esker has a more ovoid outline than *C zaltanensis* sp nov, The male is more similar in outline to *C zaltanenis* sp nov. *C zaltanensis* sp nov is very similar to *C ewekoroesis* Reyment; it differs in having a more evenly rounded posterior margin; *C ewekoroensis* lacks the anterior rim of *C zaltanensis* sp nov; and *C zaltanenis* sp nov differs in dorsal view, having a more tapered anterior end and more inflated posterior end.

Occurrence- Upper Palaeocene.

Cytherella mouzoghii sp nov
pl. 3, figs. 1-5

Material- 362 carapaces and 5 valves; 138 carapaces and 3 valves Well YY1-6; 2 carapaces Well 3H1-6; 168 carapaces KK1-6; 27 carapaces Well AA1-6; 18 carapaces from the Heira section; 9 carapaces and two valves from El-Fogha; GLAHM 100893-897.

Derivation of name- After Dr Ahmed Mouzoghi.

Diagnosis- Carapace ovate in lateral view; surface smooth to finely punctate; with shallow depression in the central dorsal area.

Holotype- Male carapace; pl.3, fig. 2, GLAHM 100894.

Paratype- Female carapace; pl.3, fig.1, GLAHM 100893.

Type locality- Heira depression, sample S1-5.

Type horozon- Shurfah Formation (Buras member).

Description- Carapace ovate to subquadrate in lateral view; anterior and posterior margins evenly rounded; dorsal margin convex in the right valve, nearly straight in the left valve with a slight anterior concavity; maximum height slightly posterior to the mid length; maximum length at mid height; right valve larger than left and overlapping all around; carapace surface smooth to finely punctate; with shallow depression in the central dorsal area. Sexual dimorphism is not pronounced. Internal features not seen.

Dimension of figured specimens (in µm)

	Length	Height	L/H	width
Female carapace; GLAHM 100893	692	471	1.47	380
Male carapace; GLAHM 100894	700	457	1.53	342
Female carapace; GLAHM 100895	666	447	1.49	309
Male carapace; GLAHM 100896	659	413	1.59	306
Female carapace; GLAHM 100897	676			331

Remarks- This species shows some similarities to *Cytherella* gp *piacabucuensis* Neufville, 1979 recorded from the late Maastrichtian-Danian of the Sirt Basin (Keen *et al* 1994); *C mouzoghi* sp nov differs in having a less obvious dorsal depression, more developed anterior marginal rim and is more oval in lateral outline; Also the studied specimens show some similarities in lateral outline to *Cytherella guasarensis* recorded from the Palaeocene of Trinidad by Van den Bold, (1957), the latter species differs in its arched dorsal margin and its posterior margin is obliquely rounded with an obtuse angle. It resembles the widely quoted *C ovata* of the European Cretaceous, differing in its less conspicuous valve overlap and less obvious highest point, which is more centrally situated in the *C ovata*.

Occurrence- Palaeocene-Lower Eocene.

Cytherella saidi sp nov

pl.1, figs. 1-5

1978 *Cytherella* sp 2 Said, p. 214, pl. 24, fig. 2.

Material- 699 carapaces, 47 valves and 6 juvenile; 200 carapaces and 2 juvenile well YY1-6; 171 carapaces and 4 valves well PP2-6; 107 carapaces and 4 valves well 3H1-6; 77 carapaces well KK1-6; 40 carapaces and 4 juvenile well AA1-6; 41 carapaces and 35 valves from the Heira and 20 carapaces and 4 valves from the El- Fogha; GLAHM 100867-871.

Derivation of name- After Micropalaeontologist Dr Rakia Said who first described this species from Tunisia.

Diagnosis- Carapace smooth to finely punctate with ghost depression in the central dorsal area; anterior margin broadly and evenly rounded; posterior margin obliquely rounded; right valve strongly overlapping left valve, with moderately developed marginal rim throughout anterior, posterior and ventral margin.

Holotype- Female left carapace; pl.1, fig.1, GLAHM 100867.

Paratype- Male left carapace; pl.1, fig.5, GLAHM 10871.

Type locality- Heira depression, S1-3.

Type horizon- Shurfah Formation (Buras member)

Description- Carapace elongate to subovate in lateral view; anterior margin broadly and evenly rounded; posterior margin obliquely rounded; dorsal margin nearly straight at anterior half, convex posteriorly; ventral margin slightly concave in the middle; maximum height at anterior third, maximum length at mid height; right valve larger than left and strongly overlapping the left valve all around, surface reticulate with fine punctae, there is ghost depression in the central dorsal area; internal features not seen, sexual dimorphism is distinct; males being more elongate than females.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100867	742	457	1.62	411
Male carapace; GLAHM 100871	733	426	1.72	291
Female carapace; GLAHM 100870	829	532	1.55	376
Female carapace; GLAHM 100868	770			370
Female carapace; GLAHM 100869	785			370

Remarks- The figured species resembles *Cytherella* sp 2 recorded from the Maastrichtian-Palaeocene of the Siliana-Sers region of Tunisia (Said, 1978), although the latter species is larger (869-910 cf 733-829) and has a smooth carapace. *C saidi* sp nov shows some similarities to *Cytherella* aff *C compressa* Muenster figured and illustrated from the Middle Eocene (Bartonian) beds of northern and eastern Spain by Swain, 1984. The latter species differs in its narrow rounded posterior margin and anterior margin of the left valve bears a double row of pustules.

Occurrences- Palaeocene of Tunisia and Palaeocene-Eocene of Libya

Cytherella sp
pl. 3, figs. 10,11

Material- 2 carapaces from El-Fogha; samples F-15 and F-17; GLAHM 100900-901.

Description- carapace subrectangular in lateral outline; anterior margin evenly rounded, with weakly developed rim; posterior margin broadly rounded; dorsal and ventral margins nearly straight; right valve larger than left and entirely overlapping the left valve; in dorsal view maximum width posteriorly; maximum height at third length from posterior; maximum length at mid height; the carapace surface in punctate, with smooth areas possibly caused by corrosion. Sexual dimorphism is distinct, males being more elongate than females. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100900	529	334	1.58	241
Male carapace; GLAHM 100901	600	337	1.78	251

Remarks- This species shows some similarities in lateral outline and ornamentation to *Cytherella medianoda* recorded from Northen Australia by Whatley *et al*, 1995 the former differs in smaller size (595 cf 830) and the right valve stronge overlap the left valve.

Occurrences- Upper Palaeocene of Libya.

Genus *Cytherelloidea* Alexander, 1920
Type species: *Cythere williamsoniana* Jones, 1489
Cytherelloidea musacea Carbonnel, 1990
pl. 3, figs. 8,9 & pl. 4, figs. 1-2

1990 *Cytherelloidea musacea* Carbonnel *et al*, p.673, pl. 1, fig. 23.

1991 *Cytherelloidea libyaensis libyaensis* El Sogher, p. 47, pl. 2, figs. 9-11, 16.

Material- 9 carapace and 3 valves; 2 carapace in the well 3H1- 6 at depth of 9020 ft and 2 carapace in the Well PP2- 6 at depth of 7700 & 7860 ft; 2 carapace and 1 valve from the Heira and 3 carapace and 2 valves from El-Fogha; GLAHM 100902-905.

Diagnosis- Carapace subrectangular in lateral outline; prominent marginal ridge parallel to margin of carapace except central dorsal area; elongate median ridge evenly curved upward at quarter length from anterior which may join anterior margin ridge at anterior dorsal area; remainder of carapace smooth. Males less high than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100903	636	370	1.72	282
Female carapace; GLAHM 100902	590	350	1.68	270
Male carapace; GLAHM 100904	557	301	1.85	199
Female carapace; GLAHM 100905	578			250

Remarks- *Cytherelloidea musacea* was described from the Palaeocene of Niger. The diagnostic feature was stated to be the resemblance of the median ridge to a banana; this ridge does not appear to join the anterior ridge. In the majority of the Libyan material the median ridge does clearly join the anterior ridge, but in a few specimens it does not. This character is taken to be of intraspecific significance. El Sogher recognised two subspecies of his *C. libyaensis*; one as described here, the other *C libyaensis* punctata, with punctae between the ridges. This second subspecies has not been found in the present study.

Occurrences- Upper Palaeocene of Niger and Libya.

Cytherelloidea sp

pl. 4, fig. 3

Material- 2 carapaces; 1 from the Heira sample S3-5 and 1 from the El-Fogha sample F-5; GLAHM 100906.

Description- carapace subrectangular in lateral outline; anterior margin broadly and evenly rounded; posterior margin truncate; dorsal margin slightly convex; ventral margin slightly concave; maximum height at mid length; maximum length at mid height; carapace coarsely punctate with three ridges, dorsal and ventral ridges attached by posterior vertical ridge, and at anterior.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 100906	526	305	1.72	218

Remarks- This is similar in lateral outline and ornamentation to *Cytherelloidea* sp A recorded by El Sogher (1991) from the Waha Formation of the Sirt Basin.. However, *Cytherelloidea* sp. lacks the prominent anterior marginal rim of El Sogher's species, is more coarsely punctate, and differs in the details of rib pattern, especially the curved junction at the anterior of the dorsal and median ribs, and a less prominent ventral rib.

Occurrences- Upper Palaeocene of Libya.

Cytherelloidea sp A

pl. 4, fig. 4

Material- 1 carapace from the Heira sample S1-8; GLAHM 100907.

Description- Carapace elongate to subrectangular in lateral outline; anterior margin evenly rounded with distinct marginal rim; posterior margin obliquely rounded with distinct marginal rim; dorsal and ventral margins are concave in the middle; right valve larger than left, overlapping all around; maximum height at anterior fourth, maximum length at mid height; the whole carapace is reticulate with deep rounded fossae; the muscle scar area is indicated by a shallow depression.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Left carapace; GLAHM 100907	576	294	1.95	190

Remarks- *Cytherelloidea* sp A shows some similarities in lateral outline and pattern of anterior and posterior ridges to

Cytherellodea sp recorded from the subsurface Miocene sediments of the Sirt Basin (Gammudi & Keen, 1993); the latter differs in having smaller punctae and thicker posterior and anterior ridges.

Occurrence- Upper Palaeocene of Libya.

Family Cytheriddeidae Sars, 1825

Subfamily Cytherideinae Sars, 1825

Genus *Isohabrocythere* Apostolescu, 1961

Isohabrocythre teiskotensis Apostolesu, 1961

pl. 4, figs. 10-12 & pl. 5, fig.5

1961 *Isohabrocythere teiskotensis* Apostolescu, p.794, pl.1, figs.15-17, pl.15, figs.297-298.

1963 *Isohabrocythere teiskotensis* Apostolescu, Barsotti, p. 1524, pl.1, fig.2.

1966 *Isohabrocythere* aff *I teiskotensis* Apostolescu, Salahi, p.14, pl.2. fig.20.

1976 *Isohabrocythere teiskotensis* Apostolescu, Ficcarelli, p.734, pl.90, fig.8.

1981 *Habrocythere teiskotensis* Apostolescu, Reyment, p.57, pl.1, figs.13-14, pl.3, fig.1.

1983 *Isohabrocythere teiskotensis* Apostolescu, Foster, Swain and Petters, p.113, pl.3, figs.11-13, pl.8, figs,1,2.

1990 *Isohabrocythere teiskotensis* Apostolescu, Bassiouni & Luger, p.794, pl.6, figs.1,2,4,5,7,8.

Material- 490 carapaces and 79valves; 132 carapaces and 2 valves well YY1-6; 51 carapaces well PP2-6; 19 carapaces and 1valve well 3H1-6; 162 carapace well KK1-6; 19 crapaces well AA1-6; 60 carapaces and 52 valves from Heira; 42 carapaces and 24 valves from EL-Fogha; GLAHM 100913-16.

Diagnosis- Carapace subelliptical in lateral view; anterior margin broadly and evenly rounded with distinct marginal rim; maximum height at third length from anterior; eye tubercle weakly developed; surface of carapace reticulate with fine to medium pits, anterior compressed area smooth. Sexual dimorphism distinct, males being more elongate than females.

Dimension of figured specimens (μm).

	Length	Height	L/H	Width
Female carapace; GLAHM 100914	536	347	1.54	272
Male carapace; GLAHM 100915	651	387	1.68	272
Female carapace; GLAHM 100913	588	376	1.56	263
Dorsal carapace; GLAHM 100916	625			256

Remarks- This species has a wide geographical distribution in African continent; it was first described from the Palaeocene of west African countries i.e Senegal, Ivory Coast, Dahomey, and Togo (Apostolescu, 1961); subsequently from the Upper Palaeocene and Lower Eocene of Libya (Barsotti,1963 & Salahi,1966); the Palaeocene of the Soko Basin N.W Nigeria (Ficcarelli, 1976); the late Palaeocene of Nigeria (Foster *et al* 1983) and the Palaeocene to Lower Eocene of Egypt (Bassiouni, & Luger, 1990).

The length of the specimens described here varies from 518-659μm; this is similar to the previously described species, except for those illustrated by Apostolescu, (1961); the latter species is slightly smaller 500.

The specimens illustrated by Reyment & Reyment (1981) & Keen *et al* (1994) from the Palaeocene of Libya appear to belong to a different species, recorded here as *Isohabrocythere heiraensis* sp nov.

Isohabrocythere heiraensis sp nov
pl. 4, figs. 5-9

1980 *Isohabrocythere teiskotensis* Apostolescu, Reyment & Reyment, pl. 1, fig. 1.

1994 *Isohabrocythere teiskotensis* Apostolescu, Keen *et al*, pl.16.1, figs. 3,6.

Material- 279 carapaces, 14 valves and two juvenile; 90 carapaces and 2 juvenile well YY1-6; 58 carapaces and 1 valve well PP2-6; 37 carapaces and 1 valve well 3H1-6; 78 carapaces well KK1-6; 4 carapaces well AA1-6; 12 carapaces and 12 valves from the Heira; GLAHM 100908-912.

Derivation of name- After the Heira area.

Diagnosis- Carapace subtrapezoidal in lateral view; surface ornamented with fine punctae concentrically arranged around the margin of carapace, becomlng coarser towards the centre; area of muscle scar is smooth.

Holotype- Female carapace; pl.4, fig. 6, GLAHM 100909.

Paratype- Male carapace; pl.4, fig. 7, GLAHM 100910.

Type lcality- Heira depression, sample S1-4.

Type horizon- Shurfah Formation (Bu Ras member).

Description- Carapace subtrapezoidal in lateral outline; anterior margin broadly evenly rounded and compressed; posterior margin obliquely rounded; dorsal margin arched with a pointed highest point and sloping straight anteriorly and posteriorly; ventral margin slightly convex; left valve larger than right and overlapping all around except postero-dorsal margin; maximum height slightly anterior to mid length; maximum length at mid height; surface reticulate with fine punctae concentrically arranged around the carapace margin becoming coarser towards the centre of the carapace; in dorsal view the carapace is compressed anteriorly and broadly rounded posteriorly; maximum width third of way from posterior; muscle scar area is smooth. Internal features not known. Sexual dimorphism pronounced, males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100909	588	364	1.61	279
Male carapace; GLAHM 100908	572	344	1.66	306
Male carapace; GLAHM 100910	597	359	1.66	303
Male carapace; GLAHM 100911	582			294
Female carapace; GLAHM 100912	577			322

Remarks- *Isohabrocythere teiskotensis* is known from Mali, the Ivory Coast, Nigeria, Niger and Egypt; here it is also described for the first time from Libya (see above). Previous records from Libya (Reyment & Reyment 1980, Keen *et al* 1994) belong to *Isohabrocythere heiraensis* sp nov. The new species differs from *I teiskotensis* in lateral outline; the postero-dorsal margin is less tapered, the highest point of the valve is more pointed on the dorsal margin; in dorsal view the carapace is much thicker; and the ornament of punctae are slightly larger.

Occurrences- Palaeocene of Libya.

Suborder Podocopina Sars, 1866
Superfamily Bairdiacea Sars, 1888
Family Bairdiidae Sars, 1888
Genus *Bairdia* McCoy, 1844
Bairdia gp *ilaroensis*
pl. 5, figs.1-4

1959 *Bairdia ilaroensis* sp nov Reyment & Reyment, p. 59, pl. 1, figs. 1-7, text figs. 1a-b, 3 a-n, 5a-h.

1981 *Bairdia ilaroensis* Reyment & Reyment, Reyment, p. 56, pl. 9, figs. 6,7.

1983 *Bairdoppilata ilaroensis* Reyment & Reyment, Foster *et al*, p. 109, pl. 1, figs. 5, 7-11.

1990 *Bairdia ilaroensis* Reyment & Reyment, Bassiouni & Luger, p. 780, pl. 1, fig. 15.

1992 *Bairdia ilaroensis* Reyment & Reyment, El-Waer, p. 47, pl. 4, figs. 4-9.

1991 *Bairdia* aff *B ilaroensis* Reyment & Reyment, El Sogher, p. 53, pl. 4, figs. 1-5.

1994 *Bairdia* gp *ilaroensis* Reyment & Reyment, Keen *et al*, pl. 16.1, fig. 5.

Material- 186 carapaces, 74 valves and 4 juvenile; 88 carapaces, 12 valves and 4 juvenile well YY1-6; 17 carapaces well PP2-6; 3 carapaces well KK1-6; 51 carapaces and 35 valves from Heira; 27 carapaces and 27 valves from El-Fogha.

Description- Carapace bairdoid form in lateral view; anterior margin obliquely rounded; posterior margin pointed; dorsal margin strongly convex; particularly in the left valve; ventral margin convex in the left valve sinuous in the right; maximum height at centre of carapace, maximum length below mid height; left carapace larger than right and entirely overlapping all around right valve; surface of carapace finely punctate.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100918	878	565	1.55	509
Female carapace; GLAHM 100919	989	659	1.50	597
Male carapace; GLAHM 100917	882	542	1.62	502
Male carapace; GLAHM 100920	877			508

Remarks- The figured species are similar to *B* gp *ilaroensis* recorded from the Heira Formation Raguba oil field Sirt Basin by Keen *et al*, (1994), but are larger. The Libyan material shows similarities in lateral outline to *Bairdia ilaroensis* from the Maastrichtian of Ghana (Reyment 1959) and the Palaeocene of Niger (Reyment & Reyment, 1981). The later has marginal denticulation. *Bairdoppilta ilaroensis* from the Palaeocene of Nigeria illustrated by Foster *et al*, (1983) has a similar outline but differs in the lateral extremities of the right valve not being overreached by the left valve. Bassiouni & Luger (1990) recorded the species from Maastrichtian-Eocene in Egypt; their illustration differs in the lack of valve overlap, and the postero-ventral and antero-ventral are denticulate; their specimens are also larger (1.29 cf 996).

Occurrence- Recorded from the Palaeocene of Libya, Mastrichtian of Ghana, Palaeocene Niger and Tunis and Maastrichtian -lower Eocene of Egypt.

Bairdia cf *B septentrionalis* Bonnema, 1941
pl. 5, fig. 7

Material- 1 carapace from the well YY1- 6 at depth of 6940 ft; GLAHM 100922.

Description- Large carapace with the typical shape of the genus in lateral view; strongly convex dorsal margin and ventral margin; rounded anterior margin; very distinct pointed posterior margin; postero-dorsal slightly concave and convex postero-ventral; left carapace larger than right and obviously overreaching throughout dorsal and ventral margin; maximum height at mid length; maximum length at mid height; surface of the carapace is smooth, internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 100922	1500	941	1.59	693

Remarks- This shows some similarities in lateral outline to *B septentrionalis* Bonnema 1941 figured by Esker (1968) from the Danian El Kef section in Tunisia, but the latter species differs in being much smaller (884 cf1500 μm). *Bairdia* sp1 recorded from the Cretaceous-Palaeocene of the Siliana area of Tunisia (Said,1978) differs in its less pointed posterior margin and highly arched dorsal margin.

Occurrences- ?Middle Palaeocene.

Bairdia libyaensis sp nov
pl. 5, figs. 8-13& pl. 6, fig. 4

Material- 477 carapaces, 99 valves and 3 juvenile; 94 carapaces well YY1-6; 16 carapaces and 1 valve well PP2-6; 25 carapaces, 1 valve and 1 juvenile well 3H1-6; 198 carapaces, 5 valves and 2 juvenile well KK1-6; 48 carapaces and 10 valves well AA1-6; 64 carapaces and 67 valves from the Heira; 32 carapaces and 15 valves from the El-Fogha; GLAHM 100923-928.

Derivation of name- After Libya.

Diagnosis- A large species of *Bairdia* with height equal to more than half length; anterior margin higher than posterior.

Holotype- Left carapace; pl.5, fig.8, GLAHM 100923.

Paratype- Right carapace; pl.5, fig.9, GLAHM 100924.

Type locality- Heira depression, sample No S1-3.

Type horizon- Shurfah Formation (Bu Ras member).

Description- Massive and large carapace subrounded in lateral view; dorsal margin strongly convex; ventral margin convex; anterior and posterior margins obliquely rounded; posterior margin lower than anterior; maximum height at mid length; maximum length at mid height; left valve larger than right and obviously overlapping throughout dorsal and ventral margin; surface of carapace is smooth, sexual dimorphism is not distinct. Internal features not seen.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Carapace; GLAHM 100924	1424	958	1.48	809
Carapace; GLAHM 100923	1370	932	1.46	775
Carapace; GLAHM 100925	1370	870	1.57	672
Carapace; GLAHM 100927	1210	829	1.45	660
Carapace; GLAHM 100926	1360	904	1.50	727
Carapace; GLAHM 100928	1200			618
Carapace; GLAHM 100932	1361			750

Remarks- This is similar to *Bairdia* sp 3 from the lower Eocene of Tunisia (Said 1978); the latter differs in having a strongly convex ventral margin and its smaller size (1000 cf1420 µm).

Occurrence- Palaeocene of the outcrops and subsurface studied area.

Bairdia sp aff *B buisae*, El-Waer, 1992
pl. 5, fig. 6.

Material- 1 carapace well YY1-6 at depth of 6460 ft and 2 carapaces well PP2-6 at depth of 7300 ft; GLAHM 100921.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Carapace; GLAHM 100921	830	492	1.68	383

Remarks- This species resembles *B buisae* El-Waer, 1992 from the Buisa Formation (Maastrichtian) of well J1-NC41 N. W offshore Libya; the latter species differs in its pronounced arched dorsal margin and convex dorsal margin.

Occurrences- Lower-Upper Palaeocene.

Bairdia sp
pl. 6, figs. 1-3

Material- 90 carapaces, 6 valves and 4 juvenile; 56 carapaces, 2 valves and 1 juvenile well YY1-6; 20 carapaces well

PP2-6; 10 carapace well 3H-6; 8 carapaces, 4 valves and 3 Juvenile well KK1-6; GLAHM 100929-931.

Description- Small carapace typical of the genus; anterior margin obliquely rounded; pointed posterior; dorsal margin of the left valve more strongly convex than right valve; ventral margin convex in the left valve, slight concave in the right valve; maximum height near centre, maximum length one third height from ventral margin; left carapace larger than right, overlapping right valve all around except poster-ventral area; sexual dimorphism is not recognised . Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 100929	505	340	1.48	264
Carapace; GLAHM 100930	545	370	1.47	274
Carapace; GLAHM 100931	537			303

Remarks- This shows some similarities in lateral outline to *Bairdoppilata magna* Alexander, 1927, but the latter differs in its highly arched dorsal margin, lower posterior margin, and greater size.

Occurrences- Palaeocene of the Sirt Basin.

Bairdia sp A

pl.6, figs. 5-8

Material- 22 carapaces from the well YY1-6; GLAHM 100933-936.

Description- A large species with typical outline the genus; posterior margin lower and narrower than anterior; left valve has rounded margin, right valve with distinct posterior concavity on dorsal margin, and almost straight anterior part of dorsal margin. Left valve larger than right strongly overlapping dorsal margin and central part of the ventral margin; maximum height towards anterior, maximum length at mid height; sexual dimorphism exists but is not distinct. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width

Carapace; GLAHM 100933	1333	820	1.62	621
Carapace; GLAHM 100934	1368	868	1.57	632
Carapace; GLAHM 100935	1288	820	1.57	644
Carapace; GLAHM 100936	1207			621

Remarks- This species is very similar to *Bairdia libyaensis* sp nov, the latter having a more evenly arched dorsal margin with its highest point more centrally placed.

Occurrences- Palaeocene of the Sirt Basin.

Genus *Bairdoppilata* Coryell, Sample & Jennings, 1935

Bairdoppilata magna Alexander, 1927

pl. 6, figs. 9-13.& pl. 7, fig. 9

1927 *Bairdia magna* Alexander, p. 32, pl. 6, figs. 5, 7-8.

1963 *Bairdoppilata magna* Alexander, Barsotti, p. 1524, pl. 1, fig. 1.

1976 *Bairdia magna* Alexander, Ficcarelli, p. 733, pl. 19, figs. 1-2.

1991 *Bairdoppilata magna* Alexander, El-Sogher, p. 57, pl. 4, figs. 16-17, pl.5, figs. 19-20.

1993 ?*Bairdoppilata magna* Alexander, Whatley *et al*, p. 129, pl. 1, fig. 4.

Material- 47 carapaces, 12 valves and 1 juvenile; 1 carapace well YY1-6; 9 carapaces well PP2-6; 4 carapaces well AA1-6; 17 carapaces and 1 valve from Heira; 16 carapaces, 11 valves and 1 juvenile from El-Fogha; GLAHM 100937-942.

Diagnosis- Carapace subtriangular in lateral outline; dorsal margin highly arched; ventral margin straight; posterior margin pointed rounded and lower than half length; surface carapace smooth to finely punctate.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 100939	905	612	1.47	518
Carapace; GLAHM 100940	854	555	1.53	462
Carapace; GLAHM 100941	839	548	1.53	540
Carapace; GLAHM 100937	835	530	1.58	444

Carapace; GLAHM 100938	817	515	1.60	413
Carapace; GLAHM 100942	802			412

Remarks- This species was first described from the Late Cretaceous-Palaeocene of the U. S. A (Alexander, 1927) and subsequently by Barsotti, (1963.), from the Palaeocene outcrops of El-fogha and subsurface well A1-85; from the Palaeocene of the Sirt Basin and subsurface Cretaceous-Palaeocene Sirt Basin (El-Sogher,1991 M.S). Ficcarelli, (1976) described material from the Upper Cretacous- Palaeocene of the Sokoto Basin N. W. Nigeria and placed *B ilaroensis* into the synonymy of *Bairdia magna*, but his illustration differs from the Libyan specimens particularly in a higher and evenly rounded dorsal margin.

Whatley *et al*, (1993) recorded this from the Lower and Middle Eocene of the Tripoli Basin, offshore Libya, pointing out that their material differs slightly in outline. This difference is considered here to be of specific importance.

Occurrence- Cretaceous-Palaeocene.

Bairdoppilata sp

Pl. 7, figs.1-4

Material- 3 carapaces and 4 valves from the Heira; 2 carapace and 9 valves from the El-Fogha section; GLSHM 100943-946.

Description- Carapace subtrapezoidal in lateral view; anterior margin obliquely rounded; posterior margin pointed with a prominent concave outline at the junction with the dorsal margin; dorsal margin arched with a distinct posterior cardinal angle, anterior part straight; ventral margin straight; maximum height anteriorly; maximum length at third height from ventral; left valve strongly overlaps the right valve all around; the entire carapace is finely punctate; some five denticles are present along the ventro-anterior margin, and five around the ventro-posterior margin of the left valve. Sexual dimorphism is distinct females are higher than males and also tend to be larger. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female right valve; GLAHM 100943	800	462	1.73	
Female carapace; GLAHM 100944	780	452	1.72	420
Male carapace; GLAHM 100945	740	422	1.75	374
Male right valve; GLAHM 100946	773	410	1.88	

Remarks- This species shows similarities in lateral outline and ornamentation to *Bairdia* gp *pseudoseptentrionalis* (Mertens, 1956) figured by Babinot (1985 pl. 55, fig. 16) from the upper Cenomanian of Bouche-du-Rhone, France; the studied specimens are smaller (800 µm cf 1000) and have a stronger overlap; *Bairdia dolicha* van den Bold, 1957 from the middle Eocene Navet Formation of Freindship Quarry of Trinidad, differs in its more pointed posterior margin.

Occurrence- Upper Palaeocene.

Genus *Bythocypris* Brady, 1988

Type species: *Bythocypris reniformis* Brady, 1880

Bythocypris curryi sp nov

pl.7, fig. 14 & pl. 8, figs.1-5.

Material- 679 carapaces, 18 valves and 28 juvenile; 231 carapaces and 9 juvenile well YY1-6; 145 carapaces, one valve and 4 juvenile well PP2-6; 97 carapaces and 4 juvenile well 3H1-6; 120 carapaces, 1 valve and 7 juvenile well KK1-6; 52 carapaces, 1 valve and 3 juvenile well AA1-6; 32 carapaces and 15 valves from the Heira; 2 carapaces and 1 juvenile from the El-Fogha; GLAHM 100955-960.

Derivation of the name- In honour Dr G. B. Curry.

Diagnosis- Carapace elongate to subelleptical in lateral view; dorsal margin convex, more prominently so in right valve.

Holotype- Female carapace; pl. 8, fig.1, GLAHM 100956.

Paratype- Male carapace; pl. 8, fig. 5, GLAHM 100960.

Type locality- Heira depression, sample S1-5.

Type horizon- Shurfah Formation (Bu Ras member)

Description- Carapace elongate to subelleptical in lateral outline; anterior margin evenly rounded; posterior margin obliquely rounded; dorsal margin convex, more prominently so in the right valve; ventral margin straight; maximum height just to posterior of centre; maximum length at mid height, left carapace larger than right and overlapping the right valve along the anterodorsal and ventral margin. In dorsal view the carapace is biconvex, maximum width at anterior third. The surface of the carapace is smooth. Sexual dimorphism distinct, males being more elongate than females. Internal features not observed.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100956	755	333	2.26	289
Male carapace; GLAHM 100959	739	309	2.39	274
Female carapace; GLAHM 100957	726	325	2.23	278
Male carapace; GLAHM 100960	714	395	1.80	243
Male carapace; GLAHM 100958	757			279
Female carapace; GLAHM 100955	721			271

Remarks- This species is identical to *Bythocypris* sp A recorded from the Waha and Heira Formation of the Sirt Basin Libya, by El Sogher (1991 M.S). *Argilloecia ghalilae* described from the Middle Eocene Ghalile Formation of offshore N.W Libya by El-Waer (1992) is very similar; the right valve of *A ghalilae* has a straighter dorsal margin with its highest point near the posterior, and the left valve has a more tapered posterior margin. It is larger (920-1020 µm cf 707-760), *B curryi* sp nov shows some similarities to *Bythocypris* cf *B olaredodui* recorded from the Palaeocene of western Senegal, by Diop *et al* (1980); the latter differs in its narrowly rounded anterior margin.

Occurrence- Maastrichtian, Palaeocene-Eocene of Libya.

Bythocypris n sp 1 Salahi, 1966
pl.7, figs.10-13

1966 *Bythocypris* n sp 1 Salahi, p. 6, pl. 1, figs. 1-3.

Material- 17 carapaces and juvenile; 6 carapaces and 1 juvenile well YY1-6; 11 carapaces well PP1-6; GLAHM 100951-954.

Diagnosis- Carapace subtrapezoidal in lateral outline; maximum height at anterior cardinal angle; L/H of female carapace 1.71.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Carapace; GLAHM 100952	677	355	1.90	285
Carapace; GLAHM 100951	656	343	1.91	282
Carapace; GLAHM 100953	548	297	1.84	250
Juvenile carapace; GLAHM 100954	426	225	1.89	182

Remarks- This species was first described from the subsurface Lower Eocene sediments of well C3-6 Sirt Basin by Salahi (1966). *Bythocypris* n sp1 shows similarities in lateral outline to *B cuisensis* Keij recorded from the Eocene of Al-Jabal al Akhdar, north eastern Libya by Heldmdach *et at* (1980), but the latter differs in having a larger size (1010µm cf 656).

Occurrences- First recorded from Lower Eocene of Sirt Basin by Salahi (1966), in the present studied recorded from Palaeocene of the Sirt Basin.

Bythocypris ajdabiyaensis sp nov
pl. 7, figs. 5-8

Material- 17 carapaces; 1 carapace well YY1-6; 15 carapaces well PP1-6; 1 carapace well KK1-6; GLAHM 100947-950.

Derivation of name- After Ajdabiya village, Libya.

Diagnosis- Large and massive carapace subtriangular in lateral outline; dorsal margin strongly arched; surface of carapace is smooth.

Holotyope- Carapace; pl. 7, fig. 5, GLAHM 100947.

Paratype- Carapace; pl. 7, fig. 7, GLAHM 100949.

Type locality- Well PP2-6, at depth of 7300 ft.

Type horizon- Hagfa Formation (Upper Palaeocene).

Description- Carapace subtriangular in lateral view; dorsal margin strongly arched with a distinct postero-dorsal angle in both valves; ventral margin nearly straight in the left valve and slightly concave in the right; anterior margin evenly rounded; posterior margin tapered and rounded; maximum height slightly anterior to the middle; maximum length ventrally; left valve larger than right and entirely overlapping the right valve; surface of carapace is smooth, sexual dimorphism in not distinct. Internal features not seen.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 100949	980	528	1.85	448
Carapace; GLAHM 100947	1002	560	1.78	501
Carapace; GLAHM 100948	961	514	1.86	457
Carapace; GLAHM 100950	935			444

Remarks- The figured species shows similarities in lateral outline to *Paracypris trosliensis* recorded from the Paris Basin of France by Apostolescu (1956), and illustrated by Ducasse *et al*, (1955); the later species differs in its more pointed posterior margin and less prominent postero-dorsal angle of the left valve; *Paracypris sokotoensis* recorded from the Palaeocene of north west Nigeria by Reyment, (1981) is similar but is smaller (1002μm cf 750) and has a strongly pointed posterior.

Occurrences- Palaeocene- Lower Eocene Sirt Basin.

Bythocypris elsogheri sp nov

pl. 8, figs. 6-11.

1991 *Bythocypris* sp El Sogher, p. 59, pl. 5, figs. 7-10.

Material- 153 carapaces, 23 valves and 8 juvenile; 72 carapaces, 1 valve and 4 juvenile well YY1-6; 21 carapaces, 2 valves and 2 juvenile well PP2-6; 16 carapaces and 4 valves well 3H1-6; 29 carapaces and 1 juvenile well KK1-6; 6 carapace and 1 juvenile well AA1-6; 1 carapace and 2 valves from Hiera; 8 carapaces and 14 valves from El-Fogha; GLAHM 100961-966.

Derivation of name- In honour of the Osracodologist Mr Ali Elsogher Mohamed Salah.

Diagnosis- Carapace subreniform in lateral view; dorsal margin highly arched. particularly in the left valve; maximum height posterior to middle length and equal to more than half length; surface of carapace smooth.

Holotype- Female carapace; pl.8, fig. 6, GLAHM 100961.

Paratype- Male carapace; pl.8, fig.11, GLAHM 100966.

Type locality- Well YY1-6, holotype at depth of 7220 ft and paratype at depth of 7280 ft.

type horizon- Hagfa Formation (Upper Palaeocene).

Description- Carapace subreniform in lateral outline tapering towards anterior; dorsal margin highly arched in the left valve; ventral margin sinuous and concave in the middle; anterior margin evenly rounded; posterior margin obliquely rounded and higher than anterior margin; maximum height towards posterior; maximum length just below mid height; left valve larger than right and overlapping all around the right valve, surface of carapace is smooth. Internal features not observed. Sexual dimorphism distinct, males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 100966	1006	548	1.83	467
Female carapace; GLAHM 100961	1003	577	1.73	490
Male carapace; GLAHM 100965	1005	530	1.89	460
Female carapace; GLAHM 100962	1007	583	1.73	489
Male carapace; GLAHM 100962	1007			444
Female carapace; GLAHM 100964	1146			504

Remarks- This is identical to *Bythocypris* sp recorded from the Waha and Heira Formations of the Sirt Basin, Libya by El Sogher (1991 M.S). It has some similarities to *Bythocypris* sp 1 described from the Kalambaina Formation (Late Palaeocene) of north western Nigeria by Foster *et al*, (1983), pl.2, figs 12-15 but the latter differs in its more symetrical convex dorsal margin. *Bythocypris* sp B recorded by Reyment, (1981) from the Palaeocene of Nigeria is very similar in lateral outline, differing in its smaller size; Reyment states that his *B* sp B is rare and this could be a juvenile of *B elsoghari*. *Bythocypris angulata* recorded from the Lower Eocene of the Aquitaine Basin, France (Ducasse, 1967) differs in its less rounded postero-dorsal margin.

Occurrences- Palaeocene of Libya.

Superfamily Cypridacea Baird, 1845
Family Paracyprididae Sars, 1923
Genus *Paracypris* Sars, 1866
Type species: *Paracypris polita* Sars, 1866
Paracypris khawlai sp nov
pl. 9, figs. 11-15 & pl. 10, figs ,7,8

Material- 33 carapaces, 3 valves and two juvenile; 7 carapaces and 2 juvenile well YY1-6; 25 carapaces and 3 valves well 3H1-6; 1 carapace well AA1-6; GLAHM 100979-983, 990,991.

Derivation of the name- In honour of my daughter Khawla.

Diagnosis- Carapace elongate tapered in lateral outline; anterior margin evenly rounded; tapered posterior maximum height less than half length.

Holotype- Male carapace; pl. 9, fig. 15, GLAHM 100983.

Paratype- Female carapace; pl. 9, fig. 14, GLAHM 100982.

Type locality- Well 3H1-6 at depth of 8360 ft.

Type horizon- Hagfa Formation (upper part).

Description- Large elongate tapered carapace in lateral view; the lateral outline of the valves varies between the presumed male and female. Male carapaces are slightly lower, with the highest point in a more anterior position; the right valve of the male has a prominent antero-dorsal identation in lateral view, a feature less developed in the female; the dorsal margin is curved with a prominent postero-dorsal angle leading to tapered posterior margin; anterior margin evenly rounded; ventral margin concave; left valve larger than right and overlapping all around; internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100980	1111	444	2.50	361
Male carapace; GLAHM 100981	1111	422	2.63	345
Male carapace; GLAHM 100979	1136	431	2.63	343
Male carapace; GLAHM 100983	1122	433	2.59	359
Female carapace; GLAHM 100982	1126	448	2.51	354
Female carapace; GLAHM 100990	1135			402
Male carapace; GLAHM 100991	1136			352

Remarks- The outline of this species is typical of Paracypris it shows some similarities to *Paracypris* n sp 1 recorded from the Surfa Formation well C3-6 Sirt Basin by Salahi (1966), but the latter differs in having a convex dorsal margin and less drawnout posterior margin; it also resembles *P jonesi* Bonnema (1941), recorded from the Danian of Tunisia by Esker (1968), but the latter differs in its less tapered posterior margin. *Paracypris tripoliensis* sp nov differs in its smaller size, markedly concave ventral margin, and anterior position of greatest height.

Occurrences- Upper Palaeocene of the Sirt Basin.

Paracypris tripoliensis sp nov
pl. 9, figs. 6-10

Material- 8 carapaces and 1 juvenile; 4 carapaces well YY1-6; 3 carapaces well PP2-6; 1 carapace and1 juvenile well AA1-6; GLAHM 100974-978.

Derivation of the name- After the capital of Libya.

Diagnosis- Carapace subtriangular in lateral outline; anterior margin well rounded; posterior margin narrowly rounded; ventral margin strongly concave; maximum height towards anterior.

Holotype- Female carapace; pl. 9,fig. 6, GLAHM 100974.

Paratype- Female carapace; pl. 9, fig. 7, GLAHM 100975.

Type locality- Well PP2-6, holotype at depth of 7300 ft and paratype at depth of 7340 ft.

Type horizon- Khalifa Formation (Lower Eocene).

Description- Smooth carapace, subtriangular in lateral outline; anterior margin evenly rounded; posterior margin tapered; dorsal margin convex with prominent postero-dorsal angle; ventral margin broadly concave in the middle; maximum height in anterior quarter; maximum length slightly above the ventral margin; left valve larger than right, overlapping all around the right valve, obviously overlapping through dorsal and ventral margin. Internal features not seen; sexual dimorphism present but not distinct.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100974	889	357	2.49	282
Female carapace; GLAHM 100975	875	383	2.28	282
Male carapace; GLAHM 100976	819	336	2.43	253
Juvenile carapace; GLAHM 100977	704	302	2.33	219
Female carapace; GLAHM 100978	845			258

Remarks- This species shows similarities to *Paracypris* sp A recorded from Waha and Heira Formation Sirt basin (El Sogher, 1991 M.S), but the latter differs in its smaller size, posterior margin less drawnout and less convex dorsal margin; it also shows some similarity to *Paracypris communis* Van den Bold (1946), recorded from the Palaeocene of Trinidad (Van den Bold, 1957), but the latter differs in its less drawnout posterior margin and less concave ventral margin.

Occurrences- Palaeocene- Lower Eocene.

Paracypris sirtensis sp nov
pl. 10, figs. 1-6, Pl. 11, fig. 9

Material- 1146 carapaces, 168 valves and 12 juvenile; 413 carapaces, 7 valves and 4 juvenile well YY1-6; 251 carapaces and 14 valves well PP2-6; 164 carapaces, 7 valves and 6 juvenile well 3H1-6; 118 carapaces and 3 valves well KK1-6; 35 carapaces, 5 valves and 2 juvenile well AA1-6; 68 carapaces and 76 valves from the Heira; 97 carapaces and 56 valves from the El-Fogha; GLAHM 100984-989, 106005.

Derivation of name- After Sirt Basin.

Diagnosis- A species of *Paracypris* with large elongate carapace in lateral view; straight ventral margin; concave dorsal margin.

Holotype- Female carapace; pl.10, fig.1, GLAHM 100984.

Paratype- Male carapace; pl.10, fig. 3, GLAHM 100986.

Type locality- Heira depression, sample S1-3.

Type horizon- Shurfah Formation (Bu Ras member).

Description- Carapace elongate in lateral outline; anterior margin rounded; posterior margin tapered; dorsal margin arched gently slopping towards anterior, steeply towards posterior; ventral margin straight; maximum height anterior to the middle length; maximum length at quarter height from ventral margin; left valve larger than right and obviously overlapping the right valve along anterior, ventral and posterior margins; surface of carapace is smooth. Internal features not known. Sexual dimorphism present, males being more elongate.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 100984	1063	484	2.19	419
Male carapace; GLAHM 100985	1084	463	2.34	397
Male carapace; GLAHM 100986	1122	477	2.35	429
Female carapace; GLAHM 100987	992	470	2.11	396
Female carapace; GLAHM 100988	1081	497	2.17	402
Male carapace; GLAHM 100989	1000			407
Female carapace; GLAHM 106005	1002			360

Remarks- This species resembles *Paracypris* sp recorded from the Upper Cenomanian of the Dordogne France by Colin, (1974) and Babinot *et al* in Oertli (1985). The latter is smaller (828 μm cf 992-1010) and has a more tapered posterior margin.

Occurrences- Palaeocene of the Sirt Basin and outcrop sections.

Paracypris keeni sp nov

pl. 8, figs. 12,13 & pl. 9, figs. 1-5.

Material- 100 carapaces, 2 valves and 22 juvenile; 35 carapaces and 3 juvenile well YY1-6; 18 carapaces and 2 juvenile well PP2-6; 15 carapaces and 1 valve well 3H1-6; 27 carapaces, 1 valve and 16 juvenile well KK1-6; 5 carapaces and 1 juvenile well AA1-6; GHAHM 100967-973.

Derivation of the name- In honour of Dr M. C. Keen.

Diagnosis- Large smooth carapace subtriangular in lateral view; dorsal margin highly arched and maximum height equals less than half length.; tapered posterior margin.

Holotype- Female carapace; pl. 9, fig. 2, GLAHM100970.

Paratype- Male carapace; pl. 9, fig. 1, GLAHM 969.

Type locality- Well YY1-6, holotype at depth of 7040 ft and paratype at depth of 7100 ft.

Type horizon- Hagfa Formation (Upper Palaeocene).

Description- Carapace subtriangular in lateral outline; anterior margin well rounded; tapered posterior margin; dorsal margin highly arched with the highest point pointed in the left valve, more evenly convex in the right valve both valves with a prominent angularity at junction with posterior margin; ventral margin concave in the right valve and straight in the left valve; left valve larger than right and overlapping all around the right valve; maximum height slightly anterior to middle; maximum length at fifth height from ventral margin; surface carapace is smooth. Internal features not known. Sexual dimorphism is distinct, males being less high than females; in dorsal and ventral view the greatest width is at middle, and nearly equal to half the length of the carapace.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 100968	1136	537	2.11	428
Female carapace; GLAHM 100967	1111	566	1.96	464
Male carapace;GLAHM 100969	1063	505	2.05	423
Female carapace; GLAHM 100970	1152	564	2.04	?455
Juvenile carapace; GLAHM 100971	666	320	2.08	238
Female carapace; GLAHM 100972	1051			447
Male carapace; GLAHM 100973	1085			436

Remarks- This is placed into *Paracypris* on the basis of lateral outline, larger left valve, and differences in the outline of the dorsal margin of the two valves.

Occurrences- Palaeocene of the Sirt Basin.

Paracypris hagfaensis sp nov
pl. 10, figs. 9-12 & pl.11, fig. 8

1994 *Paracypris* sp Keen *et al*, pl.16.1, fig. 9, 10.

1991 *Paracypris* sp aff P sp A Esker 1968, El Sogher, p.60, pl.5, fig.15-18; GLAHM 100992-995, 106004.

Material- 12 carapaces and1 valve; 6 carapaces well YY1-6; 3 carapaces well PP2-6; 2 carapaces well 3H1-6; 1 carapace and 1 valve well AA1-6.

Derivation of the name- After Hagfa area.

Diagnosis- Carapace smooth, elongate in lateral outline; dorsal margin slightly arched; maximum height approximately 1/3 from anterior.

Holotype- Female carapace; pl. 10, fig. 12, GLAHM 100995.

Paratype- Male carapace; pl.10, fig.10, GLAHM 100993.

Type locality- Holotype well PP2-6 at depth of 7300ft and paratype well YY1-6 at depth of 6940 ft.

Type horizon- Khailfa Formation (Lower Eocene).

Description- Carapace elongate in lateral outline; anterior margin broadly rounded; posterior margin tapered; dorsal margin slightly arched with distinct anterior and posterior cardinal angles; ventral margin sinuous and slightly concave in the middle; maximum height approximately one third from anterior; maximum length at mid-height; left valve larger than right and overlapping all around. Surface of carapace smooth. Internal features not known. Sexual dimorphism well pronounced, females higher than males.

Dimension of figured specimens (in μm).

	Length	Height	L/H	Width
Female carapace; GLAHM 100992	1061	520	2.04	404
Male carapace; GLAHM 100993	1094	505	2.16	435
Female carapace; GLAHM 100994	1097	543	2.02	456
Female carapace; GLAHM 100995	1122	533	2.10	464
?Female carapace; GLAHM 106004	925			351

Remarks- This species is similar in lateral outline to *Paracypris* sp recorded from the Heira Formation of the Sirt Basin Libya (Keen *et al*, 1994), apart from its larger size (1.11mm cf .728). *Paracypris* sp A Esker figured by Donze *et al* (1982), differs in its more tapered posterior margin; *Bythocypris* sp 1 recorded from the Upper Maastrichtian-Lower Palaeocene of the Siliana region of Tunisia (Said 1978) differs in its smaller size (670-700 cf 1011). Said considered her species to be the same as *Bythocpris* n sp

Salahi 1966, but in fact the latter species is very different in lateral outline.

Occurrences- Maastrichtian-Lower Eocene of the Sirt Basin.

Paracypris sp B

pl. 11, figs. 1,2

Material- 2 carapaces from the well PP2-6 at depth of 7300 ft; GLAHM 100997-998.

Description- Carapace elongate-subtriangular in lateral view; anterior margin evenly rounded; posterior tapered; dorsal margin slightly convex with straight postero- dorsal area, ventral margin concave; maximum height in anterior third; maximum length slightly above the ventral margin; left valve larger than right and obviously overlapping around dorsal and ventral margins; the entire carapace is smooth. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 100997	1010	424	2.38	365
Carapace; GLAHM 100998	975	380	2.56	305

Remarks- This differs from *Paracypris* sp A in its less prominent postero-dorsal angle and more tapered overall appearence. *Paracypris* n sp 2 recorded from Beshima Formation Lower Eocene Sirt Basin by Salahi (1966) shows similarities to the figured species but the latter species differs in its more tapered posterior and more convex dorsal margin. *Paracypris goodlandensis* Howe & Laurencich, 1958 from the lower Cretaceous of Florida and North eastern Spain (Swain *et al*, 1991), is larger (1033μm cf 1010) and has an obliquely rounded anterior margin and less concave ventral margin.

Occurrences- Upper part of the Hagfa Formation.

Paracypris sp A

pl. 10, fig. 13.

Material- 1 carapace from the well PP1-6 at depth of 8740 ft; GLAHM 100996.

Diagnosis- Carapace elongate in lateral outline; maximum height at anterior third; dorsal and ventral margin nearly subparallel; anterior margin well rounded; postero-dorsal angle prominent; posterior margin pointed rounded, ventral margin concave.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 100996	909	355	2.56	265

Remarks- This species is similar to *Paracypris* n sp 2 Salahi (1966), recorded from the subsurface Beshima Formation of the Sirt Basin; it differs in lacking the concave postero-dorsal margin of Salahi's species and in having a more prominent postero-dorsal angle. This is probably the same as *Paracypris* sp A recorded by El Sogher, (1991 M.S), from the Waha and Heira Formation of the Sirt Basin.

Occurrence- Occurrs in the transition zone between the Maastrichtian-Danian.

? *Paracypris harashensis* sp nov
pl. 32, figs. 10-13, pl. 33, fig.5

Material- 35 carapaces; 7 carapaces well YY1-6; 12 carapaces well PP2-6; 1 carapace well 3H1-6; 8 carapaces well KK1-6; 7 carapaces well AA1-6; GLAHM 106300-304.

Diagnosis- Carapace subtrapezoidal in lateral outline; with distinct anterior and posterior cardinal angle in the right valve; left valve larger than right and overlaps all around; surface of carapace is smooth.

Derivation of the name- After Harash area, Sirt Basin.

Holotype- Female carapace; pl.32, fig.10, GLAHM 106300.

Paratype- Male carapace; pl. 32, fig. 12, GLAHM 106302.

Type locality- Well PP2-6 at depth of 7300 ft.

Type horizon- Harash Formation (Lower Eocene).

Description- carapace subtrapezoidal in lateral view; anterior margin evenly rounded; posterior margin obliquely rounded; dorsal margin with distinct anterior and posterior cardinal angle in right valve, posterior cardinal angle in left valve; ventral margin nearly straight in right valve, slightly convex in left; maximum height at anterior cardinal angle; maximum length just below mid height; in dorsal and ventral view maximum width posteriorly; left valve larger than right, overlaps all around; surface of carapace is smooth; sexual dimorphism is distinct, males more elongate than females. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106300	588	431	1.36	274
Male carapace; GLAHM 106301	612	343	1.78	285
Male carapace; GLAHM 106302	580	309	1.87	256
Female carapace;GLAHM 106303	592	347	1.70	294
Female carapace; GLAHM 106304	550			275

Remarks- The generic assignment of this genus is difficult. This species shows similarity to *Ovocytheridea* sp recorded from the Maastrichtian-Palaeocene of Tunisia by Ra Said (1978) but the latter differs in having a higher arched dorsal margin and less rounded poster-ventral margin.

Occurrences- occurs in the Lower Eocene of the Sirt Basin.

Genus *Pontocyprella* Lyubimova, 1955

Type species: *Bairdia harrisiana* Jones, 1849

Pontocyprella recurva Esker, 1968

pl. 11, figs. 4-7

1968 *Pontocyprella recurva* n sp Esker, p. 323, pl. 1, figs. 6-7, pl. 4, fig. 7.

1982 *Pontocyprella recurva* Esker, Donze *et al*, p. 281, pl. 2, figs. 1-2.

1982a ?*Pontocyprella recurva* Esker, Boukhary *et al*, pl. 2.

1992 *Pontocyprella recurva* Esker, El-Waer, p. 73, pl. 57, figs. 1-3.

Material- 10 carapaces; 1 carapaces well YY1-6; 4 carapaces well PP2-6; 1 carapace well 3H1-6; 3 carapaces well AA1-6; GLAHM 10100, 106001-6003.

Description- The dorsal margin of the left valve is convex, prominently overlapping the right valve in the antero-dorsal region where the right valve is concave. The anterior margin is obliquely rounded towards the dorsal margin. The posterior margin is less tapered than in many species. The ventral margin is concave in the right valve, and straight in the left. Surface of the carapace is finely punctate to smooth. Males more elongate than females. No internal details could be observed in the specimens studied, but Esker (1968) records an adont hinge, wide anterior and posterior marginal areas with a moderate number of simple straight radial pore canals.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 101000	787	400	1.97	320
Male carapace; GLAHM 106002	802	375	2.14	295
Female carapace; GLAHM 106001	781	373	2.08	311
Female carapace; GLAHM 106003	633			240

Remarks- This species was originally described from the Danian Zeubbeus Formation of Oued R' mel near El Kef Tunisia by Esker (1968) and subsequently recorded from the Maastrichtian-Danian of the El Kef section (Donze *et al*, 1982), the Palaeocene of Egypt (Boukhary *et al*, 1982a) and the Maastrichtian-Palaeocene of offshore N. W. Libya (El-Waer, 1992). The Egyptian material is queried because it is more ovate in lateral outline than the Libyan and Tunisian material. Whatley *et al* (1993) also recorded this species from the Eocene of the offshore Tripoli Basin. However, their illustration shows a species differing from *P recurva* in its more tapered posterior outline and larger size (1.5 cf.7-.94 mm).

Occurrences- Maastrichtian-Danian of Tunisia, Palaeocene of Egypt, and Maastrichtian-Palaeocene of Libya.

Pontocyprella sp

pl. 11, fig. 3

Material- 6 carapaces; 1 carapace well YY1-6; 2 carapaces well PP2-6.; 1 carapace well KK1-6; 2 carapaces well AA1-6; GLAHM 100999.

Description- Carapace elongate trapezoidal in lateral view; posterior margin narrowly rounded in the left valve tapered in the right; dorsal margin with prominent highest point third away from anterior, left valve larger than right and overreaching all around except along dorsal area. surface of carapace is smooth, internal feature not known.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 100999	721	350	2.06	282

Remarks- The figured species resembles *P recurva* previously recorded here, the latter species differing in its more tapered posterior margin, more curved dorsal margin and no overlap along the anterior margin.

Occurrences- Palaeocene-Lower Eocene.

Family Pontocyprididae Muller, 1894

Genus *Propontocypris* Sylvester-Bradley, 1947

Type species: Propontocypris trigonella Sars, 1866

Propontocypris triangulata sp nov

pl. 11, figs. 10-14, pl.12, fig.6

Material- 24 carapaces and one juvenile; 12 carapaces and 1 juvenile well YY1-6; 4 carapaces well PP2-6; 4 carapaces well 3H1-6; 4 carapaces from the El-Fogha; GLAHM 106006-6010, 106012.

Derivation of name- After its shape.

Diagnosis- A species of *Propontocypris* with small smooth carapace; right valve larger than left valve; the left valve being higher than the right.

Holotype- Female carapace; pl.11, fig.10, GLAHM 106006

Paratype- Male carapace; pl.11, fig.12, GLAHM 106008.

Type locality- El-Fogha area, sample F9.

Type horizon- Shurfah Formation (Ammur member).

Description- Small carapace subtriangular in lateral view; anterior margin broadly rounded; posterior margin narrow rounded; dorsal margin arched, ventral margin straight in left valve and slightly convex in the right valve; maximum height slightly anterior to the middle; maximum length at third from ventral; right valve larger than left valve and obviously overlapping ventrally, posterodorsally and anterodorsally; left valve dorsally somewhat higher than right valve; in dorsal view the carapace is biconvex, maximum width slightly anterior to the middle. Internal features not known. Sexual dimorphism is distinct; the females tend to be larger, as well as higher.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106006	497	303	1.64	246
Male carapace; GLAHM 106008	457	255	1.79	200
Juvenile carapace; GLAHM 106010	397	205	1.93	165
Male carapace; GLAHM 106009	446	241	1.85	184
Female carapace; GLAHM 106007	515	305	1.68	247
Male carapace; GLAHM 106012	464			211

Remarks- This is placed into *Propontocypris* on the basis of lateral outline, larger right valve, smooth surface. *Eucythere* aff *E triordinis* Schmidt recorded from late Eocene of Al-Jabal al Akhdar north eastern Libya by Helmdach *et al* (1980) pl. 1, fig. 23 differs in having a straight ventral margin and more elongated postero-dorsal margin.

Occurrences- Upper-Lower Palaeocene of the Sirt Basin and El-Fogha area.

Propontocypris aff *P tarabulusensis* El-Waer, 1992
pl. 11, fig. 15.

Material- 1 carapace recorded from Well YY1-6 at depth of 6000 ft; GLAHM 106011.

Description- Carapace subtriangular in lateral view; maximum height slightly posterior to the centre; greatest length at third height from ventral margin; dorsal margin highly arched;

ventral margin sinuous; anterior margin broadly and evenly rounded; posterior margin pointed; left valve larger than right and overlapping all around except central posterior and postero-ventral area; surface of the carapace is smooth.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106011	638	363	1.75	324

Remarks- This species resembles female *Propontocypris tarabulusensis* El-Waer (1992) recorded from the Samdun Formation (Middle Eocene) of Well F1-NC41 Tarabulus Basin, N.W offshore Libya. But the latter is smaller (592 cf 638).

Occurrences- Lower-Middle Eocene of Libya.

Superfamily Cytheracea Baird, 1850

Family Brachycytheridae Puri, 1954

Genus *Brachycythere* Alexander, 1933

Type species: *Cythere sphenoides* Reuss, 1858

Brachycythere spinosa sp nov

pl. 12, figs. 1-5.

Material- 31 carapaces; 29 carapaces well YY1-6; 1 carapace well 3HH-6; 1 carapace well AA1-6; GLAHM 106013-17.

Derivation of name- After the presence of the spine on the posterior margin of each valve.

Diagnosis- Carapace subrectangular to subovate in lateral view; distinct spine on posterior margin of each valve; at ventral swelling with longitudinal ridge ending in a posterior spine.

Holotype- Carapace; pl.12, fig. 1, GLAHM 106013.

Paratype- Carapace; 12, fig. 2, 106014.

Type locality- Well YY1-6 at depth of 6340 ft.

Type horizon- Gir Formation (lower Eocene).

Description- Carapace subrectangular in lateral outline; maximum height at anterior cardinal angle; greatest length passing through mid height; anterior margin broadly rounded and bearing 12 small spines; posterior margin subtruncate with distinct large spine and a second very small spine in each valve; dorsal margin straight to slightly convex; ventral margin slightly convex; left valve larger than right and overlapping entire margin. Carapace smooth to weakly punctate. There is a prominent ventral swelling with a ridge along its top ending posteriorly in a spine at quarter length from posterior. Internal features not seen and sexual dimorphism is not distinct.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106013	721	393	1.83	343
Carapace; GLAHM 106015	689	364	1.89	363
Carapace; GLAHM 106014	684	374	1.82	329
Carapace ; GLAHM 106016	625	350	1.78	353
Carapace; GLAHM 106017	662			304

Remarks- This is unlike any species of the genus described so far. It resembles genus of *Bosquetina*, but this genus is much smaller in size and has weaker ventral ridge.

Occurrences- Lower Eocene of the Sirt Basin.

Genus *Pterygocythereis* Blacke, 1933

Type species: *Cythereis jonesii* Baird, 1850

Pterygocythereis tarabulusensis El-Waer, 1992

pl. 12, figs. 10,11.

1966 *Pterygocythereis* n. sp.1 Salahi, p.7, pl. 3, figs.9-11.

1992 *Pterygocythereis tarabulusensis* El-Waer, p.120, pl. 21, figs.7,9-12.

Material- 3 carapaces from the well YY1-6; GLAHM 10621-22.

Diagnosis- Carapace subquadrate in lateral outline; with distinct rounded eye tubercle and short ventral lateral ridge.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106021	456	260	1.75	222
Carapace; GLAHM 106022	472	292	1.61	238

Remarks- This species was first described from the subsurface Oligocene sediments of Well C3-6 in the Sirt Basin, Libya by Salahi (1966). El-Waer (1992) formally described the species from the Ghalil Formation (Mid-Upper Eocene) of offshore N.W.libya. The figured specimens are similar to the species described by Salahi and El-Waer, differing only in their smallar size, and more rounded posterior margin. The posterior spines are better preserved on the species described here.

Occurence- Lower Eocene-Oligocene of Libya.

Pterygocythereis sp
pl. 16, fig. 4

Material- 4 carapaces and 1 valve from the El-Fogha sample F9; GLAHM 106065.

Description- Carapace subrectangular in lateral outline; anterior margin broadly rounded; posterior margin subtriangular; ventral margin nearly straight and converging posteriorly; maximum height just front to eye tubercle; maximum length at mid height. The anterior border is "frilled" with a row of some 11 elongate shallow depressions separated by muri, remaining parallel to the anterior margin. The antero-dorsal part of the anterior margin forms a spine, with the well developed eye tubercle below, and to the posterior of it. The dorsal margin has two large backward projecting spines, the anterior of which is " blade like"; the broken bases of a further two dorsal spines can be seen. The posterior probably have spines; although only five are preserved the broken base of a sixth can be discerned. There is a long curved ventral ridge ending in a spine; the ridge is covered by adhering sediment, but gives the impression of being ponticulate; there is a short small spine immediately below the posterior spine of the ventral ridge. **Dimension of figured specimens (in µm)**

	Length	Height	L/H	With
Right valve; GLAHM 106065	855	500	1.71	

Remarks- This species is only recorded from the El-Fogha area, and differs from any described species. *Alatacythere ivani* Howe from Eocene-Oligocene of the Gulf coast of North America is the most similar, but differs in being more quadrate, and having a spinose anterior margin, and a more prominent ventral ridge which forms a "wing".

Occurrence- Upper Palaeocene of El-Fogha.

Genus *Dahomeya alata* Apostolescu, 1961

Type species: *Dahomey alata* Apostolescu, 1961

Dahomeya alata Apostolescu, 1961

pl. 12, figs.7-9

1961 *Dahomey alata* Apostolescu, p. 796, pl.2, figs.23-25.

1963 *Dahomey alata* Apostolescu, Reyment, p.117, pl.1, figs.5a-c.

1963 *Dahomey alata* Apostolescu, Barsotti, p. 1524, pl.1, figs.3-3a.

1981 *Dahomey alata* Apostolescu, Reyment, p.57, pl.1, figs.11,12, pl.2, fig. 3.

1982 *Dahomey alata* Apostolescu, Donze *et al*, p. 294, pl.9. figs.3-5.

1986 *Dahomey alata* Apostolescu, Carbonnel, p.81. pl. 5, figs.4-5.

1990 *Dahomey alata* Apostolescu, Bassiouni & Luger, p. 787.

1992 ?*Dahomey alata* Apostolescu, El-Waer, p.127, pl.22, figs. 1-7.

1993 ?*Dahomey alata* Apostolescu, Whatley *et al*, p. 137, pl. 3, figs. 12-13.

Material- 120 carapaces and 9 valves; 9 carapaces well PP2-6; 40 carapaces, 3 valves El-Heira section and 71 carapaces and 3 valves El-Fogha; GLAHM 106018-20.

Diagnosis- A species of *Dahomeya* characterised by short ridge above ventral margins; prominent anterior rim and ovate in lateral view; surface of carapace smooth to punctate.

Dimension of figured specimens (in µm)

	Length	Height	L/H	width
Carapace; GLAHM 106018	515	342	1.50	261
Carapace; GLAHM 106019	537	358	1.50	295

Carapace; GLAHM 106020 524 253

Remarks-The figured specimens are typical of the species *Dahomeya alata.* This species was first described from the Paleocene of the Ivory coast (Apostolescu 1963), and subsequently from Libya outcrops at El-Fogha and Well A1-85 (Barsotti,1963); from the Palaeocene-Lower Eocene of the El Kef section N.W.Tunis (Donze *et al,* 1982) and from the Palaeocene and Lower Eocene of Senegal (Carbonnel 1986). El-Waer, (1992) recorded two species, *D alata* and *D* sp A from the Late Palaeocene-Middle Eocene of North West offshore Libya; El-Waer's specimens differ from previous records of the species in lateral outline and in being strongly punctate; the material illustrated by Whatley *et al* (1993) appears to be the same as El-Waer's species, and this should perhaps be separated as a distinct species. Whatley's material is from the Lower-Middlle Eocene of the offshore Tripoli Basin, so this new species may have a range from Latest Palaeocene to Middle Eocene, *D* sp A seems to be identical to *D alata* of previous mention. There is some variation in the size of *D alata*; Apostolescu's specimens are 550 µm, Carbonnel 610 µm, Donze *et al* 710-888 µm, Reyment 640 µm, El-Waer 781-888 µm and Whatley *et al* 980 µm.

Occurrence- Palaeocene-Lowest Middle Eocene.

Family Bythocytheridae Sars, 1926

Genus *Bythoceratina* Hornibrook, 1952

Type species: *Bythoceratina mestayerae* Hornibrook, 1952

Bythoceratina sp

pl. 13, fig. 1,2

Material- 2 carapaces; one male well KK1-6 at depth of 12280 ft; 1 female well AA1-6 at depth of 11020 ft; GLAHM 106023-24.

Description- Carapace subquadrate in lateral outline; anterior margin rounded; posterior margin with short caudal process; dorsal margin straight; ventral margin convex; valves are equal sized with strong ventral inflation; there is a vertical sulcus just in front of mid point and trace of a ventral lateral spine in the posterior half; the entire carapace is reticulate with subrounded pits except for the anterior and posterior areas which are mostly smooth. Sexual dimorphism is distinct. Internal features not seen.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106024	726	385	1.88	376
Female carapace; GLAHM 106023	725	407	1.78	287

Remarks- This may be the same as *Bythoceratina* sp recorded from the late Palaeocene of Egypt by Bassiouni and Luger (1990, pl. 4, fig. 5), although it differs in its truncated anterior margin and less rounded posterior; this may be due to preservation. *B tamarae* Rosenfeld, 1974 figured by Bismuth *et al*, 1981 from the Middle and Upper Cretaceous of Jabal Semmam, Tunis, is similar but differs in having a straight ventral margin and reticulation with longitudinal ribs parallel to the carapace margin.

Occurence- Recorded from the Hagfa Formation of the Sirt Basin.

Genus *Monoceratina* Roth, 1928

Type species: *Monoceratina ventrale* Roth, 1928

Monoceratina gaziryi El Sogher M S, 1991

pl. 13, figs. 3-9.

1991 *Monocertina gaziryi* El Sogher, p. 63, pl. 6, Figs. 4-10.

Material- 25 carapaces and 1 juvenile; 8 carapaces and 1 juvenile well YY1-6; 4 carapaces well PP2-6; 4 carapaces well 3H1-6; 9 carapaces well KK1-6; GLAHM 106025-31.

Diagnosis- A species of *Monoceratina* with swollen and compressed anterior, ventral, and posterior margins; surface smooth to finely punctate, four-seven weak ribs on the ventral swelling parallel the margins of the swelling, with punctae or weakly reticulation between them; prominent shallow depression parallel to anterior margin; sexual dimorphism pronounced males being more elongate than females.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width

Female carapace; GLAHM 106026	619	361	1.71	376
Male carapace; GLAHM 106025	537	303	1.77	324
Male carapace; GLAHM 106031	550	300	1.83	315
Juvenile carapace; GLAHM 106030	480	266	1.80	257
Female carapace; GLAHM 106027	577	341	1.69	344
Female carapace; GLAHM 106028	619			357
Female carapace; GLAHM 106029	623			376

Remarks- This species was first described from the subsurface upper part of the Heira Formation of the Raguba oil field (wells E46-20 and E56-20) of the Sirt Basin by (El Sogher, 1991 M.S). The specimens in this study are better preserved than those of El Sogher, and occur in much greater abundance. The better preservation allows on amendment to the original description; the lateral surface is now seen to be finely punctate over most of its area, and the ventral ribs may be more numerous (up to 7) and covers a larger area than in El Sogher's illustration.

Occurrences- Upper Palaeocene.

Monoceratina salemi sp nov
pl. 13, figs. 10-12

Material- 4 carapaces; 1 carapace from the Heira sample S1-9; 3 carapaces from the El-Fogha sample F9; GLAHM 106032-34.

Derivation of the name- In honour of Dr M. G. Salem.

Holotype- Carapace; pl.13, fig. 11, GLAHM 106033.

paratype- Carapace; pl.13, fig. 12, GLAHM 106034.

Type locality- Heira depression, holotype sample S1-9 and paratype El-Fogha Sample F9.

Type horizon- Shurfah Formation (Bu Ras member).

Diagnosis- A species of *Monoceratina* with subcentral vertical sulcus; short caudal process, and 2-3 weakly developed ribs on the swollen area.

Description- Carapace small, elongate-subrectangular in lateral outline; anterior margin evenly rounded; posterior margin with short caudal process; dorsal margin hidden in lateral view by overreach of dorsal ridge; ventral margin sinuous and strongly curved upward posteriorly; Maximum height at centre; Maximum length passing through central dorsal area, valves nearly equal in size. A ventral sulcus runs from about midway along dorsal margin to the centre of the valve; the valve is swollen around the ventral end of the sulcus. The anterior and posterior areas adjacent to the sulcus have 2-3 concentric ribs with scattered punctae; the anterior has a broad punctate anterior area with a broad depression between it and the striate area adjacent to the sulcus. The posterior is smooth, sexual dimorphism not observed. Internal features not seen.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106033	404	200	2.0	224
Carapace; GLAHM 106034	400	198	2.0	209
Carapace; GLAHM 106032	373			218

Remarks- This species is similar to *M ? striata* Deltel, 1964 from the Eocene of Aquitain Basin France, (Ducasse *et al*,1985) in lateral outline and surface ornamentation; *M ? striata* differs in outline, having parallel dorsal and ventral margins which are straight, and having a node in the posterior part of the ventral swelling.

Occurrenceas- Middle-Upper Palaeocene.

Family Cytherettidae Triebel, 1952

Genus *Cytheretta* G. W. Muller, 1894

Type species; *Cytheretta rubra* Muller, 1894

Cytheretta aff *Cytheretta* n sp 1 Salahi, 1966

pl. 16, fig.1.

Material- 1 carapace from well YY1- 6 at depth of 6000 ft; GLAHM 106062.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106062	543	309	1.75	292

Remarks- The carapace is reticulate with short ribs and slot-like pits between them in the posterior half, the rest of carapace is smooth to finely punctate. This species shows similarities to *Cytheretta* n sp 1 described from the subsurface Oligocene sediments of the Sirt Basin by Salahi (1966), but the latter differs in having small spines anteriorly, its posterior margin is subtriangular and it is larger (900 cf 547). El-Waer (1992) recorded only two specimens of *Cytheretta* n sp 1 Salahi from the Eocene sediments of the Tarabulus Basin Well J1-NC41 N.W. of offshore Libya. The El-Waer specimens differ from Salahi's specimens in their rounded posterior margin, more prominent posterior cardinal angle, and smaller size; they differ from the studied species in lateral outline, larger size and very distinct posterior cardinal angle.

Occurrences- Recorded from Early Eocene.

Type species: *Cythere pavonia* Brady, 1866

Loculicytheretta cf *L cavernosa*, Apostolescu and Magné

pl. 16, fig. 2

Material- 1 valve from the well KK1-6 at depth of 8860 ft; GLAHM 106063.

Description- Carapace subrectangular in lateral outline; anterior margin obliquely rounded; dorsal margin nearly straight; ventral and lower part of posterior margin reticulate with six well developed loculi; surface of carapace finely pitted and carapace partly corroded.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Right valve; GLAHM 106063	905	491	1.843	

Remarks- This differs from *L cavernosa* in its tappered outline and lack of weak postero-ventral ridges. The specimen is almost certainly derived from higher levels in the well (i.e Middle Eocene).

Family Cytherideidae Sars, 1925

Subfamily Krithinae Mandelstam in Bubikan, 1958

Genus *Krithe* Brady, Crosskey and Robertson, 1874
Type species: *Ilyobtes praetexta* Sars, 1866
Krithe echolsae Esker, 1968
pl. 14, figs. 6-9.

1968 *Krithe echolsae* Esker, P. 330, pl. 3, figs. 1-4.

1978 *Krithe* cf *echolsae* Esker, p. 232, pl. 26, figs. 1-4.

1982 *Krithe echolsae* Esker, Boukary *et al*, pl. 2, figs. 8-9.

1982 *Krithe echolsae* Esker, Donze *et al*, p. 283, fig. 4.

1987 *Krithe echolsae* Esker, Honigstein *et al*, p. 425, pl. 1, figs. 5-6.

1990 *Krithe echolsae* Esker, Bassiouni & Luger, p. 795, pl. 16, figs. 10-11.

Material- 34 carapaces and 1 juvenile; 1 carapace well YY1-6; 11 carapaces well PP2-6; 3 carapaces well 3H1-6; 14 carapaces well KK1-6; 5 carapaces and one juvenile well AA1-6.

Diagnosis- Carapace subrectangular in lateral outline; anterior margin rounded; posterior margin obliquely truncated with very prominent circular depression seen in dorsal view; dorsal margin convex in the females straight in males. Sexual dimorphism is distinct, males being more elongate.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106040	714	385	1.85	376
Female carapace; GLAHM 106041	704	380	1.85	343
Male carapace; GLAHM 106042	754	343	2.19	313
Female carapace; GLAHM106043	700	377	1.85	338

Remarks- The specimens are identical to *K echolsae*, Esker recorded from the Upper Kharga Shale of Dakhla Formation (Middle Palaeocene Praecursoria zone) of Egypt (Bassiouni & Luger, 1990). The figured species are smaller size than those previously described from Tunisia (648-754 μm cf 780-870).

Occurrences- This species was first recorded from the Danian of Tunisia (Esker, 1968), and subsequently from the Late Campanian-Middle Palaeocene of Tunisia (Donze *et al*, 1982) and the Middle-Late Palaeocene of Egypt (Bassiouni & Luger 1990, Boukhary, 1982).

Krithe gp *kalambainaensis* Reyment, 1981
pl. 14, figs. 1-5

1981 *Bythocypris kalambainaensis*, Reyment, p. 56, pl. 1, figs. 2-4.

1990 *Parakrithe ? kalambainaensis*, Reyment, Bassiouni & Luger, p. 797, pl. 7, figs. 1-4.

1990 *Krithe kalambainaensis* Reyment, Carbonnel et al, p. 678, pl. 2, fig. 9.

1994 *Krithe* cf *kalambainaensis* Reyment, Keen *et al*, pl. 16.1, fig. 13.

Material- 533 carapaces, 6 valves and 9 juvenile; 184 carapaces, 2 valves and 2 juvenile well YY1-6; 148 carapaces, 1 valve and 3 juvenile well PP2-6; 42 carapaces and 3 juvenile well 3H1-6; 54 carapaces well KK1-6; 105 carapaces, 3 valves and 1 juvenile well AA1-6; GLAHM 106035-39.

Diagnosis- Carapace elongate to subrectangular in lateral view; anterior margin broadly and evenly rounded; posterior margin obliquely truncated; dorsal and ventral margin concave in the middle more obvious in ventral margin; surface of carapace is smooth, sexual dimorphism is distinct; males being more elongate than females.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106035	625	313	1.99	265
Female carapace;GLAHM 106036	615	311	1.97	268
Male carapace; GLAHM 106037	645	316	2.04	255
Male carapace; GLAHM 1066038	675	318	2.12	273
Female carapace; GLAHM 106039	606			263

Remarks- Reyment (1981) described and illustrated *B kalambainaensis* from the Palaeocene of North west Nigeria. *Krithe Kalambainaensis* from the Upper Palaeocene of Niger (Carbonnel, 1990) is identical to Reyment's species (pl. 1, fig. 3.) apart from its slightly larger size (610 µm cf 530).

The figured species and those described earlier from Egypt, Niger and Libya (Bassiouni and Luger, 1990, Carbonnel *et al*, 1990 and Keen *et al*, 1994), are identical in all aspects. Bassiouni and

Luger, (1990) placed this species in *Parakrithe* ? instead of *Bythocypris* on the basis of muscle scar patterns arranged in a vertical row of four scars, the rest of the internal features could be not observed due to poor preservation.

Occurrences- Palaeocene of Niger, Upper Palaeocene of Nigeria, Upper Palaeocene to Lower Eocene of Egypt, Waha and Heira Formations (Cretaceous to Palaeocene) of Libya.

Krithe barsottii sp nov
pl.14, figs. 10-15

1963 *Krithe* cf *K perattica* Alexander, Barsotti, p.1524, pl. 3, figs. 21, 21a.

Material- 1470 carapaces, 145 valves and 28 juvenile; 220 carapaces, 4 valves and 5 juvenile well YY1-6; 133 carapaces and 3 valves well PP2-6; 88 carapaces, 1 valves and 15 juvenile well 3HH-6; 459 carapaces and 8 juvenile well KK1-6; 79 carapaces well AA1-6; 186 carapaces and 61 valves from the Heira; 305 carapaces and 76 valves from the El- Fogha; GLAHM 106044-49.

Derivation of name- In honour of Mr G Barsotti who had previosly recorded this species.

Diagnosis- A small elongate carapace, dorsal margins convex with greatest height towards posterior; lacks the *Krithe* posterior notch.

Holotype- Carapace; pl. 14, fig. 10, GLAHM 106044.

Paratype- Carapace; pl. 14, fig. 11, GLAHM 106045.

Type locality- Heira depression, sample S1-4.

Type horizon- Shurfah Formation (Bu Ras member).

Description- Carapace elongate, anterior margin evenly rounded; posterior margin tapered; dorsal margin is slightly convex with maximum height at third length from posterior; ventral margin straight in the left valve, slightly concave in the right; left valve larger than right, overlapping right valve all around except postero-ventral area. Sexual dimorphism present but not distinct. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106044	589	317	1.85	293
Carapace; GLAHM 106045	587	312	1.88	291
Carapace; GLAHM 106046	584	310	1.88	285
Carapace; GLAHM 106047	606	315	1.92	287
Carapace; GLAHM 106048	566			305
Carapace; GLAHM 106049	545			295

Remarks- This species is the same as *Krithe* cf *K perattica* Alexander (1934) recorded by Barsotti (1963) from the Palaeocene of the Sirt Basin (El-fogha and subsurface well A1-85). It is unlike any of the species recorded from El Kef (Donze *et al* 1982; Peypouquet1983). It differs from *K bartonensis* Jones & *K papillosa* Bosquet in the more convex dorsal margin.

Occurrences- Occurs in the Palaeocene-Lower Eocene of the Sirt Basin and outcrops.

Genus *Parakrithe* Van Den Bold, 1958

Type species: *Cytheridea* (*Dolocytheridea*) *vermunti* Van Den Bold, 1946

Parakrithe crolifa Bassiouni & Luger, 1990

pl.15, figs.1-4

1979 *Krithe* sp Cronin & Khalifa, p. 410, pl.1, figs. 26-27.

1983 *Bythocypris kalambainaensis* n sp Reyment, p. 56, pl. 1, fig. 4.

Material-135 carapaces, 3 valves and 8 juvenile; 18 carapaces, 1 valve and 1 juvenile well YY1-6; 27 carapaces and 1 valve well PP2-6; 16 carapaces well 3HH-6; 39 carapaces and 4 juvenile well KK1-6; 35 carapaces, 1 valve and 3 juvenile well AA1-6; GLAHM 106050-53.

Diagnosis- A species of *Parakrithe* with variably wide anterior vestibulum, no posterior vestibulum; dorsal margin convex.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106050	543	301	1.85	226
Male carapace; GLAHM 106051	548	289	1.89	229

Male carapace; GLAHM 106052	544	301	1.80	240
Male carapace; GLAHM 106053	566			244

Remarks- The material studied here is similar to that illustrated by Bassiouni & Luger (1990); their material shows some variation in outline between individuals; the specimens studied here do not show such variation, and the females are identical to those illustrated by Bassiouni & Luger, pl. 6, fig. 19. Bassiouni & Luger described the internal features but these cannot be seen in the Libyan material, and presumably on this basis, together with a lack of the posterior identation, placed the species into *Parakrithe* rather than *Krithe*; this generic assignment has been followed.

Occurrences- Occurs in the Middle Palaeocene of Egypt and Palaeocene-Lower Eocene of the Sirt Basin.

?*Parakrithe* sp
pl. 15, figs. 5-7

Material- 11 carapaces; 8 carapaces well YY1-6; 3 carapaces well 3HH-6; GLAHM 106054-56.

Description- Elongate carapace, anterior margin evenly rounded; posterior margin obliquely rounded; dorsal margin straight; ventral margin slightly convex in the right valve nearly straight in the left valve; ventral and dorsal margins subparallel; maximum height at middle length; maximum length at mid height; left valve larger than right, overlapping all around the margin except in the postero-dorsal and centro-posterior areas; Carapace surface smooth, sexual dimorphism not recognised. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106054	678	351	1.93	307
Carapace; GLAHM 106055	697	367	1.89	295
Carapace; GLAHM 106056	715			314

Remarks- This is tentatively placed into *Parakrithe* on the basis of its lateral outline; exact generic status must wait until specimens showing internal features have been found.

Occurrences- Upper Palaeocene of the the Sirt Basin.

Family Cytheruridae G. W Muller, 1894
Genus *Cytherura* Sars, 1866
Type species: *Cythere gibba* Muller, 1785
Cytherura n sp1 Salahi, 1966
pl. 15, figs. 10-12

1966 *Cytherura* nsp1 Salahi, p.14, pl.3, figs. 1-8.

Material- 45 carapaces and 4 valves; 5 carapaces well YY1-6; 1 carapace well PP2-6; 2 carapaces well 3H1-6; 10 carapaces well KK1-6; 8 carapaces and 1 valve from Heira; 19 carapaces and 3 valves from El-Fogha; GLAHM 106059-61.

Diagnosis- Carapace subrhomboidal in lateral outline; maximum height central; posterior caudal process distinct, located at mid height and directed upwards; surface ornamented with ribs with punctae between them; ventral region characterised by three longitudinal ribs subparallel to ventral margin.

Description- Carapace outline in lateral view typical of Semicytherura, with a prominent posterior caudal process at about mid height. The right valve is higher than left with a strongly curved dorsal margin, highest point approximately central. There are prominent ventral and posterior swellings. Ornamentation is distinctive, with several longitudinal ridges formed from strengthening of reticulation muri. Four ridges run from near the anterior to posterior margins approximately paralell to the ventral margin and converging over the ventral swelling; two of these are more prominent. One prominent ridge runs from the anterior towards the centre of the valve, curving upwards towards the mid point of the dorsal margin; several minor ridges are parallel to this in the antero-dorsal area. Three longitudinal ridges are present on the posterior swelling. Reticulation is developed between the ridges. The posterior part of the posterior swelling has macro and micro reticulation developed; the macro reticulation disappears towards the dorsal area, leaving an ornamentation of punctae.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106060	421	230	1.83	189
Carapace; GLAHM 106059	409	207	1.97	176
Carapace; GLAHM 106061	397			190

Remarks- Salahi pointed out some variation in the position of the caudal process and lateral outline of the carapace. His pl.3 figures 1-3 & 7,8 shows pointed upward caudal process although in figures 4-6 the caudal process points backward; the dorsal margin of figures 1-4 are more curved than figure 7. The specimens figured here are similar Salahi's pl.3. figures 4-6. The postero-dorsal area is less ornamented than Salahi's figures.

Occurences- Occurs in the Palaeocene of the Sirt Basin and outcrops.

Genus *Cytheropteron* Sars, 1866
Type species: *Cythere latissima* Norman, 1865
Cytheropteron sp cf *C lekefense* Esker, 1968
pl.15, figs. 8,9

1968 *Cytheropteron lekefense* Esker, p.332, pl.2, figs. 3-5.

1982 *Cytheropteron lekefense* Esker, Donze, P.297, pl.12, fig.11.

1992 ?*Cytheropteron lekefense* Esker, El-Waer, p.239, pl.39, fig.12.

Material- 8 carapaces and 1 juvenile from the well KK1-6; GLAHM 106057, 58.

Diagnosis- Carapace subrhomboidal in lateral view; posterior margin angular with short caudal process; carapace inflated in the middle and compressed at both ends in dorsal view; each valve alate having a median sulcus extending towards the ventral margin, usually deepest towards the margin of the ala with a short curved ridge at the ventral end of the sulcus. Carapace usually fine punctate anteriorly and coarsely punctate to reticulate on the alae and on posterior end; ornamentation variable among specimens but always stronger at the posterior end.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106057	327	195	1.67	239
Male carapace; GLAHM 106058	345	185	1.86	195

Remarks- This species was first described from the Danian of Tunisia by Esker (1968) and subsequently recorded from the El Kef section of North western Tunisia by Donze *et al* (1982) and from the Maastrichtian of offshore N.W Libya, Well N1-NC41 by El-Waer(1992). The figured specimen is smaller than the type species (345 cf 430), but lies within a range given by Said (1978). In other respects it is similar to the Tunisian material, but differs in having a short curved ridge at the ventral end of the median sulcus. It is not clear whether this Libyan species should be classified with the Tunisian species; if so, it would extend the range of the species from Danian to late Palaeocene. For the moment it is left outside the species. El-Waer's specimen differs from *C lekefense* in its more highly arched dorsal margin and truncated anterior margin. According to published information from Tunisia (Esker, Said and Donze *et al*) this species is restricted to the Middle Danian, especially the *pseudobulloides* zone. This casts some doubt on El-waer's species from the Maastrichtian.

Occurrences- Occurs Upper Palaeocene.

Genus *Cytheropteron* Sars, 1866

Cytheropteron sp

pl. 16, fig. 3

Material- 1 carapace from the Well YY1- 6 at depth of 7780 ft; GLAHM 106064.

Description- Carapace subrhomboidal in lateral outline; with distinct alae on each valve; lateral surface finely punctate anteriorly while coarsely punctate to reticulate posteriorly and around alae; a short rib is present in the postero-dorsal area.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106064	356	218	1.63	212

Remarks- This species is similar to *C lekefense* Esker (1968) but differs in its more convex dorsal margin, anterior margin drawn downward; the posterior margin is truncated, but this may be due to being broken.

Occurrence- Recorded from the Hagfa Formation Middle Palaeocene of the Sirt Basin.

Genus *Eucytherura* G. W. Muller, 1984

?*Eucytherura* sp

pl. 16, fig. 5

Material- 1 carapace from Well 3H1- 6 at depth of 7460 ft; GLAHM 106066.

Description- Carapace tapered towards posterior in lateral outline; anterior margin obliquely rounded; posterior margin small caudal process; dorsal margin nearly straight; ventral margin straight but hidden by ventral ridge in lateral view; maximum height at anterior cardinal angle; maximum length at mid height; left valve slightly larger than right and obviously overlapping at postero dorsal area. The surface of the carapace has coarse to medium reticulation; anterior marginal rim pronounced and joins lower ventral ridge; two parallel ventral ridges are present, the lower ridge subparallel to the ventral margin ending at third length from posterior, the second upper short ridge centrally placed. The eye tubercle is not distinct.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106066	486	281	1.73	242

Remarks- The figured specimen is very similar to *Eucytherura* sp 1 recorded from the late Palaeocene (Velascoensis zone) of Egypt by Bassiouni & Luger (1990) but the latter has a more pronounced posterodorsal node. Neither the Libyan nor Egyptian specimens are well preserved so it could be the same species, the Egyptian specimens being female and the Libyan male.

Occurrences- Occurs in the Lower Eocene Harash Formation.

Genus *Paijenborchellina* Kuznetsova, 1957
Type species: *Paijenborchellina exelens* Kusnetzova, 1957
Paijenborchellina sp
pl. 16, figs. 6-8

Material- 8 carapaces from El-Fogha; GLAHM 106067-69.

Description- Carapace pear shaped in lateral outline; anterior margin obliquely rounded; posterior margin with caudal process directed downward; dorsal margin highly arched; ventral margin sinuous; left valve larger than right and overlapping right valve all around; maximum height at third length of carapace from anterior. The carapace is ornamented with coarse punctae and fine pits in antero dorsal area, the punctae arranged in a rows parallel carapace margins; intersection of these punctae formed ribs parallel to carapace margins; there is a depression parallel to anterior margin; posterior part of the caudal process is smooth. Sexual dimorphism is distinct, male being more elongate; internal features not known.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106067	527	276	1.90	281
Female carapace; GLAHM 106068	522	274	1.90	245
Male carapace; GLAHM 106069	?532	255	2.08	259

Remarks- The figured species is similar in lateral outline to *P benghaziensis* El Sogher M.S.1991, illustrated as *Paijenborchella* sp. in Keen *et al* (1994), which comes from the Maastrichtian-Danian of the Sirt basin; it differs in having prominent reticulation over the whole valve rather than the weaker riblets of *P* sp. it is also similar in lateral outline to *Paijenborchellina libyca* Szczechura, 1980 from the Miocene of the Sirt Basin but has a shorter caudal process, lacks the saddle like dorsal margin and has reticulation rather than punctae.

Occurrences- Occurs in Lower Eocene Bishema Formation (Kheir member).

Genus *Semicytherura* Wagner, 1957
Type species: *Cythere nigrescens* baird, 1838
Semicytherura elfoghaensis sp nov
pl. 16, figs. 9-13

Material- 16 carapaces and 9 valves from the El-Fogha section; GLAHM 106070-74.

Derivtion of name- After El-Fogha village.

Diagnosis- A species of *Semicytherura* with well developed caudal process and ventral swelling; surface ornamented by coarse to fine punctae with 3-4 weak lateral ventral ribs.

Holotype- Female carapace; pl.16, fig.9, GLAHM 106070.

Paratype-Male carapace; pl.16, fig. 10, GLAHM 106071.

Type locality- El-Fogha section, sample F9.

Type horizon- Shurfah Formation (Ammur member).

Description- Carapace elongate-subovate in lateral outline; anterior margin obliquely rounded; posterior margin with well developed caudal process; dorsal margin convex; ventral margin hidden due to ventral lateral swelling; maximum height at mid length; maximum length at mid height; left valve larger than right and obviously overlapping throughtout dorsal margin; carapace reticulate with variably sized punctae; coarser at centre of carapace and finer around the margins; three ribs almost parallel to ventral swelling; carapace subovate in dorsal view; in ventral view the carapace has 4-5 longitudinal ribs; no eye spots apparent sexual dimorphism is distinct males being more elongate; internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106071	573	315	1.81	376
Female carapace; LAHM 106070	515	335	1.53	354
Male carapace; GLAHM 106072	532	295	1.80	337
Female carapace; GLAHM 106074	553			340
Female carapace; GLAHM 106073	541			324

Remarks- The generic assignment of this species is difficult; its general outline, lack of eye spots, and ventral swelling suggest *Cytheropteron*, but it lacks the ventral wings often present in this genus. *Mehesella* has a similar outline but has eye spots. *Kroemmelbeinella* has a similar appearence, but has weaker ventral swelling and less pronounced caudal process. This species has been recorded as *Semicytherura* sp B by El Sogher (1991 M.S) from Waha and Heira Formations Sirt Basin. *M paleobiafrensis* Reyment 1960 (Maastrichtian-Palaeocene of Nigeria) is similar in size and general appearence but has less prominent ventral swelling, while *M biafrensis* is much larger in size as well as having a less prominent ventral swelling.

Occurrences- occurs in the upper Palaeocene.

Family Hemicytheridae Puri, 1953

Genus *Uromuellerina* Bassiouni, 1969 C

Type species: *Uromuellerina saidi* Bassiouni, 1969c

Uromuellerina sinhai sp nov

pl. 16, fig.14, pl. 17, figs. 1, 3-6

Material- 6 carapaces from the well YY1-6; GLAHM 106075-80.

Derivation of name- In Honour of senior staff Geologist in the P. R. C. Mr R. N. Sinha, who died in 1994.

Diagnosis- A species of *Uromuellerina* with weak subcentral tubercle and three longitudinal ridges.

Holotype- Female carapace; pl.17, fig.5, GLAHM 106079.

Paratype- Male carapace; pl.17, fig.1, GLAHM 106076.

Type locality- Well YY1-6, holotype at depth of 6140 ft and paratype at depth of 6000 ft.

Type horizon- Gir Formation (lower Eocene).

Description- Carapace subrectangular in lateral view; maximum height at anterior cardinal angle; maximum length at mid height; anterior margin broadly rounded with prominent marginal rim and double row of punctae; posterior margin subtruncate with distinct marginal rim; dorsal margin straight obscured by overreach of dorsal ridge; ventral margin nearly straight, with a broad rim; left valve slightly larger than right and overlapping posterior, ventral and anterior margin. Carapace ornamented with longitudinal ridges and subrounded fossae; the ridges are developed more noticeably in the right valve, but they are never very strong. The dorsal ridge starts from below the eye tubercle, running posteriorly in a curved form ending before the anterior cardinal angle; median ridge starts from behind the poorly defined subcentral tubercle ending at about third length from posterior where it bends slightly downwards. A continuation of this ridge extends anterior of the subcentral tubercle finishing at anterior margin depression. A second short ridge runs from the lower limit of the subcentral tubercle to the anterior depression. The ventral ridge starts from the anterior depression ending posteriorly at third length from posterior. The area between the ridges has elongate subrounded fossae. A prominent relatively unornamented depression runs parallel to the anterior, ventral and posterior margins and contains "ghost" outlines of coarse reticulation; a prominent marginal rim is also present around these margins. The eye tubercle is distinct, internal features not known, and sexual dimorphism is distinct. Males being more elongate than females.

Dimension of figured specimens (in μm).

	Length	Height	L/H	Width
Female carapace; GLAHM 106077	572	344	1.66	314
Male carapace; GLAHM 106076	703	365	1.92	331
Female carapace; GLAHM 106079	618	375	1.64	327
Male carapace; GLAHM 106078	675	345	1.95	?264
Female carapace; GLAHM 106075	632			327
Female carapace; GLAHM 106080	606			297

Remarks- This species is very similar to *U saidi* Bassiouni, 1969. This was originally described from the Upper Eocene of Egypt and subsequently recorded from the Late Eocene of N. E. Libya (Helmdach & El Khoudary.1980) and the Middle Eocene of offshore N.W.Libya (El-Waer.1992). The Libyan species differ slightly from the Egyptian in having more obvious longitudinal ridges. These Libyan records of *U saidi* differ from *U sinhai* sp nov in having a slightly less obliquely rounded outline to the anterior margin, and in having a fourth longitudinal ridge lying between the ventral and median ridges, and include larger specimens (621-836 μm cf 572-690, El-Waer 1992).

Occurrences- Occurred from Upper Palaeocene-Lower Eocene.

Family Leguminocytherideidae Howe, 1961
Genus *Leguminocythereis* Howe,1936
Type species: *Leguminocythereis scarabaeus* Howe & Law, 1936
Leguminocythereis lokossaensis Apostolescu, 1961
pl. 17, figs. 2, 7-9.

1961 *Leguminocythereis lokossaensis* Apostolescu, p.823, pl.10, figs.184-186.

1963 *Leguminocythereis lokossaensis* Apostolescu, Barsotti, p.1527, pl. 2, figs.16-16a.

1966 *Leguminocythereis lokossaensis* Apostolescu, Salahi, p.16, pl. 4, figs. 15-17.

1966 *Leguminocythereis* n sp 2, Salahi, p.17, pl. 4, figs. 11-13.

1986 *Leguminocythereis lokossaensis* Apostolescu, Carbonnel, p.87, pl. 3, figs.1-3.

1989 *Leguminocythereis lokossaensis* Apostolescu, Carbonnel & Johnson, p.419, pl. 3, fig. 9.

1990 *Leguminocythereis lokossaensis* Apostolescu, Bassiouni & Luger, p.792, pl.5, figs. 3-8

1992 *Leguminocythereis lokossaensis* Apostolescu, El-Waer, p.170, pl. 34, figs. 1-4.

Material- 10 carapaces and 1 valve; 6 carapaces and 1 valve well YY1-6; 1 carapace well PP2-6; 1 carapace well 3H1-6; 2 carapaces well AA1-6; GLAHM 106081-84

Diagnosis- A species of *Leguminocythereis* characterised by a swollen carapace and subovate to subrhomboidal lateral outline; carapace reticulate with longitudinal ridges, and rounded pits between them; eye tubercle distinct and maximum height at anterior cardinal angle.

Dimension of figures specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106081	606	351	1.73	358

Male carapace; GLAHM 106083	679	364	1.86	371
Female carapace; GLAHM 106082	610	358	1.70	342
Female carapace; GLAHM 106084	500			284

Remarks- This species has a wide geographic distribution on the African continent. It was first described from the Lower Eocene of Togo, and also from Dahomey and Palaeocene of the Ivory Coast (Apotolescu, 1961), and subsequently from the Late Palaeocene of Libya (Barsotti, 1963), Lower Eocene of Sirt Basin and Senegal (Salahi, 1966 & carbonnel, 1989), Late Palaeocene- Lower Eocene of Egypt, (Bassiouni & Luger, 1990) and the Palaeocene-Lower Eocene of N.W. offshore, Libya El-Waer, (1992).

Specimens described by Apostolescu, (1961) and Barsotti (1963) are larger (850 µm cf 676) and have less prominent ridges i.e the reticulation appears to be more even than the specimens recorded here. However, the specimens studied here are identical to those described by Salahi (1966), Carbonnel (1986), Bassiouni & Luger (1990) and El-Waer (1992). Salahi's *Leguminocythereis lokosaensis* is herein recognised as the female dimorph and his *Leguminocythereis* n sp 2 as the male dimorph.

Keen *et al* (1994) illustrated specimens from the Danian of the Sirt basin identified as *Leguminocythereis* gp *lokosaensis*; this differs from the specimen studied here in lateral outline, lacking the angular postro-dorsal angle, and in having weaker cross ridges in the reticulation .

Reyment (1980) placed *Leguminocythereis lokosaensis* into the synonymy of *Mehesella biafrensis* Reyment (1960); this is not followed here, important differences being the dorsal and antero-ventral outline, and prominent unornamented dorsal area of *M biafrensis*; the details of the reticulation also differ.

Occurrences- Occurrs from upper Palaeocene-Lower Eocene.

Leguminocythereis cirtaensis Apostolescu & Magné, 1956
pl. 35, figs.6-8

1956 *Leguminocythereis cirtaensis* Apostolescu & Magne, p.39, pl.1, figs.1,2.

1966 *Leguminocythereis* n sp 4 Salahi, p.17, pl.4, figs.28-30.

1993 *Leguminocythereis cirtaensis* Apostolescu & Magne, Whatley *et al*, p.130, pl.1, fig. 15.

Material- 4 carapaces and 4 valves; GLAHM 106331-33.

Diagnisis-Carapace subrectangular in lateral outline; with distinct postero dorsal process in the left valve cardinal; surface ornamented with elongate to subrounded deep fossae.

Dimension of figured specimens (in μm)

	Length	Heigth	L/H	Width
Female carapace; GLAHM106332	592	330	1.79	300
Female carapace; GLAHM106333	606	339	1.78	305
Male carapace; GLAHM 331	648			310

Remarks- This species is identical to *Leguminocythereis* n sp 4 described by (Salahi, 1966) from the Oligocene of the Sirt Basin. The specimens from the Sirt Basin are smaller than the type species from the Upper Lutetian of Algeria (Apostolescu & Magné,1956) and also smaller than the material from Eocene of the Tripoli Basin recorded by Whatley *et al* (1993). This species appears to have a long stratgraphic range, being recorded throughout the Eocene by Whatley *et al* and also from the Oligocene by Salahi. Whatley's material consisted of ditch cuttings so the true first stratigraphical appearence is unknown. The material recorded here is primarily from the Lower Eocene, but as it is always rare it is difficult to know whether its presence is due to contamination from the higher horizons. Its first stratigraphical appearence may be useful in separating Palaeocene from Eocene.

Family Loxoconchidae Sars, 1925

Genus *Loxoconcha* Sars, 1866

Type species: *Cythere rhomboidea* Fisher, 1855

Loxoconcha aff *L marionsis* Salahi, 1966 .

pl. 18, figs. 1-3.

1966 *Loxoconcha* aff *L marionsis* Salahi, 1966, p.19, pl. 2, fig. 21.

Material- 12 carapaces from the well YY1-6; GLAHM 106088-90.

Description- Carapace subrectangular in lateral view with prominent ventral swelling; anterior margin rounded with prominent marginal rim, posterior margin obliquely rounded, dorsal margin straight, ventral margin hidden by overreach of ventral swelling; maximum height at the middle of carapace; maximum length above the mid height, surface punctate, larger punctae in central area of carapace. The ventral swelling has 2 prominent concentric ridges, and further indistinct ribs associated with cocentrically arranged punctae. There is smooth area parallel to posterior margin. Eye tubercle is weakly developed. Internal feature not known. Sexual dimorphisim well distinct males being smaller than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106088	594	341	1.74	294
Male carapace; GLAHM 106089	582	337	1.72	284
Male carapace; GLAHM 106090	580	341	1.68	306

Remarks- This species was described from the sediments of Middle Eocene Well C3- 6 Sirt Basin, Salahi, (1966). The figured specimens are identical to Salahi's species apart from larger size (597 cf 400). This can be distinquished from *Loxoconcha* n sp 2 by ventral swelling and strong ventral ribs.

Occurrences- Recorded from middle Eocene in the well C3-6 by Salahi, 1966 and occurred in the lower Eocene well YY1-6 Sirt Basin.

Loxoconcha burtoni sp nov
pl.17, figs. 10-12

Material- 3 carapaces from the El-Fogha, sample F- 9; GLAHM 106085-87.

Derivation of name- In honour of Dr C. J. Burton.

Diagnosis- Swollen carapace, subquadrate in lateral view; anterior and posterior marginal areas smooth; 3-4 concentric ribs parallel to anterior, ventral and posterior margins; remainder of carapace with fine reticulation.

Holotype- Carapace; pl.17, fig. 11, GLAHM 106086.

Paratype- Carapace; pl. 17, fig. 12, GLAHM 106087.

Type locality- El-Fogha section, sample F9.

Type horizon- Shurfah Formation (Ammur member).

Description- Carapace subquadrate in lateral outline; anterior margin broadly rounded; posterior margin subtriangular; dorsal margin slightly convex; ventral margin nearly straight; maximum height at mid length; maximum length above mid height; left valve nearly equal in size to right valve; a broad smooth area runs parallel to the anterior and posterior margins and extends along the ventral margin; 3-4 concentric ribs are present in the anterior, ventral and ventro-posterior areas; these have punctae between them. The central area of the carapace has a finely reticulate or coarsely punctate ornamentation. In dorsal view the carapace is swollen, with compressed anterior and posterior margins. Sexual dimorphism is not distinct. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106086	404	272	1.48	220
Carapace; GLAHM 106087	423	271	1.56	217
Carapace; GLAHM 106085	398			230

Remarks- This species differs from any previously described species so far.

Occurence- Occurs in the Upper Palaeocene-Lower Eocene of the El-Fogha outcrop.

Loxoconcha sp

pl. 18, figs. 4-9

Material- 6 carapaces and 1 valve from the El-Fogha; GLAHM 106091-96.

Description- Carapace subrhomboidal in lateral view; anterior margin obliquely rounded; posterior margin truncated; dorsal margin arched; ventral margin straight antero-ventral and strongly curved upward posteriorly; maximum height nearly at mid length; maximum length below mid height from ventral margin; anterior margin compressed in dorsal and ventral view with maximum width at middle length; the carapace is unornamented except for the ventral area, where four longitudinal ridges run the length of the ventral margin. 3 other ridges present in the postero-ventral region; sexual dimorphism not recognised. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106091	618	376	1.64	294
Carapace; GLAHM 106092	579	364	1.59	273
Carapace; GLAHM 106093	607	366	1.56	284
Carapace; GLAHM 106096	618	375	1.65	263
Carapace; GLAHM 106095	595			276
Carapace; GLAHM 106094	600			290

Remarks- This species is unlike any previously described species.

Occurrences- Occurs in the upper Palaeocene-Lower Eocene of the El-Fogha outcrop.

Family Schizocytheridae Howe, 1936

Genus *Schizocythere* Triebel, 1950

Type species: *Schizocythere hollandica* Triebel, 1950

Schizocythere qaltahensis sp nov.

pl. 18, figs.10-15.

Material- 11 carapaces and 2 valves; 4 carapaces and 1 valve from the Heira and 7 carapaces and 1 valve from the El-Fogha; GLAHM 106097-102.

Derivation of name- After Qaltah area

Diagnosis- Carapace subquadrate in lateral view; ornamented with coarse reticulation and prominent anterior rim subparallel to anterior margin.

Holotype- Female carapace; pl.18, fig. 11, GLAHM 106098.

Paratype- Female carapace; pl.18, fig. 10, GLAHM 106097.

Type locality- Hiera depression, sample S3-6.

Type horizon- Shurfa Formation (Ammur member).

Description- Carapace subquadrate in lateral view tapering towards posterior; anterior margin broadly rounded; posterior margin rounded to subtriangular; dorsal margin straight; ventral margin strongly curved upward at posterior; maximum height at the prominent eye tubercle; maximum length at mid height. Surface ornamented with coarse reticulation; there is a distinct anterior rim subparallel to the anterior margin; reticulation muri on some specimens forms weak ridges parallel to the anterior margin; a weak ventral ridge is present with a node developed towards its posterior. Sexual dimorphism is distinct with more elongate males. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106097	444	266	1.67	234
Female carapace; GLAHM 106098	485	297	1.63	257
Female carapace; GLAHM 106102	469			246
Female carapace; GLAHM 106100	478	292	1.63	259
Female carapace; GLAHM 106101	466	274	1.70	249
Male carapace; GLAHM 106099	515	285	1.80	226

Remarks- This species resembles *Schizocythere salahii* Bassiouni & Luger, 1990 from lower Eocene of the Garra Formation of Egypt (Bassiouni & Luger, 1990); the latter species differs in lateral outline and in having a distinct caudal process. *Schizocythere* sp described from the late Eocene of Jabal Al Akhdar, north eastern Libya, (Helmdach *et al*, 1980) differs in its more tapered posterior margin.

Occurrences- Upper Palaeocene-Lower Eocene outcrops from Heira and El-Fogha.

Paijenborchella Kingma, 1948

Type species: *Paijenborchella iocosa* Kingma, 1948

Paijenborchella sp

pl. 19, fig. 1.

Material- 3 Carapaces; 2 carapaces well YY1-6; 1 carapace well KK1-6; GLAHM 106103.

Description- The species is poorly preserved; a small carapace, ovate in lateral view; anterior margin obliquely rounded; posterior margin triangular with distinct short caudal process; dorsal and ventral margin convex; maximum height at anterior cardinal angle; maximum length at mid height; left valve slightly larger than right and overlapping right valve along posterior margin, and the postero-dorsal and postero-ventral areas. The surface of the carapace ornamented with vertical sulcus running from dorsal margin and ending at ventral ridge. Three longitudinal ridges are on lateral surface; a short dorsal posterior ridge lies between dorsal margin and median ridge, commencing at the sulcus and ending level with median ridge; median ridge starts from centro-anterior passes through sulcus end near to posterior margin; Ventral ridge runs from antero-ventral area in sinuous form ending at the postero ventral margin. Carapace punctate.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106103	378	215	1.75	211

Remarks- This species is only recorded from the upper part of the Hagfa shale and differs from any species described so far.

Occurrences- Occurs upper Palaeocene (Hagfa Formation).

Family Mauritsinidae Deroo, 1962

Subfamily Mauritsininae Deroo, 1962

Genus *Mauritsina* Deroo, 1962

Type species: *Cypridina hieroglyphica* Bosquet, 1847

Mauritsina coronata Esker, 1968

pl. 19, figs. 2,3

1968 *Cythereis coronata* n sp Esker, p. 323, pl. 1, figs. 1-3, pl. 4, fig. 5.

1970 *Mauritsina arabica* n p Bassiouni, p. 21, pl. 2, figs. 8-9.

1976 *Dorcythereis arabica* Bassiouni, Grundel, P. 1300.

1978 *Actinocythereis arabica* Bassiouni, Said, p. 239, pl.26, figs. 20-22.

1982 *Actinocythereis ? coronata* Esker, Donze *et al*, p. 291, pl. 9, figs. 1-4.

1984 *Mauritsina coronata* Esker, El Sweify, p. 63, pl. 9, figs. 1-4.

1990 *Mauritsina coronata* Esker, Bassiouni & Luger, p. 812. pl. 11, figs. 13-15.

1994 *Mauritsina coronata* Esker, Keen *et al*, pl. 16.3, figs. 5,8.

Material- 2 carapaces; 1 carapace from the well YY1-6 at depth of 7100 ft and 1 carapace from the well PP2-6 at depth of 8540 ft; 106104-105.

Diagnosis- Carapace subtrapezoidal in lateral outline; anterior and posterior margin denticulate and with distinct marginal rim; surface ornamented with three longitudinal rows of short nodes; subcentral tubercle pronounced, well developed eye tubercle.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106104	853	500	1.70	459
Carapace; GLAHM 106105	757	478	1.58	409

Remarks- The illustration of Esker, 1068, Ra Said, 1978, Donze *et al*, 1982 and Keen *et al*,1994 have slightly more pointed posterior margin than the species illustrated here, other details are identical.

Occurrence- Occurs in the Maastrichtian-Palaeocene of the Sirt Basin, Libya. Maastrichtian-Middle Palaeocene of Tunisia, the Palaeocene Early Eocene of Jordan, and the Middle Late Palaeocene of Egypt.

Family Trachyleberididae Sylvester-Bradley, 1948

Genus Trachyleberis Brady, 1898

Type species: *Cythere scabrocuneata* Brady, 1880

Trachyleberis modesta Apostolescu, 1961

pl. 19, figs. 4-7

1961 *Actinocythereis modesta* Apostolescu, p.831, pl. 13, figs. 259-263.

1963 *Actinocythereis modesta* Apostolescu, Barsotti, p. 1526, pl. 1, fig. 6.

Pars ?1963 *Trachyleberis teiskotensis* Apostolescu, Reyment, p. 165,

1967 *Trachyleberis modesta* Apostolescu, Ficcarelli, p.735, pl. 90, figs. 11, 12.

Pars ?1983 *Trachyleberis teiskotensis* Apostolescu, Foster, Swain and Petters, p. 131. pl. 8, figs. 15-16.

1990 *Trachyleberis modesta* Apostolescu, Bassiouni and Luger, p. 820, pl. 13, figs.19-24 and pl. 14, figs. 1-2.

1994 *Trachyleberis modesta* Apostolescu, Keen *et al*, pl.16., fig. 4.

Material- 396 carapaces, 104 valves and 2 juvenile; 125 carapaces and 2 juvenile well YY1-6; 36 carapaces well PP2-6; 34 carapaces and 1 valve well 3H1-6; 33 carapaces well KK1-6; 3 carapaces well AA1-6; 106 carapaces and 89 valves from the Heira; 59 carapaces and 14 valves from the El-Fogha; GLAHM 106106-109.

Diagnosis- Carapace subrectangular in lateral outline; maximum height at eye tubercle; maximum length at mid height; anterior marginal rim pronounced and bearing nine small tubercles; posterior margin subtriangular with distinct cardinal angle in the left valve; lateral surface ornamented with scattered large tubercles around the centre of carapace; sexual dimorphism pronounced males, being more elongated than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106109	784	403	1.94	366
Male carapace; GLAHM 106107	795	402	1.97	368
Female carapace; GLAHM 106106	656	406	1.61	373
Male carapace; GLAHM 106108	763			355

Remarks- There has been some disagreement over the interpretation of the species *Trachyleberis modesta* and *Trachyleberis teiskotensis*. Apostolescu in his original description and illustrations separates the two on the basis of size: *T modesta* female L= 0.52, male L= 0.65 mm, *T teiskotensis* (no sexual dimorphism recognised) L= 0.87 mm; and ornamentation: *Trachyleberis modesta* having small tubercles in the posterior 2/3 of the carapace, the anterior and areas between tubercles being smooth; *A teiskotensis* has very numerous pustules covering the whole surface of the valve with some punctae between. Reyment (1963) placed these two species into the single species *Trachyleberis teiskotensis*, stating that *T modesta* constituted larvae and females, while *T teiskotensis* constituted males and females. This conclusion was followed by Foster *et al* (1983). Bassiouni & Luger regarded the two species as being distinct, emphasising Apostolescu's original description of the ornamentation and also that *T teiskotensis* has a rounded posterior while that of *T modesta* is triangular.

The specimens described here clearly fit the diagnosis of *T modesta* apart from their larger size. The dimensions of Bassiouni & Luger's species are midway between Apostolescu's and the Libyan material. There would appear to be two distinct species present in West Africa, but only *T modesta* in North Africa. The opinion of Bassiouni & Luger is followed, although the illustrations of Foster *et al* , including pl. 8, figs. 15-16, suggest a single species, i.e *T teiskotensis*.

Occurrences- This species has a wide geographical distribution in the African continent, recorded from the Palaeocene of Mali, Ivory Coast and Benin (Apostolescu, 1961), the Cretaceous to late Palaeocene of Libya (Barsotti 1963 and El Sogher 1991 M.S), the Late Palaeocene of Nigeria (Reyment !963, Swain *et al* 1983), and the Late Palaeocene-Lower Eocene of Egypt Bassiouni & Luger 1990.

Trachyleberis teiskotensis Apostolescu, 1961
pl. 19, figs. 8-13

1961 *Actinocythereis teiskotensis* Apostolescu, p. 814, pl. 13, figs. 253-258.

1963 *Trachyleberis teiskotensis* Apostolescu, Reyment, p. 165, pl. 4, figs. 3a-b, 4a-b, pl.14, figs. 7-11, pl. 15, figs. 3a-b.

1963 *Actinocythereis teiskotensis* Apostolescu, Barsotti, p. 1526, pl. 1, figs.7,8.

1983 *Trachyleberis teiskotensis* Apostolescu, Foster, Swain & Petters, p.131, pl.8, figs. 5,7-16; pl.9, fig11; pl.11, figs. 5,6.

Material- 14 carapaces and 4 valves from the El-Fogha; GLAHM 106110-115.

Diagnosis- Carapace ornamented with tubercles and spines, the spines are bifurcated and sharp; reticulation between the spines.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM106110	822	440	1.86	417
Female carapace; GLAHM 106111	720	449	1.60	422
Male carapace; GLAHM 106112	836	431	1.93	418
Female carapace; GLAHM 106113	723	440	1.64	375
Male carapace; GLAHM 106115	785			400
Juvenile carapace; GLAHM 106114	619			375

Remarks- Reyment (1963), considered *Trachyleberis modesta* and *Trachyleberis teiskotensis* to be synonymous after biometric analysis, but Bassiouni & Luger (1990), separated them on the basis of differences in ornamentation, i.e *modesta* has rounded nodes on the posterior 2/3 third and the rest of carapace is smooth, while *teiskotensis* has the whole carapace covered with nodes and spines, the spines being sharp and bifurcated, and the areas between are reticulate. The lateral outline also differs, *teiskotensis* is rectangular with a rounded posterior while *modesta* is subrectangular with a triangular posterior.

Occurrence- This was recorded from the late Palaeocene of Ivory coast, Mali, Libya, and North west and southwest Nigeria.

Genus *Actinocythereis* Puri, 1953

Actinocythereis joshensis sp nov

pl. 20, figs. 1-6

1991 *Actinocythereis* aff *teiskotensis*, El Sogher , P. 79, pl. 9, Figs. 6-14

Material- 19 carapaces; 4 carapaces well YY1-6; 7 carapaces well PP2-6; 7 carapaces well 3H1-6; 1 carapace well AA1-6; GLAHM 106116-121.

Derivation of the name- After Josh village, Libya.

Diagnosis- Carapace subrectangular in lateral view; with moderately distinct postero-dorsal process; surface reticulate with superimposed tubercle; eye tubercle and subcentral tubercle pronounced.

Holotype- Female carapace; pl.20, fig. 2, GLAHM 106117.

Paratype- Male carapace; pl.20, fig.1, GLAHM 106116.

Type locality- Well PP2-6 at depth of 7900 ft.

Type horizon- Hagfa Formation (upper Palaeocene).

Description- Carapace subrectangular in lateral outline; anterior margin rounded with seven small pustules lying on the marginal rim; Posterior margin obliquely rounded with five distinct spines in the postero-ventral area; dorsal margin straight and hidden by overreach reticulation; ventral margin slightly concave in the middle; maximum height at eye tubercle; maximum length at midheight; left valve slightly larger than right and obviously overlapping at posterior cardinal angle; posterior cardinal angle well pronounced in the left valve. The whole carapace is reticulate with superimposed pustules; postero-dorsal process moderately developed, eye tubercle and subcentral tubercle are distinct, ventral ridge more or less developed and consists of 6-7 tubercles; anterior row of reticulation coarse and subquadratic. Internal features not seen. Sexual dimorphism distinct, males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106117	715	420	1.70	411
Male carapace; GLAHM 106116	836	448	1.86	408
Female carapace; GLAHM106119	722	430	1.68	382
Female carapace;GLAHM 106121	672	411	1.63	382
Male carapace; GLAHM 106118	794	425	1.87	400
Female carapace; GLAHM 106120	683			300

Remarks- This species shows some similarities to *Actinocythreis teiskotensis* from the Palaeocene of Mali

(Apostolescu, 1961). The type illustrations (pl.XIII, figs. 253-258) show variation in ornamentation, some having prominent tubercles (pl. 13, figs. 253, 254), others being more reticulate (fig. 257). *Actinocythereis* sp nov is most similar to the reticulate form; Apostolescu's material may contain 2 different species and the reticulate form may be the same as *A joshensis* sp nov; The figured material is identical to *Atinocythereis* aff *A teiskotensis* El Sogher (1991 M.S) recorded from Heira Formation. The Libyan material differs from Apostolescu's species in being more reticulate and lacking the prominent tubercle. *Trachyleberis* (*Acanthocythereis*) *decoris* Siddiqui, 1971) recorded from the middle Eocene Upper Choclate Clay of the Rakhi Nala, Pakistan, differs in its less distinct subcentral tubercle, more superimposed postules, and anterior and posterior margins bearing a double row of short spines. The described species resembles *Acanthocythereis meslei palaeocenica* n ssp recorded from the Bassal Garra Formation (Late Palaeocene *Pseudomenardii* zone) of Egypt by Bassiouni & Luger (1990), but the latter is smaller (730 µm cf 834), has more obvious marginal spines and a nearly straight ventral margin, and the reticulation in the posterior half is more concentrically arranged compared with the radial pattern of *A joshensis* sp nov.

Occurrence- This was recorded from the lower Palaeocene-upper Palaeocene of the Sirt Basin.

Genus *Acanthocythereis* Howe, 1963

Type species: *Acanthocythereis araneosa* Howe, 1963

Acanthocythereis stymatoura Al-Furaih, 1980

1980 *Acanthocythereis stymatoura* Al-Furaih, p. 22, pl, 14, figs. 1-4.

Diagnosis- A species of *Acanthocythereis* with moderately developed posterior cardinal process in the left valve; anterior and posterior marginal rim pronounced; surface reticulate with subrounded fossae with or without superimposed pustules; eye tubercle rounded, and subcentral tubercle well developed ; males more elongate than females.

Acanthocythereis stymatoura libyaensis sub sp nov
pl. 20, figs. 7-10

1994 *Acanthocythereis stymatoura* Al-Furaih, Keen *et al*, pl. 16. 3, fig. 12.

1991 *Acanthocythereis stymatoura* Al-Furaih, El Sogher, P.87, pl. 11, figs. 2-12.

Material- 26 carapaces;12 carapaces well YY1-6; 10 carapaces well PP2-6; carapace well 3H1-6; 2 carapaces well KK1-6; 1 carapace well AA-6; GLAHM 106122-125.

Derivation of the name- After Libya.

Diagnosis- A subspecies of *Acanthocythreis stymatoura* with a rounded posterior end in the lateral outline.

Holotype- Male carapace; Pl. 20, fig. 7, GLAHM 106122.

Type locality- Well YY1-6 at depth of 7280 ft.

Type horizon- Hagfa Formation.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106122	757	379	1.99	343
Male carapace; GLAHM 106123	761	395	1.92	348
Male carapace; GLAHM 106124	784	408	1.92	386
Male carapace; GLAHM 106125	704			271

Remarks- This subspecies differs from the type species described from the lower Palaeocene of Saudia Arabia, in having a more rounded and less triangular posterior margin in lateral view, and lacks the very prominent upward-pointing posterior cardinal angle of the type species. This subspecies has been recorded previously from the Sirt Basin as *A stymatoura* by Keen *et al* (1994) and El Sogher (1991 M.S)

Occurrences- Palaeocene of the Sirt Basin.

Genus *Buntonia* Howe, 1935

Type species; *Buntonia shubutaensis* Howe, 1935

Buntonia sp cf *B tichittensis* Apostolescu, 1961

pl. 20, figs.11-14 .

1961 *Buntonia tichittensis* n sp Apostolesscu, p.805, pl. 5, figs. 91-93.

1963 *Buntonia tichittensis* Apostolesscu, Barsotti, p.1525, pl. 3, figs. 24-25.

1966 *Buntonia tichittensis* Apostolesscu, Salahi, p. 10, pl. 2, fig. 17.

?1983 *Buntonia tichittensis* Apostolesscu, Foster *et al*, p.123, pl. 6, figs 6,9 & pl. 7, fig.10.

Material- 104 carapaces and 3 valves; 43 carapaces and 1 valve well YY1-6; 12 carapaces well PP2-6; 12 carapaces well 3H1-6; 1 carapace well AA1-6; 9 carapace and 2 valves from the Heira section; 27 carapaces from the El-Fogha; GLAHM 106126-129.

Diagnosis- A species of characterised by an arched dorsal margin; surface ornamented with small to coarse punctae, the larger punctae located at the centre of carapace. Sexual dimorphism is distinct.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106127	492	289	1.70	254
Female carapace; GLAHM 106126	426	292	1.48	235
Female carapace; GLAHM 106128	426	287	1.46	238
Female carapace; GLAHM 106129	417			225

Remarks- This has been described from West and North Africa by several authors. In general the North African specimens have a similar lateral outline with a more highly arched dorsal margin than in material from West Africa. The species was first described from the Palaeocene of the Sudan district of Mali by Apostolescu (1966). The material studied here differs from Apostolescu's specimens in the highly arched dorsal margin and in having coarser punctae. Barsotti (1963) recorded specimens from the Upper Palaeocene of the El-Fogha area (Libya), which are very similar to the specimens described here, differing in the anterior margin of the females being more obliquely rounded.

The specimens described by Salahi (1966) from the subsurface Lower Eocene of the Sirt Basin are identical apart from a slightly larger size (550 μm cf 489). The specimens recorded by Foster *et al* (1982) from the Upper Palaeocene of Nigeria differ from all previously described specimens in lateral outline and ornamentation. Bassiouni & Luger (1990), recorded and described specimens of *Buntonia* sp cf *B tickittensis* from Late Palaeocene-Lower Eocene of Egypt which is similar to the studied specimens in lateral outline but differs in having a much smaller and less prominent punctae, From this evidence it may be concluded that more than one species is present; although the consensus is that there is one highly variable species. The Libyan species is considered to lie outside this variation.

Occurrences- This species is widely distribution in the North and East African continent and ranges from Palaeocene to Lower Eocene.

Buntonia tatteuliensis Apostolescu, 1961
pl. 20, figs. 15,16, pl. 21, figs. 1-5

1961 *Ambocythere ? tatteuliensis* Apostolescu, p. 814, pl. 9, figs. 175-179, pl. 15, fig. 300.

1963 *Ambocythere ? tatteuliensis* Apostolescu, Barsotti, p. 1526, pl. 1, fig. 9.

1967 *Ambocythere ? tatteuliensis* Apostolescu, Ficcarelli, p. 737, pl. 90, figs. 13-14.

1980 *Ambocythere ? tatteuliensis* Apostolescu, Reyment & Reyment, pl. 1, figs. 4.

1981 *Nucleolina tatteuliensis* Apostolescu, Reyment, p. 58, pl. 3, figs. 8-12.

1983 *Buntonia tatteuliesis* Apostolescu, Foster, Swain and Peters, p. 122, pl. 5, figs. 3-9, pl. 6, fig. 12, pl. 7, figs. 4-5.

1990 *Nucleolina tatteuliensis* Apostolescu, Basiouni & Luger, p. 793, pl. 5, figs. 9-11.

1994 *Buntonia tatteuliesis* Apostolescu, Keen *et al*, pl. 16.2, figs. 11,14.

Material- 1668 carapaces, 60 valves and 23 juvenile; 716 carapaces, 4 valves and 7 juvenile well YY1-6; 260 carapaces and 3 juvenile well PP2-6; 133 carapaces, 2 valves and 3 juvenile well 3HH-6; 309 carapaces, 4 valves and 9 juvenile well KK1-6; 46

carapaces, 1 valve and 1 juvenile well AA1-6; 52 carapaces and 12 valves from the Heira; 152 carapaces and 37 valves from the El-Fogha; GLAHM 106130-136.

Diagnosis- Carapace subrectangular to ovoid in lateral outline; surface ornamented with a series of subparallel longitudinal ribs in the central area converging posteriorly; remainder of carapace smooth; anterior and posterior margin are compressed; eye tubercle distinct; sexual dimorphism pronounced males being more elongate.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Juvenile carapace; GLAHM 106134	625	356	1.75	321
Male carapace; GLAHM 106133	822	483	1.70	428
Male carapace; GLAHM 106132	836	475	1.76	417
Female carapace; GLAHM 106130	746	463	1.61	409
Female carapace; GLAHM 106131	696	441	1.57	396
Male view; GLAHM 106136	842			408
Female carapace; GLAHM 106135	778			396

Remarks- Although this species was placed by Apostolescu (1961), into the genus *Ambocythere* ? because of poorly preserved internal features and radiate pore canals closely similar to *Ambocythere*, he also suggested that it could be a new genus. Foster *et al*, (1983) recorded the species from the Upper Palaeocene of Nigeria, observing internal features and hinge elements indicating a close relationship with *Buntonia* Howe, 1935 as figured in Benson *et al*, (1961).

Reyment, (1981) and Foster, (1983) recorded two different forms from the Upper Palaeocene Kalambaina Formation of Nigeria, differentiated by the ornamentation; in the first the entire carapace is ornamented by longitudinal riblets with fine pitting in between; in the second only the centre or posterior half is ornamented by longitudinal ridges with the areas between smooth, as is the rest of the carapace. The material studied here relates to the second form.

Occurrence- Upper Palaeocene Nigeria, Mali, Late Palaeocene? to basal Eocene Egypt and upper Palaeocene-Lower Eocene of Libya.

Buntonia (*Buntonia*) *salahii* sp nov
pl. 21, figs. 6-9

1966 *Buntonia* (*Buntonia*) n sp 2, Salahi, p. 10, pl. 2, figs. 8,9.

Material- 369 carapaces and 3 juvenile; 55 carapaces well YY1-6; 29 carapaces and 1 juvenile well PP2-6; 52 carapaces 3H1-6; 182 carapaces and 1 juvenile well KK1-6; 41 carapaces and 1 juvenile well AA1-6; 10 carapaces from the El-Fogha; GLAHM 106137-140.

Derivation of the name- After Dr D. Salahi who first described this species from the Sirt Basin.

Diagnosis- Carapace elongate to subtriangular in lateral outline; surface reticulate to punctate; two weak longitudinal ridges in the posterior part of the central area, with coarse reticulation between them.

Holotype- Female carapace; pl. 21, fig. 6, GLAHM 106137.

Type locality- Well YY1-7 at depth of 7100 ft.

Type horizon- Harash Formation (Lowr Eocene).

Description- Carapace elongate to subtriangular in lateral outline; the ornamentation consists of reticulation, punctae, and ridges. Two weak longitudinal ridges are present in the posterior part of the central area with coarse reticulation between them; coarse reticulation is present in the area above and below these ridges; other areas of the valve have punctae rather than reticulation, but there is variation between specimens. There is a broad flattened area around the anterior margin which tends to be less ornamented. In dorsal view anterior and posterior margin compressed. Internal features not known. Sexual dimorphism distinct, males being more elongate than females.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106138	573	303	1.89	256
Male carapace; GLAHM 106139	578	306	1.88	258
Female carapace; GLAHM106137	480	310	1.54	246
Female carapace; GLAHM 106144	460			234

Remarks- This species was first described from the Palaeocene of the Sirt Basin Libya by Salahi (1966).

Occurrence- Palaeocene-Lower Eocene of Libya.

Buntonia fortunata Apostolescu, 1961
pl. 21, figs. 10-17

1961 *Buntonia fortunata* Apostolescu, p. 801, pl. 3, figs. 61-67.

1963 *Buntonia fortunata* Apostolescu, Reyment, p. 197, pl. 17, figs. 6-7, pl. 18, fig. 1.

1983 *Buntonia* (*Buntonia*) *fortunata* Apostolescu, Foster, Swain, Petters, p. 120, pl. 3, figs. 10 & pl. 7, figs. 8,9.

1994 *Buntonia fortunata* Apostolescu, Keen *et al*, pl. 16.2, figs. 6-9.

Material- 701 carapaces, 40 valves and 5 juvenile; 121 carapaces and 1 juvenile well YY1-6; 88 carapaces well PP2-6; 64 carapaces, 2 valves and 2 juvenile well 3H1-6; 257 carapaces and 2 juvenile well KK1-6; 35 carapaces well AA1-6; 136 carapaces and 30 valves from Heira and 4 valves from El-Fogha; GLAHM 106141-148.

Diagnosis- Carapace triangular in lateral view; surface ornamentation varies, from variable sized punctae to entirely smooth; posterior hinge ear well developed; depression behind eye tubercle; there is flat area behind and parallel to the anterior margin; sexual dimorphism is distinct, males being more elongate than females.

Description- Keen *et al*, 1994 considered the variation within the species as morphotypes, so that they recognised three morphotypes based on the strength of development of ornament.

Morphotype A
pl. 21, figs. 10-12

The whole carapace is punctate; coarse punctae situated in posterior half with four weakly developed ridges present in postero-median area; there are two ribs parallel to the ventral margin in the left valve, and a smooth area parallel to the anterior margin; the eye tubercle is weakly developed.

Dimension of figured specimens (in μm)

	Length	Height	L/H	width
Female carapace; GLAHM 106141	625	383	1.63	312
Female carapace; GLAHM 106143	597	369	1.61	332
Male carapace; GLAHM 106142	793	397	1.99	324

Morphotype B

pl. 21, figs. 13-15

This morphotype has only fine punctae and the longitudinal ridges are hardly developed.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106144	850	446	1.91	374
Male carapace; GLAHM 106146	844	443	1.91	323
Female carapace; GLAHM 106145	651	401	1.62	317

Morphotype C

pl.21, figs. 16,17

The carapace is mostly smooth, with rare fine punctae in the median area of the valve.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106147	650	394	1.65	306
Male carapace; GLAHM 106148	796	406	1.96	298

Remarks- This species has a wide geographical distribution in West and North Africa, The material studied here is identical to *B fortunata* recorded from the Maastrichtian-Danian of the Sirt Basin by, Keen *et al* (1994) apart from being slightly larger. Morphotype A is very similar to *Buntonia fortunata* originally described from Dahomey (Globigerinid zone) by Apostolescu (1961). The material recorded and illustrated from the Late Palaeocene of

Nigeria by Foster *et al* (1983), differs slightly in having a less drawn-out posterior end, and lacks the flat smooth anterior area. *Protobuntonia aegyptiaca* from the Late Palaeocene (*Pseudomenardii* zone) of Egypt (Bassiouni & Luger, 1990) differs in its highly arched dorsal margin, particularly in the female, and in having a distinct posterior spine. In general these taxa are very similar to each other. Grekoff (1954) regarded *Protobuntonia* as a junior synonymy of *Buntona*, other authors have accepted them as separate genera or subgenera. *Protobuntonia* differs in its larger size, distinct sexual dimorphism, and more drawn-out posterior end.

Occurrences- occurs in the late Palaeocene of Nigeria (Foster *et al*, 1983), and Palaeocene of Dahomey (Apostolescu, 1961), and Palaeocene of Nigeria (Reyment, 1963), Late Maastrichtian-Danian of the Sirt Basin Keen *et al* (1994) in this studied ranges into upper Palaeocene.

Buntonia harashensis sp nov
pl. 22, figs. 1-8

Material- Twenty seven carapaces; 2 carapaces well 3H1-6; 20 carapaces well KK1-6; 5 carapaces AA1-6; GLAHM 106149-156.

Derivation of name- After Harash area, Libya.

Diagnosis- Carapace subrectangular in lateral outline in males, subtriangular in females; surface of carapace smooth to finely punctate with 2-3 weak ventral ribs and two short ribs in the central dorsal area; posterior margin truncated with or without spine in each valve.

Holotype- Female carapace; pl.22, fig.1, GLAHM 106149.

Paratype- Male carapace; pl.22, fig. 4, GLAHM 106152.

Type locality- Well KK1-6 at depth of 11200ft.

Type horizon- Hagfa Formation.

Description- Carapace subrectangular in males and subtriangular in females; anterior margin broadly rounded with distinct marginal rim extending along the ventral; posterior margin truncated; dorsal margin straight and sloping posteriorly; ventral margin straight to slightly convex; maximum height at anterior cardinal angle; maximum length below mid height; left valve slightly larger than right and overlapping at postero-dorsal, ventral and anterior margins. In dorsal view the anterior margin is compressed, with maximum width at mid point. A small spine is present in the postero-ventral area in some specimens; this may be present on both valves, or just on the left or right valve, or may be absent from both valves. Surface of carapace mostly smooth to slightly punctate; two to three riblets parallel to the ventral margin and two short parallel ribs in the central-dorsal area. Sexual dimorphism is distinct, males more elongate than females. Internal features not seen.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106153	695	425	1.63	294
Male carapace; GLAHM 106150	742	401	1.85	257
Male carapace; GLAHM 106152	757	409	1.85	289
Female carapace; GLAHM 106149	744	451	1.64	295
Female carapace; GLAHM 106154	704	415	1.69	284
Female carapace; GLAHM 106151	714	421	1.69	311
Female carapace; GLAHM 106156	673			282
Female carapace; GLAHM 10155	670			300

Remarks- This is very similar to *Iorubaella* sp 1 recorded by Salahi (1966) from the Palaeocene of the Sirt Basin. Salahi's specimens differ in having more extensively developed longitudinal riblets or striations; however Salahi describes these as varying from weak to strong so they could be variants of *Buntonia* sp nov. Salahi's material has the same lateral outline, and the variable posterior spine.

Soudanella cf *ioruba* (Reyment 1963) illustrated in Keen *et al* (1994) is similar to *B harashensis* sp nov; it differs in lacking the posterior spine and has riblets over most of the surface similar to Salahi's species.

Occurrences- Occurs in the Upper Palaeocene of the Sirt Basin.

Genus Cythereis Jones, 1849
Type species: *Cytherina ciliata* Reuss, 1846
Cythereis teiskotensis Apostolescu, 1961
pl. 22, figs. 9-13

1961 *Bradleya teiskotensis* Apostolescu, p. 819, pl. 12, figs. 241-245.

1980 *Cythereis teiskotensis* Apostolescu, Reyment & Reyment, pl. 1, fig. 7.

1994 *Cythereis teiskotensis* Apostolescu, Keen *et al*, pl. 16.3, figs. 10, 11.

Material- 82 carapaces; 12 valves and 2 juvenile; 25 carapaces and 2 juvenile well YY1-6; 15 carapaces and 1 valve well PP2-6; 4 carapaces well 3H1-6; 5 carapaces well KK1-6; 4 carapaces well AA1-6; 22 carapaces and 11 valves from Heira; 7 carapaces from El-Fogha; GLAHM 106157-161.

Diagnosis- Carapace subrectangular in lateral view; anterior margin broadly and evenly rounded with distinct anterior marginal rim passing through ventral and posterior margin; surface ornamented with two well developed nodes on the dorsal margin; subcentral tubercle well pronounced; short posterior median ridge formed by four small nodes and short ventral ridge formed by clusters of nodes and reticulation in the ventro central area, rest of carapace smooth to punctate; eye tubercle well pronounced; sexual dimorphism distinct males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106157	755	419	1.80	364
Female carapace; GLAHM 106158	754	447	1.68	440
Female carapace; GLAHM 106159	752	436	1.72	420
Male carapace; GLAHM 106160	869	469	1.85	459
Female carapace; GLAHM 106161	725			405

Remarks- The specimens illustrated by Apostolescu, (1961) show some variation in development of the dorsal nodes, subcentral tubercle and ventral ridge; pl. 12, figs. 241, 242 and 244 shows two distinct nodes at the dorsal margin while figures 243, 245 show ridges connecting the nodes. The specimens described by Barsotti, (1963) and Reyment, (1963) are similar to *Cythereis* cf *teiskotensis*, described below.

Occurrences- Occurs in the Palaeocene of Mali (Apostolescu, 1961), the Palaeocene of Libya (Reyment and Reyment 1980), and (Keen *et al*, 1994) as well as the present studied.

Cythereis sp cf *C teiskotensis* Apostolescu, 1961
pl. 22, figs. 14,15, pl. 23, figs. 1,2,6

1961 *Cythereies teiskotensis* Apostolescu, Barsotti, p. 1527, pl. 2, fig. 19.

1966 *Cythereies teiskotensis* Apostolescu, Salahi, p. 24, pl. 4, fig. 24.

1984 *Cythereies teiskotensis* Apostolescu, Woller, photo. 12, fig. 9.

1991 M.S *Cythereies* cf *teiskotensis* Apostolescu, El Sogher, p. 114, pl. 17, figs. 5-8 and 12,13.

Material- 557 carapaces, 183 valves and 17 juvenile; 182 carapaces and 9 juvenile well YY1-6; 38 carapaces and 1 valve well PP2-6; 27 carapaces, 4 valves and 4 juvenile well 3H1-6; 98 carapaces and 3 juvenile well KK1-6; 24 carapace and 1 juvenile well AA1-6; 123 carapaces and 167 valves from Heira; 65 carapaces and11 valves from El-Fogha; GLAHM 106162-166.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106162	920	486	1.89	469
Female carapace; GLAHM 106165	821	477	1.72	455
Female carapace; GLAHM 106163	900	527	1.70	537
Male carapace; GLAHM 106164	928	486	1.90	472
Female carapace; GLAHM 106166	803			467

Remarks- This differs from *C teiskotensis* principally in the dorsal ornamentaion. *C teiskotensis* has two prominent tubercles on the dorsal margin (pl, 22, fig. 11), while *C* sp cf *C teiskotensis* shows variation ranging from a continuous dorsal ridge (pl. 22, fig. 14), to several distinct tubercles along the dorsal margin. The anterior part of the ridge tends to separate, becoming a distinct tubercle (pl. 22, fig. 15), while the larger posterior part may separate into some three smaller tubercles (pl. 23, fig. 2); this variation is possibly continuous in nature. The median and ventral ridges of *C* sp cf *C teiskotensis* are also stronger and not tuberculate, *C* sp cf *C teiskotensis* is also larger (female length 800µm cf female length 698µm). For more details see El Sogher, (1991 M.S)

Occurrences- Palaeocene of the Sirt Basin Libya (Basotti 1963); (Salahi1966); (Woller 1984) and El Sogher (1991 M.S).

Cythereis kheirensis sp nov
pl. 23, figs. 3-5.

Material- 4 carapaces; 3 carapaces from the well YY1-6; 1 carapace from the well AA1-6; GLAHM 106167-169.

Derivation of name- After the Kheir area, Libya.

Diagnosis- A species 0f *Cythereis* characterised by three longitudinal ridges, very distinct subcentral tubercle; and strong anterior marginal rim.

Paratype- Male carapace; pl.23, fig, 3. GLAHM 106167.

Holotype- Female carapace; pl.23, fig.4, GLAHM 106168.

Type locality- well YY1-6 at depth 6140 ft.

Horizon - Kheir Formation (Lower Eocene).

Description- Carapace subrectangular in lateral outline; maximum height at anterior cardinal angle; greatest length at mid height; dorsal and ventral margins nearly straight, converging posteriorly; anterior margin broadly and evenly rounded with small denticulation; posterior margin subtriangular concave postero-dorsal and convex postero-ventral with five spines. Surface ornamented with irregular longitudinal ridges and tubercles, many of which are pore cones. There is a prominent circular subcentral tubercle; a dorsal ridge running from just below eye tubercle towards the posterior; below this is a short ridge lying above the subcentral tubercle which continues posteriorly as a row of some 4 tubercles; 2 short tuberculate ridges run from behind the subcentral tubercle. Ventral ridge slightly wing-like, long and straight with a node at its posterior end. The anterior area is reticulate, the strength of the reticulation varies between specimens. The anterior marginal rim is well developed; left valve larger than right and overlapping at postero-dorsal area; eye tubercle very clear and rounded; internal features not known.

Dimension of figured specimens (in µm).

	Length	Height	L/H	Width
Male carapace; GLAHM 106167	671	342	1.96	302
Female carapace; GLAHM 106168	637	350	1.82	341
Male carapace; GLAHM 106169	634	333	1.90	316

Remarks- This Palaeocene species from the Sirt Basin differs from any species described so far. The generic assignment of this species is difficult due to the absence of any information on internal morphology. It is placed in *Cythereis* on the basis of external morphology.

Occurrences- occurs from Early Eocene of the Sirt Basin.

Genus *Occultocythereis* Howe, 1951
Type species: *Occultocythreies delumbata* Howe, 1951
Occultocythreis confirmatus El Sweify, 1984
pl. 23, figs. 7-10

1966 *Caudites* n sp 1 Salahi, p. 15, pl. 4, fig. 22.

1984 *Occultocythreis confirmatus* n sp El Sweify, p. 49, pl. 3, figs. 6-8.

1984 *Occultocythreis accinctus* n sp El Sweify, p. 51, pl. 3, figs. 9-12.

1990 *Occultocythreis confirmatus* El Sweify, Bassiouni & Luger, p. 828, pl. 17, figs. 8-14.

Material- 22 carapaces and 2 valves; 7 carapaces well YY1-6; 14 carapaces and 1 juvenile from Heira; 1 carapace and 1 juvenile from El-Fogha; GLAHM 106170-173.

Diagnosis- Small carapace subrectangular in lateral view; anterior margin ornamented with denticles and posterior margin with four spines; marginal rim distinct throughout anterior, ventral, and posterior margins; surface ornamented with short dorsal and ventral ridges connected by small vertical ridge posteriorly, well pronounced elongate subcentral tubercle, the rest of carapace reticulate and punctae. Internal features not known. Sexual dimorphism distinct, males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106171	438	223	1.96	183
Male carapace; GLAHM 106172	467	220	2.12	157
Male carapace; GLAHM 106170	455	214	2.12	150
Male carapace; GLAHM 106173	432			134

Remarks- El Sweify (1984) described this species from the Middle-Late Palaeocene of Egypt, together with *O accinctus*; Bassiouni & Luger (1990) regarded these as synonymous, *O confirmatus* being the male dimorph, *O accinctus* the female. The species was also recorded by Salahi (1966) from the Palaeocene -Lower Eocene of the Sirt Basin. The material studied here does not have such distinct marginal spines as do the specimens figured by Bassiouni & Luger, but have a strong subcentral tubercle and ridges.

Occurrences- Occurs from Palaeocene-early Eocene of Libya and subsequently recorded from middle-late Palaeocene of Egypt.

Occultocythereis sp
pl. 23, fig. 11.

Material- 1 carapace from the well AA1-6 at a depth of 10480 ft; GLAHM 106174.

Description- Carapace subrectangular in lateral view; anterior margin rounded with pronounced rim bearing double row of bifurcated spines; posterior margin subtriangular with distinct rim with seven small spines; dorsal margin not obvious due to the overreach of the dorsal ridge which consists of a combination of nodes and spines; ventral margin straight with small spines; there is a swollen discontinuous ridge running obliquely across the carapace from the postero-dorsal area towards the antero-ventral area; a prominent vertically oriented node forms the posterior end of the ridge; a second node forms the sub central tubercle; the anterior end is marked by 3 pore cones. A further prominent pore cone is present just below the eye tubercle. A nodal complex is present near the centre of the ventral lateral area; the rest of carapace is smooth.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Right carapace; GLAHM 106174	815	435	1.87	347

Remarks- No comparable species have been found.

Occurrences- Occurs in the Lower Eocene of the Sirt Basin.

Genus *Protobuntonia* Grekoff, 1954

Type species: *Protobuntonia numidica* Grekoff, 1954

Protobuntonia nakkadii Bassiouni, 1971

pl. 23, figs. 12,13, pl. 24, figs. 1,3

1971 *Protobuntonia nakkadii* Bassiouni, p. 23, pl. 2, figs. 1-3.

1978 *Protobuntonia numidica* , Grekoff, Said, p. 226, p. 1. 25, fig. 9.

1982 *Protobuntonia nakkadii* Bassiouni, Donze *et al*, p. 295, pl. 12, fig. 1, pl. 14, fig. 6.

1990 *Protobuntonia nakkadii* Bassiouni, Bassiouni & Luger, p. 845, pl. 23, figs. 23,24.

1994 *Protobuntonia nakkadii* Bassiouni, Keen *et al*, pl. 16.2, fig. 12.

Material- 35 carapaces and 1 valve; 5 carapaces well YY1-6; 4 carapaces well PP2-6; 4 carapaces well 3H1-6; 9 carapaces and 1 valve well KK1-6;13 carapaces well AA1-6; GLAHM 106175-178.

Diagnosis- A species of *Protobuntonia* subtriangular in lateral view, surface smooth to finely punctate; 1-2 faint ribs parallel to ventral margin (clearly seen in the left valve); eye tubercle weak.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106177	835	480	1.74	445

Male carapace; GLAHM 106175	970	510	1.90	399
Female carapace; GLAHM 106178	831	517	1.60	376
Female carapace; GLAHM 106176	795			354

Remarks- The figured species are identical to *Protobuntonia nakkadii* recorded from the Maastrichtian of the Sirt Basin by Keen *et al* (1994). The Libyan material is slightly different in lateral outline to the specimens recorded from the Late Maastrichtian-Late Palaeocene of Tunisia (Donze *et al* 1982) and the Lower Danian of Tunisia (Said 1978) which have a more tapered posterior. The specimens recorded from the Middle Palaeocene of Jordan by Bassiouni, (1970) are slightly larger (1000-1220 µm cf 833-970).

Occurrences- This species was originally described from the Middle Palaeocene of Jordan, the late Maastrichtian-late Palaeocene of Tunisia, and the Lower-Middle Palaeocene of Libya.

Protobuntonia spinosa sp nov
pl. 24, figs. 4-10

1966 *Buntonia* (*Protobuntonia*) n sp 1 Salahi, p. 11, pl. 2, figs. 10-15.

Material- 9 carapaces from the well KK1-6; GLAHM 106180-186.

Derivation of name- After its long spine on the posterior margin.

Diagnosis- Carapace is small and subtriangular in lateral outline; posterior margin characterised by a long spine on each valve; with prominent marginal rim along anterior which continues 3/4 length of carapace from anterior along the ventral margin. Carapace surface smooth to finely punctate, some punctae are arearranged in rows in posterior half; eye tubercle weakly developed.

Holotype- Male carapace; pl.24, fig. 4, GLAHM 106180.

Paratype- Female carapace; pl.24, fig. 7, GLAHM 106183.

Type locality- Well KK1-6, Holotype at depth of 11260 ft and paratype at depth of 11440ft.

Type horizon- Hagfa Formation.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106180	603	323	1.86	255
Male carapace; GLAHM 106181	589	321	1.83	248
Female carapace; GLAHM 106182	558	327	1.70	248
Female carapace; GLAHM 106183	575	337	1.70	277
Female carapace; GLAHM 106184	434	243	1.78	185
Male carapace; GLAHM 106185	585			227
Female carapace; GLAHM 106186	547			252

Remarks- This species was first described from the Palaeocene of the Sirt Basin by Salahi (1966).

Occurence- Occurs in Palaeocene of the Sirt Basin.

Protobuntonia sp B El Sogher, 1991 M.S
pl. 24, fig. 2

1991 *Protobuntonia* sp B El Sogher, p. 136, pl. 21, figs. 14-15 and pl.22, figs 1-2.

Material- 1 carapace in the well AA1-6 at depth of 11140 ft; GLAHM 106179.

Description- Carapace subtriangular in lateral view; anterior margin broadly and evenly rounded; posterior margin pointed; dorsal and ventral margin straight and converging posteriorly; maximum height just behind eye tubercle; maximum length at mid height; left valve slightly larger than right and overlapping throughout ventral margin and postero-dorsal area. The carapace surface is smooth.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106179	547	321	1.70	253

Remarks- Occurs in the Waha Formation (Maastrichtian) and Hagfa Formation (Palaeocene) of the Sirt Basin.

Genus *Quadracythere* Hornibrook, 1952
Type species: *Cythere truncula* Brady, 1898

Quadracythere kaoensis Carbonnel *et al* , 1990
pl. 24, figs. 11-15, pl. 25, fig. 13

1990 *Quadracythere kaoensis* sp nov Carbonnel *et al*, p. 677, lp. 3, fig. 13.

1990 *Schizocythere* sp 1 Bassiouni and Luger, 1990, p. 815, pl. 12, figs. 9-11, 14-15.

Material- 90 carapaces and 9 valves; 56 carapaces and 6 valves from the Heira; 34 carapaces and 3 valves from the El-Fogha; GLAHM 106187-192.

Diagnosis- Carapace subquadrate in lateral view; and surface characterised by coarse ridges and punctae.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106187	580	356	1.62	309
Male carapace; GLAHM 106189	533	305	1.74	255
Female carapace; GLAHM 106188	552	347	1.59	298
Male carapace; GLAHM 1061190	518	300	1.72	238
Female carapace; GLAHM 106191	517			268
Female carapace; GLAM 106192	508			256

Remarks- *Quadracythere kaoensis* was recorded from the late Palaeocene of Niger by Carbonnel *et al*, (1990) the Libyan material is the same. This species is also recorded from the Upper Palaeocene-base Eocene of the Garra Formation of Egypt (Bassiouni & Luger 1990).

The material studied here shows variation due to preservation, but also including intraspecific variation. This has enabled a comparison with the illustrations of Carbonnel and Bassiouni & Luger. The material of Bassiouni & Luger is poorly preserved, but is very similar to the specimens illustrated here on pl. 24, fig .11-15. Variation in ornamentaion is seen in firstly the presence or near absence of 2 connected ridges parallel to the anterior margin (pl.24, fig.11,12?) and in the strength of the connecting ridge running from the posterior half of the median ridge to the posterior node of the ventral ridge.

The species illustrated by Carbonnel has both features poorly developed and similar to pl. 24, fig. 11.

All described specimens are small in size L = 650 µm Carbonnel, L= 590µm Bassioni &Luger and 580 for the Libyan specimens.

The generic assignment of this species is not clear, however, the opinion of Carbonnel *et al* (1990) has been followed.

Occurrence- Occurs from late Palaeocene of Niger, Egypt and Libya.

Genus *Hornibrookella* Moos, 1965
Type species: *Cythere anna* Lienenklaus, 1894
Hornibrookella episcelis Al-Furaih, 1977
pl. 25, Figs.1-4

1977 *Hornibrookella episcelis* Al-Furaih, p. 492, pl. 56, figs. 1-4.

1994 *Hornibrookella episcelis* Al-Furaih, Keen *et al*, pl.16.3, fig. 13.

Material- 7 carapaces from the well 3H1-6; GLAHM 106193-196.

Diagnosis- A species of *Hornibrookella* with distinct caudal process; surface reticulation with coarse fossae; weakly developed longitudinal ridges, more obvious in the dorsal area.

Dimension of figured specimen (in µm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106193	729	442	1.65	380
Female carapace; GLAHM 106194	753	446	1.68	405
Male carapace; GLAHM 106195	763	427	1.78	385
Female carapace; GLAHM 106196	735	447	1.64	383

Remarks- The figured specimens are identical to those illustrated by Keen *et al*, (1994) from the Maastrichtian-Lower Palaeocene of the Sirt Basin. The specimens from the Sirt Basin Libya are slightly smaller than those originally described from the uppermost Cretaceous-Lower Palaeocene of Saudi Arabia (Al-Furaih, 1977) otherwise they are identical.

Occurrences- Occurs from the Maastrichtian-Early Palaeocene of Saudi Arabia and Maastrichtian-Lower Eocene of Sirt Basin.

Hornibrookella heiraensis sp nov
pl. 25, figs. 5-12

Material- 209 carapaces and 199 valves; 90 carapaces and 93 valves from the Heira; 119 carapaces and 106 valves from the El-fogha; GLAHM 106197-106204.

Derivation of the name - After the Heira area, Libya.

Diagnosis- Carapace subquadrate in lateral outline; reticulated with deep fossae and weakly developed ventral ridge.

Holotype- Female carapace; pl.25, fig.5, GLAHM 106197.

Paratype- Male carapaec; pl.25, fig. 9, GLAHM 106201.

Type locality- Heira depression, sample S1-7.

Type horizon- Shurfa Formation (Bu Ras member).

Description- Carapace subquadrate in lateral view; anterior margin obliquely rounded with prominent marginal rim; posterior margin subtruncated; maximum height at eye tubercle; maximum length at mid height; dorsal and ventral margins partly hidden in lateral view by overhanging dorsal and ventral ridges; left valve larger than right, overlapping through postero-dorsal and antero-dorsal areas. Carapace ornamented with subrounded deep fossae, partly concentrically arranged; eye tubercle prominent; dorsal ridge weakly developed, begins from eye tubercle runs backward ending at postero-dorsal area; ventral ridge runs from antero-ventral into postero-ventral. Sexual dimorphism is distinct, males being more elongate than females. Internal features not seen.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106197	695	425	1.63	443
Male carapace; GLAHM 106198	727	426	1.70	440
Male carapace; GLAHM 106200	703	434	1.61	444
Female carapace; GLAHM 106199	669	421	1.58	455
Male carapace; GLAHM 106201	733	444	1.65	467
Female carapace; GLAHM 106202	677	400	1.69	439
Female carapace; GLAHM 106203	617			395
Female carapace; GLAHM106204	645			394

Remarks- This species shows some similarities to *Hornibrookella cyclopea* Al-Furaih (1977) recorded from the lower

Palaeocene of Saudi Arabia, but the latter species is larger (855 µm cf 677) and the intersection of reticulation in the dorsal area forms more obvious ribs. *Hornibrookella* cf *quinquecellulosa* Al-Furaih, 1977 recorded from the Heira and Waha Formations of the Sirt basin (El Sogher, M. S 1991) are similar to *H heiraensis* sp nov although the latter species differs in the concentric arrangement of reticulation on the surface. *H heiraensis* sp nov could however be conspecific with El Sogher material if we consider this slight variation as being intraspecific. *Alocopocythere* (*Isalocopocythere*) nov subgenus *immodica* (Al-Furiah, 1980) recorded from the upper Palaeocene of Niger (Carbonnel *et al*, 1990) is very similar to the male left valve (pl. 25, fig.9) apart, from its broadly rounded anterior margin. The description and illustrations given by Al-Furaih of *Hornibrookella quinquecellulosa* are very similar to *H heiraensis* sp nov; the former differs in having a stronger dorsal ridge, and the ventral ridge at its posterior projects more when seen in lateral view; there is a less obvious concentric arrangement of reticulation rows.

Occurrences- Occurs from Upper Palaeocene outcrop sections.

Genus *Ortliella* Pokorny, 1964

Type species: *Cythere reticulata* Kafka, 1886

Oertliella heiraensis sp nov

pl. 26, figs. 1-6

1966 *Acanthocythereis* ? n sp 2 Salahi, p.21, pl. 5, figs. 9-10.

Material- 76 carapaces and 39 valves; 6 carapaces well YY1-6; 6 carapaces well PP2-6; 2 carapaces well KK1-6; 44 carapaces and 31 valves from the Heira; 18 carapaces and 8 valves from the El-Fogha; GLAHM 106205-210.

Derivation of name- After the Heira area, Libya.

Diagnosis- A species of *Oertliella* with distinct subcentral tubercle bearing four spines or nodes; dorsal ridge with five spines, ventral ridge with seven spines; carapace reticulate with scattered tubercles.

Holotype- Female carapace; pl. 26, fig.2, GLAHM 106206.

Paratype-Male carapace; pl.26, fig. 1, GLAHM 106205.

Type locality- Heira depression, sample S1-5.

Type horizon-Formation (Bu Ras member).

Description- Carapace subrectangular in lateral outline; anterior margin broadly rounded with traces of spines; posterior margin concave in dorsal part, slightly pointed; dorsal and ventral margins straight and converging posteriorly; maximum height at eye tubercle; maximum length at mid height; left valve equal to right valve; surface reticulate with distinct subcentral tubercle bearing spines or tubercles, dorsal ridge slightly curved with four prominent spines; ventral ridge straight with seven spines; 6 tubercles are present to posterior of subcentrale tubercle 4 to anterior; remainder of carapace reticulate with subrounded deep fossae. Internal features not known. Sexual dimorphism is pronounced males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106206	540	314	1.72	332
Male carapace; GLAHM 106205	593	297	1.99	295
Female carapace; GLAHM 106208	515	306	1.68	316
Male carapace; GLAHM106207	582	294	1.79	315
Female carapace; GLAGM 106209	536			300
Female carapace; GLAHM 106210	513			309

Remarks- This species was first recorded from the Palaeocene of the Sirt Basin by Salahi (1966) and differs from *Oertliella vesiculosa* (Apostolescu) as illustrated by Apostolescu (1961) and Carbonnel (1986) from West Africa in its more prominent eye tubercle, larger more complex subcentral tubercle, shorter ventral ridge, less prominent anterior marginal rim, and lateral tubercle. It is very similar to the species illustrated by Bassiouni & Luger (1990) as *Oertliella vesiculosa* Apotolescu from the Late Palaeocene of Egypt, differing only in the number of dorsal spines (4 compared with 3), and a less truncated posterior margin in the left valve.

El Sogher (1991 M.S) recorded *Oertliella petraensis* Al-Sheikly, Ph D 1980 from the Palaeocene Heira Formation of the Sirt Basin; this may be the same as *Oertliella delicata* sp nov Bassiouni & Luger (1990) described from the Middle Palaeocene of Egypt; this differs in having a much less spinose dorsal ridge, simpler subcentral tubercle, prominent posterior process and a more even lateral ornamentation.

Occurrences- Upper Palaeocene of Sirt Basin and outcrops sections

Genus *Ordoniya* Al-Sheikhly, 1985

Type species: *Hazelina ordoniya* Bassiouni, 1970

?*Ordoniya* (*O*) *burmaensis* (Bassiouni, 1970)

pl. 26, figs. 7,8.

1968 *Isocythereis acies* n sp Esker, p.226, pl.1, figs. 9-11, pl.4, fig.6.

1970 *Hazelina burmaensis* Bassiouni, p. 32, pl. 5, figs. 3,4.

1982 *Isocythereis acies* Esker, Donze et al, p.284, pl.7, figs1,2.

1985 *Ordoniya* (*O*) *burmaensis* Al-Sheikhly (paper unobtainable, page, plate, figs unknown)

Material- 4 carapaces and 1 valve; 2 carapaces and 1 valve well YY-6; 2 carapaces well PP2-6; GLAHM 106211-212.

Diagnosis- A species placed with a query into the genus *Ordoniya* characterised by prominent three longitudinal ridges; surface reticulated with subrounded fossae.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106211	636	363	1.75	260
Carapace; GLAHM 106212	645	355	1.82	288

Remarks- The figured specimens slightly differ from *H acies* described by Donze, (1982) from the El Kef section Tunisia being smaller in size with less concave ventral margin. It resembles the species *Ordynia* (*O*) *burmaensis* Bassiouni, (1970) recorded from Jordan, apart from smaller size (639 µm cf 750) and less distinct eye tubercle. One of the Libyan specimens has a straight ventral margin. It is not certain that this is the same as Bassiouni's species, but is considered to be the same as the Tunisian species. *Ordoniya* (*O*) *burmaensis* shows some differences in reticulation of the specimens; older specimens have small reticulations, while younger specimens have ornamentation within the primary reticulation (see Al-Sheikhly unpuplished thesis pl. 14, figs.6, 8-10). The material recorded from Tunisia (Donze *et al*, 1982) and the studied material did not show any sign of ornamentation within the primary reticulation although they are very close in their morphology as to be indistiquishable. They have a similar stratigraphic range.

Occurence- Maastrichtian, Thanetian of El Kef Section Tunisia, and from Danian Zebbeus Formation

Genus *Soudanella* Apostolescu, 1961

Type species: *Soudanella laciniosa laciniosa* Apostolescu, 1961

Soudanella ghaniensis sp nov.

pl. 26, figs. 9-13, pl.27, fig. 9

1963 *Soudanella* cf *S laciniosa triangulata*, Barsotti, p. 1525, pl. 3, figs. 20,20a.

Material- 9 carapaces; 5 carapaces well YY1-6; two carapaces well 3H1-6; one carapace well AA1-6 and one carapace from the El-Fogha; GLAHM 106213-218.

Derivation of the name- After Ghani escarpment.

Holotype- Female carapace; pl.26, fig. 10, GLAHM 106214.

Paratype- Male carapace; pl.26, fig.9, GLAHM 106213.

Type locality- Well YY1-6, holotype at depth of 7360 ft and paratype at depth of 7440 ft.

Horizon- Hagfa Formation.

Diagnosis- Carapace triangular to subtriangular in lateral outline; ornament of longitudinal ribs in the posterior half converging towards the posterior end, remainder of carapace smooth to slightly punctate; anterior marginal area with depression; anterior and ventral margin rim weakly developed.

Description- Female carapace is triangular in lateral view, male elongate to subpyriform; anterior margin broadly rounded; posterior margin tapered; dorsal margin straight; ventral margin slightly convex; maximum height at anterior third; maximum length below mid height; left valve slightly larger than right, overlapping around dorsal and ventral margins. Surface of carapace with 12 ridges in the posterior half; the rest of carapace smooth to slightly punctate; there is a weak marginal rim along the anterior and ventral margins, the dorso-anterior area is depressed giving the effect of a large "dimple" extending to the ventro-anterior region. In dorsal view maximum width posterior to the mid length, anterior margin compressed. Internal features not known, sexual dimorphism is distinct male being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106214	676	387	1.74	305
Female carapace; GLAHM 106216	651	390	1.66	287
Male carapace; GLAHM 106213	730	350	2.08	278
Male carapace; GLAHM 106215	728	352	2.06	360
Male carapace; GLAHM 106217	703			275
Male carapace; GLAHM 106218	716			297

Remarks- *Soudanella* cf *S laciniosa triangulata* described and illustrated from the Palaeocene of Libya by Barsotti (1963). appears to be the same as this species. *Soudanella ghaniensis* sp nov is similar in lateral outline to *Buntonia vergulata* Apostolescu recorded from the Palaeocene of Mali and the Eocene of Senegal (Apostolescu, 1961) and subsequently recorded from the Palaeocene of the Sirt Basin by Barsotti (1963) and Salahi (1966), but the latter species differs in having longer ridges and an slightly more evenly rounded anterior margin.

Soudanella cf *S laciniosa* Apostolescu, 1961 recorded from Lower Ypresian of the Siliana-Sers region Tunisia Said, 1978 differs in its more pronounced posterior cardinal angle.

Soudanella laciniosa triangulata differs in lateral outline, the ornament of ridges covering most of the carapace, and a prominent broad anterior area with reticulation (see Reyment and Arakani 1991).

Occurrences- Occurs from the upper Palaeocene of the Sirt Basin and El-Fogha section.

Soudanella sp cf *S ioruba* Reyment, 1963
pl. 27, figs. 1-3

1994 *Soudanella* cf *Ioruba* Reyment, Keen *et al*, pl. 16. 2, figs. 4,5.

Material- 41 carapaces; 23 carapaces well YY1-6; 9 carapaces well PP2-6; 6 carapaces well 3H1-6; 3 carapaces from Heira section; GLAHM106219-221.

Description- Carapace subtriangular in lateral view; anterior margin broadly rounded with distinct marginal rim continuing into the ventral margin; posterior margin truncated; dorsal and ventral margins straight and converging posteriorly; maximum height at eye tubercle; maximum length at mid height; left valve slightly larger than right and obviously overlapping around the dorsal and ventral margins. The lateral surface is ornamented with 12-13 longitudinal ribs, which are arched upwards in the dorsal area; an area around the anterior margin is unornamented. Eye tubercle weakly developed. Internal features not seen. Sexual dimorphism is distinct with more elongate males.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106219	682	366	1.86	259
Female carapace; GLAHM 106220	699	397	1.76	319
Male carapace; GLAHM 106221	770	385	2.00	311

Remarks- This species was first illustrated from the Palaeocene well A5-32 of the Sirt Basin as *Buntonia* (*Protobuntonia*) *ioruba* by Reyment (1980). Keen *et al*, (1994) recorded and illustrated identical material from the Heira Formation of the Sirt Basin. Reyment's illustration (pl.1, fig. 2) appears to be extremely large for this species (1020μm) if the magnification is correct. *S ioruba* was described from Nigeria

(Reyment 1960), and differs in having a smooth antero-median area and reticulation around the anterior margin, although both of these characters are variable. Reyment & Aranki (1991) have carried out a statistical analysis of *S ioruba* and its successor species *S lacinosa* Apostolescu, 1960 and shown these to be two distinct species. *S ioruba* ss is only present in the Maastrichtian-Danian. In his original description Reyment (1960) described a smooth area parallel to the anterior margin for Cretaceous specimens, which is reticulate in Palaeocene specimens.

Occurrences- Occurs from Upper Palaeocene of the Sirt basin and Heira section.

Genus *Paragrenocythere* Al-Furaih, 1975
Type species: *Paragrenocythere biclava* Al-Furaih, 1975
Paragrenocythere gravis Al-Furaih, 1980
pl. 27, figs. 4-8

1980 *Paragrenocythere gravis* Al-Furiah, p.50, pl.42, figs.1-4.

1988 *Paragrenocythere gravis* Al-Furiah, Athersuch, pl.3, fig.16.

1991 *Paragrenocythere gravis* El-Furiah, El Sogher, p.138, pl.22, figs.3-8.

Material- 177 carapaces and 15 valves; 69 carapaces well YY1-6; 47 carapaces well PP2-6; 7 carapaces well 3H1-6; 15 carapaces well KK1-6; 3 carapaces well AA1-66; 12 carapaces and 12 valves from the Heira; 24 carapaces and 3 valves from the El-Fogha; GLAHM 106222-226.

Diagnosis- A species of *Paragrenocythere* characterised by massive postero-dorsal clavae and well developed ventral ridge which may be alate posteriorly.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106225	717	424	1.69	510
Female carapace; GLAHM 106223	729	442	1.65	538
Male carapace; GLAHM 106222	778	446	1.74	521
Male carapace; GLAHM 106224	768	448	1.71	?402

Female carapace; GLAHM 106226 748 488

Remarks- The material studied shows variation in the development of both the postero-dorsal clavae and the posterior ala of the ventral ridge. *P gravis* and *P biclavata* Al-Furaih, both originally described from the Maastrichtian-Palaeocene of Saudi Arabia, are very similar; the differences noticed by Al-Furaih (1980) lie in the larger size and curved ventral margin of *P biclavata* and the massive clavae and straight ventral ridge of *P gravis*. He used the straight ridge criteria to separate *P gravis* and *P biclavata*. The specimens found in this study are very similar to *Bradleya* aff *B cultrata* Apostolescu (1961) recorded from the Zemam & Surfa Formation of the Sirt basin, Libya by Salahi (1966); the latter is larger (900 cf 768). *Phalcocythere cultrata* figured and illustrated by Bassiouni & Luger (1990) from the late Palaeocene-Early Eocene of Egypt shows similarities to the studied specimens in lateral outline and ornamentation, it differs in having three postero-dorsal clavae, although in some of the illustrations (pl. 9, figs. 13,17) the two anterior clavae appear to merge into a single massive clavus as in the Libyan material. The Egyptian (Bassiouni & Luger 1990) and Nigerian material (Reyment, 1981) described as *P cultrata* appear to lack the well developed subcentral tubercle of *P gravis*. Bassiouni & Luger have illustrated variation within their species (*P cultrarta*); if this variation is accepted, it could encompass the Libyan material (*P gravis*) within a single variable species. At the moment they are retained as separate taxa.

Occurrence- Occurs in Maastrichtian to Lower Palaeocene of Saudi Arabia, Campanian-Maastrichtian of Oman and Maastrichtian to Upper Palaeocene of Libya.

Paragrenocythere neoponticulata El Sogher, 1991 M.S
pl. 27, figs. 10-12,17.

1991 *Paragrenocythere neoponticulata* El Sogher, p.140, pl.22, figs. 9-14.

Material- 568 carapaces, 70 valves and 2 juvenile; 253 carapaces, 1 valve and 1 juvenile well YY1-6; 122 carapaces and 4 valves well PP2-6; 42 carapaces, 5 valves and 1 juvenile well 3H1-6; 53 carapaces well KK1-6; 4 carapaces well AA1-6; 28 carapaces and 44 valves from Heira; 66 carapaces and 16 valves from El-Fogha; GLAHM 106227-230.

Diagnosis- Carapace subquadrate to subrectangular in lateral view; lateral surface characterised by weak dorsal ridge and well developed ventral ridge.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106228	895	521	1.72	557
Male carapace; GLAHM 106227	902	486	1.86	498
Male carapace; GLAHM 106229	876	447	1.95	497
Female carapace; GLAHM 106230	893			550

Remarks- This species was first described from the Waha and Heira Formations of the Sirt Basin (Raguba oil field, El Sogher 1991 M.S). The figured specimens are similar apart from larger size (876-895 cf 704-769).

Occurrence- Occurs in Maastrichtian-Lower Eocene of Libya.

Genus *Phalcocythere* Siddiqui, 1970

Type species: *Cythere horrescens* Bosquet, 1852

Phalcocythere jebelensis El Sogher M.S, 1991

pl. 27, figs. 13-16.

1991 *Phalcocythere jebelensis* El Sogher, p. 142, pl. 23, figs. 7-13.

Material- 15 carapaces; 6 carapaces well YY1-6; 1 carapace well PP2-6; 8 carapaces well 3H1-6; GLAHM 106231-234.

Diagnosis- A species of *Phalcocythere* with postero dorsal process; surface reticulate; subcentrale tubercle prominent and surrounded by four reticules; ventral ridge moderately elevated, eye tubercle distinct.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106232	657	355	1.85	304
Female carapace; GLAHM 106233	671	356	1.88	284

Female carapace; GLAHM 106231	675	360	1.87	290
Female carapace; GLAHM 106234	550	344	1.59	310

Remarks- The figured specimens are identical in all respects to *Phalcocythere jebelensis*, recorded from the Heira Formation of the Raguba oil field, Sirt Basin by El Sogher (1991 M.S). This differs from *P ralahensis* El Sogher in its larger size, more elongate lateral shape, less quadrate posterior margin, prominent knob-like subcentral tubercle, more prominent postero-dorsal process and a more peripheral and extruding eye tubercle.

Occurrences- Occurs from upper Palaeocene of the Sirt Basin.

Phalcocythere ralahensis El Sogher M.S, 1991
pl. 28, figs. 1-4.

1991 *Phalcocythere ralahensis* El Sogher, P. 145, pl. 23, figs. 1-6.

Material- 40 carapaces; 19 carapaces well YY1-6; 8 carapaces well PP2-6; 5 carapaces well 3H1-6; 6 carapaces well KK1-6; 2 carapaces well AA1-6; GLAHM 106235-238.

Diagnosis- A species of *Phalcocythere* with reticulate surface, moderately developed ventral ridge; posterior subquadratic outline.

Dimension of figured specimens (in μm)

	Length	Height	L/H	width
Carapace; GLAHM 106237	589	340	1.73	299
Carapace; GLAHM 106236	582	342	1.70	309
Carapace; GLAHM 106235	565	331	1.70	290
Carapace; GLAHM 106238	538			285

Remarks- Type specimens of *Phalcocythere ralahensis* recorded from the Heira Formation (Danian) of Sirt basin (El Sogher, 1991 M.S), is slightly smaller (525μm cf 589).

Occurrences- Upper Palaeocene of the Sirt Basin.

Phalcocythere hagfaensis sp nov
pl. 28, figs. 5-10

Material- 21 carapaces; 14 carapaces well YY1-6; 6 carapaces well PP2-6; 1 carapaces well 3H1-6; GLAHM 106239-244.

Derivation of the name- After the Hagfa area, Libya.

Diagnosis- A species of *Phalcocythere* with prominent ventral ridge; poster-dorsal process and subcentral tubercle poorly developed; anterior two rows of reticulation almost merged; eye tubercle rounded.

Holotype- Carapace, pl.28, fig. 6, GLAHM 106240.

Paratype- Carapace, pl, 28, fig. 8, GLAHM 106242.

Type locality- well PP2-6 at depth of 7540.

Type horizon- Hagfa Formation (lower part)

Description- Carapace subrectangular in lateral view; anterior margin broadly and evenly rounded with a keel like antero-ventral angle due to the anterior concavity of the ventral margin; posterior margin obliquely rounded; dorsal margin straight but posterior half hidden by postero-dorsal reticulation; anterior and posterior marginal rims well developed; valves almost equal in size; Maximum height at eye tubercle; Maximum length at mid height. The surface is ornamented with differing types of reticulation; the anterior reticules are larger, while the posteriorly they are arranged into subparallel rows of reticulation. The two anterior rows of reticulation running parallel to the anterior margin almost merge giving the appearance of very elongate reticules. The ventral ridge is well developed. postero-dorsal and subcentral tubercle or process weakly developed; eye tubercle with small rib joining second anterior row of reticulation. Sexual dimorphism is not distinct. Internal features not seen.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106241	784	464	1.68	372
Carapace; GLAHM 106240	838	491	1.70	400
Carapace; GLAHM 106239	816	466	1.75	373
Carapace; GLAHM 106242	776	470	1.65	375

Carapace; GLAHM 106243	756	355
Carapace; GLAHM 106244	797	375

Remarks- This is very similar to *Phalcocythere (Phalcocythere) tranquillis* Al-Furaih from the lower Palaeocene of Saudia Arabia (Al-Furaih 1980), but differs in its larger size (838 cf 683) and less distinct posterior process. *Phalcocythere rete* from the upper Palaeocene of west Pakistan Siddiqui, (1971) shows similarities to this species but differs in its smaller size (650 cf 838), more pointed posterior margin and reticulation with some papillae.

Occurrences- Occurs in the Kalash and Hagfa Formations Maastrichtian-Palaeocene of the Sirt Basin.

Genus *Paracosta* Siddiqui, 1971

Type species: *Costa* (*Paracosta*) *declivis* Siddiqui, 1971

The generic concept of Keen *et al* (1994). is followed here. *Paracosta* has a wide geographic distribution, from Pakistan, the Middle East, North and West Africa, Brazil and the Caribbean. The diagnostic feature of the genus is the presence of four longitudinal ridges, together with reticulation. Five closely related genera have been described: *Reticulina* Bassiouni, 1969, *Paracosta* Siddiqui, 1971, *Paleocosta* Benson, 1977, *Archeocosta* Al-Bashir & Keen, 1984, *Reymenticosta* Bassiouni & Luger, 1990 and *Afranticythere* Cabonnel & Johnson, 1989. *Paracosta*. has become the most widely used of these genera. *Paracosta* was first described from the Eocene of Pakistan as a subgenus of *Costa* by Siddiqui (1971). He diagnosed it as being similar to *Costa* but with a fourth ventral ridge intercalated between the third ridge and the ventral margin. The fourth ridge is best observed in the right valve and best seen in stereoscopic photomicrographs. The type species of *Paracosta* is *Costa* (*Paracosta*) *declivis* Siddiqui, 1977 from Upper Eocene of Pakistan. Benson (1977), described *Palaeocosta*, type species *Costa crassireticulata* Bassiouni 1969, for those species with four very well developed longitudinal ridges. Al-Sheikly (1981) considered *Paracosta* and *Palaeocosta* to be subgenera of *Paracosta* based on the strength of ridges and reticulation, *Paracosta* (*Paleocosta*) having stronger ridges and coarser reticulation. Bassiouni & Luger, 1990 regarded *Paleocosta* as a junior synonym of *Paracosta*. The difference in reticulation is a result of amalgamation of reticulation meshes, and the strength of the ridges is related to the development of reticulation muri (walls). The strength of ornamentation varies within species (see *Paracosta bensoni*). Peypouquet, Grousset & Mourguiart (1986) considered the strength or weakness of the ornamentation to be caused by calcium carbonate saturation in the water during ecdysis, and was considered to be environmentally created polymorphism. However this may be a misuse of the term as morphs should differ genetically; it is not certain whether the variation in the ornamentation is true polymorphism or an ecophenotypic character. The polymorphism is strongly displayed in some species of *Paracosta*. *Reticulina* Bassiouni, 1969 has weakly developed longitudinal ridges as well as strongly reticulate ornamentation. However, the type species, *Carinocythereis* (*Reticulina*) *heluanensis* has four longitudinal ridges. Bassiouni & Luger (1990) and Keen *et al* (1994) regarded *Paleocosta* as a junior synonym of *Paracosta*.. Al-Basher & Keen (1984) figured and illustrated the genus *Archeocosta* from the Coniacian of Iraq that is characterised by a strong short upper median ridge, strongly arched dorsal ridge and tapered posterior end. Bassiouni and Luger (1990), described a new genus *Reymenticosta* from the late Palaeocene of Egypt; the carapace is subtriangular to oval in lateral outline because of strongly converging dorsal and ventral margins and the possession of three strong longitudinal ridges, and a weak anterior marginal rim. *Afranticythereis*, type species *Anticythereis bopaensis* Apostolecu 1961, recorded from Togo by Carbonnel and Johnson (1989), shows similarities in lateral outline and ornamentation to *Paracosta*. *Paracosta* gp *bopaensis* Keen *et al* (1994) recorded from Maastrichtian to Palaeocene is normally reticulate with very weakly developed ridges. The generic assignment of these taxa is not certain at the moment, so only two genera are recognised i.e *Paracosta* with well developed ridges, and *Reticulina* for those with mainly reticulate ornamentation.

Paracosta bensoni Damotte & Donze, 1982
pl. 29, figs. 4-12

1963 *Anticythereis bopaensis* Apostolescu, Barsotti, p. 1526, pl. 2, figs. 14.

1966 *Isobuntonia* aff *harpa* Apotolescu, Salahi, P. 11, pl. 5, fig. 14.

1977 *Paleocosta* ? sp Benson, p. 37, pl. 3, fig. 5.

1978 *Paleocosta* ? sp Benson, Said, p. 257, pl. 28, fig. 18.

1982 *Paleocosta bensoni*, Donze *et al*, p. 285, pl. 4, figs. 4-8.

1994 *Paracosta bensoni*, Damotte & Donze, Keen *et al*, pl. 16.5, figs. 6,7.

Material- 473 carapaces, 80 valves; 123 carapaces well YY1-6; 50 carapaces well PP2-6; 40 carapaces well 3H1-6; 54 carapaces Kk1-6; 12 carapaces well AA1-6; 162 carapaces and 70 valves from the Heira section; 18 carapaces and 10 valves from the El-Fogha section; GLAHM 106251-259.

Discussion- 1

The species as intrepreted here is highly variable. This is seen in the ornamentation, where the longitudinal ridges vary in prominence, and reticulation meshes may merge, especially in the anterior and median area. The lateral outline also varies; the anterior and posterior margins may be more or less acutely rounded. Some of Tunisian material, including the holotype (Donze *et al* 1982 pl. 4, fig. 4), have a more obliquely rounded anterior margin than the Libyan specimens, and show reduced merging of the reticulation meshes. Two morphotypes are recognised in the Libyan material, following El Sogher (1991 M.S) although it is not always easy to allocate individual specimens to these two groups.

Description- Carapace subtriangular in lateral view; males more elongate than females, anterior margin evenly rounded with distinct marginal rim and weakly developed denticles in some of the specimens. The reticulation is variable in shape and size, but generally coarser reticulation is restricted to the centre of the carapace; there are three main longitudinal ridges with a weak fourth ridge lying between the median and ventral ridges. Three depressions are present on the carapace, one located between the eye tubercle and down turned dorsal ridge, referred to as the antero-dorsal depression; the second lies just behind the down-turned dorsal ridge, and is termed the dorsal depression; the third is located just posterior to the muscle scar area, and is termed the central depression.

Morphotype A
pl. 29, figs. 4-8

This morphotype is characterised by stronger longitudinal ridges and amalgamation of the two anterior rows of reticulation; the postero-ventral margin is strongly curved upward, particularly in the female; the eye tubercle is distinct and bears three small pores. The figured specimens are typical of the material recorded from the Sirt Basin by Keen *et al* (1994). Morphotype A is very similar to *Paleocosta bensoni* from the El Kef section, Tunisia (Donze *et al* 1982), but has a slightly more curved postero-ventral margin, more prominent ridges, and less subdivided reticulation between ridges..

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106252	644	385	1.67	327
Female carapace; GLAHM 106253	641	391	1.63	354
Female carapace; GLAHM 106254	675	397	1.70	362
Male carapace; GLAHM 106251	716	379	1.88	346
Male carapace; GLAHM 106225	751	392	1.91	350

Morphotype B
pl. 29, figs. 9-12

This morphotype differs from morphotype A in having less developed longitudinal ridges, and the antero-dorsal depression is usually reticulate.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106258	697	413	1.68	373

Male carapace; GLAHM 106257	716	361	1.98	379
Female carapace; GLAHM 106256	673	373	1.80	336
Female carapace; GLAHM 106259	675	377	1.79	369

Remarks- Morphotype B is the same as the species recorded by Salahi (1966) as *Isobuntonia* aff *Isobuntonia* harpa {apart from being smaller (751 cf 850) } from the subsurface Upper Cretaceous-Palaeocene of the Sirt Basin. This morphotype also shows similarities to *P* gr *bopaensis*; the latter differs in having very weak longitudinal ridges, more even reticulation without merged meshes and lacking an anterior marginal rim. This demonstrates the difficulties involved in distinguished many of the species of *Paracosta.*

Discussion- 2

Reymenticosta bensoni (Damotte & Donze) recorded by Bassiouni and Luger (1990) from the Late Palaeocene to basal Eocene of Egypt differs in the lateral outline of the posterior margin, is larger, and the reticulation between the ridges do not amalgamate, giving the appearance of more and smaller reticulation. *Reymenticosta parabensoni* Bassiouni & Luger (1990) from the late Palaeocene-lower Eocene of Egypt shows similarity in lateral outline, but differs in having more prominent longitudinal ridges and stronger reticulation walls.

Occurrence- Recorded from Thanetian of Tunisia and from Upper Palaeocene of Libya and Egypt, The true range believed to be Upper Palaeocene only.

Paracosta palaeomokattamensis Bassiouni & Luger 1990
pl. 28, fig.11-13, pl. 29, fig.1-3

1990 *Paracosta palaeomokattamensis* Bassiouni & Luger, p.835, pl.20, figs. 1-6.

Material- 39 carapaces; 8 carapaces well YY1-6; 2 carapaces well PP2-6; 27 carapaces well KK1-6; 2 carapaces well AA1-6; GLAHM 106245-250.

Diagnosis- Carapace subrectangular in lateral outline; areas between longitudinal ridges non reticulate apart from occasional short vertical ribs; anterior of valve reticulate.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106246	705	363	1.94	315
Male carapace; GLAHM 106245	666	340	1.96	310
Female carapace; GLAHM 106247	604	356	1.69	306
Female carapace; GLAHM 106248	604	346	1.75	305
Female carapace; GLAHM 106249	664			348
Female carapace; GLAHM 106250	584			309

Remarks- This species was first described from the Middle Palaeocene of the Kharga Shale of Egypt (Bassiouni & Luger 1990). The Libyan specimens differ in being smaller (females 588-667 cf 770) and have less prominent marginal spines. The specimens studied also show similarities to *P* aff *mokattamensis* recorded from El Kef Tunisia by Donze *et al* (1982); the latter differs in having a broadly rounded posterior margin and a distinct anterior marginal rim and lacks anterior reticulation.

Occurrences- occurs in the Middle Palaeocene of Egypt and Libya.

Paracosta warriensis Reymént, 1960
pl. 29, figs. 13-15, pl. 30, figs.1-3

1960 *Veenia warriensis* Reyment, p. 180, pl. 12, figs. 2a-b & 3 & pl. 18, figs. 1a-b.

1963 *Veenia* (*Veenia*) *warriensis* Reyment, Reyment, p. 186, pl. 5, figs. 3a-c.

1966 *Costa dahommeyi* (Apostolescu, 1961) n. sub sp 1, Salahi, p. 23, pl. 5, figs. 18-20.

1980 *Veenia warriensis* Reyment, Reyment & Reyment, pl. 1, fig. 8.

1981 *Paracosta ? warriensis* Reyment, Reyment, p. 63, pl. 8, fig. 14.

1989 *Paracosta dahomeyi* Apostolescu, Carbonnel & Johnson, p. 42o, pl. 3, figs. 4-6.

1994 *Paracosta warriensis* Reyment, Keen *et al,* p. 16.5, figs. 3-5.

Material- 543 carapaces and 68 valves; 202 carapaces and 3 valves well YY1-6; 113 carapaces well PP2-6; 50 carapaces and 3 valves well 3H1-6; 99 carapaces and 3 valves well KK1-6; 3 carapaces well AA1-6; 29 carapaces and 46 valves from the Heira; 47 carapaces and 13 valves from the El-Fogha; GLAHM 106260-265.

Diagnosis- A species of *Paracosta* with prominent longitudinal ridges; the area between dorsal and median ridges and median and ventral ridges ornamented with coarse elongate reticulation; anterior, ventral and posterior areas with small reticulation meshes; anterior rim distinct.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106263	916	453	2.02	?452
Male carapace; GLAHM 106260	880	465	1.89	336
Female carapace; GLAHM 106264	794	460	1.73	421
Female carapace; GLAHM 106261	773	440	1.75	410
Female carapace; GLAHM 106262	764			416
Female carapace; GLAHM 106265	775			429

Remarks- The species described and figured by Reyment (1960, 1963 and 1981), from the Cretaceous to Lower Tertiary of Nigeria shows some differences in ornamentation and lateral outline. The longitudinal ridges are well developed in the illustrations of Reyment 1960 & 1963, while the illustration of Reyment1981, shows the longitudinal ridges to be poorly developed. The figured specimens are identical to *Costa dahomeyi* (Salahi, 1966), *Veenia warriensis* (Reyment,1980) and *Paracosta warriensis* (Keen *et al*, 1994) recorded from the Palaeocene of the Sirt Basin. The material is very similar to that illustrated by Reyment (1963) apart from the presence of two parallel ribs originating from the subcentral area and ending in the antero-ventral area.

Occurrences- Cretaceous to Lower Tertiary of Nigeria, Upper Palaeocene of Togo, and Maastrichtian-Palaeocene of Libya.

Paracosta gp *bopaensis* Apostolescu, 1961
pl. 30, figs. 4-9

1980 *Anticythreis bopaensis* Apostolescu, Reyment & Reyment, p. 250, pl.1, fig. 6.

1994 *Paracosta* gp *bopaensis* Apostolescu, Keen *et al*, pl. 16.5, fig. 8.

Material- 1404 carapaces, 23 valves and 43 juvenile; 393 carapaces, 4 valves and 16 juvenile well YY1-6; 193 carapaces and one valve well PP2-6; 161 carapaces, 11 valves and 6 juvenile well 3H1-6; 624 carapaces, 2 valves and 18 juvenile well KK1-6; 73 carapaces, 5 valves and 3 juvenile well AA-6; GLAHM 106266-271.

Diagnosis- Carapace elongate to subrectangular in lateral outline; carapace reticulate with consistence ornamentation; central, dorsal and antero-dorsal depressions are reticulate; logitudinal ridges very weakly developed or absent.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106266	769	438	1.75	409
Female carapace; GLAHM 106267	826	478	1.72	443
Male carapace; GLAHM106268	915	430	2.12	459
Male carapace; GLAHM 106269	900	453	1.98	427
Male carapace; GLAHM 106270	915			460
Male carapace; GLAHM 106271	921			464

Remarks- This belongs to the new species *Parcosta keeni* described by El Sogher(1991 M.S) and illustrated by Keen *et al* (1994) as *P* gp *bopaensis*. The material illustrated here has longitudinal ridges so weak as to be virtually absent; this character is shown to be variable by El Sogher (1991). The material described here is larger than that of El Sogher (769-921μm cf 625-850). *Anticythereis bopaensis* (Apostolescu,1961) was described from the Palaeocene of Dahomey; it has stronger longitudinal ridges than the Libyan material and more evenly rounded anterior margin. *Anticythereis bopaensis* recorded from the Palaeocene Well A5-32 of the Sirt Basin by Reyment & Reyment (1980) is identical to the figured specimens; *Afranticythereis attitogoensis* Apostolescu (1961) recorded by Carbonnel and Johnson, 1989 from the lower

Eocene of Togo shows similarities, differing in lateral outline and having smaller reticulation.

Occurrences- Maastrichtian to Palaeocene of Libya.

Genus *Reticulina* Bassiouni, 1969c

Type species: *Carinocythereis* (*Reticulina*) *heluanensis* Bassiouni, 1969 c

Reticulina proteros Bassiouni, 1969 c

pl. 30, figs. 10,11,13

1969b *Carinocythereis* (*Reticulina*) *scitula proteros* n. ssp, Bassiouni, p. 11, pl. 1, fig. 8 & pl. 2, figs. 6,7.

1978 *Reticulina scitula proteros* Bassiouni, Ra Said, p. 261, pl. 29, figs. 5-8.

1982 *Reticulina proteros* Bassiouni, Donze et al, p. 287, pl. 5, figs. 7,8.

1990 *Reticulina proteros* Bassiouni & Luger, p. 836, pl. 20, figs. 16-21.

1994 *Reticulina proteros* Bassiouni. Keen *et al.* pl.16.5. figs. 12, 16.

Material- 139 carapaces; 8 carapaces well YY1-6; 22 carapaces well 3H1-6; 76 carapaces well KK1-6; 33 carapaces well AA1-6; GLAHM 106272-274.

Diagnosis- Carapace subrectangular in lateral view; prominent almostly vertical rib join eye tubercle with ventral ridge; longitudinal ridges weakly developed, carapace reticulate, the reticulation to the anterior of the vertical rib is radial.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106273	825	450	1.83	380
Female carapace; GLAHM 106272	800	448	1.78	366
Male carapace; GLAHM 106274	855	444	1.92	385

Remarks- The figured species has a different outline and more obvious longitudinal ribs than material recorded from the Middle Eocene of Jordan (Bassiouni, 1968). However the specimens described from the Late Palaeocene of Egypt (Bassiouni & Luger

1990) are identical to the figured specimens. Donze *et al*, 1982 recorded this species from the Ypresian of El Kef although those specimens are larger with more prominent ridges (pl.5, fig. 8). The longitudinal ridges varies from weakly to strongly developed.

Occurrences- Occurs from the Palaeocene-early Eocene of Jordan (Bassiouni, 1969b) and Tunisia Donze *et al* (1982), Late Palaeocene of Egypt Bassiouni and Luger (1990) in the present studied recorded from lower-upper Palaeocene of the Sirt Basin.

Reticulina sangalkamensis Apostolescu, 1961
pl. 30, figs. 12,14,15, pl.31, fig. 6

1961 *Bradleya ? sangalkamensis* n sp Apostolescu, p. 818, pl. 14, figs. 288-290.

1990 *Reticulina sangalkamensis* Apostolescu, Bassiouni & Luger, p.836, pl. 20, figs. 11, 13-15.

Material- 39 carapaces; 3 carapaces well YY1-6; 3 carapaces well 3H1-6; 27 carapaces well KK1-6; 6 carapaces well AA1-6; GLAHM 106275-278.

Diagnosis- Carapace subrectangular in lateral view; surface of carapace entirely reticulate with subrounded fossae and three weak though distinct longitudinal ridges; anterior and postero-ventral margins denticulate. Eye tubercle well developed. Sexual dimorphism distinct males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male right carapace; GLAHM106277	898	442	2.03	385
Female carapace; GLAHM 106275	898	490	1.83	417
Female carapace; GLAHM 106276	909	472	1.83	430
Male carapace; GLAHM 106278	870			383

Remarks- The figured species are similar to those previously recorded from Senegal (Apostolescu, 1961) and Egypt (Bassiouni & Luger, 1990).

Occurrence- Early Palaeocene of Senegal and Middle Palaeocene-Lower Eocene of Egypt. and Palaeocene-Lower Eocene of the Sirt Basin.

Reticulina cf *R proteros* Bassiouni, 1969b
pl.31, figs.1-5.

1966 *Acanthocythereis* nsp1 Salahi, p.20, pl. 5, figs.24-26.

1969b *Acanthocythereis salahi* Bassiouni, p.389, pl.25, figs.1-2.

1981 *Acanthocythereis salahi* Bassiouni, Mechmeche, p.48, pl.2, figs.5-10.

1992 *Acanthocythereis salahi* Bassiouni, El-Waer, p.102, pl.17, figs.1-8.

Material- 8 carapaces and 2 valves from the well YY1-6; GLAHM 106279-283.

Description- Carapace elongate to subrectangular in lateral outline; anterior margin rounded with row of spines in each valve and faint marginal rim carrying seven spines; posterior margin subtruncated; with four small spines at central posterior; dorsal margin straight with six spines; ventral margin straight and slightly concave at third length from anterior; maximum height at eye tubercle; maximum length at mid height. The surface reticulated with subtriangular punctae having superimposed pustules. Eight subquadrate fossae parallel anterior margin, a nearly vertical rib joins eye tubercle with ventral ridge, the ventral ridge is not well developed. Sexual dimorphism distinct, males more elongate than females, and with parallel sides in dorsal view.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106280	925	453	2.04	376
Female carapace; GLAHM 106279	755	427	1.76	339
Female carapace; GLAHM 106281	825	461	1.78	388
Female carapace; GLAHM 106282	832			424
Male dorsal carapace; GLAHM 106283	1024			392

Remarks- Differs from illustrated specimens of *Reticulina proteros* in being more spinose; in particular, small spines are well developed along ventral margin, as well as anterior & posterior spines. Six projecting spines can be seen along the dorsal margin. The posterior margin is less pointed than illustrated specimens. In dorsal view the male carapace has parallel sides, unlike illustrations of *Reticulina proteros* (e.g Bassiouni and Luger 1990, pl. 20, fig. 21).

Occurrences- Occurs in the Early Eocene of the Sirt Basin.

Genus *Schizoptocythere* Siddiqui & Al-Furaih, 1981

Schizoptocythere sp

pl. 31, fig. 8

Material- 2 carapaces; 1 carapace well 3H1-6 at depth of 8240 ft; 1 carapace well YY1-6 at depth of 7140 ft; GLAHM 106284.

Description- This species has a weakly developed ventro-central swelling with a row of three nodes on the dorsal side of this swelling, plus pore cone at each end of the row. The remainder of the surface is smooth. Evidence of prominent spines can be seen around the anterior and ventral margin. The dorsal and ventral margins tapered towards the posterior.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106284	598	315	1.89	240

Remarks- This resembles *Schizoptocythere arshadensis* El (EL Sogher, 1991 M.S) described from Waha and Heira Formations (Maastrichtian-?Danian) of the Sirt basin, differing in the presence of the row of three nodes.

Occurrence- Occurs from upper Palaeocene of the Sirt Basin.

Genus *Asymmetricythere* Bassiouni, 1971

Type species: *Asymmetricythere hiltermanni* Bassiouni, 1971

Asymmetricythere ahmedi sp nov

pl. 31, figs. 11-13, pl. 32, figs. 1-4

Material-19 carapaces and 3 valves; 17 carapaces and 3 valves well YY1-6, 1 carapace well KK1-6 and 1 carapace well AA1-6; GLAHM 106287-89, 106291-294.

Derivation of the name- In honour of my son Ahemd.

Diagnosis- Carapace subtriangular in lateral view; surface with 3-4 short longitudinal ridges or depression in the postero-median area with additional elongated ventral ridge; anterior margin has sixteen spines; posterior margin with strong spine in each valve and small five denticles

Holotype- Female carapace; pl.32, fig. 1, GLAHM 106291

Paratype- Male carapace; 31, fig. 11, GLAHM 106287.

Type locality- wells YY1-6 at depth of 6000 ft.

Horizon- Gir Formation.

Description- Carapace subtriangular in lateral view tapered towards posterior; anterior margin rounded with sixteen small spines along central and antero ventral area; posterior margin subtriangular with distinct spine and five small denticles in the lower half; dorsal margin straight in the right valve and sinuous in the left valve; ventral margin convex in left valve, straight in right; maximum height at anterior cardinal angle; maximum length at middle height; left valve slightly larger than right and obviously overreaching along dorsal margin. The carapace surface ornamented by 3-4 subparallel short ridges in the postero-median area; [elongate ventral ridge], A prominent marginal rim can be traced around the anterior and ventral margins, a prominent elongate groove is present above the ventral part of this rim; the rest of carapace is smooth; internal feature not known; sexual dimorphism is distinct males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106291	718	394	1.82	352
Female carapace; GLAHM106292	711	394	1.80	322
Male carapace; GLAHM 106287	721	371	1.94	328
Female carapace; GLAHM 288	642	353	1.81	325
Female carapace; GLAHM 106289	623	354	1.75	323
Female carapace; GLAHM 106293	686			320
Female carapace; GLAHM 106294	675			310

Remarks- *A ahmedi* shows some similarity to *Asymmetricythere* aff sp1 Carbonnel (1986) recorded from Lower Eocene offshore Cape Timiris, Mauritania (Carbonnel,1988) but the latter differs in having longer ridges and being less tapered posteriorly and lacking the posterior spines. *A ahmedi* resembles *A fossrum* El-Waer recorded from the Samdun Formation (Middle Eocene) of the Tarabulus Basin N.W offshore Libya (El-Waer, 1992), but the later species differs in being larger (800-947µm cf 621-718) and the ventral margin is straight to slightly concave anteriorly, and in lacking the posterior spine.

The material studied here resembles specimens illustrated by Bassiouni *et al* (1984) from the Middle Eocene of Fayoum, Egypt and identified as *A yousefi*. They differ in having slightly elongate ridges and lacking an anterior spine. The specimens from Fayoum differ from the original description of *A yousefi* (Bassiouni,1971) as does the material studied here.

In his original description Bassiouni illustrated two different types of ornament for this species, one having strong reticulation over the whole carapace, the other having less prominent reticulation and stronger longitudinal ribs; the Fayoum specimens are closer to the latter. Cronin & Khalifa (1979) also describe variability in development of longitudinal ridges and pitting between them. They state that usually there are 3-5 ridges present. The ridges in all illustrations of *A yousefi* are longer and more prominent than in the studied material.

Occurrences- occurs in the Lower Eocene of the Sirt Basin.

Asymmetricythere sp
pl. 31, figs. 9,10.

Material- 7 carapace and 1 valves; 4 carapaces and 1 valve well YY1-6; 3 carapaces well AA1-6; GLAHM 106285-286.

Description- Carapace elongate to subrectangular in lateral view; anterior margin obliquely rounded with small spines in the lower half; posterior margin subtriangular bearing 5 spines at central posterior; dorsal and ventral margin are straight converging posteriorly; maximum height at eye tubercle; maximum length at mid height; left valve larger than right and clearly overlapping along dorsal, postero-dorsal and antero-dorsal margins, The surface of the carapace is reticulate, with eight subparallel longitudinal ribs posteriorly, and between these ribs rounded to subrounded fossae. The left and right valves differ in lateral outline, the right valve having a straight dorsal margin and being less triangular. The most noticeable difference is the presence of a strong ventral ridge which is swollen in the right valve, but not in the left. The third longitudinal ridge from the ventral margin ends as a posteriorly pointed spine. The muscle scar area is smooth. Internal features not seen. Sexual dimorphism is pronounced, males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106285	612	291	2.10	273
Female carapace; GLAHM 106286	529	300	1.72	276

Remarks- This species resembles *Ruggieria* n sp 2 Salahi, (1966) recorded from the subsurface Oligocene sediments Well C3-6 of the Sirt Basin; but this is a larger species (940 cf 612) having more elongated ridges. *Asymmetricythere* sp resembles *Asymmetricythere yousefi* recorded from the Middle and Upper Eocene of Egypt (Bassiouni,1971) that differs in having reduced that reticulation around the anterior area and is larger in size (750μm-820 cf 529-612). The material from Libya and Egypt could be morphotypes of the same species however, as *A yousefi* has been shown to be highly variable (for further discussion of this see *A ahmedi* sp nov).

Occurrences- Recorded from Lower Eocene-Oligocene of the Sirt Basin.

Asymmetricythere sp A

pl. 31, fig. 14

Material- 1 carapace from Well AA1-6 at a depth of 10180 ft; GLAHM 106290.

Description- Carapace subtriangular in lateral view; anterior margin rounded, with some 20 marginal denticles; posterior margin subtriangular with five small marginal spines in postero-ventral area; dorsal and ventral margin strongly converging posteriorly; maximum height at eye tubercle, maximum length at mid height; surface ornamented with vague ridges and punctae, but preservation is not good.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106290	751	391	1.92	366

Remarks- This species shows some similarities in lateral outline and ornamentation to *Asymmetricythere asymmetrella* from the Eocene of Egypt (Bassiouni,1971). The latter differs in having stronger ridges, coarser punctae and obliquely rounded anterior margin.

Occurrences- Lower Eocene of well AA1-6.

Family Xestoleberididaee Sars, 1828

Genus *Xestoleberis* Sars, 1866

Type species: Cythere aurantica Baird, 1838

Xestoleberis tripoliensis El-Sogher, 1991

pl. 32, figs. 5-9

1991*Xestoleberis tripoliensis* El Sogher, P. 178, pl.33, figs. 3-8.

Material- 449 carapaces, 3 valves and 2 juvenile; 62 carapaces well YY1-6; 107 carapaces and 2 juvenile well PP2-6; 33 carapaces well 3H1-6; 213 carapaces well KK1-6; 8 carapaces well AA1-6; 2 carapaces from the Heira; 24 carapaces and 3 valves from the El- Fogha; GLAHM 106295-299.

Diagnosis- Carapace subovate in lateral outline; posterior margin symmetrically rounded in female, postero-dorsal angulated in the male; carapace smooth, sexual dimorphism distinct, males more elongate than females. Internal features not seen.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106295	617	395	1.56	430
Female carapace; GLAHM 106296	645	412	1.56	437
Female carapace; GLAHM 106299	586			405
Female carapace; GLAHM 106297	627	420	1.49	420

Male carapace; GLAHM 106298	619	384	1.61	367

Remarks- This species was described from the Maastrichtian and Danian Waha and Heira Formations of the Sirt Basin by El Sogher (1991 M.S). In the current study it is recorded from the Hagfa Formation of the Sirt Basin and outcrops of the Heira and El-Fogha sections.

Occurrences- Occurs from Maastrichtian-Lower Eocene in the Sirt Basin and Upper Palaeocene of outcrop sections Heira and El-Fogha.

Xestoleberis sp aff *X kiseibaensis* Bassiouni & Luger, 1990
pl. 33, figs.1-4

Material- 687 carapaces and 10 juvenile; 138 carapaces well YY1-6; 46 carapaces and 1 juvenile well PP2-6; 186 carapaces and 9 juvenile well 3H1-6; 242 carapaces well KK1-6; 75 carapaces well AA-6; GLAHM 106305-308.

Description- Carapace egg shaped in lateral view; anterior margin evenly rounded and lower than posterior; posterior margin obliquely rounded to subtruncated; dorsal margin arched; ventral margin almost straight; carapace smooth and strongly swollen; maximum height at about mid length; greatest length at third height from ventral margin. Sexual dimorphism distinct, females higher than males. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106305	505	318	1.58	346
Female carapace; GLAHM 106306	494	338	1.46	360
Female carapace; GLAHM 106307	495	325	1.52	372
Femal carapace; GLAHM 106308	425			302

Remarks- The figured species is similar to *Xestoleberis kiseibaensis* recorded from late Palaeocene to ?Lower Eocene by Bassiouni & Luger (1990), although it differs in the highest point more centrally placed, postero-ventral margin more quadrate while the latter is highest pointed posteriorly, has a more rounded posterior margin but otherwise very similar. The studied species shows some similarities to *Xestoleberis* n sp 2 recorded from Lower Eocene of Sirt Basin, by Salahi (1966); the latter differs in having a rounded postero-dorsal margin and is larger (650µm cf 505).

Occurrences- Recorded from lower Eocene of the Sirt Basin.

Family Cytheridae Baird, 1850

Genus *Uroleberis* Triebel, 1958

Type species: *Eocytheropteron parnensis* Apostolescu, 1955

Uroleberis oculata libyaensis sub sp nov

pl. 33, figs. 6-14, pl. 34, figs.1-3

Material- 1491 carapaces, 44 valves; 476 carapaces, 1 valve well YY1-6, 226 carapaces well PP2-6, 177 carapaces, 2 valves well 3H1-6, 237 carapaces, 3 valves well KK1-6; 63 carapaces, 3 valves well AA1-6; 108 carapaces, 15 valves from Heira; 204 carapaces, 21 valves from El-Fogha; GLAHM 106309-320.

Derivation of name- After Libya.

Diagnosis- A species of *Uroleberis* with coarse subrounded fossae except dorsally. 4-5 prominent concentric ventral ribs; eye tubercle stronger on the right valve.

Holotype- Female carapace; pl. 33, fig. 10.

Paratype- Female carapace; pl.33, fig. 12.

Locality- Recorded throughout the studied wells and the outcrops of Heira and El-Fogha.

Horizon- Hagfa Formation and Bu Ras member of the Shurfah Formation.

Description- Carapace subtriangular in lateral outline; anterior margin obliquely rounded, posterior margin more evenly rounded with weakly developed caudal process; maximum height slightly to posterior of mid length; maximum length below mid height; left carapace larger than right, overlapping all around. The carapace is reticulate with subrounded fossae cocentrically arranged around the anterior and ventral margins of carapace, more weakly at the posterior. 3-4 ridges development at margin of carapace except central area; eye tubercle more prominent in right valve. In dorsal view female carapaces taper towards anterior subtruncated posteriorly; male carapaces taper towards anterior and posterior. maximum width posterior to mid length; Internal features not known. Sexual dimorphism distinct, especially in dorsal view.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace; GLAHM 106309	516	358	1.44	336
Male carapace; GLAHM 106310	485	346	1.40	322
Male carapace; GLAHM 106311	463	311	1.49	366
Male carapace; GLAHM 106312	480	332	1.45	371
Female carapace; GLAHM 106313	531	374	1.42	398
Female carapace; GLAHM 106314	516	360	1.43	394
Female carapace; GLAHM 106315	518	364	1.44	408
Female carapace; HLAHM 106316	479	352	1.36	369
Male carapace; GLAHM 106318	449			301
Male carapace; GLAHM 106 317	489			344
Female carapace; GLAHM 106320	531			410
Female carapace; GLAHM 106319	500			382

Remarks- This differs from the nominate species in its smooth dorsal area which lacks fossae, especially when seen in dorsal view. The species recorded by El Sogher in keen *et al*, 1994 belong to the nominate subspecies.

Occurences- Occurs from Palaeocene-lower Eocene of the Sirt Basin and outcrop sections of Heira and El-Fogha.

Uroleberis aff *U glabella* Apostolescu, 1961
pl. 34, figs. 4,5

Material- 5 carapaces; 1 carapace well YY1-6; 1 carapace well 3H1-6; 1 carapace in the well KK1- 6; 2 carapaces from the El-Fogha; GLAHM 106321-322.

Description- Carapace ovate in lateral view; anterior margin narrowly rounded; posterior with small caudal process; dorsal margin broadly and evenly convex; postero and antero-dorsal slightly convex; ventral margin sinuous with a slight concave at

1/3 length from anterior margin; ventral margin hidden by swollen ventral area; maximum height at mid length; maximum length below mid height; left valve larger than right and obviously overlapping throughout dorsal and anterior margins; the carapace has fine punctae. Sexual dimorphism distinct. Internal features not seen.

Dimension of figured specimen (in µm)

	Length	Height	L/H	Width
Carapace; GLAHM 106321	544	378	1.43	367
Carapace; GLAHM 106322	494	348	1.41	336

Remarks- This resembles *U glabella* from the Palaeocene (*Globorotalia velascoensis* zone) of Mali (Apostolescu, 1961), but the latter differs in having a less drawnout anterior margin and a smooth carapace. Barsotti (1963) recorded *U glabella* from the Palaeocene of well A1-85 in the Sirt Basin which shows similarities to the studied specimens, but his material has a highly arched dorsal margin and a slightly rounded ventral margin. Ficcarelli, 1976 recorded *U glabella* from N.W Nigeria (Kalambaina Formation), which resembles the figured species but differing in the caudal process lying at mid height, and the antero-dorsal margin being nearly straight. *Foveoleberis trapezium* Al-Furaih, 1984 recorded from the Maastrichtian of Saudi Arabia is similar, but differs in its posterior caudal process being located higher at near mid height.

Occurrences- Recorded from Palaeocene-lower Eocene of Sirt Basin and lower Eocene of El-Fogha outcrops.

Uroleberis sp

pl. 34, fig. 6

Material- 1 carapace in the sample F 10 El-Fogha; GLAHM 106323.

Description-Carapace trapezoidal in lateral view; swollen latero-ventral; anterior margin narrowly rounded; posterior margin with short caudal process; dorsal margin broadly convex; ventral margin nearly straight; maximum height posterior of mid-length; maximum length below mid height; left valve larger than right and overlapping right valve all around; surface of carapace finely punctate.

Dimension of figured specimen (in μm)

	Length	Height	L/H	Width
Carapace; GLAHM 106323	532	385	1.38	407

Remarks- This species shows some similarity to *U* aff *U glabella* but the latter differs in its highly arched dorsal margin and less swollen lateral ventral area.

Occurrences- Recorded from lower Eocene of El-Fogha outcrops.

Family uncertain

Genus *Exophthalmocythere* Triebel, 1938

?*Exophthalmocythere* sp

pl. 34, figs. 7-11

Material- 10 carapaces; 7 carapaces from Heira and 3 carapaces from El-Fogha; GLAHM 106324-328.

Description- Carapace subtriangular in lateral outline; anterior margin quadrately to obliquely rounded with some 16 prominent spines; posterior margin subtriangular with prominent spine on upper part, lower part fringed with spines which continue along the ventral margin, some 15 in all; ventral margin concave in the middle; dorsal margin straight, sloping posteriorly; the dorsal margin has a small central spine and a clump of longer spines in the potero-dorsal area; the eye tubercle is prominent, forming a long projection, with a short vertical bar running from it towards the centre of the valve.; there is a marginal rim running from the ventral part of the anterior margin along the whole of the ventral margin; maximum height at eye tubercle, maximum length below mid height, surface of carapace smooth. Sexual dimorphism is distinct with more elongate males. Internal features not seen.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106324	751	481	1.56	221
Male carapace; GLAHM 106325	765	446	1.71	247

Female carapace; GLAHM 106326	778	441	1.76	245
Juvenile carapace; GLAHM 106328	729	437	1.66	184
Juvenile carapace; GLAHM 106327	712	405	1.75	224

Remarks- The species recorded by Salahi(1966) as *Trachyleberis* ?sp A, from the Palaeocene of Libya may be the same, but Salahi records reticulation, nodes and spines on the lateral surface, as well as potero-ventral swelling. The species *Exophthalmocythere ? usmandanfodioi* Reyment 1981 resembles this species, especially the juveniles. Reyment's juveniles are smaller than the species studied here however; the lateral outline differs, and there also do not seem to be any spines along the posterior part of the ventral margin, and the ventral marginal rim is absent. *Schizoptocythere ventricosta* from the lower part of Lower Eocene of Pakistan (Siddiqui & Al-Furaih 1981) is very similar to the study species apart from its smaller size (551 cf 778) and ventral lateral swelling.

Occurrences- Recorded from upper Palaeocene-Lower Eocene of Heira and El-Fogha outcrops.

Genus *Ruggieria* Keij, 1957

Ruggieria sp

pl. 34, figs. 12,13.

Material- 11 carapaces from the well YY1-6; 106329-330.

Description- Carapace subrectangular in lateral outline; dorsal margin sinuous; ventral margin convex in the left valve slightly straight in the right valve, anterior margin rounded with small marginal denticles particularly in the right valve; four spines are present in the antero-ventral area set back from the anterior margin; posterior margin subtriangular with five spines the third from the dorsal being the larger; maximum height at anterior cardinal angle; maximum length at mid height; left valve larger than right and strongly overlapping along the dorsal, postero-dorsal and antero-dorsal margins. The carapace surface has a longitudinal ventral ridge and prominent spine posteriorly; the carapace is smooth. Internal features not known. Sexual dimorphism distinct, males being more elongate than females.

Dimension of figured specimens (in µm)

	Length	Height	L/H	Width
Female carapace; GLAHM 106329	658	354	1.85	323
Male carapace; GLAHM 106300	750	356	2.10	305

Remarks- This species is probably the same as that recorded by Salahi (1966) as *Ruggieria* n sp1 from the Oligocene well cutting C3-6 of the Sirt Basin Libya. The latter species differs in lacking the posterior spine of the lateral surface, and in its larger size (751 cf 940).The absence of the posterior spine may however be due to preservation, prominent varies amongst the specimens studied here.

Occurrences- occurs from the lower Eocene the of the Sirt Basin.

The following species have been recorded as contaminants from higher levels in the wells.

Suborder Podocopina Sars, 1866

Superfamily Bairdiacea Sars, 1888

Family Bairdiidae Sars, 1888

Genus Bythocypris Brady, 1880

Bythocypris tripoliensis Gammudi and Keen, 1993

pl. 35, fig. 1

Material- 7 carapace and 3 valves.

Dimension of figured specimen (in µm)

	Length	Height	L/H
Female right carapace	883	437	2.020

Remarks- This is previously recorded from the Miocene Marada Formation (Gammudi & Keen 1993).

Superfamily Cytheracea Baird, 1850

Family Cytherideidae, Sars, 1925

Subfamily Cytherideinae Sars, 1925
Genus *Cytheridea* Bosquet, 1852
Cytheridea joshensis Gammudi and Keen, 1993
pl. 35, fig. 2

Material- 2 carapace and 4 valves in the well KK1-6.

Dimension of figured specimen (in μm)

	Length	Height	L/H
Female carapace	681	357	1.907

Remarks- This is known from the Miocene of the Sirt Basin (Gammudi & Keen 1993).

Genus *Cyamocytheridea* Oertli, 1956
Cyamocytheridea idrisi Gammudi in press
pl. 35, figs. 3,4

Material- 1 carapace and 2 valves from the well KK1- 6.

Dimension of figured specimen (in μm)

	Length	Height	L/H
Male valve	773	371	2.083
Female carapace	717	384	1.867

Remarks- This species is recorded from the Miocene outcrops of Ar-Rahlah member of Marada Formation (Gammudi in press) and certainly derived from higher levels in the well.

Genus *Cyprideis* Jones, 1857
Cyprideis maradaensis Gammudi and Keen, 1993
pl. 35, fig. 5

Material- 1 right valve in the well AA1-6 at depth of 8980 feet.

Dimension of figured specimens (in μm)

	Length	Height	L/H
Right valve	805	447	1.800

Remarks- This is previously recorded from the Miocene Marada Formation Sirt Basin (Gammudi & Keen 1993), and almost Certainly derived from higher levels in the well.

Family Loxoconchidae sars, 1925
Genus *Loxoconcha* Sars, 1866
Loxoconcha n sp 2 Salahi, 1966
pl. 35, figs. 10-13

1966 *Loxoconcha* n sp 2 Salahi, p.19, pl.2, fig. 22-24.

Material- 20 carapaces, 2 valves and 1 juvenile from the YY1-6.

Diagnosis- Carapace subrhomboidal in lateral view; anterior margin compressed with distinct two ribs parallel anterior margin; and another two short ribs parallel ventral margin. Eye tubercle weakly developed; carapace punctate, area of muscle scars smooth. Internal feature not known. Sexual dimorphism is pronounced males being more elongate than females.

Dimension of figured specimens (in μm)

	Length	Height	L/H	Width
Male carapace	545	294	1.854	
Female carapace	500	308	1.61	
Male carapcae	480			225
Male carapace	480			234

Remarks- This species was first described from Oligocene subsurface sediments well C3-6 Sirt Basin Libya. Salahi, (1966)

Occurrence- Recorded from Oligocene of the Sirt Basin.

Family Schizocytheridae Howe, 1961
Genus *Neomonoceratina* Kingma,1949
Neomonoceratina miocaenca El-Waer, 1988
pl. 35, fig. 14

Material- 2 carapaces and 1 Juvenile from the well KK1-6 at depth of 8980 ft and 1 carapace from the well AA1-6 at depth of 8980 ft

Dimension of figured specimens (in μm)

	Length	Height	L/H
Male carapace	570	299	1.906

Remarks- This is previously recorded from Miocene Al khums Formation exposed 2 Km north of Qabilat ash Shurfah, N.W Libya (El-Waer, 1988) and it is certainly derived from higher levels of the wells.

Buntonia cf *B tellilae* El-Waer, 1992
pl. 35, fig. 15

Martial- 1 carapace from well KK1-6 at depth of 8860 ft.

Description- This species is similar to *Buntonia tellilae* El-Waer, 1992 in lateral outline and ornamentation. It differs in the exact details of ornamentation; ridges 4 & 6 (from dorsal margin) join at anterior unlike in *B tellilae*; the anterior parts of ridges 3 & 4 are more irregular; the antero-dorsal area has some nodes unlike *B tellilae.*

Dimension of figured specimen (in μm)

	Length	Height	L/H
Right carapace	757	424	1.785

Remarks- This species is similar in lateral outline and ornamentation to *Buntonia tellilae* El-Waer, 1992 from the Eocene of well J1-NC41 North west Libya (pl. 28 and fig. 3) but the former species differs in having stronger ribs and a well pronounced posterior cardinal angle. This specimen may belong to *B tellilae*, and may therefore be a contaminant.

Genus *Hermanites* Puri, 1955
Hermanites n sp1 Salahi, 1966
pl.35, fig.16

1966 *Hemaintes* n sp 1 Salahi, p.24, pl.4, fogs.1-3.

Material-2 carapaces.

Diagnosis- A species of *Hermanites* with three longitudinal ridges; dorsal and median ridges curved and subparallel, dorsal ridge separated from eye tubercle by depression and joining median ridge posteriorly; ventral ridge straight, surface ornamented with coarse reticulation.

Dimension of figured specimens (in µm)

	Length	Height	L/H
Male carapace	768	400	1.92

Remarks- The figured species is similar to *Hermanites* n sp 1 described from subsurface Oligocene sediments in Well C3-6 Sirt Basin, Libya Salahi, (1966), apart from its smaller size (756 cf 1007).

it also resembles *Hermanities zaltanensis* from the Miocene of the Sirt Basin, (Gammudi & Keen, 1993); the latter species differs in having coarser reticulation and more prominent curved dorsal and median ridges.

Keijella aff *Hodgii* Brady, 1866
pl. 35, fig. 17

Material- 3 carapace in the well KK1-6.

Dimension of figured specimen (in µm)

	Length	Height	L/H
Male carapace	934	429	2.177

Remarks- This species very similar to *K hodgii* although lacking a posterior ventro-lateral spine. *K hodgii* is recorded from the Recent eastern Mediterranean (Brady 1866) and from the Tortonian of Sarivia, Italy (Capeder, 1902). It is certainly derived from higher levels of the well.

Genus *Costa* Neviani, 1928
Costa n sp 3 Salai, 1966
pl. 35, fig 18

1966 Costa n sp3, p.23, pl.5, figs.1-3.

Material- 1 carapace.

Diagnosis- A species of *Costa* characterised by three longitudinal ridges, and a small rib originating from eye tubercle and running downwards to join the median ridge; ventral ridge ending with spine posteriorly. Carapace smooth apart from a few tubercle between ridges.

Dimension of figured specimens (in μm)

	Length	Height	L/H
Carapace	600	351	1.70

Remarks- The figured specimen was first described from the subsurface Oligocene sediments of the Well C3-6 in the Sirt Basin, Libya (Salahi, 1966). The illustrated species is slightly smaller (597μm cf 660). The figured species shows similarities to the *Costa oligicaenica* recorded by El-Waer, (1992) from N.W. offshore Libya. The latter species differs in its concave ventral margin, triangular posterior margin and more ornamentation between the ridges.

This is similar to the specimens described by Salahi (1966) as *Costa* n sp 3; El-Waer placed this in his new species *C oligocaenica*. Our material differs from El-Waer's in having a straight, not concave ventral margin, a rounded not triangular posterior margin and lacks the anterior reticulation of El-Waer's species. There is sufficient similarity between these taxa to suggest the specimen identified here is a contaminant from Eocene or Oligocene strata.

CHAPTER THREE

BIOSTRATIGRAPHY

Biostratigraphy

Previous studies- The Palaeocene of the Sirt Basin has traditionally been divided into three: Danian, Montian and Landenian, corresponding to Lower, Middle, and Upper Palaeocene. Montian and Landenian are unfortunate choices because these are poorly defined and dated in their type areas in Belgium, western Europe. The Thanetian is the recognised upper Palaeocene stage. Here Lower, Middle and Upper Palaeocene are used in preference to stage names. The Palaeocene of the Sirt Basin has been dated on the basis of Planktonic foraminiferal faunas.

Barr & Weeger, (1972), writing on the subsurface Tertiary of the Sirt Basin, considered the Hagfa Formation to be Danian and the Kheir to be late Palaeocene-Lower Eocene based on the presence of the Planktonic foraminifera *Globorotalia compressa* recorded in the lower part of the Hagfa Formation and *Globorotalia velascoensis* and *Globorotalia subbotinae.* in the Kheir Formation; the Middle Palaeocene was not distinguished due to the lack of index fossils, so the dating of the remainder of the sediments is based on stratigraphic position.

Eliagoubi (1980) studied Palaeocene outcrops in N. E Libya of the type section of the Al Uwaylia Formation. He recorded eleven Planktonic foraminifera species belonging to the two genera *Globogerina* and *Globorotalia;* among these are *Globorotalia angulata* and *Globorotalia pseudomenardii*, which indicates a Middle-Upper Palaeocene age.

Wöller (1985) studied Early Tertiary outcrops along the south western border of the Sirt Basin but could not date the sequences firmly, except for the Qaltah member of the Shurfah Formation where *Planorotalites pseudomenardii* (P.4 zone sensu Blow,1969) indicates late Palaeocene; the remainder of the succession was dated on the basis of stratigraphic position. Thus the age dating of the early Tertiary sediments in both subsurface and outcrops is unclear.

Tamalla(1991) studied the Cretaceous-Tertiary boundary from ditch cutting samples from well A1a-NC29A in the northern Sirt Basin, from a thick sequence (1662 feet) of Palaeocene, including the Hagfa shale. He redefined the Cretaceous-Tertiary boundary to lie 14 feet lower than the earlier boundary on the basis of planktonic foraminifera (*Eoglobigerina minutula* zone); the author did not give any biostratigraphic zonation for younger Palaeocene sediments.

Lower Tertiary sediments have been studied and accurately divided into stages using planktonic foraminifera outside of Libya: El-Naggar, (1969) in Egypt, Said, (1978), Tunisia and Blow, (1969, 1979) see (Table. 3.1) for standard planktonic foraminifera zonations Scheme.

Previous studies of Early Tertiary Libyan ostracods

Several studies of Libyan Tertiary Ostracods have been carried out. Barsotti (1963) recorded twenty three species from the Upper Palaeocene of the El-Fogha area and well A1-85 of the Sirt Basin, Salahi (1966) described sixty species from the sediments in well C3-6, covering the Upper Cretaceous, Palaeocene, Eocene and Oligocene in an attempt to define time stratigraphic units in the Sirt Basin.

Wöller (1984) recorded eight ostracod species from exposures of the Shurfah Formation in the geological map sheet El-Fogha South on the western border of the Sirt Basin.

El Sogher (1991 M.S) recorded seventy three species and two subspecies from the Waha and Heira Formations (Maastrichtian-Danian) of the Raguba oil field, Sirt Basin.

Keen *et al* (1994) studied Tertiary Ostracods of North Africa and the Middle East including sediments from subsurface Upper Cretaceous, Danian and Miocene of the Sirt Basin. They indicated that ostracod faunas could be used for biostratigraphy. The first downhole occurrences of *Cristaleberis fornicata* Bassiouni (1970) can be employed to delimit the Cretaceous Tertiary boundary. *Paracosta pervinquiri* Donze and Said, (1982) ranges from Late Maastrichtian to Early Palaeocene (early *pseudobulloides* zone) while *Cytheropteron lekefense* Esker (1968) is restricted to late

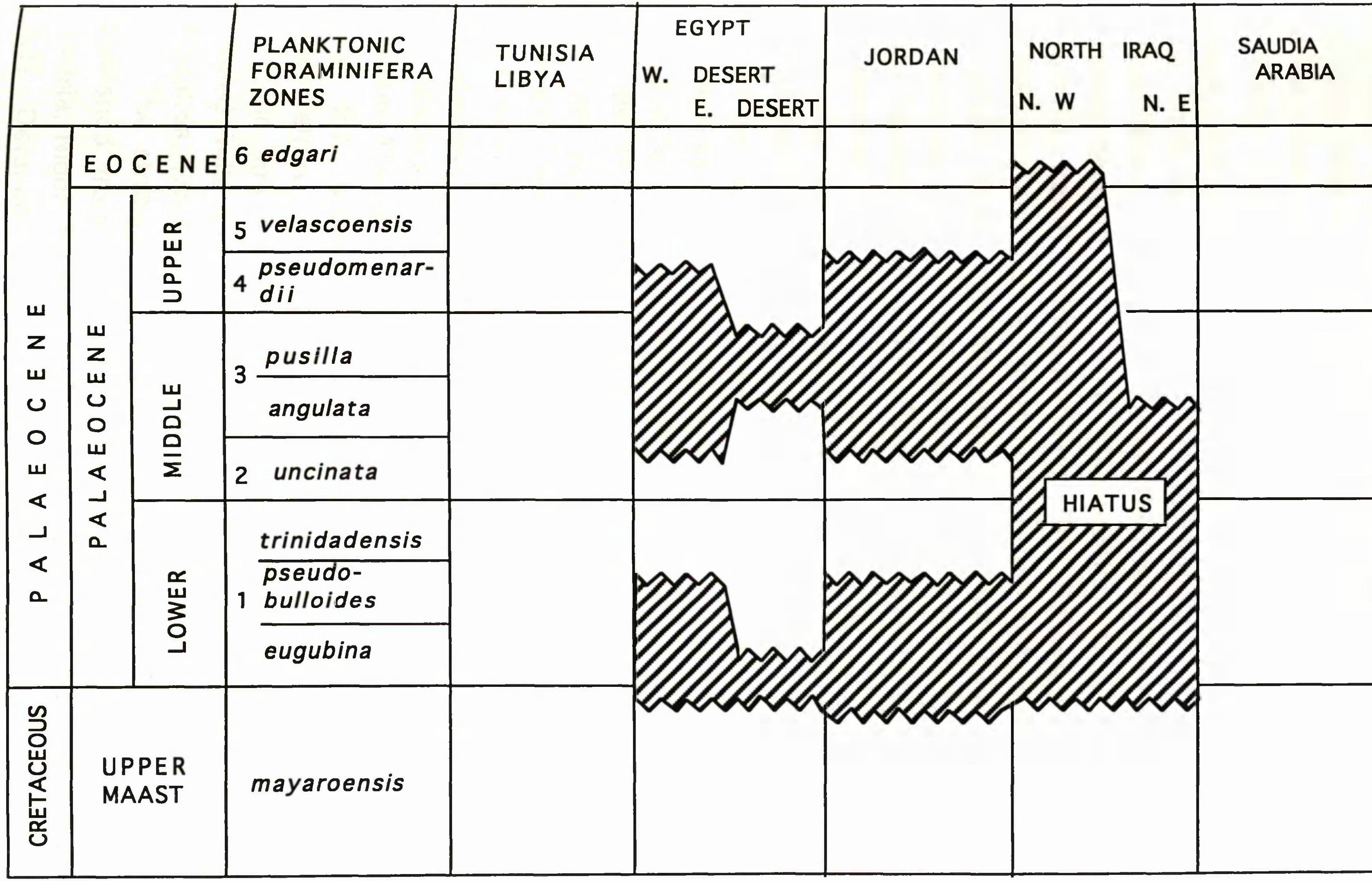


Table (3.1) Standrad Planktonic foraminifera zonation scheme After Blow (1969, 1979) *eugubina* to early *pseudobulloides* zone but is only recorded from Tunisia, *Acanthocythere stymatoura* Al-Furaih (1980) is restricted to the lower Palaeocene of Saudia Arabia. *Hornibrookella episcelis* Al-Furaih (1977) and *Paragrenocythere garvis* Al-Furaih (1980) range from late Maastrichtian-early Palaeocene of Saudia Arabia and could be used to define the boundary between Lower and Middle Palaeocene. *Ordoniya ordoniya* Bassiouni, (1970) is an important species ranging from Late Maastrichtian to Middle Palaeocene (*pusilla* zone), characterising the Palaeocene rather than Cretaceous and has an important overlap with *Reticulina proteros* Bassiouni (1969) which ranges from the *pseudobulloides* to *subbotinae* zone. These species are found throughout North Africa from Tunisia to the Middle East and indicate late Danian or Middle Palaeocene.

One hundred twenty two species and subspecies of ostracods are recorded in the present study, thirty nine of which have been described from various localities in West and North Africa and the Middle East; thirty five new species and subspecies are proposed; ten species recorded here are certainly contaminants coming from younger sediments; the remainder are left in open nomenclature, although some of these show similarities to previously described species. Twenty seven species are important for stratigraphic age determination Table (3.2). Six of these species indicate late Palaeocene, one species is restricted to the middle Palaeocene and 12 species have long ranges from Palaeocene into the Lower Eocene. The remainder also have long ranges through the Palaeocene into the Maastrichtian, but still give some stratigraphic information.

The stratigraphic range charts and ostracod distribution in the studied wells and outcrops are shown in the Tables (3. 2,3,3a,4, 4a, 5,5a,6,6a,7,7a,8,9) and Fig (3.1,2)

The stratigraphic range of the ostracods is based on literature published from localities in Saudia Arabia, Jordan, Egypt, Libya, Tunisia, Niger, Nigeria, Ivory Coast, Dahomey, Togo and Senegal (Fig 3.3). Detailed distributions of each species are given in the systematic description (chapter 2).

Lower Eocene- This study is mainly into the Palaeocene

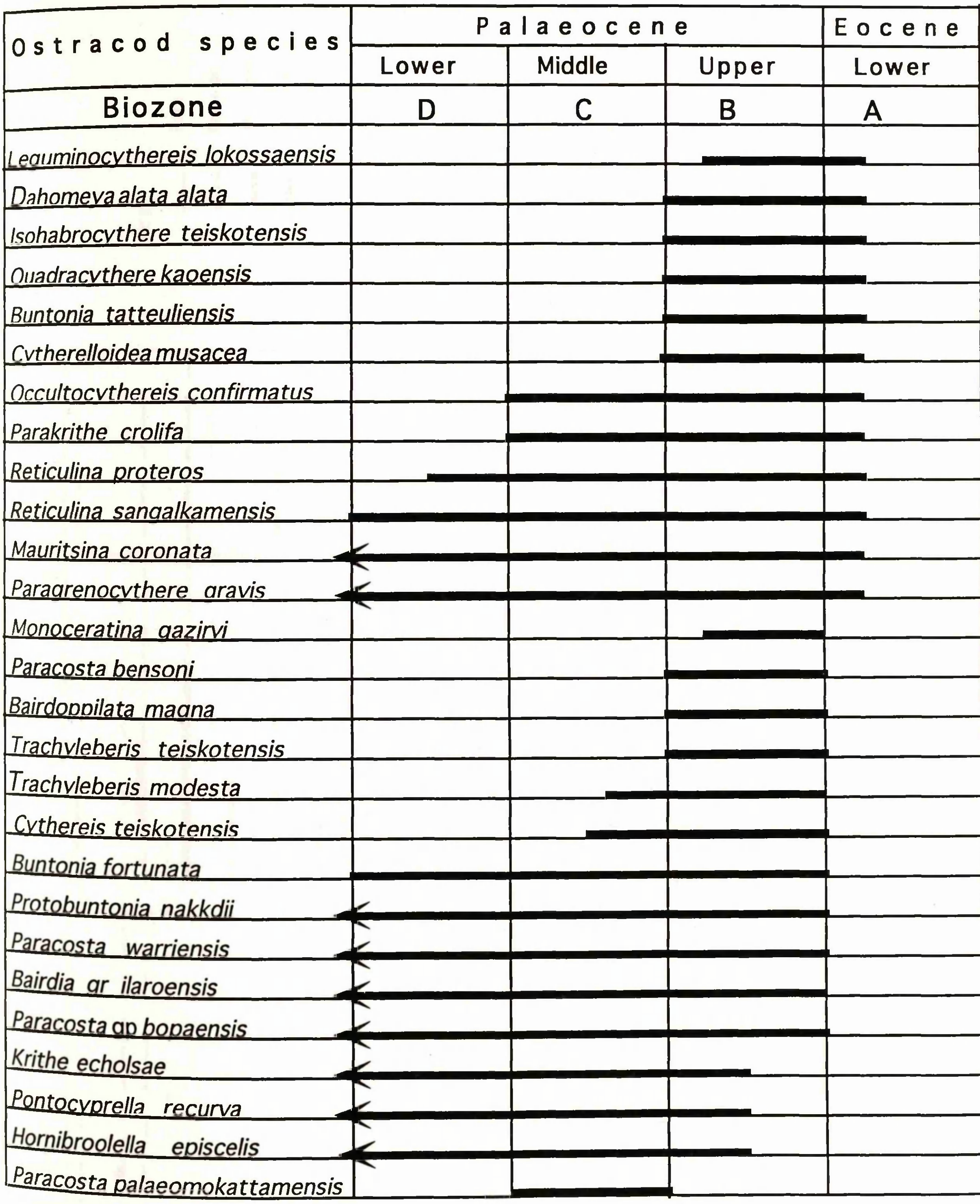


Table 3.2 Ostracod range chart

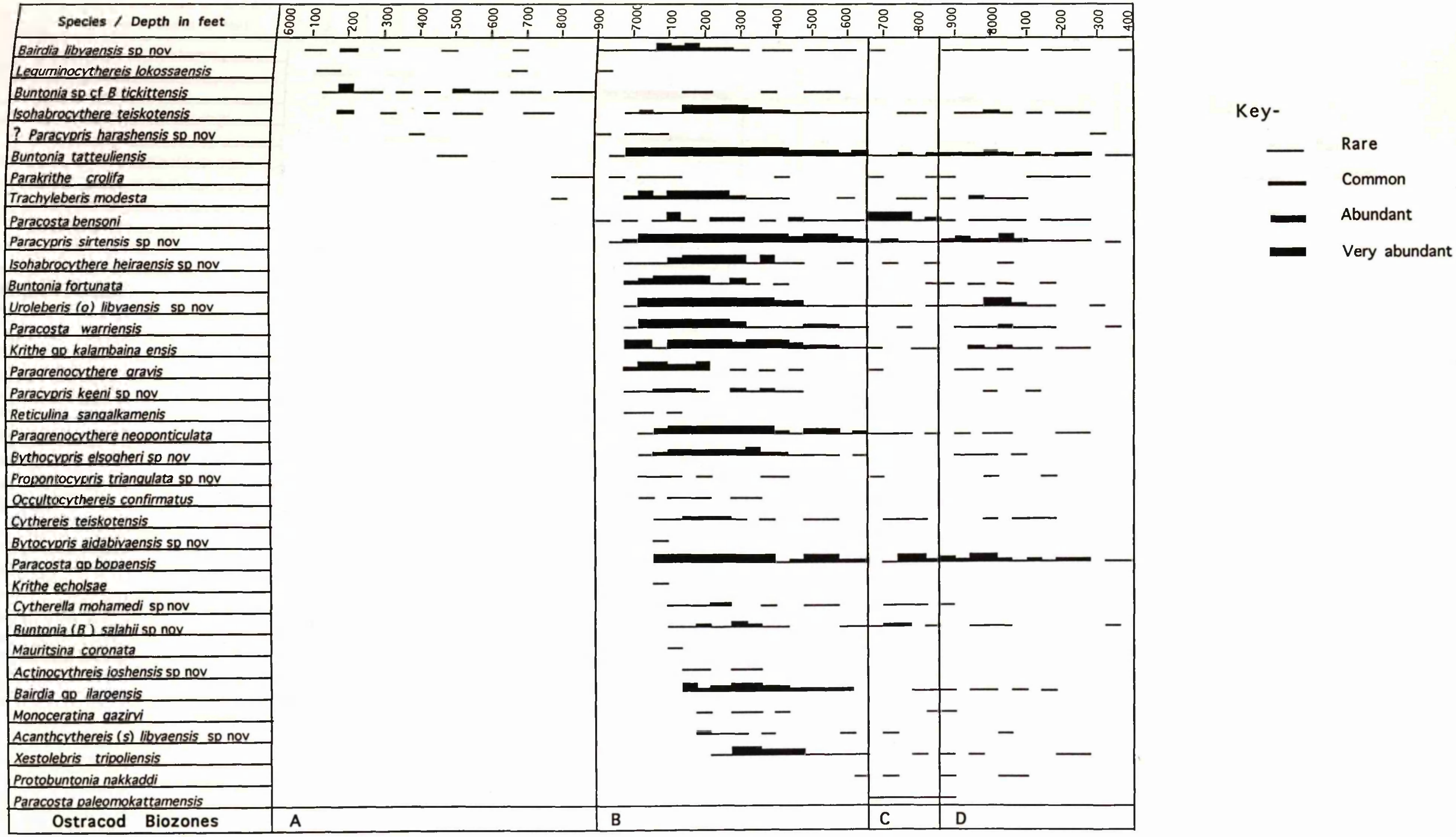


Table 3.3a Ostracoda chart of important species in the well YY1-6

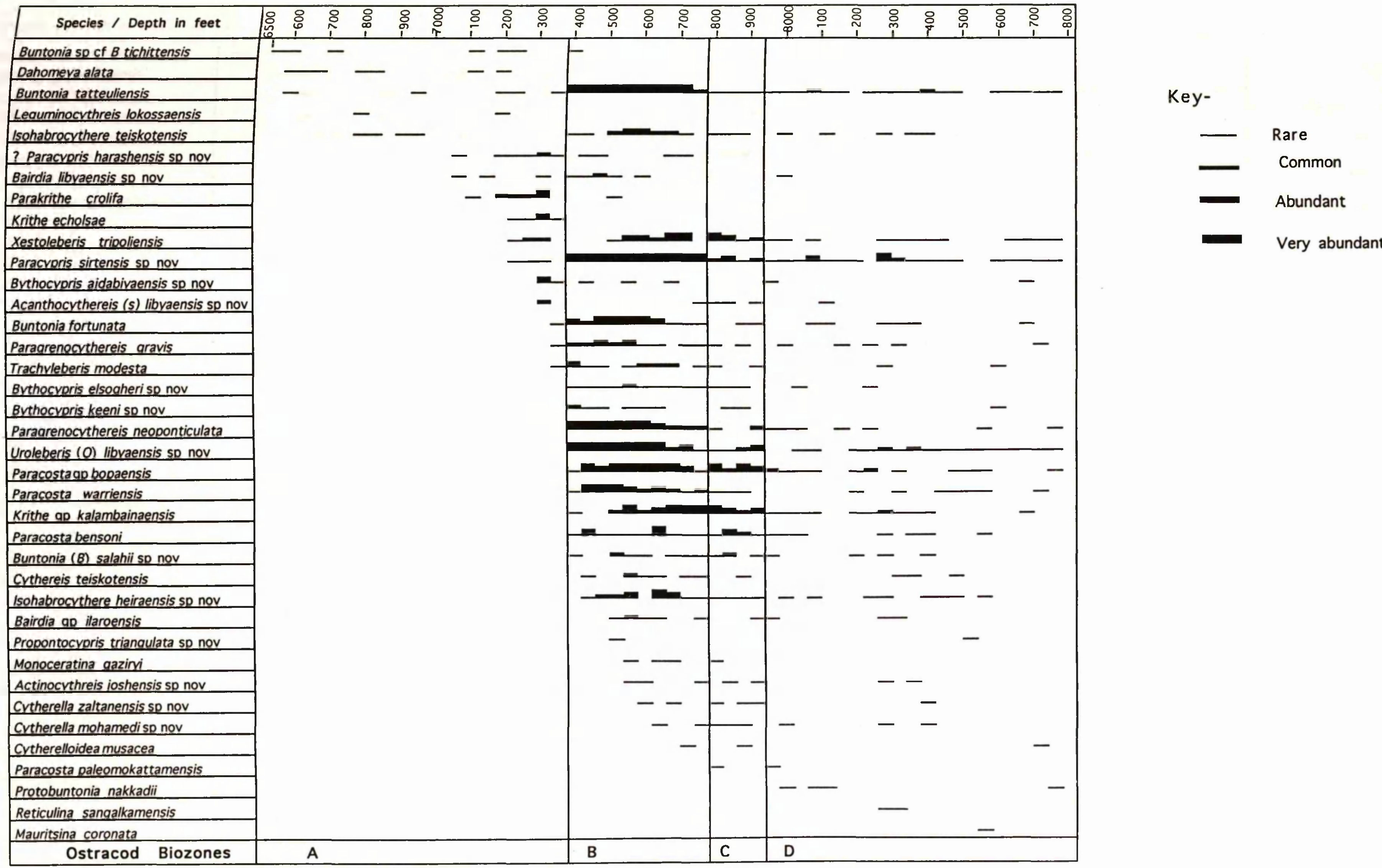


Table 3.4a Ostracods chart of important species in the well PP2-6

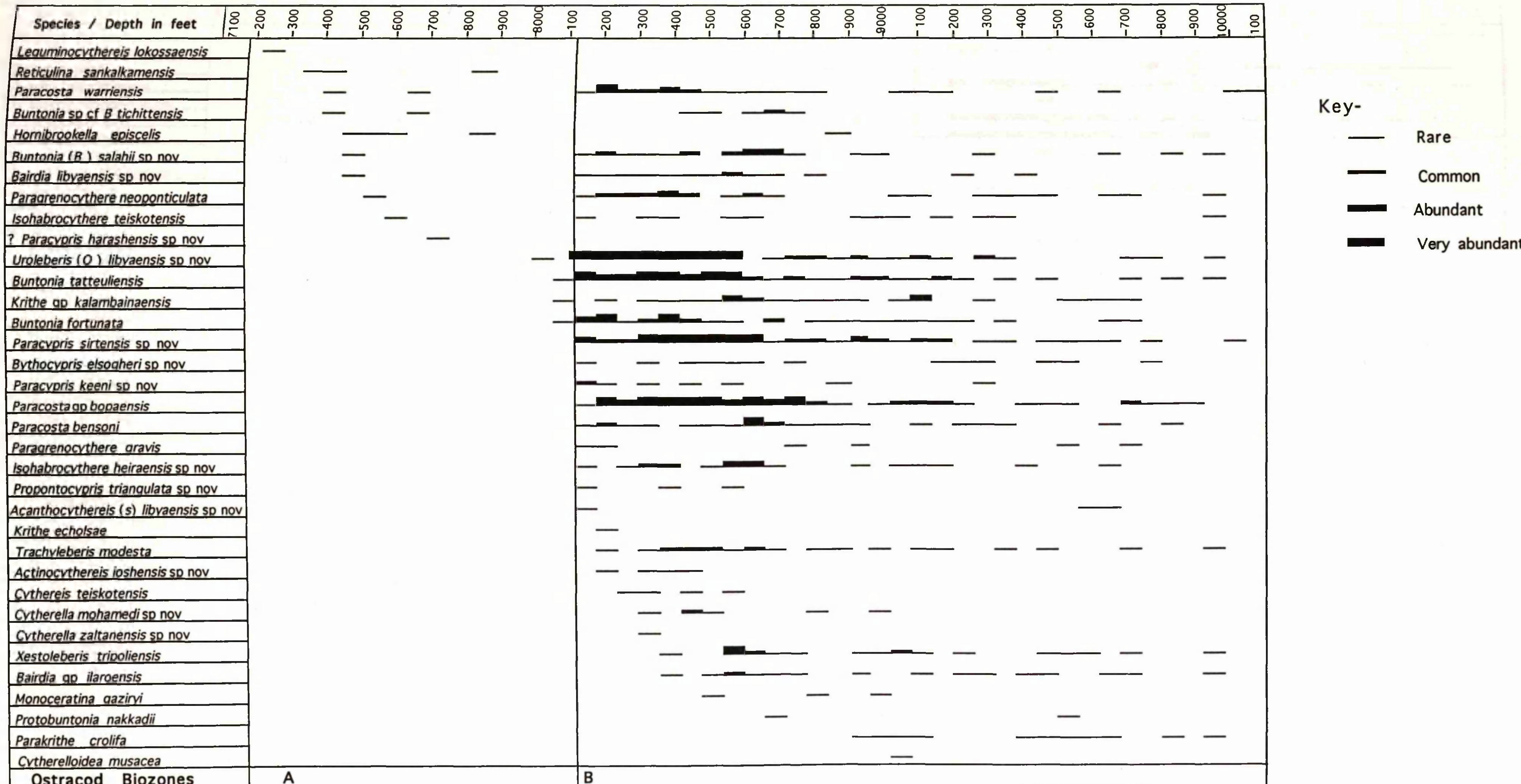


Table 3.5a Ostracods chart of important species in the well 3H1-6

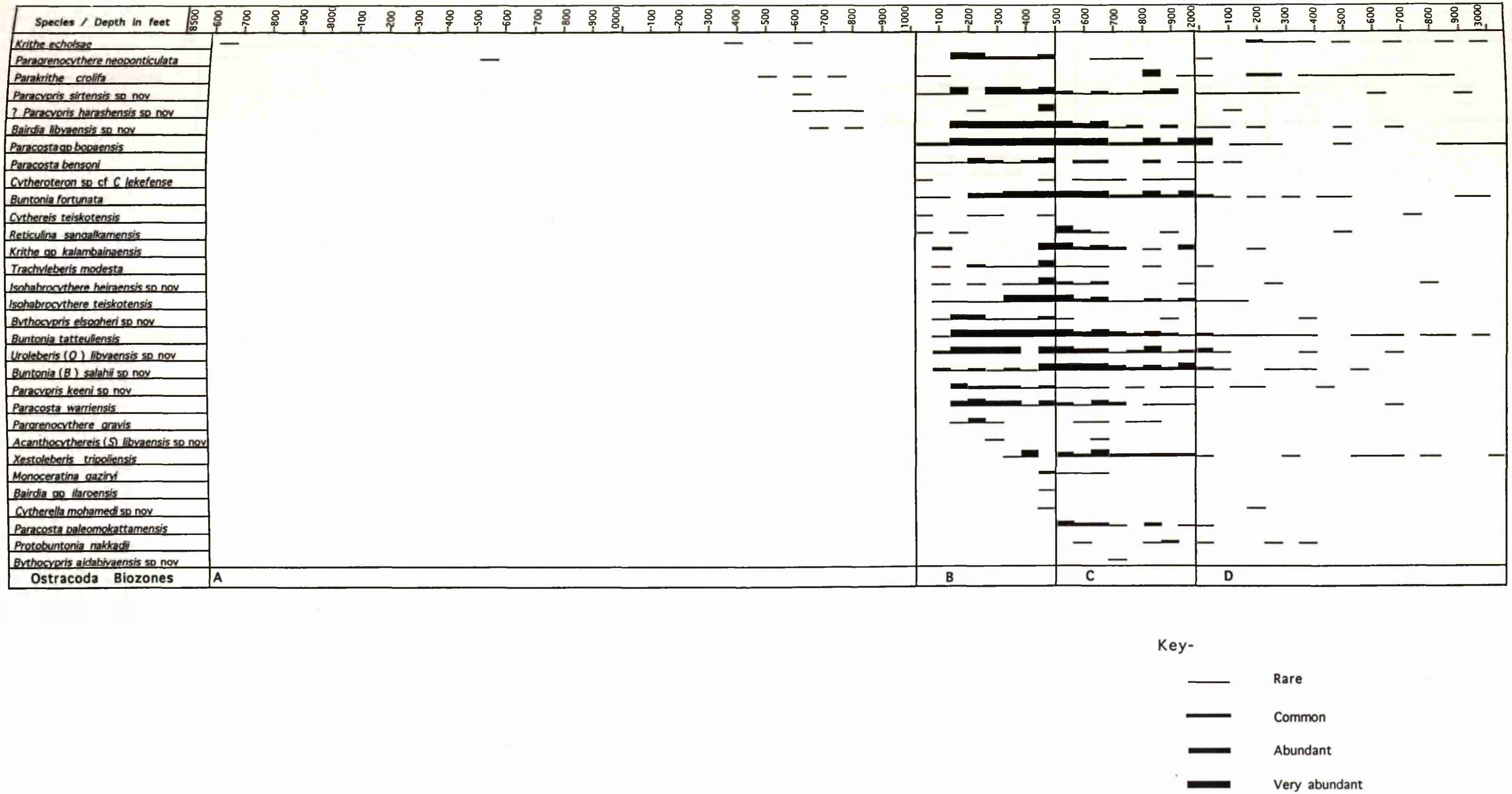
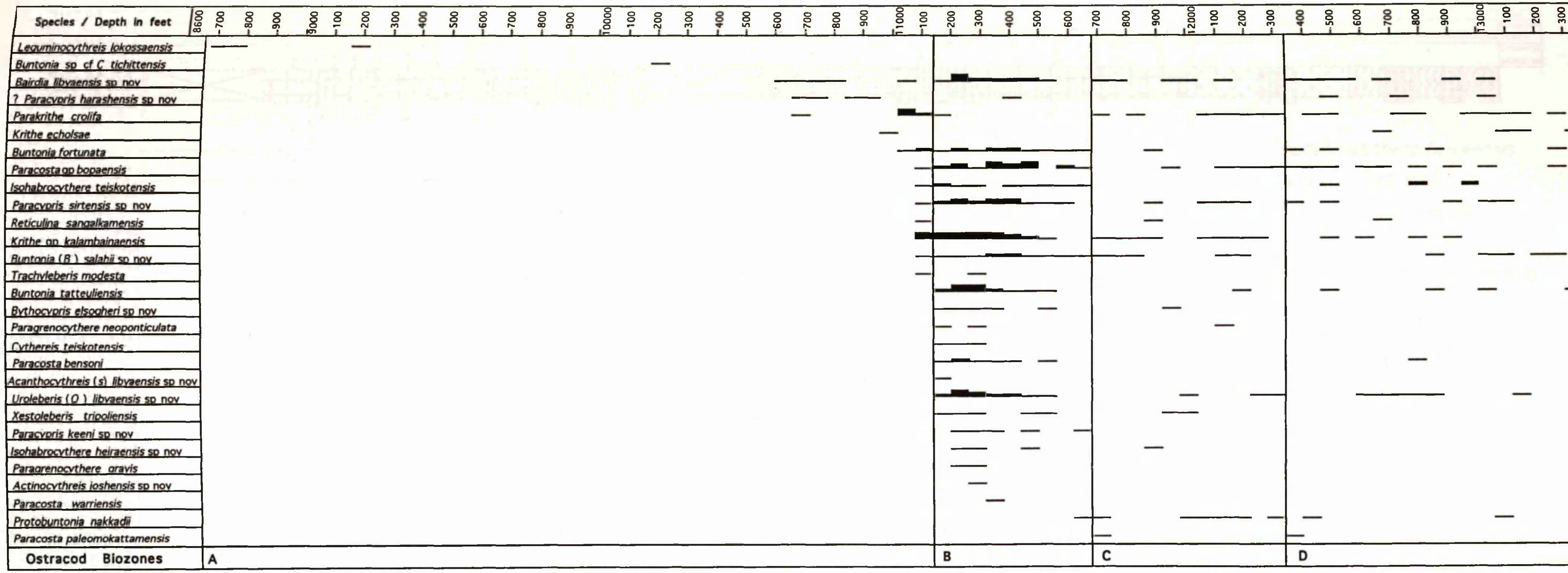


Table 3.6a Ostracoda chart of important species in the well KK1- 6



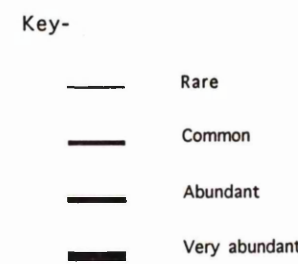
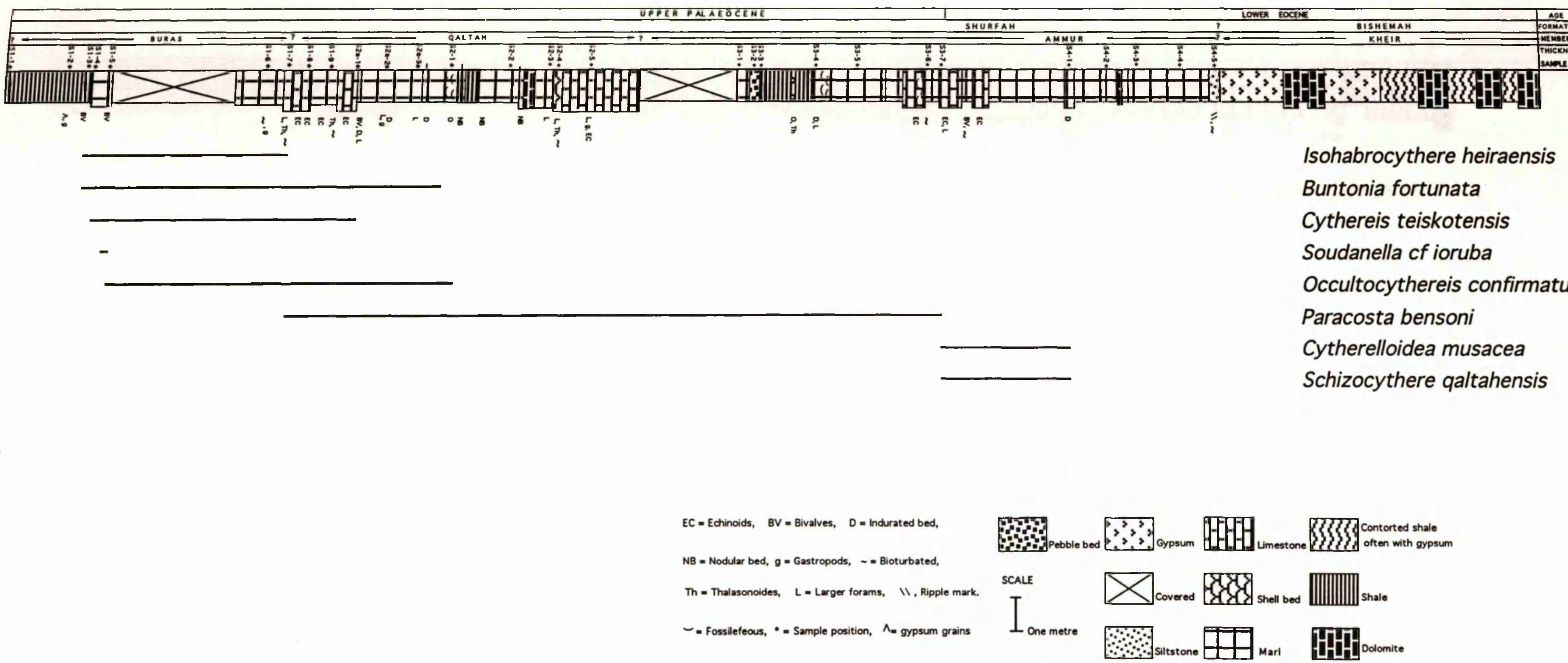


Table 3.7a Ostracoda chart of important species in the well AA1-6



Key to stratigraphic section

Figure 3.1 Composite section of the Heira Depression showing the ranges of important ostracoda species

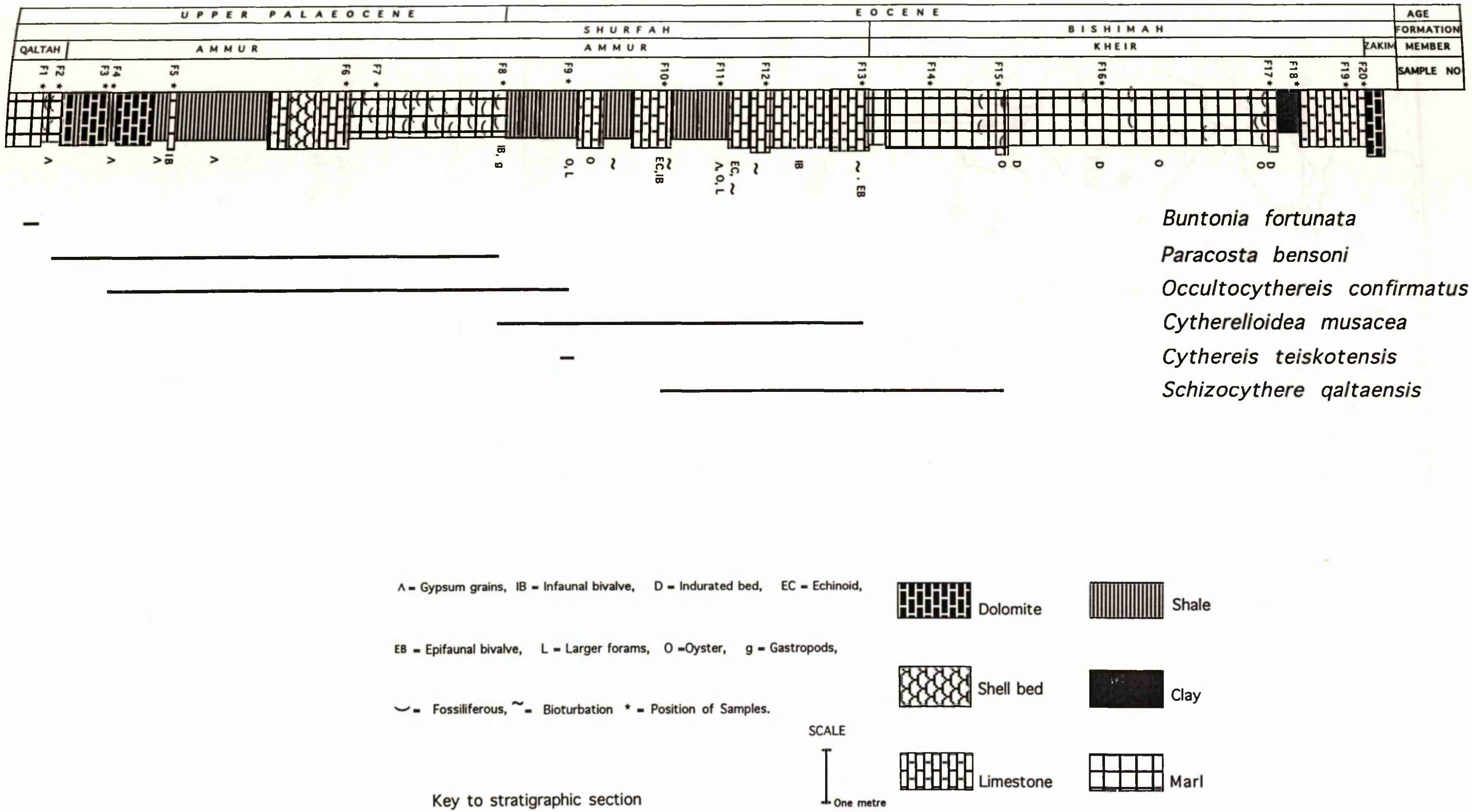


Figure 3.2 Geological section of the El-Fogha showing the ranges of important ostracoda species

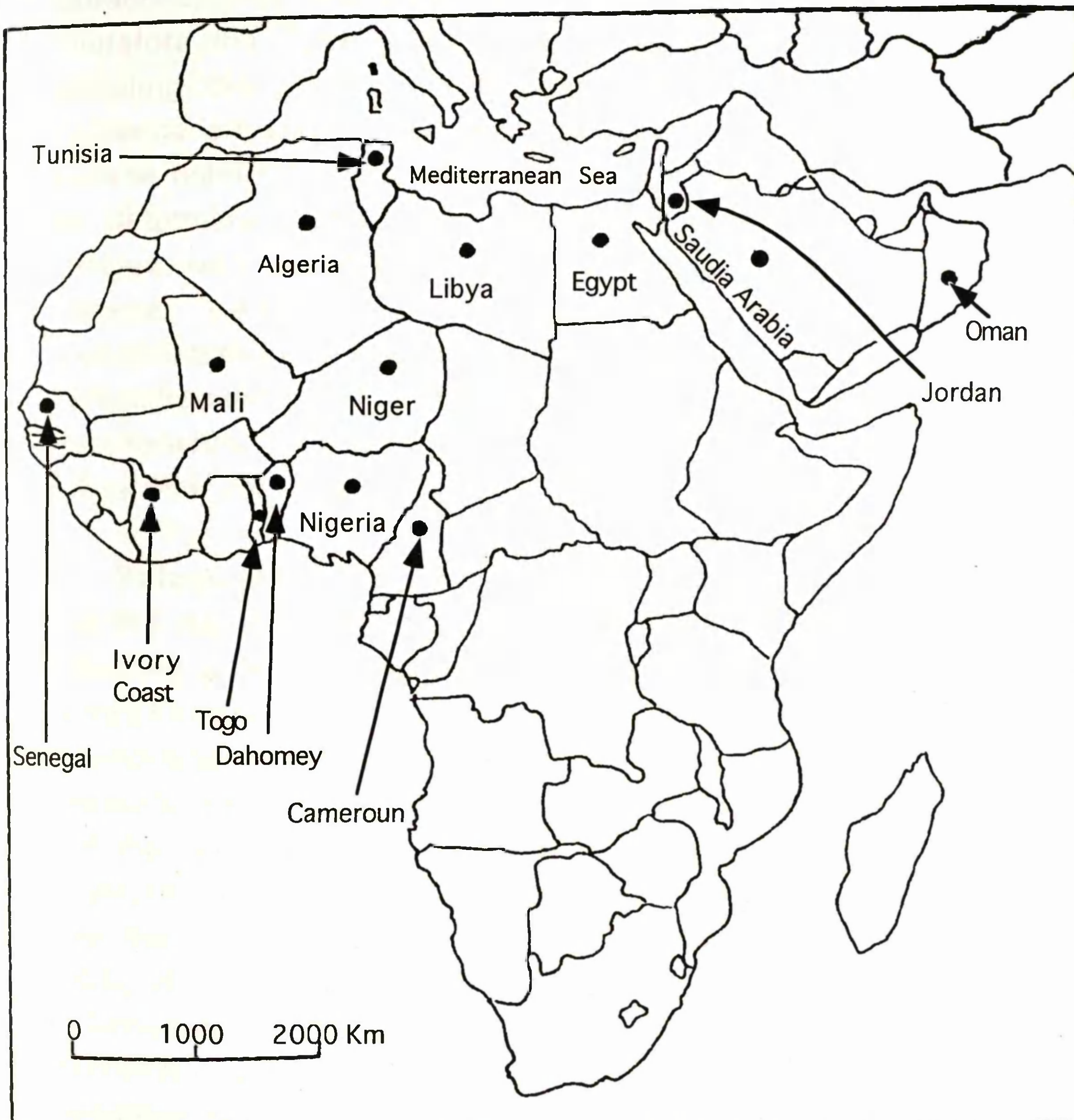


Fig 3.3 Location of some important studies of upper Cretaceous and Palaeocene ostracods in North and West Africa, and the Middle east.

ostracods, only the lower part of the Eocene has been studied. Therefore the FDO of the Eocene species is not known because sampling did not include high enough levels in the wells. The Palaeocene/Eocene boundary has been recognised, so a lower Eocene ostracod can be discerned although its upper limits have not be determined. This could be recognised by the assemblage of species with variable ranges from Upper Cretaceous to Lower Eocene: *Leguminocytheries lokossaensis*, *Dahomey alata*, *Isohabrocythere teiskotensis*, *Quadracythere kaoensis*, *Buntonia tatteuliensis*, *Cytherelloidea musacea*, *Occultocythereis confimatus*, *Parakrithe crolifa*, *Reticulina sangalkamensis*, *Mauritsina coronata*, *Paragrenocythre gravis*.

Palaeocene/Eocene boundary- The ostracod charts show that the top of the Hagfa Formation is characterised by a rich fauna indicating a late Palaeocene age. Important species are: *Buntonia tatteuliensis* Apostolescu, (1961) recorded from the Upper Palaeocene of Niger and Mali, the late Palaeocene of Libya (Barsotti, 1963), late Palaeocene of Nigeria (Foster *et al*, 1983), and the late Palaeocene to basal Eocene of Egypt (Bassiouni and Luger,1990); *Cythereis teiskotensis* Apostolescu,1961 recorded from the Palaeocene of Dahomey and Libya (Reyment & Reyment, 1980); *Buntonia fortunata* Apostolescu, 1961 from the Palaeocene of Dahomey and the late Palaeocene of Nigeria (Foster *et al* , 1983); *Paracosta bensoni* Damotte & Donze, 1982 recorded from the Thanetian (late Palaeocene) of Tunisia, late Palaeocene of Libya ((Barsotti, 1963; Salahi,1966), late Palaeocene (*velascoensis* zone) of Egypt (Bassiouni & Luger, 1990). This species has been taken as the index fossil restricted to the late Palaeocene so the *Paracosta bensoni* zone is proposed below.

Middle Palaeocene- This is indicated by the presence of *Paracosta paleomokattamensis* Bassiouni & Luger, (1990) which has been recorded from the Middle Palaeocene of Egypt and is restricted to the *angulata* zone.

Lower Palaeocene- The Lower Palaeocene is not clear due to a lack of fossils in the lower part of Hagfa Formation, but it could be recognised by last downhole appearance of *Paracosta paleomokattamensis* which has a short stratigraphic range; the base is not defined.

Other formations- Khalifa, Zelten, Harash and Kheir are considered to be related to the Eocene in this study, rather than Palaeocene as previously stated by various authors. The evidence for this is the presence of many species ranging from the Late Palaeocene to the Eocene, such as *Leguminocythereis lokossaensis* Apostolescu, (1961) which was first described from the Lower Eocene of Togo, the Palaeocene of Dahomey and Ivory Coast. The figured species is typical of Salahi's material recorded from the Lower Eocene of the Sirt Basin (1966), Lower Eocene of Senegal (Carbonnel,1989), and late Palaeocene-early Eocene of Egypt (Bassiouni & Luger,1990). *Dahomey alata* Apostolescu,(1961) recorded from the Palaeocene of Ivory Coast, from the Palaeocene outcrops of El-Fogha in Libya (Barsotti,1963), the Palaeocene-Lower Eocene of El Kef, N.W Tunisia (Donze *et al*, 1982), the Palaeocene-Lower Eocene of Senegal (Carbonnel, 1986); *Isohabrocythere teiskotensis* Apostolescu, (1961) first described from the Palaeocene of West Africa, and from Upper Palaeocene-Lower Eocene of Libya (Barsotti,1963) and Salahi, (1966), the Palaeocene-lower Eocene of Egypt (Bassiouni & Luger, 1990).

Although some of the ostracod species recorded here have a long stratigraphic range and wide distribution they can still make contributions important to biostratigraphic analysis.

Ostracod biozonation in the Early Tertiary

The material studied is ditch cutting samples from five oil wells drilled by the Esso oil company in the Sirt Basin, and from outcrops of the Heira depression and the El-Fogha area lying south west of the border of the Sirt Basin. Most of the cutting samples were taken at forty to sixty feet intervals, which means that it is impossible to determine the true distribution of the microfossils in the wells, because the contamination of material usually happened as a result of well caving and drilling operation problems.

This can be mitigated by considering first appearances downhole of the fauna, while features such as abundance and the nature of preservation could be taken into account.

Ostracod biozones are proposed based on the first appearance downhole of one or more index species. The species chosen have a wide geographical distribution, their stratigraphic ranges are short and well documented, they are easily identified, and they are reasonably abundant.

The international Stratigraphic Guide (Hedberg, 1976) has defined different types of zones: assemblage zone, a group of strata characterised by natural assemblages of fossils; the acme zone, characterised by the maximum abundance of a taxon; the range zone, which is the total range of a taxon; the concurrent range zone based on the ranges of two or more taxa; the oppel zone, which uses a more complex mixture of concurrent ranges of selected taxa; and the interval zone which lies between two biostratigraphic horizons such as the first and last appearance of species.

The biozone allows correlation between sedimentary strata by means of their fossil content, giving a relative time scale based on the distribution of faunas. A chronozone may be based on a biozone, which is then the absolute time span defined by the maximum time span of the biozone using all means available and including all strata and all gaps equivalent in age to the maximum elapsed time in the zone.

Several authors have applied ostracods to establish biostratigtraphic zonations; Bassiouni (1970) on the Maastrichtian-Tertiary of Jordan, Keen (1983) on Ostracods and Tertiary Biostratigraphy, Siddiqui, (1983) on Biostratigraphy of Early Tertiary of Pakistan, Bassiouni & Luger (1990) on Maastrichtian-Lower Eocene of southern Egypt, El-Waer (1992) on Maastrichtian-upper Eocene of offshore. N.W Libya, and Keen *et al* (1994) on Tertiary ostracods of North Africa and the Middle East.

The ostracod faunas recorded in the present study are similar to those previously described from West and North Africa and the Middle East. There are some notable differences between the fauna described here and those from Tunisia and Jordan, primarily due to facies differences, the presence of unconformities and problems associated with the study of subsurface ditch cuttings means that the true stratigraphic range of species is difficult to measure. The exact dating of sequences has also posed many problems, especially when successions are redated and ranges extended in the literature need revision (see Keen *et al*, 1994).

The following four biozones have been recognised in the wells studied.

A- Lower Eocene- An assemblage zone. The top of this zone has not been recognised, the base is defined by the first downhole occurrence of *Paracosta bensoni*.

B- *Paracosta bensoni* Biozone- The top of this zone is recognised by the first downhole occurrence of *Paracosta bensoni*; the base is defining by the first downhole occurrence of *Paracosta paleomokattamensis*. This is probably equivalent to the upper Palaeocene. Many characteristic and wide spread late Palaeocene species appear near or at the top of this see (Tables 3.3a,4a,5a,6a,7a), and have their first downhole occurrences more or less coinciding with the top of the zone.

C- *Paracosta paleomokattamenis* Biozone- The top of this zone is recognised by first downhole occurrences of*Paracosta paleomokattamensis*; the base of the zone is defined by the last appearance of the species, although this cannot be recognised accurately in the wells.

D- Lower Palaeocene- The top of this zone is recognised by the last appearance of *Paracosta paleomokattamensis*, the base is not recognised. Important lower Palaeocene ostracod species have not been found in this study. However, studies in Tunisia (Donze *et al*), Egypt and Jordan (Bassiouni), and Libya (El Sogher) indicate that ostracods can be used for subdivision of the Lower Palaeocene (Keen *et al*,1994). (El Sogher, 1991) recorded *Paracosta pervinquieri* from the northern part of the Sirt Basin, indicating early Palaeocene (*eugubina-pseudobulloide* zones) but this species has not been discovered here.

Description of Biozones in the wells.

Well YY1-6. This well (tables 3. 3,3a) has four zones as follows.

A- Lower Eocene Biozone- An assemblage zone is recognised by the presence of the following species, *Leguminocythreis lokossaensis*, *Buntonia* cf *tichittensis*, *Isohabrocythre teiskotensis*, *Buntonia tatteuliensis*, *Parakrithe crolifa*, the top is not recognised, the base indicated by the first downhole occurrence of *Paracosta bensoni.*

B- *Paracosta bensoni* Biozone- The top of this zone recognised by the first occurrence downhole of *Paracosta Bensoni* at a depth of 6900 ft, the base of this is probably defined by the first appearance of *Paracota paleomokattamensis.*

C- *Paracosta paleomokattamensis* Biozone- This zone recognised by the first downhole occurrence of *Paracosta paleomokattamensis* at a depth of 7660 ft, the base defined by last appearance.

D- Lower Palaeocene Biozone- This zone is not obvious due to lack of fossils in the lower part of the Hagfa Formation, but it could be indicated by last appearance of *Paracosta paleomokattamensis*, the base of this is not recognised.

Well PP2-6. This well (tables 3.4,4a) has four biozones as follows.

A- Lower Eocene Biozone- An assemblage zone is recognised by the following species *Buntonia* cf *tichittensis*, *Dahomey alata*, *Buntonia tatteuliensis*, *Leguminocythereis lokossaensis*, *Isohabrocythere teiskotensis*, *Parakrithe crolifa*, the top of this zone is not recognised, the base defined by the first downhole occurrence of *Paracosta bensioni.*

B- *Paraccosta bensoni* Biozone- The top of this zone is recognised by the first downhole occurrence of *paracosta bensoni* at a depth of 7380 ft, the base is defined by the first downhole occurrence of *Paracosta paleomokattamensis* .

C- *Paracosta paleomokattamensis* Biozone- This zone is recognised by the first downhole occurrence of *Paracosta paleomokattamensis* at a depth of 778o ft; the base is defined by last appearances.

D- Lower Palaeocene Biozone- No species have been found in this study to indicate Lower Palaeocene, but the top of this zone could be indicated by the last appearance of *Paracosta paleomokattamensis*, the base is not recognised.

Well 3H1-6. This well (tables 3.5,5a) has two biozones as follows.

A- Lower Eocene Biozone- An assemblage zone is recognised by the first downhole occurrences of the following species, *Leguminocythereis lokossaensis*, *Buntonia tatteuliensis*, *Isohabrocythere teiskotensis*, the top is not recognised, the base defined by the first appearances of *Paracosta bensoni.*

B- *Paracosta bensoni* Biozone- The top of this zone recognised by the first dowohole occurrence of *Paracosta bensoni* at a depth of 8120 ft, the base in not defined.

Well KK1-6. This well (tables 3.6,6a) Has four zones as follows.

A- Lower Eocene Biozone- This zone is defined by the presence of *Parakrithe crolifa,* the top is not recognised, the base is defined by the first downhole occurrence *Paracosta bensoni.*

B- *Paracosta bensoni* Biozone- The top of this zone recognised by the first dwonhole occurrence *paracosta bensoni* at a depth of 11020 ft, the base of this is defined by the first downhole occurrence of *Paracosta paleomokattamensis.*

C- *Paracosta paaleomokattamensis* Biozone- The top of this zone is recognised by first downhole occurrence of *Paracosta paleomokattamensis* at a depth of 11440 ft, the base is defined by its appearance.

D- Lower Palaeocene Biozone- No species restricted to this zone but it could be proposed by the last appearance downhole of *Paracosta paleomokattamensis*, the base of this is not defined.

Well AA1-6. This well (tables 3.7,7a) has four zones as follows.

A- Lower Eocene- This assemblage zone indicated by the following species, *Leguminocythereis lokossaensis*, *Buntonia* cf *tichittensis*, *Parakrithe crolifa*, *Isohabrocthere teiskotensis*, *Buntonia tatteuliensis*, the top of this zone is not recognised, the base is defined by the first downhole appearance of *Paracosta bensoni*.

B- *Paracosta bensoni* Biozone- The top of this recognised by the first downhole occurrence *Paracosta bensoni* at a depth of 11080 ft, the base is defined by the first appearance of *Paracosta paleomokattamensis*.

C- *Paracosta paleomokattamensis* Biozone- This zone is recognised by the first downhole occurrence of *Paracosta paleomokattamensis* at a depth of 11680 ft, the base is defined by its appearance at 12340 ft.

D- Lower Palaeocene- This biozone is not clear due to lack of fossils in the lower part of the Hagfa Formation, but the top of the zone could be recognised by the last appearance of *Paracosta paleomokattamensis*, the base of this zone is not defined.

Description of Biozones in outcrops

The important species in the outcrop sections of the Heira depression and El-Fogha are shown in the figure (3. 1,2). The change of fauna occurs in the lower part of the Ammur member in both sections (see above figure). *Paracosta bensoni* Damotte and Donze disappears at this level which is taken to be the boundary between the Palaeocene and Eocene.

Description of Biozones in the outcrops sections

The Heira depression has one biozone recognised as follows:

***Paracosta bensoni* Biozone-** The top of this zone is recognised by the last appearance of *Paracosta bensoni* upwards in the section in the lower part of the Ammur member, sample S3-7; the base of this zone is probably defined by first appearance in samples S1-7 near the base of the section.

El-Fogha area also has one biozone recognised as follows:

***Paracosta bensoni* Biozone-** This is recognised by the last occurrence of *Paracosta bensoni* upwards in the section in the lower part of the Ammur member, in sample F 8. The base is not defined.
In both sections, the Lower Eocene can be recognised by the appearance of *Paracosta bensoni.*

Comparison of ostracod faunas of outcrops and the wells

52 species of ostracods are recorded from the Heira depression and El-Fogha; 38 of these are found in the subsurface faunas of the Sirt Basin, indicating late Palaeocene species such as *Paracosta bensoni*, *Occultocythreis confirmatus*, *Buntonia fortunata, Cythereis teiskotensis*.

CHAPTER FOUR

GRAPHIC CORRELATION

Graphic correlation

Introduction: The graphic correlation method was devised by Shaw (1964) who used first and last appearances of fossils in several sections to build up a composite section (CSRS). The composite standard reference section chosen is usually the thickest section onto which all biostratigraphic events of other sections are projected. Biostratigraphic events in common between the sections are plotted on a graph with X, Y axes, and the line of correlation (LOC) drawn through these points. The LOC can be used to identify relative ages of formation boundaries, predict biostratigraphic events in sections where they have not been found, and to determine sedimentation rate and presence of hiatuses and unconformities.

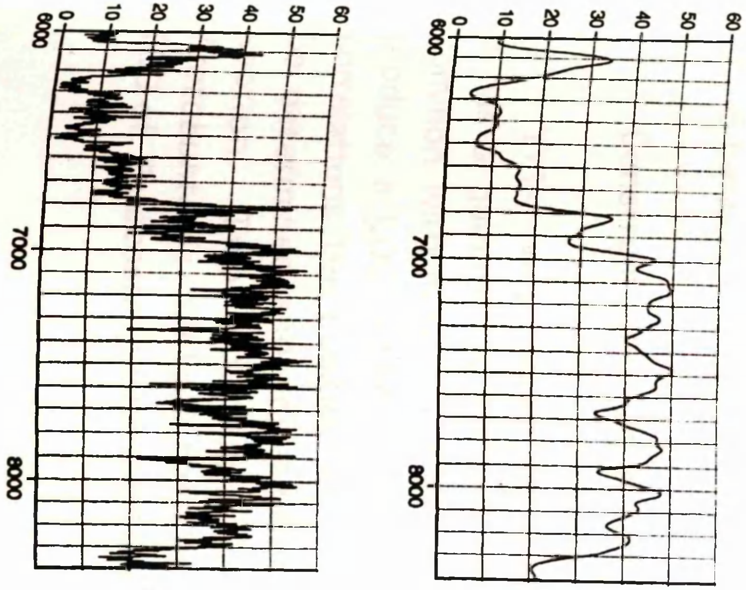
Many workers have applied the graphic correlation technique. Miller (1979) applied it to subsurface biostratigraphic events obtained from well cuttings. Edward (1989) proposed the term "supplementary graphic correlation" for a technique using wire line logs events. Melnyk, *et al*, (1991) used filtered gamma ray events to measure discrepancies in biostratigraphic events. The method used here closely follows that of Melnyk, *et al*,(1991) in producing a LOC based on filtered gamma ray logs, and superimposing biostratigraphic events upon it.

Methods-Graphic correlation techniques have been used to produce high resolution correlation between two wells in the Sirt Basin using filtered gamma ray logs. Biostratigraphic events have then been incorporated into the LOC, and the two independent sets of data used to produce a best line of correlation. The biostratigraphic events used are first downhole occurrences (FDO) of selected ostracod species. Graphic correlation has been used with biostratigraphic data from three further wells to test and refine the distribution of FDO's, so producing a composite standard reference section for the biostratigraphic events. The graphs produced by the FDO's between each of the five wells show a wide distribution of points, so the computer drawn line of best fit may not be reliable. The species chosen for the analysis are those which are thought to have reasonable stratigraphic value; however, even with these, not all have a reliable FDO. This is because many species become rare in the later parts of their stratigraphic range, so their first downhole discovery has an element of chance in it. It is also apparent that there is a facies relationship between some species and lithology, which will distort the true "potential" disappearance of species. Finally, taphonomic processes result in ostracods being more commonly discovered in the shale sequences than in the limestone sequences, which again distorts the FDO. Because of these problems the primary line of correlation (LOC) has been based on the gamma ray correlation.

Gamma ray Processing

Gamma ray logs were available for only two of five wells studied, YY1-6 and KK1-6. The original data is a table of gamma ray values for depth within the wells. This is digitised and from these values a preliminary print-out of gamma ray values is produced (Fig 4.1a). This is then filtered using the software package "Generic Mapping Tools" (GMT); This band pass filtering creates a low frequency output (Fig 4.1b.). This low frequency output is used in correlation, whereby peaks and cycles can be recognised and correlated between wells.

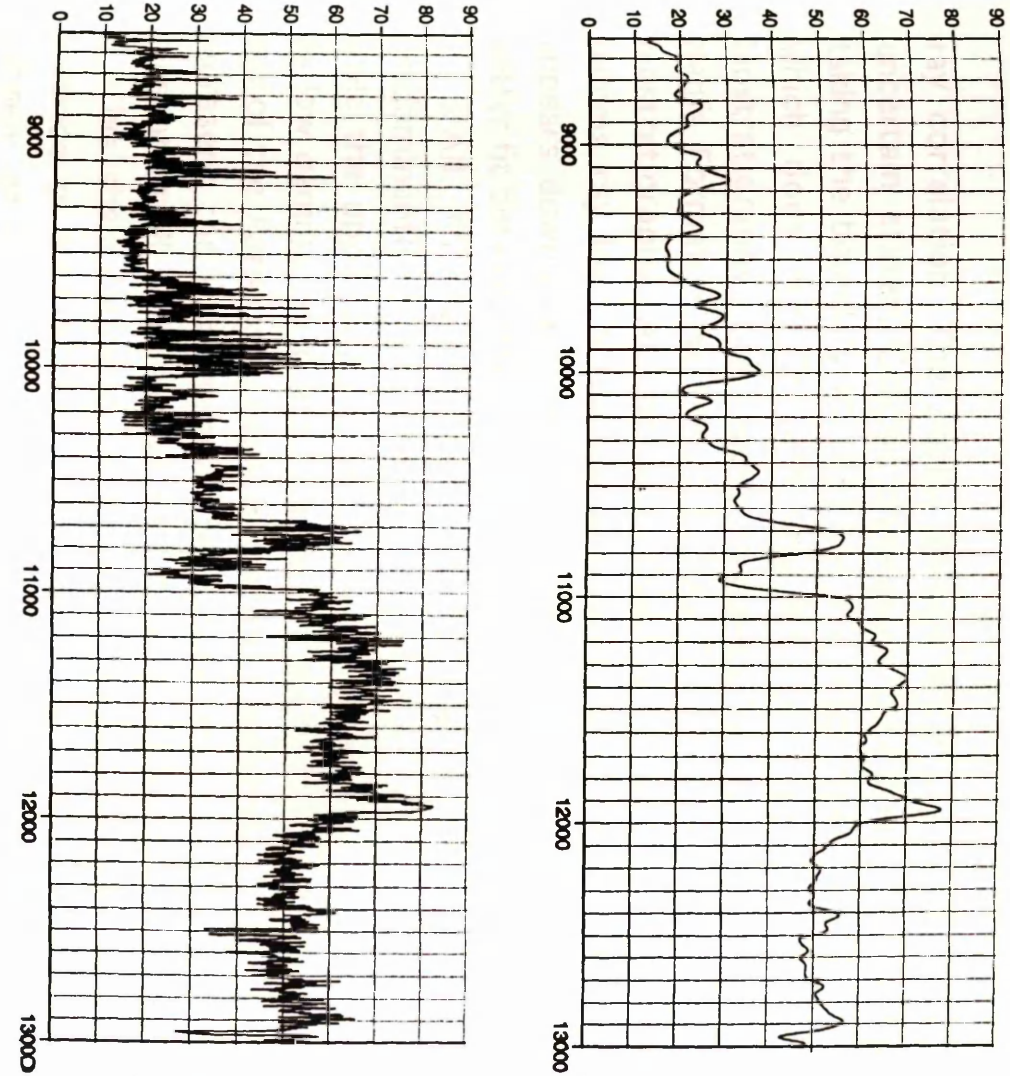
As stated above only two sets of gamma ray logs were available for graphic correlation. These wells are 73.5 km apart; well YY1-6 is situated on the Zelten platform, the second, well KK1-6 in the Agedabia trough. There are problems in correlating the two wells. The main problem is defining the top boundary of the Hagfa Formation in well KK1-6. In this well two interpretations are possible; previous workers in the oil industry have recognised the boundary at 10420 ft depth where the sequence changes downwards from an argillaceous limestone interbedded with shale to a predominantly shale sequence with prominent limestone until a depth of 11020 ft where the sequence downhole becomes a shale succession. This second level is the alternative interpretation. This means that there are two possible interpretations for the gamma



Gamma ray logs in the wellYY1-6

A - Unfiltered gamma ray log with high and low frequency component

B - Filtered gamma ray log with low frquency



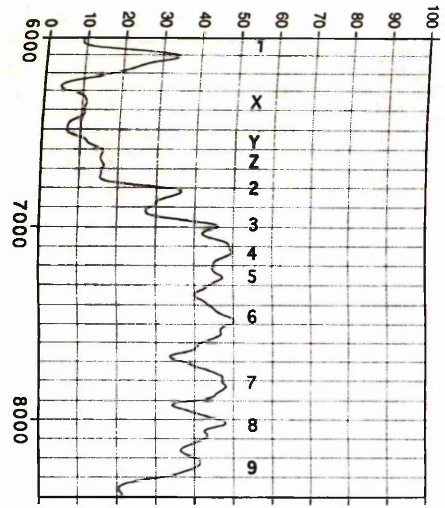
Gamma ray logs in the well KK1-6

Figure 4.1 Stages in the filtering of gamma ray log ray correlation. The peaks labelled X,Y,Z in the well logs are of uncertain states. Graphic correlation of filtered gamma ray peaks taking the boundary at 10420 ft (Fig 4.2) gives a line of correlation which does not fit with the line of correlation derived from biostratigraphy; the second interpretation placing the top of the Hagfa Formation at 11020 ft (Fig 4.3) gives a better fit with the biostratigraphy. At this level there is a prominent change in the gamma ray log, in the lithology, and a rich diverse ostracod fauna appears downhole at this level. This second correlation also gives a better fit between the pattern of cycles (Fig 4.3).

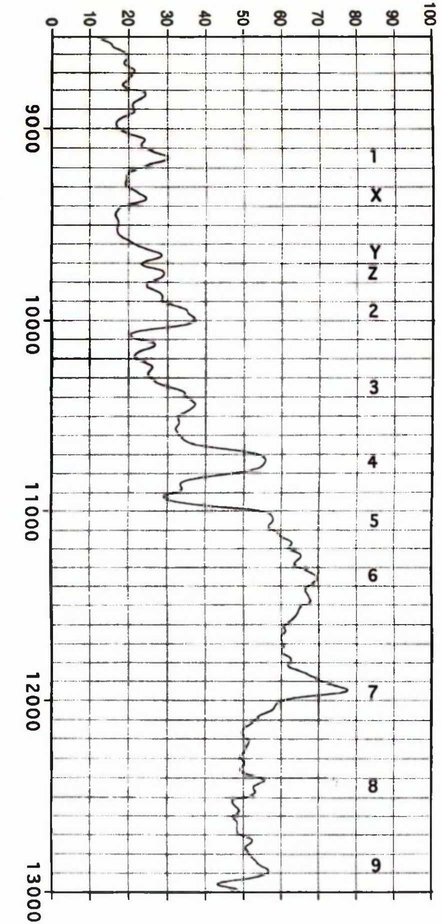
All the wells show similarities: The lower part is predominantly of shale beds, indicated by high gamma ray peaks while the upper part is predominantly carbonate sediment indicated by low gamma ray peaks. The top of the Hagfa Formation is also the top of the *Paracosta bensoni* ostracod zone, which is here taken to represent the Palaeocene/Eocene boundary. The Kheir Formation is present in all wells except KK1-6, with an average thickness of 45 ft. This shale formation has a high gamma ray peak in YY1-6,. Its absence in KK1-6 (Fig 4.3), where the succession is composed entirely of carbonates, produces problems in correlation both on grounds of gamma ray logs and lithology. The microfauna (ostracods and foraminifera) is also poor in this part of KK1-6, with many levels barren of fossils, presumably related to the type of sedimentary rock. Thus there is uncertainty in the correlation of KK1-6 between depths of 9000-11000 ft.

Construction of biostratigraphic graphic correlation

YY1-1 was chosen as the standard reference section because it has a gamma ray log and a rich ostracod fauna with species in common with most other sections. Graphic correlation was used to produce a LOC between YY1-6 and the other 4 wells. From these correlations the position of FDO for all the common species could be determined and adjustments made for the standard reference section. Two species, *Paracosta paleomokattamensis* and *Protobuntonia nakkadii* have been adjusted by this technique. The FDO of *Paracosta paleomokattamensis* in YY1-6 is at 7660 ft; other



Gamma ray log well YY1-6



Gamma ray log well KK1-6

Figure 4.2 Correlation between wells YY1-6 and KK1-6 using gamma ray peaks top of the Hagfa Formation as previously defined

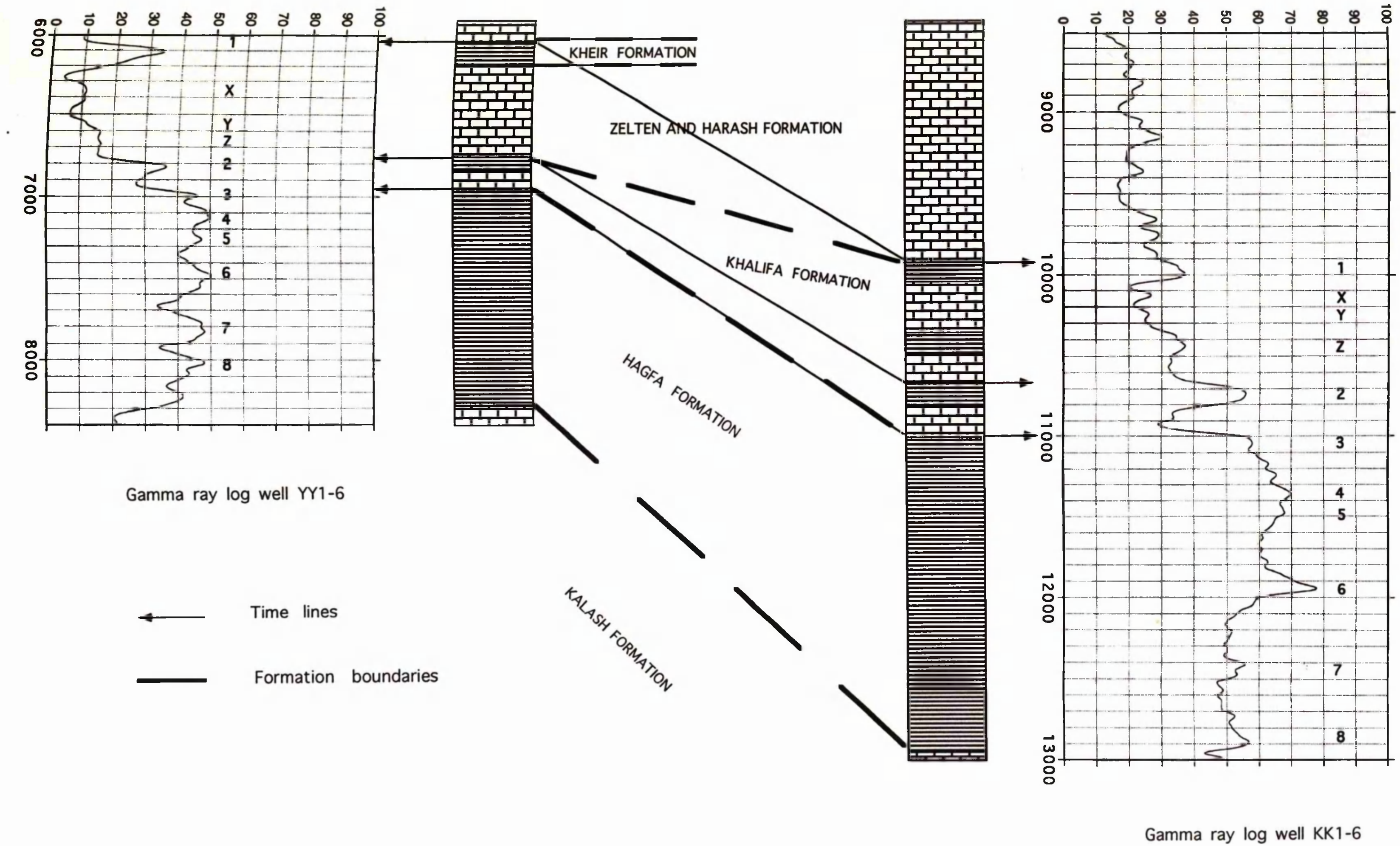


Figure 4.3 Correlation between wells YY1-6 and KK1-6 using gamma ray peaks using new top of Hagfa Formation

wells indicate that this occurrences is lower in the well than predicted and so a correction has been made for this. The predicted result is used in Fig 4.4. The FDO of this species is taken to give the middle/upper Palaeocene boundary.

Some changes from previous ideas-

a- Top Hagfa shale is lower in the well KK1-6 (11020ft instead of 10420ft).

b-Top of the Hagfa = Palaeocene / Eocene boundary.

c- Top of the Hagfa has many late Palaeocene ostracods.

d-Middle Palaeocene can be recognised from *Paracosta paleomokattamensis.*

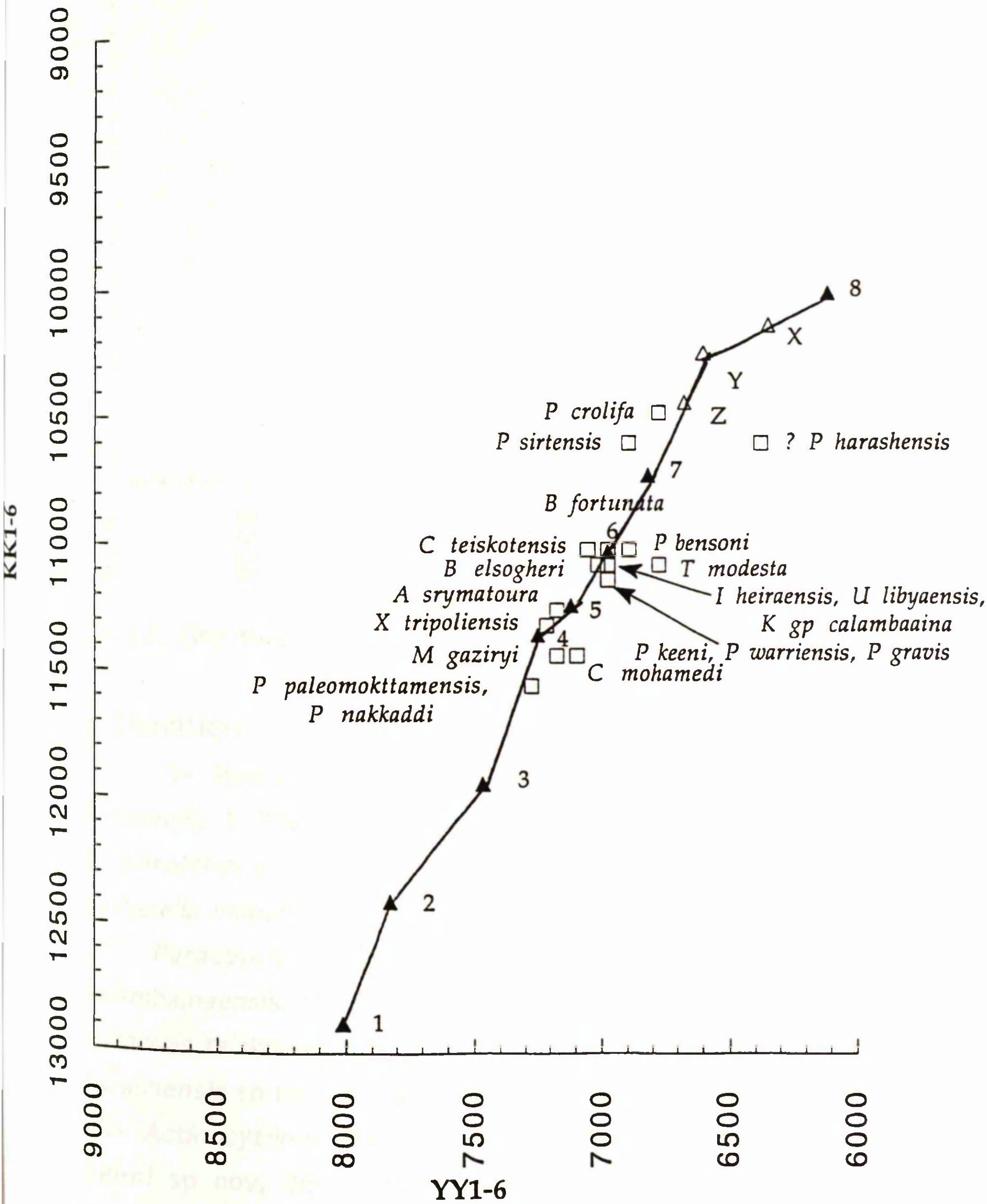


Fig (4.4) Line of correlation gamma ray and bioevents.
Gama ray peaks (▲), bioevents (□).

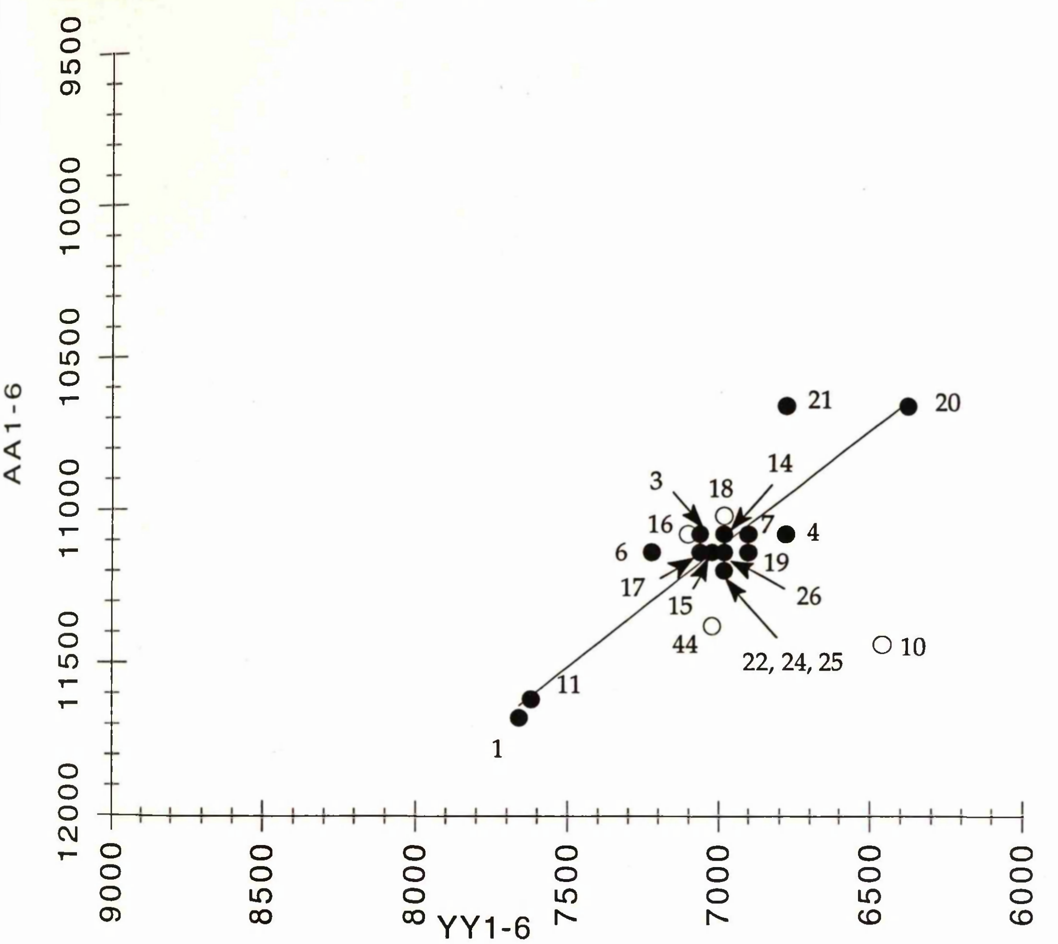


Figure 4.5 Scattered diagram of FDO species black dots reliable on

Explanation-

1- *Paracosta Paleomokattamensis*, 2- *Cytherella zaltanensis*, 3- *Paracosta* gp *bopaensis*, 4- *Trachyleberis modesta*, 5- *Acanthocythereis* (*S*) *libyaensis* sup sp nov, 6- *Xetoleberis tripoliensis*, 7- *Paracypris sirtensis*, 8- *Bythocypris* n sp1, 9- *Cytherella mohamedi* sp nov, 10- *Buntonia tatteuliensis*, 11- *Protobuntonia nakkadii*, 12- *Paracypris khawlai* sp nov, 13- *Paracosta warriensis*, 14- *Krithe* gp *kalambainaensis*, 15- *Bythocypris elsogheri* sp nov, 16- *Buntonia* (*B*) *salahii* sp nov, *Cythereis teiskotensis*, *Buntonia furtunata*, 19- *Paracosta bensoni*, 20- ? *Paracypris harashensis* sp nov, 21- *Parakrithe crolifa*, 22- *Isohabrocythere heiraensis* sp nov, 23- *Actinocythreis joshensis* sp nov, 24- *Paragrenocythere gravis*, 25- *Parcypris keeni* sp nov, 26- *Uroleberis* (*O*) *libyaensis* supsp nov, 27- *Paragrenocythre neoponticulata*, 28- *Monoceratina gaziryi*, 29- *Phalcocythere ralahensis*, 30- *Cytherell hateibensis*, 32- *Bairdia libyaensis* sp nov, 33- *Isohabrocythre teiskotensis*, 35- *Bythocypris ajdabiyaensis* sp nov, 37- *Reticulina proteros*, 38- *Phalcocythere jebelensis*, 39- *Bairid* gp *ilaroensis*, 40- *Parcypris hagfaensis* sp nov, 41- *Propontocypris triangulata* sp nov, 42- *Cytheretta* n sp 1, 43- *Pontocyprella recurva*, 44- *Paracypris tripoliensis* sp nov.

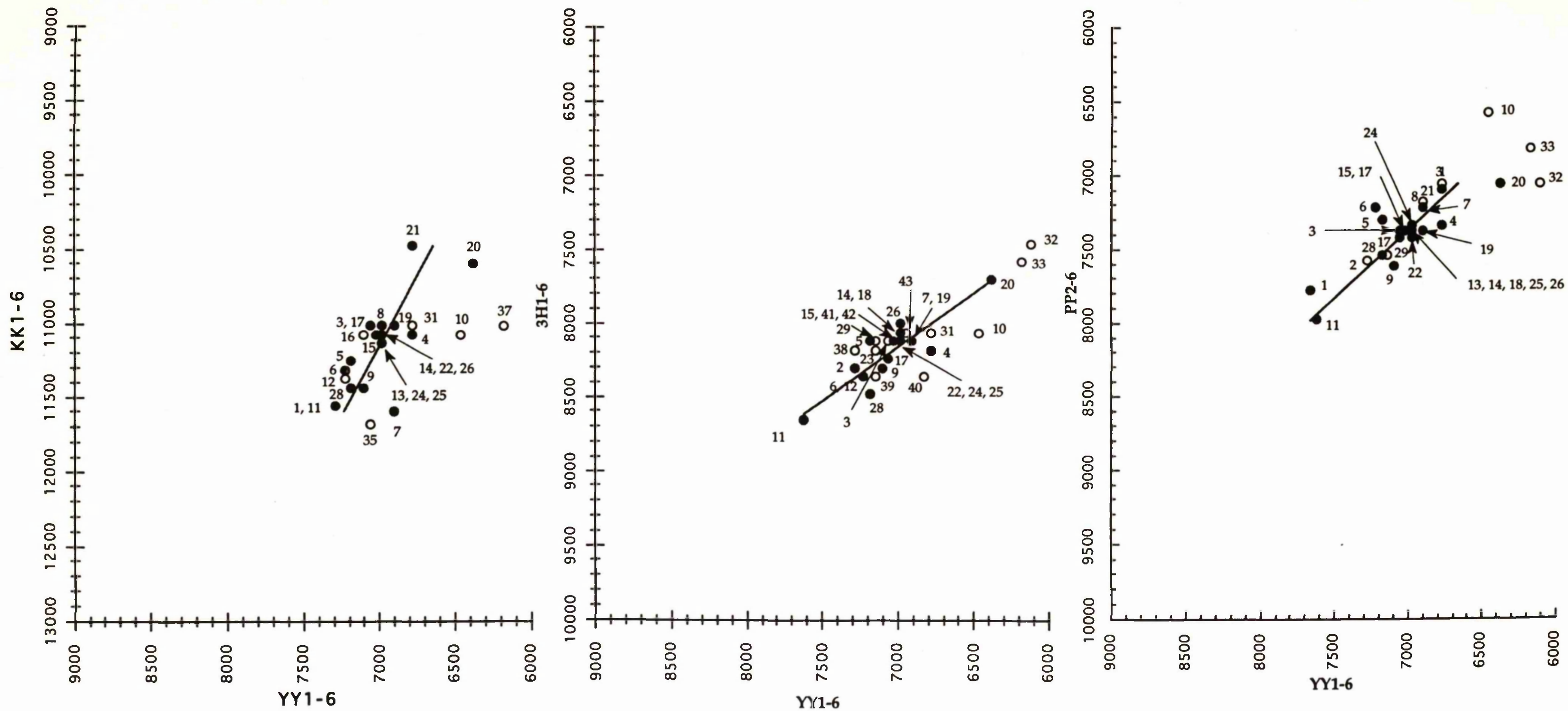


Figure 4.6 Graphic correlation using FDO of selected species showing LOC between wells YY1 and KK1, 3H1 and PP2.

CHAPTER FIVE

PALAEOENVIRONMENTS

Palaeoenvironments

Ostracod faunas are widely used for palaeoenvironmental reconstruction, because of their abundant and high diversity throughout geological history, and their occurrence in a wide environmental spectrum such as fresh, brackish water, marine and even rarely terrestrial habitats.

The main factors controlling the distribution of ostracod faunas are salinity, temperature, water depth, substrate, food supply, hydrogen ion concentration, and oxygenation.

Using the principle of uniformitarianism, the present as the key to the past, it is possible to determine the type of environments fossil ostracod faunas were likely to have inhabited.

The diversity of species living in marine environments is always greater than that of adjacent bodies of brackish water, and diversity in fresh water is usually less than shallow marine water but not always (see Whatley, 1983 for more details).

Most of the material used here in palaeoenvironmental analysis are ditch cutting samples from the five wells in the Sirt basin, together with two outcrop sections on the south western border of the Sirt Basin. The well cutting samples are usually contaminated due to drilling problems and caving of the boreholes so that it is difficult to locate a true depth of faunas. To tackle this problem the first appearance downhole, has been given importance in consideration of abundance and diversity.

When studying ostracods for palaeoenvironmental analysis it is important to determine whether these faunas are in situ or have been transported from another environments i.e whether they are autochthonous or allochthonous. Population age structure can be used to distinguish these; autochthonous faunas are generally presumed to be preserved if juveniles, males, and females are all present in the sample (Whatley, 1983).

Several authors have used ostracods for post-Palaeozoic palaeoenvironmental reconstruction: Ducasse, (1975) on Lower and

Upper Eocene of South Aquitain basin, Keen (1977) on late Eocene of the Hampshire basin, Donze, *et al* (1982) on late Campanian-Ypresian of the El Kef section in the North western Tunisia, Bassiouni and Luger, (1990) on the Maastrichtian-Early Eocene of Southern Egypt, El-Waer (1992) on the Upper Cretaceous-Early Eocene of N.W. offshore Libya and El Sogher, (1991 M.S) on the Upper Cretaceous-Lower Palaeocene of the Sirt Basin.

The most detailed study on palaeoenvironments for Palaeogene North African ostracods is that of Bassiouni and Luger (1990) on ostracod faunas from the Maastrichtian-Early Eocene of southern Egypt. Their interpretation of the ostracod faunas utilised studies based on their associated foraminiferal faunas (Luger,1985). The main points considered were estimated sea level changes (relative depth of water), and relative abundance of planktonic/benthonic forminifera (P/B), and diversity and composition of species (see Luger, 1985 for more details). They distinguished four ostracod assemblages indicating different palaeofacies in the Palaeocene-early Eocene. The fauna recorded in this study shows a wide range of marine environments i.e. neritic, bathyal and probably abyssal zones. The classification used by Bassiouni & Luger (1990) is followed and is outlined below:

South Tethyan Type- This consists mainly of calcareous clay with minor amounts of calcareous marls. The species are only recorded from localities of Southern Tethys and indicate a deeper marine environment (outer shelf-upper slope). Bassiouni & Luger recorded this from the upper Kharga shale (Middle Palaeocene) of the Kharga area, Egypt. A few species are related to the combination recorded from the younger sediments of the Tarawan Formation (*pseudomenardii* zone) and from the base of the Esna Formation (early *velascoensis* zone), so that this combination has a long stratigraphical range (early Palaeocene-early late Palaeocene). The following species which are common in this biofacies are recorded from the subsurface of the Sirt Basin: *Mauritsina coronata* Esker, *Krithe echolsae* Esker, *Parakrithe crolifa* Bassiouni & Luger, *Reticulina proteros* Bassiouni, *Paracosta paleomokattamensis* Bassiouni & Luger, *Pontocyprella recurva* Esker, *Bairdia* gp *ilaroensis*

Reyment, *Xestoleberis* cf *kiseibaensis* Bassiouni & Luger, *Reticulina sangalkamensis* Bassiouni.

Esna type- This is composed of calcareous claystone. The ostracod species are mostly new species described by Bassiouni & Luger and not known from elsewhere. They are recorded from the middle part of the Esna Formation (velascoensis zone); the fauna entirely disappeared at the velascoensis/edgari boundary then appeared again for a short period in early edgari zone. These indicate late late Palaeocene-early Eocene and their fauna belongs to the outer-middle shelf environment. The typical common species found in the present study are *Leguminocythereis lokossaensis* Apostolescu, *Reticulina proteros* Bassiouni recorded from the subsurface wells.

Garra type- This type developed in open marine infraneritic (middle shelf) conditions and consists of calcareous marls of the Garra Formation. The species are mostly new and are intermediate between the deeper infraneritic Esna type and the epineritic Afro-Tethyan type. They are well developed in the middle part of the southern Garra Formation (Late *pseudomenardii*-early *velascoensis* zone). The following species have been found in this study: *Occultocythreis confirmatus* El Sweify, *Trachyleberis modesta* Apostolescu, *Reticulina proteros* Bassiouni.

Afro-Tethyan type- This consists of calcareous marls. The fauna is well known from northern and western Africa, occurring in late Palaeocene-Early Eocene strata. They are highly diverse and epineritic species. The species in common with Libya are *Isohabrocythere teiskotensis* Apostolescu, ?*Phalcocythere cultrarta* Apostolescu, *Buntonia tatteuliensis* Apostolescu and *Rementicosta bensoni* Bassiouni; some species not related to the combination but also present are *Buntonia* cf *tichittensis* Apostolescu, *Parakrithe crolifa* Bassiouni, *Occultocythreis confirmatus* El Swefy, *Bairdia* gp *ilaroensis* Apostolescu, *Xestoleberis* cf *kiseibaensis* Bassiouni.

Donze *et al* (1982), studied the ostracod fauna from the Late Campanian-Ypresian of the El Kef section of north western Tunisia. Their Palaeoenvironment analysis indicated that the depositional environment fluctuated from upper Bathyal to outershelf during that time, i.e. upper bathyal conditions in late Cretaceous, shallowing into outershelf at the end of the Cretaceous, back into upper bathyal during Palaeocene time then shallowing again into outer shelf conditions during late Palaeocene-early Eocene. The upper bathyal environment is characterised by occurrences of smooth genera such as *Cytherella*, *Krithe*, *Bairdia*, *Macrocypris* and *Argilloecia* as well as some species of the Superfamily Cythereacea which have well developed eye structure and are interpreted as water depth range of about 400-500 metre. The analysis of *Krithe* and *Parakrithe* allowed observation of strong oxygen minimum zone at the end of Maastrichtian. The Maastrichtian fauna which indicates an upper bathyal environment are *Cristaeleberis thomasi* Donze & Said, *Acanthocythere*? *meslei* Donze & Oertli, *Megamatocythere praecursor* Colin & Oertli, *Aphrikanocythere phulmatoides* Dammote & Oertli and *Kefella marsi* Donze & Said. The Palaeocene species range from upper bathyal to outer shelf: *Paracosta pervinquiri* Donze & Said, *Protobuntonia nakkadii* Bassiouni (recorded in this study); the outer shelf species recorded by Donze *et al*, (1982) are *Megommatocythere hariaensis* Colin & Oertli, *Paracosta kefensis* Benson, *Paracosta bensoni* (Damotte & Donze) (recorded in the present study), *Paracosta* cf *mokattamensis* Bassiouni and *Soudanelle laciniosa triangulata* Apostolescu.

Al-Furaih recorded the following species *Acantocythere stymatoura*, *Paragrenocythere gravis* and *Hornibrookella episcelis* from Saudia Arabia which indicated a shallow marine environment.

The classification established by Bassiouni & Luger (1990) has been followed. Their distribution in the wells is shown in the (Fig 5.1).

All four palaeoenvironmental biofacies of Bassiouni & Luger, are present in the wells. They are arranged in ascending order, South Tethyan, Gara, and Afro-Tethyan in the Palaeocene, indicating a shallowing succession from outer shelf to inner shelf. This is overlain by Early Eocene shales with the Esna type assemblage, indicating a transgression giving mid-outer shelf water depth. The facies are distributed across the "platform" and the "trough", indicating no great differences in palaeodepth between these areas during deposition. Both show a shallowing upward succession. It is

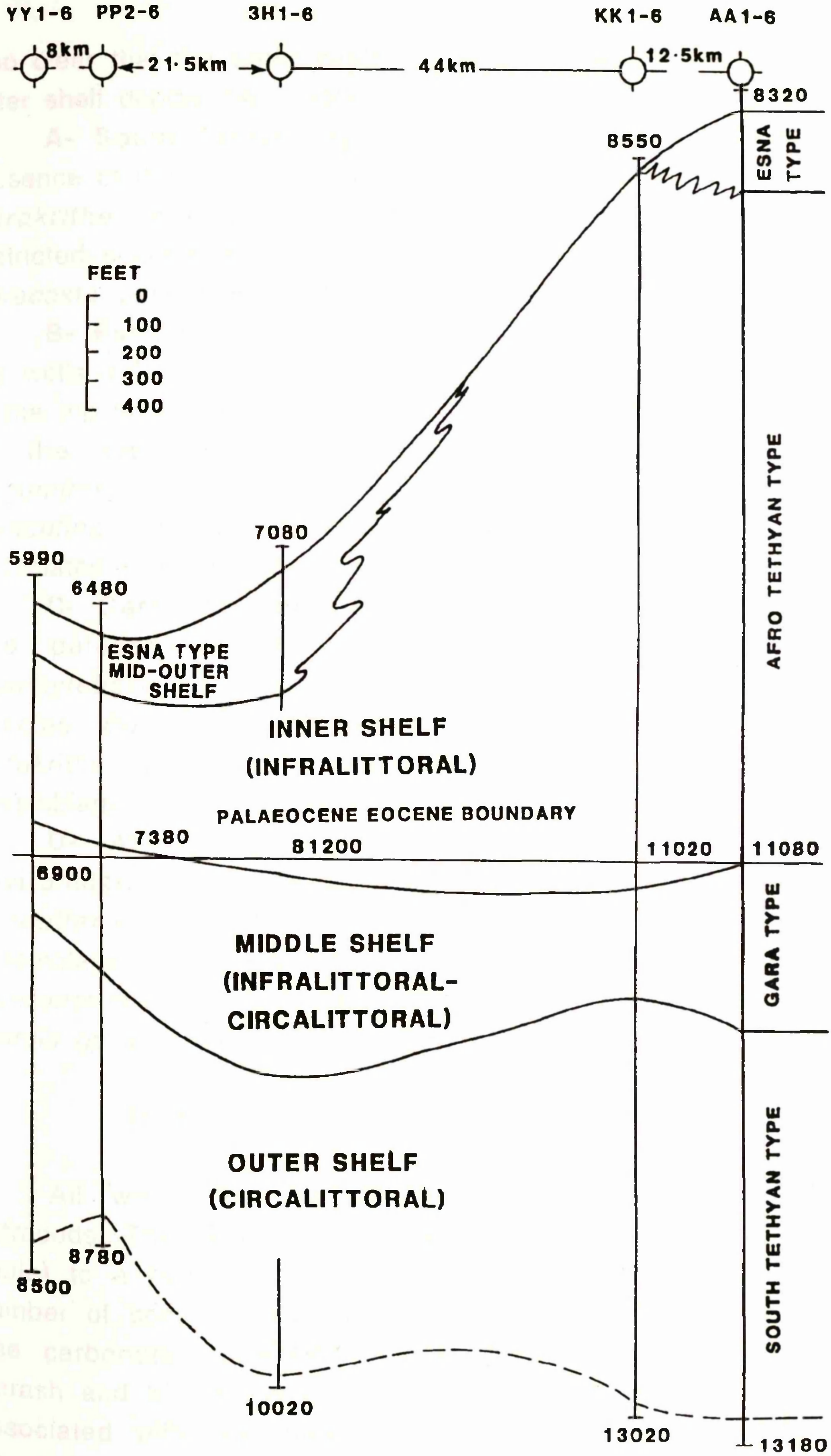


Figure 5.1 Palaeoenvironments throughout the studied wells

also clear that the water depth in the trough was never greater than outer shelf depths, i.e c. 200m.

A- South Tethyan type (outer shelf). This is indicated by the presence of the typical species *Mauritsina coronata*, *Krithe echlosae*, *Parakrithe crolifa*, *Paracypris* sp, *Reticulina proteros;* some restricted species are also present such as *Pontocyprella recurva*, *Paracosta paleomokattamenis.*

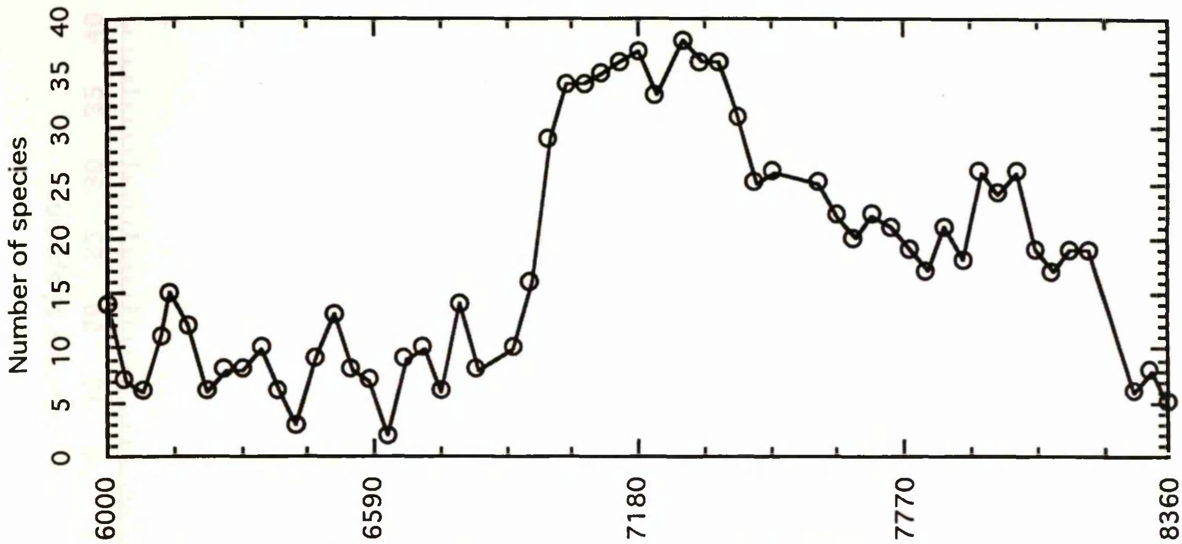
B- Esna type (outer-middle shelf). This is only recorded from the wells YY1-6, PP2-6, 3H1-6 and AA1-6 where it occurs in shales at the top of the sections studied. The fauna is not very rich, but two of the typical species of this assemblage are present, *Leguminocythereis lokossaensis*, *Reticulina proteros*, together with *Reticulina sangakamensis*, *Xestoleberis* cf *kiseibaensis* which are associated with this assemblage.

C- Gara type (middle shelf). The typical species indicating this paleoenvironment are *Occultocythereis confirmatus*, *Trachyleberis modesta*, *Reticulina proteros*, together with few species *Buntonia tichittensis*, *Isohabrocythere teiskotensis*, *Parakrithe crolifa* and *Bairdia ilaroensis* which is associated to the assemblages.

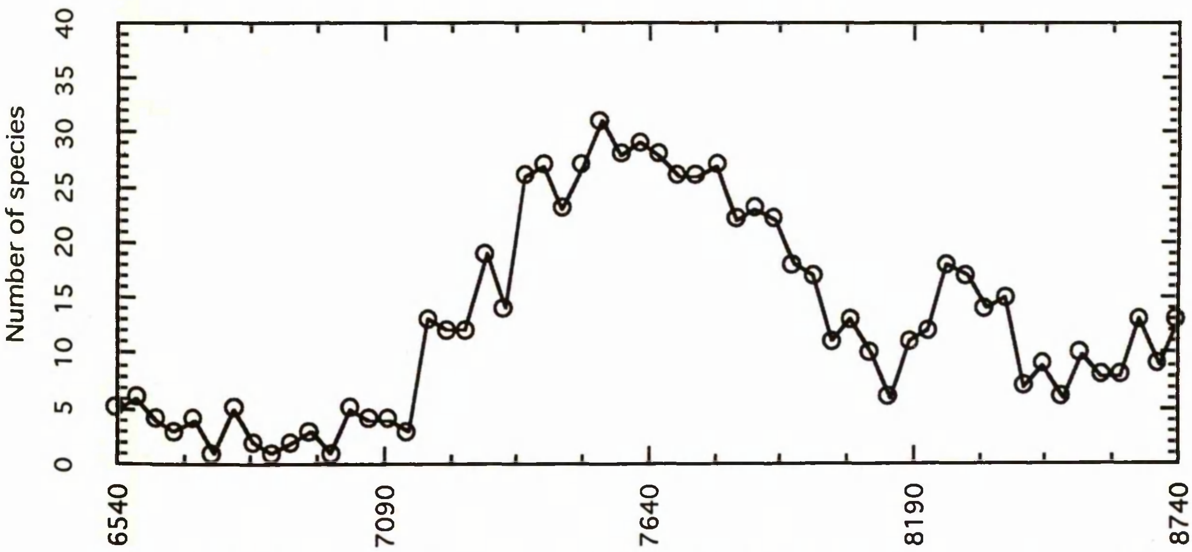
D- Afro-Tethyan type (inner shelf) the typical fauna of this environment are *isohabrocythere teiskotensis*, *Buntonia tatteuliensis*, with *Paracosta bensoni* which is restricted to the assemblage and some associated species not related to combination *Buntonia* cf *tichittensis*, *Parakrithe crolifa*, *Trachyleberis modesta*, *Bairdia gp ilaroensis* and*Leguminocythereis lokossaensis.*

Diversity of ostracods in the 5 wells

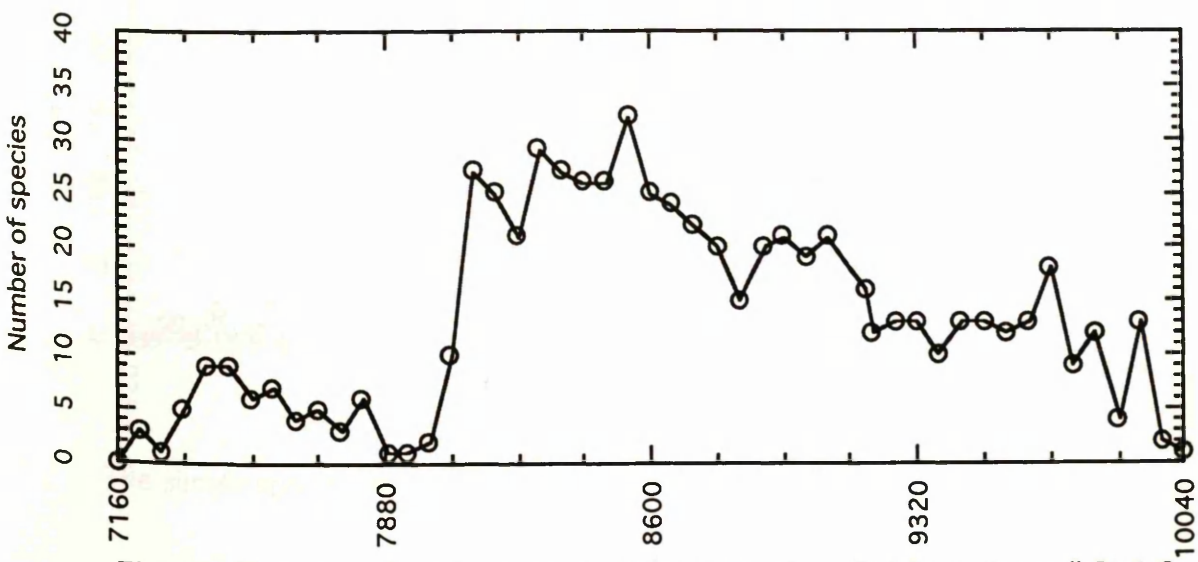
All wells show a similar pattern in the distribution of ostracods. The change from a dominantly shale succession (Hagfa shale) to a carbonate succession is marked by a large change in number of species, individuals, and also diversity (Figs 5.2,3,4,5,6). The carbonate succession of the Lower Eocene (Khalifa, Zelten, Harash and Kheir) has a small number of species (c. 2-15 species) associated with low counts of individuals (c.3-70, average around 20). The top part of the underlying Hagfa shale has c.25-37 species,



The simple species diversity per sample for interval studied from the well YY1-6.

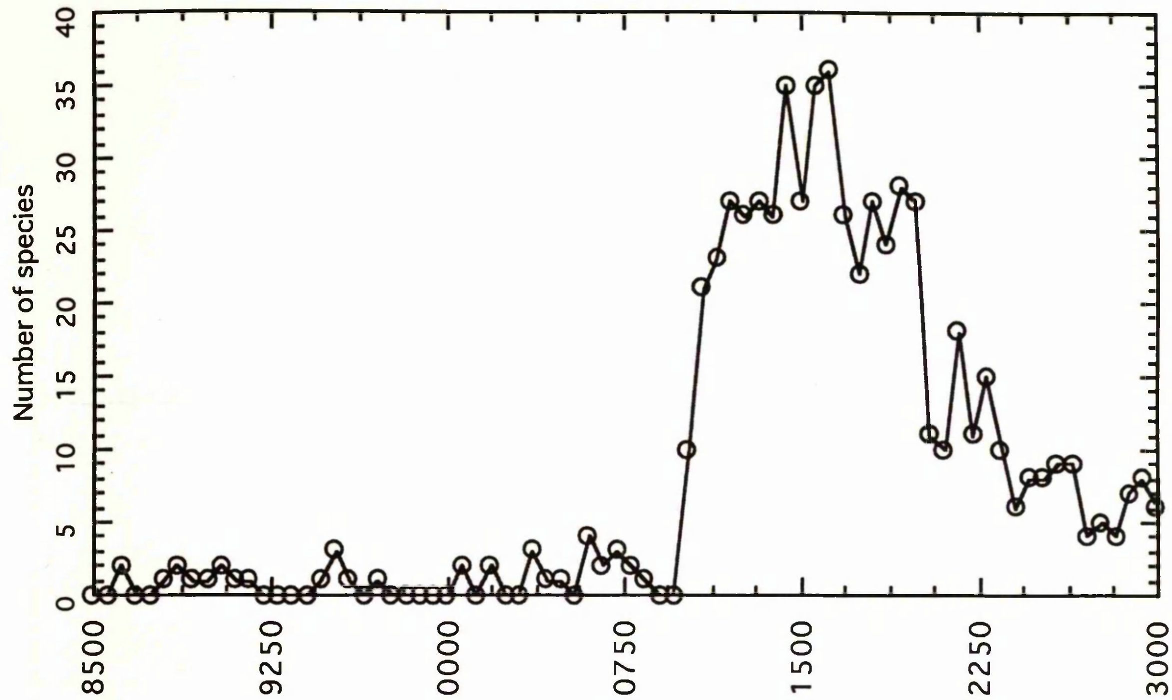


The simple species diversity per sample for interval studied from well PP2-6.

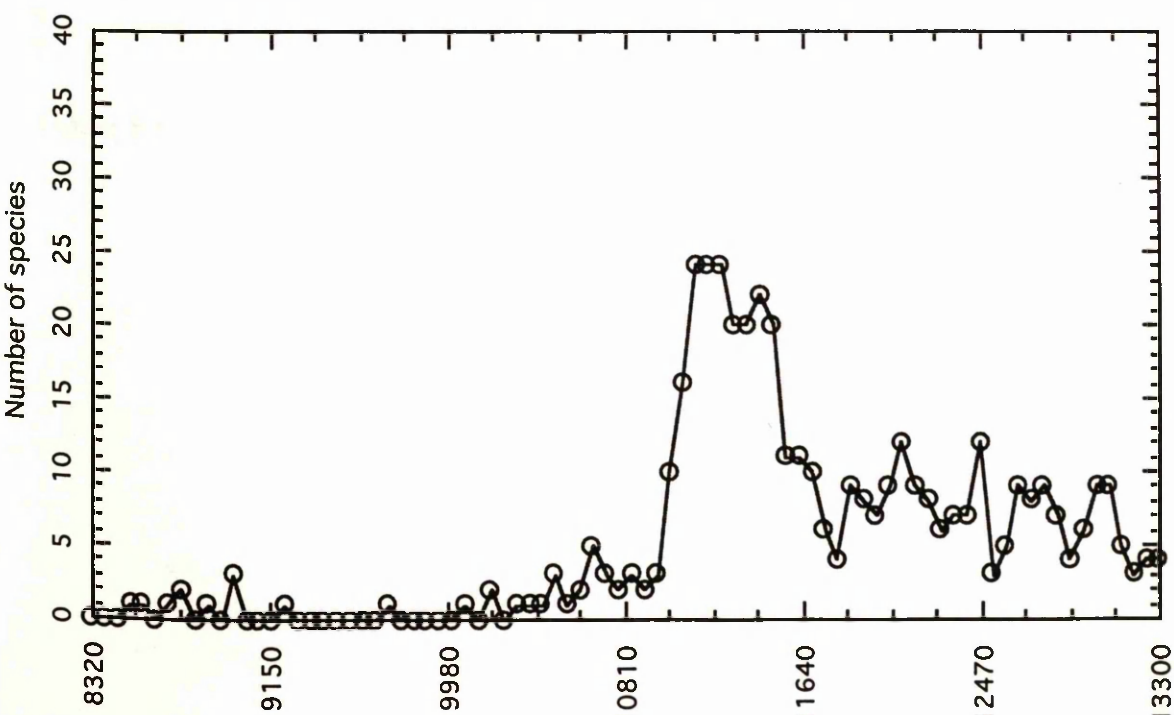


The simple species diversity per sample for interval studied from the well 3H1-6.

Figure 5.2 Simple species diversity from the platform wells



The simple species diversity per sample for interval studied from the well KK1-6



The simple species diversity per sample for interval studied from the well AA1-6.

Figure 5.3 Simple species diversity from the trough wells

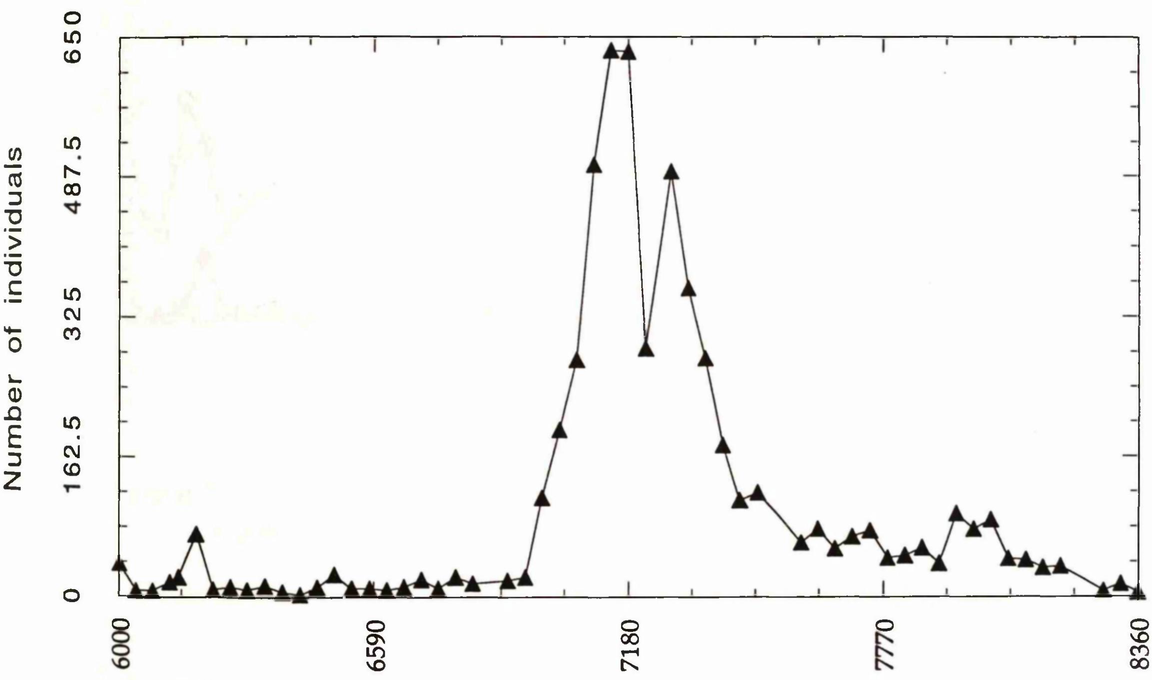


Figure 5.4 Abundance of individuals for interval studied from the well YY1-6.

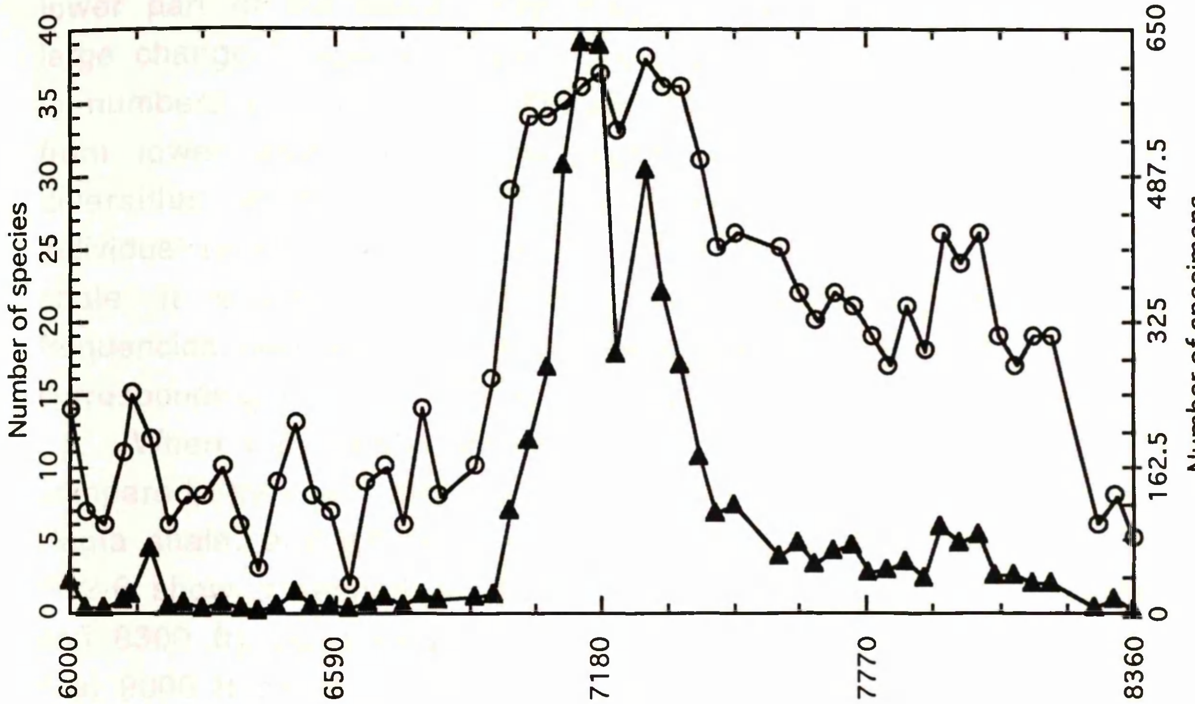


Figure 5.5 Simple species diversity (o) and abundance of individuals (▲) from the studied well YY1-6.

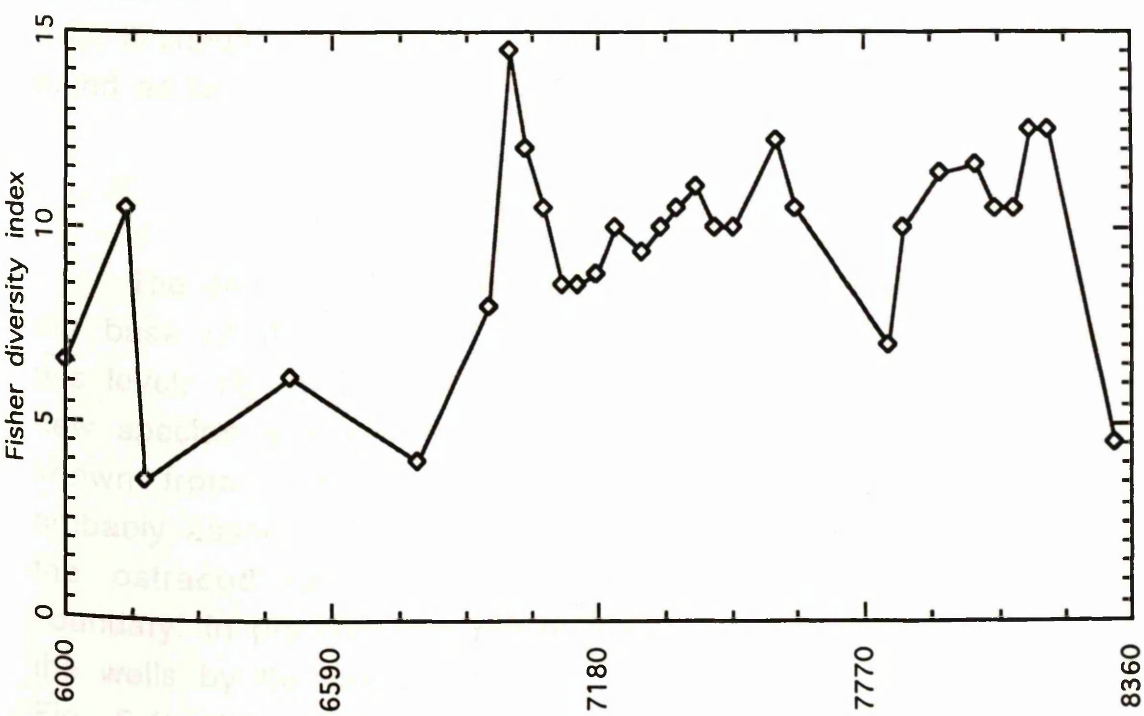


Figure 5.6 The Fisher diversity index with depth in the well YY1-6.

with counts of 100-600 individuals; These both decrease in the lower part of the shale. (Figs 5.4,5,6). As would be expected, the large change in species numbers is directly associated with a change in numbers of individuals. Although not so clear, there is a change from lower diversities in the higher parts of the well to higher diversities in the Hagfa shale. The very highest species and individual numbers and diversity is seen at the very top of the Hagfa shale. It is also noticeable that while the species and individual frequencies decline downwards through the Hagfa shales, there is no corresponding decline in diversity (Fig 5.6).

When the simple species diversity graphs for the 5 wells are compared, they all show highest diversities in the top part of the Hagfa shale, and KK1-6, AA1-6 and the "Platform" wells YY1-6 and PP2-6 show a second peak in the lower part of the shales (8000 ft and 8300 ft), possibly also present in the third "Platform" well 3H1-6 at 9000 ft depth.

The study is based on ditch cuttings. The major change at the Hagfa shale Khalifa boundary is real, i.e not influenced to any great degree by contamination. The gradual decline downwards through the Hagfa shale may however be a reflection on gradually reducing contamination from the rich levels at the top of the Hagfa shale (Fig. 5.4). It should be noted that the common late Palaeocene species are found as far down hole as the Cretaceous due to contamination

Faunal Turnover

The changes described above indicate a large faunal turnover at the base of the "Khalifa Formation" 29 species become extinct at this level, 15 survive but 5 of these soon become extinct. Only one new species is seen, *Leguminocythereis lokossaensis* and this is known from older rocks in the other areas so its incoming is probably associated with deeper water (see Fig 5.1). This change in the ostracod fauna is taken to define the Palaeocene/Eocene boundary. In practise, the top of the Palaeocene can be recognised in the wells by the sudden appearance of large number of ostracods (Fig. 5.4). 4 species from Trans Saharan were disappeared at this level.

This faunal turnover is clearly associated with a change in lithology. The comparative rarity of specimens in the carbonate rocks is probably due to a combination of original abundance, loss through diagenesis, and difficulties in extraction. The lithological change is much clearer in the 2 Platform wells 3H1-6, PP2-6; in the well YY1-6 the faunal change is not so sharp, due to the presence of the Khalifa Formation. In the "basin" KK1-6 shows a marked changes in species diversity, but this occurs within the shale sequences, although this part of the shale sequence has some limestone within it.

The problem is therefore one of disentangling facies changes from biostratigraphical changes. Many of the late Palaeocene species never reappear, so it is therefore a case of true extinction, and appears to coincide with the end of the Palaeocene. This is an important bioevent which has correlative importance.

Palaeoenvironment in the outcrop sections

The fauna from Heira lies entirely within the Afro-Tethyan type of Bassiuni & Luger, and the species found in common with their scheme are predominantly inner shelf {inner infralittoral}; *Dahomey alata* is the only species which is regarded as being solely from deeper, i.e middle shelf waters.

52 species of ostracods have been recorded from Heira and El-Fogha. Many of these are abundant throughout the sections. The over all fauna can be compared clearly with the Afro-Tethyan biofacies of Bassiouni & Luger. Three species regarded as typical of this biofacies are abundant in both Libyan sections: *Isohabrocythere teiskotensis, Buntonia tatteuliensis* and *Phalcocythere cultrata;* 2 species which are restricted to the biofacies: *Paracosta bensoni* and *Quadracythere kaoensis* (=*Schizocythre* sp1); and four associated species: *Buntonia* cf *tichittensis*, *Parakrithe crolifa*, *Occultocythereis confirmatus* and *Trachyleberis modesta*. For the other biofacies of Bassiouni & Luger only *Parakrithe crolifa* is present in the South Tethyan biofacies and none are present in the Esna biofacies. *Occultocythreis confirmatus* and *Trachyleberis modesta* are typical of the Gara biofacies, but both are also

associated with the Afro-Tethyan biofacies, *Buntonia* cf *tichittensis*, *Isohabrocythre teiskotensis* and *Parakrithe crolifa* are also present. The overlap of Gara and Esna on table 8 of Bassiouni & Luger has one species recorded from Libya as being restricted to this biofacies, *Dahomey alata alata*, which is common to abundant in Libya; *Occultocythreis confirmatus* and *Tracyleberis modesta* are also present but not restricted to this biofacies. This distribution reinforces the Afro-Tethyan biofacies, which is regarded as being inner shelf, the overlapping Esna/Gara biofacies is middle shelf.

Interpretation of the Heira section using cluster analysis

Six groups are differentiated by cluster analysis used S-Plus software (Fig 5.7) as follows:

Group A- Rare species present in the lower half of the section.

Group B- Species found in abundance in the lowest part of the section, being absent or rare higher up.

Group C- Species which are abundant in the lower half, present in the upper half but much rarer. These are more widely distribution than species of group B.

Group D- Species which are present through most of the section, but are absent in the lowest part except *Bairdia libyaensis*, and have their greatest abundance in the middle part.

Group E- *Krithe barsottii*: abundant throughout.

Group F- *Paracosta bensoni*: absent in the lowest part, abundant throughout remainder.

Groups, B, C and D are arranged sequentially going through the section, although with overlap. This suggests a changing environment or a stratigraphical input (appearance of *P bensoni* may be a true first appearance).

Group B- *Isohabrocythere heiraensis, Paracosta warriensis, Buntonia furtunata, Paragrenocythere neopoticulata* are abundant in samples S1-3,4,5; S1-4 has a low diversity fauna, with abundant *B fortunata*, *I heiraensis*, and *P neoponticulata*, and *K barsottii*; it also has fewer specimens than S1-3 or S1-5. S1-5 has the greatest number of individuals for any sample from Heira with a diversity of

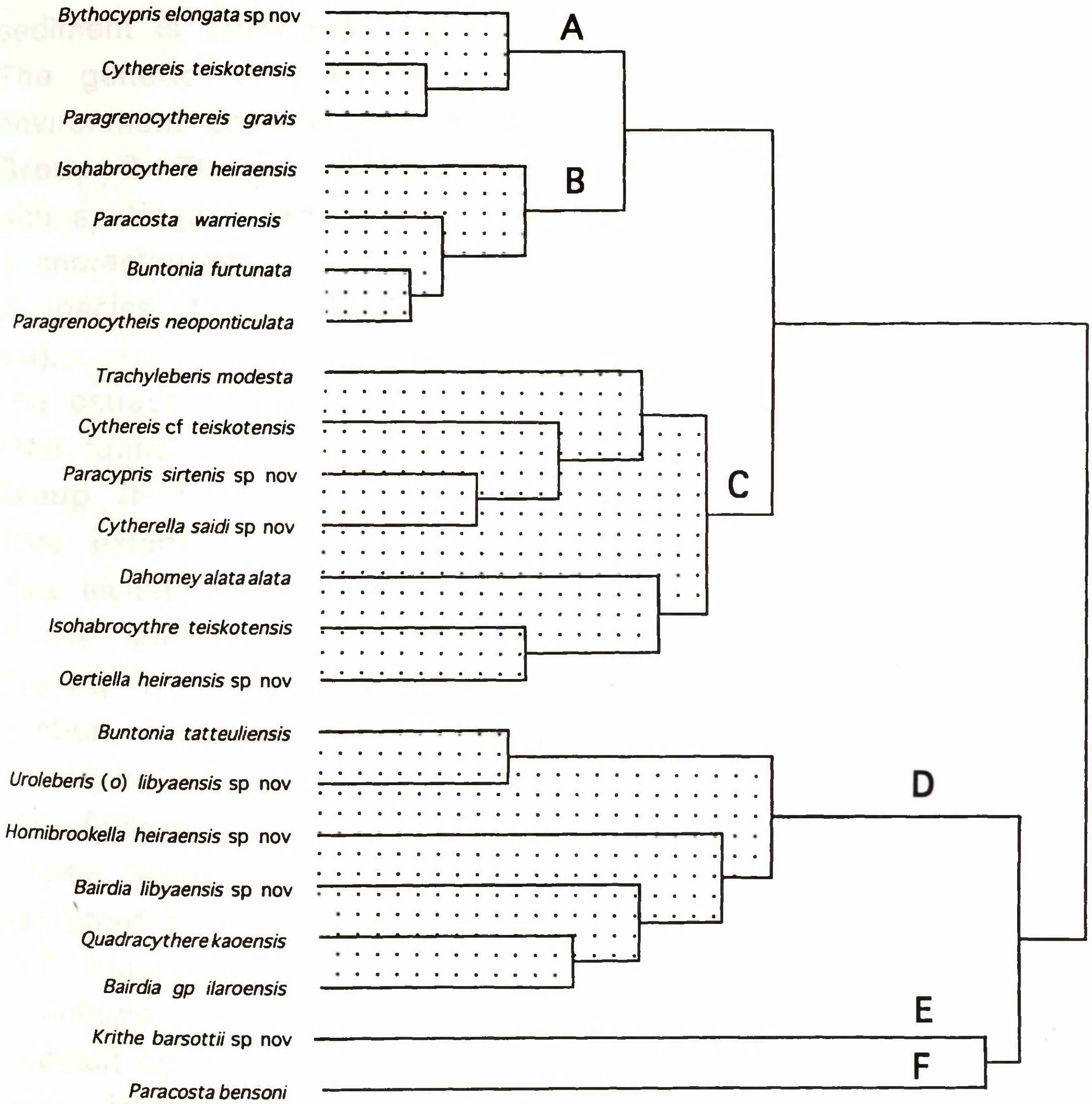


Figure 5.7 Cluster analysis of the Heira depression

4.1, S1-3 has a diversity of 2.5, S1-4, 2.3. (Fig 5.9). Thus this group is a relatively low diversity fauna compared with group C. The sediment is black-grey organic shale (S1-3), or grey marl (S1-4,5) The generic composition, plus diversity, suggests a near shore environment possibly with some restriction.

Group C- The samples are marls and occasional limestones (S1-8) with spatangoid echinoids, bivalves and oysters. The ostracod fauna is characterised by medium-high numbers of individuals, high number of species (12-20) (Fig 5.8), and a high Fisher diversity (3-5.5) (Fig 5.9).

The ostracods, Macrofossils, and faunal diversity all suggest a rich shelf fauna of moderate depth {inner-mid shelf} {infralittoral}.

Group D- These are present in similar samples to group C, but are more extensively distributed.

They include high diversity faunas, but also in the middle-upper part of the section they are found in low diversity faunas (Fisher diversity 1.2-2.5) (Fig 5.9), with low number of individuals and low number of species (Fig 5.8). The species are *Bairdia libyaensis*, *Hornibrookella heiraensis*, *Quadracythere kaoensis*, *Buntonia tatteuliensis*, *Uroleberis* (*o*) *libyaensis*, *Bairdia* gp *ilaroensis*. These species were presumably more tolerant of environmental conditions than group C. *Bairdia gp ilaroensis* was given a range over the whole shelf, from deep to shallow by Bassiouni & Luger (1990). *Buntonia tatteuliensis* and species of *Uroleberis* were regarded as "epineretic" (Coastal) by Bassiouni & Luger. Samples from above the pebble bed have low diversity faunas, eventually samples become unfossiliferous and, the number of individuals declines. This suggests an environment becoming more hostile, possibly becoming slightly hypersaline because evaporites are present higher in the section. Echinoids, burrowing organisms were still around however. Trachyleberids are rarer in the upper part of the section.

Group E- *Krithe barsottii*; a very environmentally tolerant species.

Group F- *Paracosta bensoni*, environmentally tolerant; absence in the lowest part of section may be due to its absence from the Sirt Basin, i.e due to stratigraphy rather than ecology.

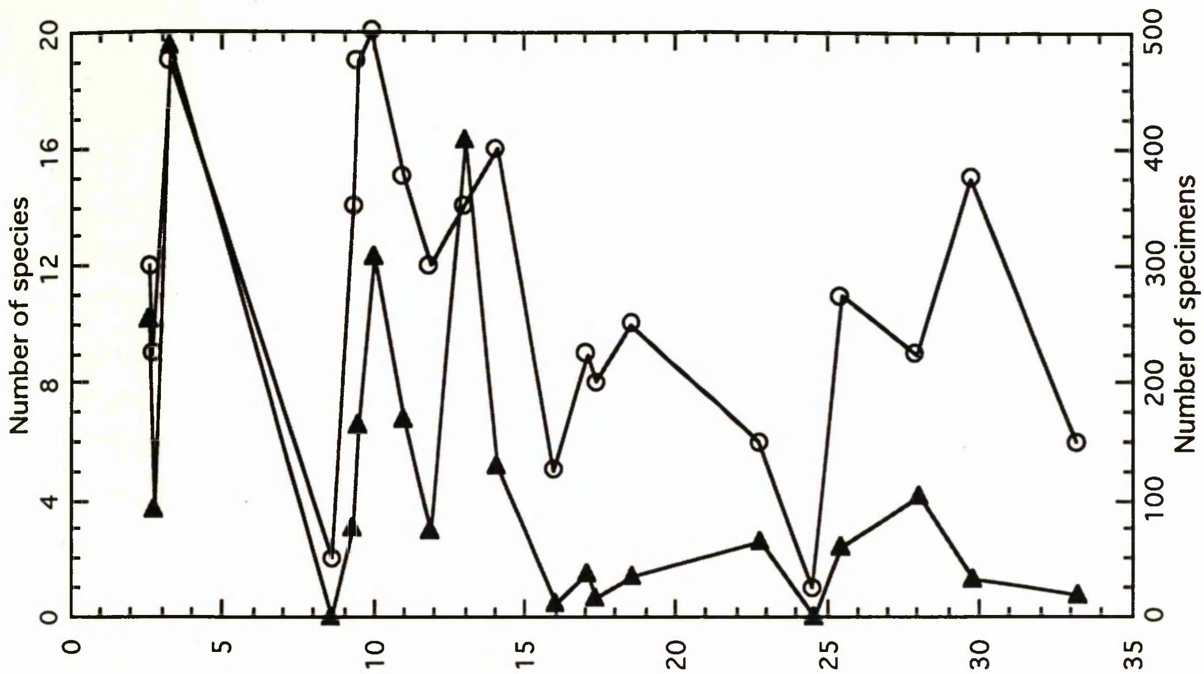


Figure 5.8 Simple species diversity (O) and abundance of individuals (▲) from the Heira depression.

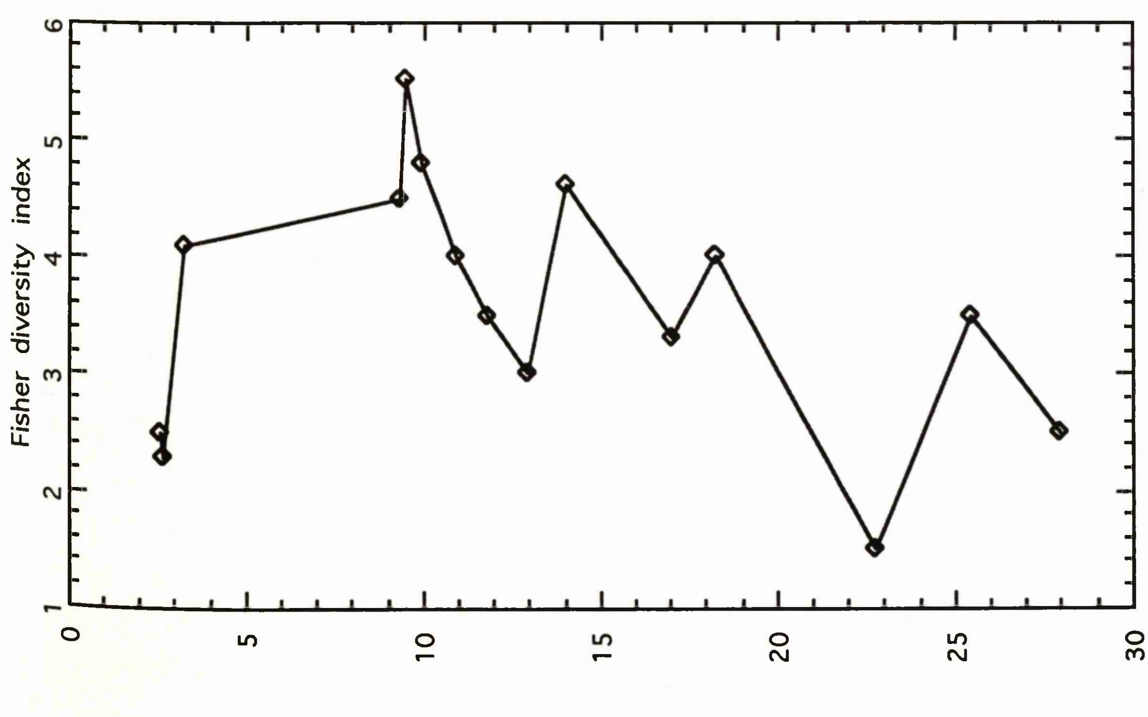


Figure 5.9 The Fisher diversity index from the Heira depression.

CHAPTER SIX

PALAEOGEOGRAPHY

Palaeogeography

The early Tertiary ostracods of Libya, and the Sirt Basin in particular, are well known for their West African affinities. several works have been published on the palaeozoogeography of these Palaeocene-Eocene faunas: Barsotti (1963), Reyment (1980), Reyment & Reyment (1981), Reyment (1983), Siddiqui (1983), Bassiouni and Luger (1990), El-Waer (1992), and Keen *et al*, (1994). See Fig 3.3 for the distribution of studies described below and Table 6.1 for Palaeogeographic distribution of important fauna.

Faunal relationships between North Africa, West Africa and the Middle east.

Tunisian faunas-

Ostracod faunas from Tunisia have been described and illustrated by several authors: Esker, 1968 (Danian), Ra Said, 1978 (Maastrichtian-Early Eocene) and Donze *et al*, 1982, (late Cretaceous-Eocene). Esker recorded twenty species from Oued R'mel southwest of El Kef in north-western Tunisia. Some of this fauna is in common with the present studies: *Mauritsina coronata*, *Krithe echlosae* and *Pontocyprella recurva*, while others species are very similar, such as *Bairdia* sp *septentrionalis* Bonnema, *Bythocypris* sp. Esker (1968) mentioned that his fauna seems to be more closely related to the north European late Maastrichtian faunas than to earlier described African faunas and suggested that there might have been a marine connection between the North Sea Basin and Tethys during the Danian. Ra Said, 1978 studied the Cretaceous-Tertiary ostracods of the Seliana-Sers region; fifty seven species were recorded, those in common with the present study being *Cytherella* sp 2, *Buntonia numidica*, *Mauritsina coronata*, ?*Ordoniya* (*o*) *burmaensis*, *Paleocosta* sp *bensoni*, *Reticulina proteros*. Finally, Donze *et al* (1982) have carried out detailed ostracod studies from late Campanian-lower Eocene in the El Kef section of north western Tunisia. Fifty species were recorded and illustrated.

Species	Libya offshore	Libya, SW Sirt Basin	Egypt	Niger	Nigeria NW	Nigeria SW	Tunis	Togo	Senegal	Mali	I Coast	Jordan	Dahomey	Benin	S Arabia
Quadracythere kaoensis		LP	LP - EE	LP											
Cytherelloidea musacea		LP		LP											
Dahomeya alata alata	LP - ME	LP	LP	LP	P - EE	P - EE	P - EE		EE		LP				
Buntonia tatteuliensis		LP - EE	LP-EE	LP	LP					LP					
Legminocythereis lokossaensis		LP	EE					EE			LP		EE		
Isohabrocythere teiskotensis		LP - EE	LP	LP	LP			LP					LP		
Mauritsina coronata		M - EP	EP				M -< LP					EP - EE?			
Trachyleberis modesta		LP	LP		LP					LP	LP				
Occultocythereis confirmatus		EP - EE?	EP												
Paracosta paleomokattamensis		MP	MP												
Reticulina proteros		LP - EE	LP				EP - EE					EP - EE			
Buntonia fortunata		UC - EP			LP	LP		LP			LP		< LP	LP	
Paracosta warriensis		M - LP				M - LP		LP							
Paracosta bensoni	LP	LP	LP				LP								
Protobontonia nakkadii		LC - EP ?	MM - MP				L M - L P					LP- MP			
Cythereis teiskotensis		LP								P					
Pontocyprella recurva	M	? EP - EE	MP-LP				M - MP								
Krithe echolsae		LP - EE	MP - LP				L Ca - LP								
Parakrithe crolifa		EE	MP - EME		LP										
Krithe gp calambainaensis		LP	LP - EE	LP	LP										
Reticulina sangalkamensis		? EP - EE	MP- EE						EP						
Paragrenocythere gravis		M-LP													M - EP
Buntonia pulvinata		LP			LP	EP		M - LP					MP - LP		
Phalcocythere cultrata		EP	LP - EE		LP					LP	LP				
Trachyleberis teiskotensis		LP			LP	LP				LP	LP				
Hornibrookella episcelis		M - LP													M - EP

Key-
Ca= Campanian
M= Maastrichtian
P= Palaeocene
E= Eocene
E= Early
M= Middle
L= Late

Table 6.1 Palaeogeographic distribution of important fauna from North Africa, West Africa and Middle East.

Several species cross the K/T boundary, and the beginning of the Danian is represented by an abundance of the genus *Paleocosta*; Thanetian and Ypresian faunas show strong similarities with those from West Africa. The species in common with this study are: *Paracosta bensoni* (Damotte and Donze), *Mauritsina coronata* Esker, *Protobuntonia nakkadii* Bassiouni, *Pontocyprella recurva* Esker, *Reticulina proteros* Bassiouni, ?*Ordoniya* (*o*) *burmaensis*, *Dahomeya alata* Apostolescu. In general the faunas recorded from Tunisia are very similar to those described from Libya, Egypt, Jordon and West Africa. This conclusion refutes that of Esker. The Tunisian faunas are mainly from deep water sediments, accounting for the differences between these and the Sirt Basin faunas.

Egypt-

Several studies of Palaeocene ostracods from Egypt have been published: Bassiouni (1969, 1970), Bassiouni and Luger (1990) and Boukhary *et al*, (1982.) The most comprehensive study is that of Bassiouni & Luger (1990) on the Maastrichtian-Early Eocene of the Western Desert. They recorded and illustrated 105 species and described three new genera (*Moosina*, *Reymenticosta* and *Rushdisaidina*). The sedimentary sequence has two hiatus; the first at the K/T boundary, the second between the Middle and Upper Palaeocene (See Luger, 1985 for more details). The ostracod faunas common to this study are *Pontocyprella recurva* Esker, *Dahomeya alata alata* Apostolescu, *Leguminocythereis lokossaensis* Apostolescu, *Buntonia tatteuliensis* Apotolescu, *Isohabrocythere teiskotensis* Apostolecscu, *Krithe echlosae* Esker, *Parakrithe crolifa* Cronin and Khalifa, *Parakrithe* ? *kalambaina* Reyment, *Mauritsina coronata* Esker, *Quadracythere kaoensis* Carbonnel *et al*, *Trachyleberis modesta* Apostolescu, *Occultocythereis confirmatus* El Sweify, *Paracosta paleomokattamensis* Bassiouni & Luger, *Reticulina sangalkamensis* Apostolescu, *Reticulina proteros* Bassiouni, *Buntonia* cf *tichitensis* Apostolescu, *Protobuntonia nakkadii* Bassiouni. Boukhary *et al*, 1982 studied lower Tertiary ostracods of the Jabal Dandara outcrops (Qena Nile valley) Egypt. Four species are in common with the current study, these are *Krithe* *echlosae* Esker, ?*Pontocyprella recurva* Esker, *Mauritsina coronata* Esker and ?*Ordoniya* (*o*) *burmaensis* Bassiouni.

Jordan-

Studies have been carried out by Bassiouni (1969, 1970) on ostracod faunas of Jordan. Bassiouni (1969) recorded seven species belonging to the genera *Costa* and *Carinocythereis* (*Reticulina*) from Palaeocene-Eocene sediments of Jordan; these species have similarities to Libyan ostracods but only one species is in common, i.e *Reticulina proteros*. Bassiouni (1970) gave more a detailed study on Maastrichtian, Palaeocene and Eocene ostracods of the subfamilies Mauritsina and Trachyleberidinae; eighteen species were obtained from marly chalky and flint limestones. These faunas show some similarities to illustrated specimens in this study whilst others are in common, i.e *Protobuntonia nakkadii* Bassiouni, *Mauritsina coronata* Esker and ?*Ordoniya* (*o*) *burmaensis*, These are quite often common between Libya, Tunisia and Egypt, but none of these are recorded from West Africa.

Niger-

Carbonnel *et al*, 1990 studied upper Palaeocene ostracod faunas from outcrops in Niger. They recorded 44 species which indicate infralittoral with occasionally circalittoral environments. The ostracod faunas of Niger fill a gap in the distribution of ostracods between North and West Africa. This will enhance the palaeogeographic reconstructions in the area. The fauna reported is very similar to the Libyan fauna and species in common exist: *Cytherelloidea musacea* Carbonnel, *Dahomeya alata* Apostolescu, *Krithe* gr *kalambaina* Reyment, *Buntonia tatteuliensis* Apostolescu, *Isohabrocythere teiskotensis* Apostolescu, *Quadracythere kaoensis* Carbonnel.

Nigeria-

Several studies have been published on ostracods from the Palaeocene of Nigeria: Reyment (1981), Foster *et al* (1983) & Ficarrilli (1976). Two main localities, NW Kalambaina and SW Ewekror areas have been studied in details. The Kalambaina

Formation is located in the north west of Nigeria, in a southern extension of the Iullemmeden Basin. This formation is widely distributed in the north and continues into the Niger Republic where it attains a maximum thickness of 18m at Malbasa quarry, and also into Mali. The Kalambaina Formation is very rich in ostracods which have contributed to the palaeogeographic reconstruction of the trans-Sahara epicontinental sea. Reyment (1981) states that Ostracoda of the Kalambaina Formation have species in common with the South Atlantic and Tethys. This evidence strongly indicates a link between the Iullemmeden Basin located on the central Saharan platform and extending beyond the Nigerian border into the western Niger republic, and eastern Mali. The sedimentary basins of coastal Nigeria and Libya during Palaeocene times had several ostracod species in common. 21 species recorded shows similarities to the Libyan fauna, and others are in common such as *Bairdia* gp *ilaroensis* Reyment and Reyment, *Krithe* gp *Kalambaina* Reyment, *Dahomeya alata* Apostolescu, *Buntonia tatteuliensis* Apostolescu, *Isohabrocythere teiskotensis* Apostolescu, *Paracosta* (*paracosta*) *wariensis* Reyment.

Foster *et al*, 1983 studied late Palaeocene ostracods of the Kalambaina Formation of north west Nigeria and the same sequences exposed in the Ewekoro limestone and Imo shale Formations in Southern Nigeria. They mentioned that ostracod faunas recorded from the Kalambaina Formation are more closely related to Tethyan types than to those of southern Nigeria, although there are species in common between these localities. This suggests some separation between these two regions of Nigeria during the Palaeocene. The species in common with Libya are *Buntonia furtunata*, *Isohabrocythere teiskotensis* Apostolescu, *Buntonia tatteuliensis* Apotolescu, *Trachyleberis modesta* Apostolescu.

Ficarrelli (1976) studied the whole sequence of the Sokoto Basin (N.W. Nigeria), giving details of Upper Cretaceous-Palaeocene sediments of the Skoto Basin and using foraminifera and ostracod faunas. The author recorded a few ostracods from the upper part of the Wurno Formation, a few species of *Paracypris* from the Dange Formation, but most species were recorded from the Kalambaina

Formation of Palaeocene age. Ostracod faunas recorded from these formations show similarities to the Libyan material and some of these are in common i.e *Bairdia magna* Alexander, *Isohabrocythere teiskotensis* Apostolescu, *Trachyleberis modesta* Apostolescu, *Buntonia tatteuliensis* Apostolescu, ?*Uroleberis glabella* Apostolescu. The associated benthonic foraminifera are *Discorbids*, *Rotalids*, *Cibicids* and *Nonionids* suggesting that the Kalambaina Formation was deposited in a shallow marine environment of not more than 50m depth.

South west Nigeria-

Reyment (1963, 1966) studied ostracods from the upper Cretaceous-Lower Tertiary, particularly Danian, Palaeocene and Eocene mainly from west and East Nigeria and Cameroons. He recorded fifty two species, of which four are common to the Libyan Material i.e *Dahomeya alata* Apostolescu, *Cythereis teiskotensis* Apostolescu, *Trachyleberis modesta* Apostolescu, and *Paracosta wariensis* and some other species having affinities with *Bairdia ilaroensis* Reyment and Reyment, and *Protobuntonia cf ioruba* Reyment.

West Africa-

In a classic work, Apostolescu (1961) studied in detail the ostracod faunas from the upper Cretaceous, Palaeocene and Eocene of Senegal, Ivory Coast, Dahomey-Togo and Mali. The faunas recorded show similarities to the Libyan specimens, i.e the Sirt Basin. Only one species, *Dahomeya alata* Apostolescu, is in common between the Lower Eocene of Senegal and Libya.

In the Ivory Coast four species are found in common with Libya *Legminocythereis lokossaensis* and *Dahomey alata* recorded from Lower Eocene, *Isohabrocythere teiskotensis* and *Buntonina fotunata* recorded from Palaeocene.

Three species from Dahomey and Togo have been found in the current study: *L lokossaensis* recorded from Lower Eocene, *Trachyleberis modesta* and *Buntonia fortunata* from the Palaeocene.

Species recorded from the Palaeocene of Mali in common with the Palaeocene of this study are *Trachyleberis modesta*

Apostolescu, *Isohabrocythere teiskotensis* Apostolescu, *Buntonia tattueliensis* Apostolescu, *Cythereis teiskotensis* Apostolescu.

Carbonnel (1986) studied Palaeogene and Neogene sediments of the Senegalo-guineen Basins; only four species are found in common with Libya, *Legminocythereis lokossaensis* Apostolescu, from the Palaeocene, *Dahomey alata* Apostolescu, from the Palaeocene-Eocene, *Reticulina proteros* Bassiouni and *Reticulina sangalkamensis* Apostolescu from the Danian

N.W Libya-

El-Waer (1992) studied upper Cretaceous-Early Tertiary ostracods from North western offshore Libya (Tarabulus Basin) and recorded one hundred and thirty three species and subspecies. Four species are in common to the present study these are *Legminocythereis lokossaensis* Apostolescu, *Dahomey alata alata* Apostolescu, *Petrygocythere tarabulusensis* El-Waer, and *Pontocyprella recurva* Esker; *Bairdia ilaroensis*, *Bairdia buisae* El-waer are similar to species found here.

Most ostracods from N.W Libya do not show a close similarity to North and West African faunas, and only three species are recorded from N and W Africa, *Pontocyprella recurva* Esker, recorded from Tunisia, Libya, Egypt, *Legminocythereis lokossaensis* Apostolescu, recorded from Egypt, Libya Sirt Basin, Libya NW offshore, Togo and Senegal, *Dahomeya alata alata* Apostolescu, Libya, Sirt Basin and offshore, Tunisia, Nigeria and Senegal. The dissimilarities of the fauna between North West offshore Libya and N. W. Africa are due to age difference; most of El-Wear's material comes from younger sediments, i.e Eocene, and few samples been taken from older sediments.

Saudia Arabia-

Al-Furaih (1980) studied Upper Cretaceous-Lower Tertiary ostracods, recording 71 species, three of which are found in common with the Libyan faunas: *Paragrenocythere gravis* and *Hornibrookella episcelis* which ranges from the upper Cretaceous-early Palaeocene in Saudi Arabia while *Paragrenocythere gravis* has a long range up to late Palaeocene in the Sirt Basin, the third species *Acanthocythereis stymatoura* is restricted to the lower Palaeocene of Saudia Arabia and is very similar to *Acanthocythreis stymatoura libyaensis* subsp nov recorded here from the upper Palaeocene of the Sirt Basin. Thus there is only a vague link between Libya and Saudia Arabia because most of Al-Furaih's faunas are not common to North and West Africa.

Previous workers on the Trans-Saharan Seaway

During Cretaceous times South America and Africa began to separate, with the south Atlantic Ocean being formed. The Trans-Saharan Seaway could not exist before the Turonian because the South Atlantic was not in existence until the Albian (Krommelbein, 1972). After complete separation of the supercontinent, periods of global transgression took place, submerging huge areas in Africa and leading to a connection between Tethys and the Gulf of Guinea via the Trans-Sahara Seaway.

Turonian transgression-

During this time a major transgression of Tethys occurred and large areas were submerged southward into East of the Hoggar area, where the Tethys water joined up with the Atlantic Ocean transgression passing through the Anambra Basin, south east Nigeria, and the Benue trough and continued further northward into Chad and Niger (Kogbe, 1981).

Maastrichtian transgression-

Furon, 1934 mentioned that there was a major transgression during the upper Cretaceous leading to the connection between Tethys and Nigeria through the area between Hoggar and Tibisti; he also remarked that the same link occurred at the beginning of the Eocene. The latter transgression corresponds to the maximum marine flooding during the Palaeocene in Libya recorded by Haynes (1962). In the mean time a major transgression reached its maximum during the Maastrichtian and extended northward to link up with the southern end of Tethys (Reyment, 1965, Kogbe, 1972b, Reyre, 1966, Adeleye, 1975). This transgression was widely distributed and is recognised on the basis of the ammonite genus *Libycoceras* sp recorded from Arabia, Palestine, Egypt, Libya, Niger, Nigeria and Angola (Reyment, 1965 & Arkell *et al*, 1968). This genus is important for Palaeogeographic reconstruction of the Maastrichtian in North and West Africa, and the absence of this genus along the Atlantic coast line of Western Africa (Senegal, Mauritania and Morocco) supports the evidence for a connection across the Sahara between Tethys and the Gulf of Guinea during the Maastrichtian. This Palaeogeographic reconstruction is supported by similar and common ostracod faunas recorded from Libya, Mali, Niger, Sokoto and Gulf of Guinea during Palaeocene (Kogbe *et al*, 1976) so that the connection formed a shallow Seaway throughout Nigeria, Niger, Mali, Algeria and Libya.

Palaeocene Transgression-

Berggren (1974) identified the Palaeocene transgression in North and West Africa, i.e Libya and Mali, on studies based on benthonic foraminifera. The Malian sediments were deposited in shelf areas less than 50m deep with a wide shallow seaway extending from Algeria to Nigeria. The Libyan Palaeocene sequences were developed in neritic environments, with depths around 200m in the structural lows of the Sirt Basin during transgressive periods.

The biostratigraphic and palaeogeographic studies of North West Africa indicate that the acme of the trans-Saharan transgression took place in late Palaeocene time. This South Tethys sea submerged the Malian region in the early stage of transgression i.e (Danian), as indicated by Apostolescu (1961) and Reyment (1966).

Kogbe *et al* (1976), Offodile (1976) and Offodile and Reyment (1977) believed that the Palaeocene marine connection between the Iullemedden Basin of the Sokoto region and Sahara occurred in the present Niger Valley.

Faunal analysis-

Apostolescu, 1961 published studies of the late Cretaceous-Palaeogene ostracods faunas from West Africa, (Senegal, Ivory

Coast, Togo, Mali and republic of Benin). This work is essential in the palaeogeographic construction Africa. Barsotti (1963) studied ostracods from the El-Fogha village and Well A1-85; he recorded 23 species of which 20 had been previously described by Apostolescu, 1961. This suggested that the majority of species could have migrated from the south. Reyment (1963, 1966), gave more detailed studies of Nigerian upper Cretaceous-lower Tertiary ostracods faunas, noticing that a large number of species are common to North and West Africa i.e Libya, NW Nigeria, Mali and Niger.

Reyment and Reyment (1981) studied Palaeocene ostracods from well A5-32 in the Sirt Basin Libya. They found at least 24 species in common with West Africa, indicating that the maximum transgression occurred in the late Palaeocene and the sea was widespread throughout the Gulf of Guinea, Niger, Mali, Algeria and Libya.

Egyptian faunas from the Western desert (Bassiouni and Luger, 1990) show higher percentages in common with Libyan faunas than those of West Africa. West Africa species are however present in Egypt and these faunas support a link between south Tethys and the Gulf of Guinea.

The wide distribution of the Libyan faunas in North and West Africa support the link between Tethys and Gulf of Guinea by a shallow seaway through Niger, Mali, and NW Nigeria during the Maximum transgression of the late Palaeocene. This connection has been confirmed by Furst (1968) and Desio (1970).

Summary-

1-The ostracods species recorded from the Lower Tertiary of the Sirt Basin and outcrops show similarities with those previously described from North and West Africa, and the Middle East. This provides a strong support for earlier conclusions reached by Barsotti (1963) Reyment (1963, 1966) Berggren (1974) Kogbe *et al*, (1976) Reyment and Reyment (1981) and Bassiouni and Luger (1990) for a shallow marine connection between South Tethys and the Gulf of Guinea. (Fig 6.1)

2- The exchanges of faunas took place during the maximum sea level rise during the late Palaeocene so that both faunas are mixed together in the Iullemeden Basin that extends from Sokoto, North West Nigeria. western part of Niger and Mali. The faunas could have migrated either way.

3- Ostracods such as *Leguminocythereis lokossaensis* and *Dahomeya alata* Apostolescu, recorded along the North and West African coast line could have migrated due to current activities of deeper water and could not tolerate the shallow water trans-Saharan sea.

4- The shallow marine trans-Saharan connection between south Tethys and the Gulf of Guinea during the maximum flood of the late Palaeocene transgression through Mali, N.W Nigeria (Iullemeden Basin) Reyment & Reyment (1981) on the basis of faunas recorded by Carbonnel, (1990) from the Niger shows that this shallow sea covered Niger as well.

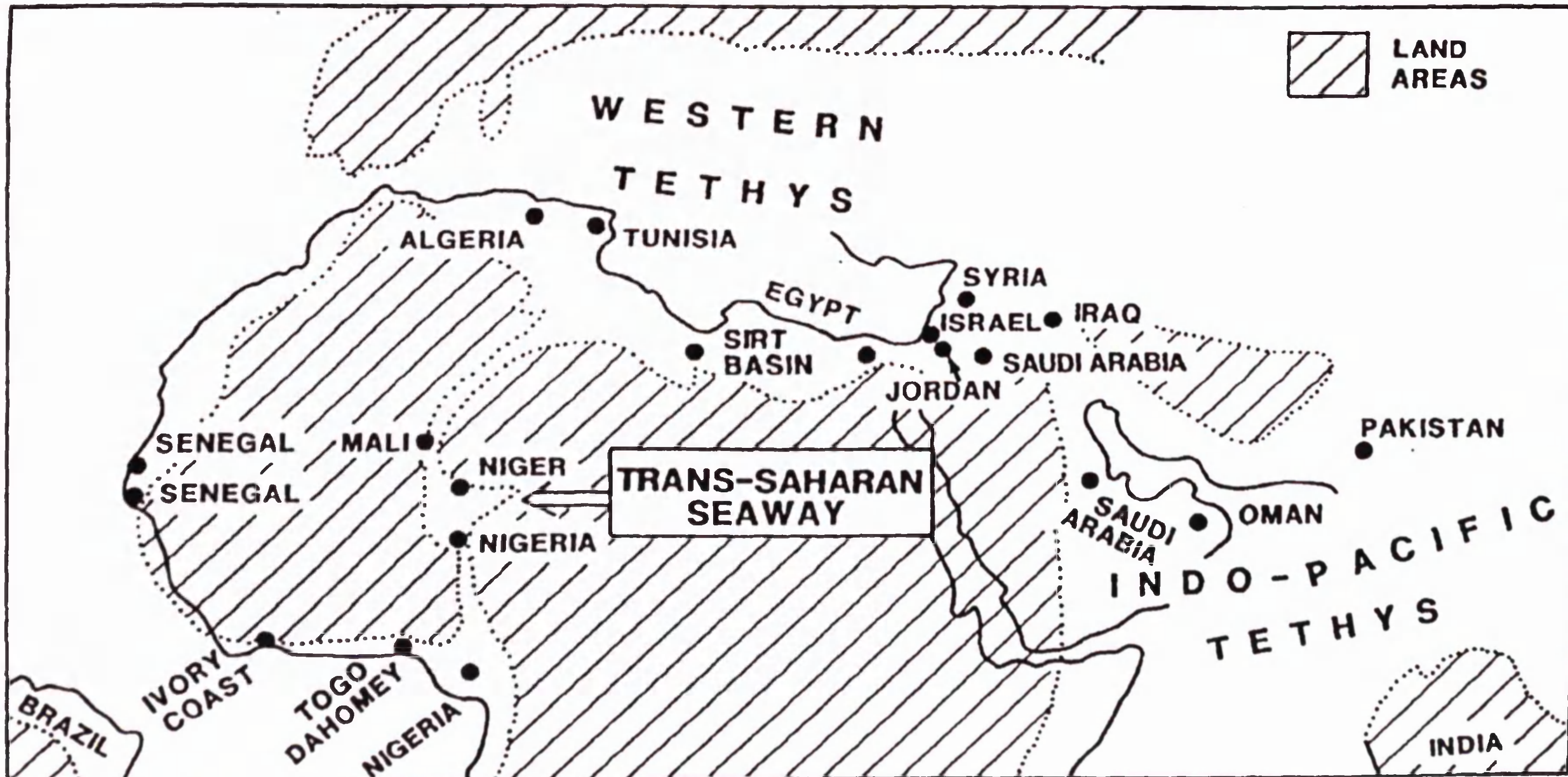


Figure 6.1 Trans-Saharan Sea way during late Palaeocene (After Keen *et al*, 1994)

CHAPTER SEVEN

CONCLUSIONS

Conclusion

35 new species and subspecies have been recorded in this study from the Sirt Basin and the outcrop sections.

Four ostracod biozones can be recognised in the sequences from 5 wells in the Sirt Basin these are: A assemblage zone of lower Eocene age characterised by the following species: *Leguminocythereis lokossaensis*, *Buntonia* sp cf *B tichittensis*, *Isohabrocythere teiskotensis*, *Buntonia tatteuliensis* and *Parakrithe crolifa*; B *Paracosta bensoni* biozone, of Upper Palaeocene age; *Paracosta paleomokattaemnsis* zone of Middle Palaeocene; and a Lower Palaeocene biozone recognised by the last downhole appearance of *Paracosta paleomokattamensis* although this cannot be recognised accuretely in the wells.

The ostracods recorded in this study indicate Palaeocene and early Eocene ages for the strata, rather than Palaeocene only (Barr & Weeger, 1972). The environment of deposition in the wells shows shallowing upwards sequences, from outer shelf to inner shelf during Palaeocene time with slightly deepening at the beginning of the Eocene. The outcrop sections indicate a shallow marine environment with Afro-Tethyan type ostracods of Bassiouni and Luger (1990).

The boundary between the Khalifa Formation and the Hagfa Formation was clearly defined using graphic correlation techniques.

The Trans-Saharan shallow seeway between Southern Tethys and the Gulf of Guinea during the upper Palaeocene is indicated by the species in common between North Africa and West Africa.

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APPENDICES

Appendix- 1

Description of the samples:

Material examined in this study include both ditch cutting samples from wells, and samples collected from measured outcrop sections.

A- Ditch cutting samples from five Wells PP2-6, AA1-6, KK1-6, YY1-6 and 3H1-6 drilled in concession six by Esso Standard Inc: a total of 321 unprocessed samples were involved in this study, 56 samples from well PP2-6 collected at 40 feet intervals, 84 samples from well AA1-6 collected at 60 feet intervals, 76 samples from well KK1-6 collected at 60 feet intervals, 49 samples from well 3H1-6 collected at 60 feet intervals and 56 samples form well YY1-6 collected at 40 feet intervals.

B- Outcrops samples:
48 samples from outcrops along the south western border of the Sirt Basin: 29 samples from the Heira depression and 19 samples from El-Fogha village.
These samples were processed as set out in the Appendix 2.

El-Fogha section
Location:

Latitude 27° 49' 18" N
Longitude 16° 22' 59" E

Sample No	Thickness	Lithology
F 20	0.35 metre	Light grey massive very hard dolomite capping section.
F 19	1.4 metre	Buff soft limestone, no obvious macrofossils
F 18	0.45 metre	Clays / shall appears to greenish in "cave" but buff in light

F 17	.95 metre	Yellowish marls, medium hard, with scattered shelly of some Oysters (Plicatula). Oyster bed at top of this indurated layer.
F 16,15,14		7.5 metre Grey marls with an indurated layer 3m. from the base (F15) and scattered shells (oysterPlicatula) near top, F14, 1.5 metre base, F16, 5 merte from base.
F 14	1.5 metre	lost during shipping of the material from Libya to U.K
F 13	0.8 metre	Hard bioturbated yellowish limestone
	1.5 metre	Hard yellowish limestone, with infaunal bivalves in life position, epifaunal type (large) bivalves seen in the talus with abundant forams.
F 12	0.40 metre	Bioturbated yellowish limestone. hard bed
	0.45 metre	Rubbly limestone with echinoderms, Bioturbation when weathered appears rubbly but not as much as in overlying bed.
F 11	1.2 metre	Light yellowish shales, gypsum veins present, bioturbated in the lower part, with oysters. *Nautilus* collected,18cm diameter, with oyster epibionts around ventre.
F 10	0.8 metre	Limestone with echinoid and has bivalves in life position (Myids).
	0.55 metre	shales light grey, wavy bedding seen , bioturbation.
	0.5 metre	Reddish weathering hard marl / limestone, with oysters.
F 9	1.5 metre	Prominent grey clay an exposure, contains Miliolidae and ostracods. oysters, small worm tubes (3 mm diameter horizontal orientation)
F 7, 8	3 metre	White chalky marl, bedding not obvious, because more argillaceous upward; fossiliferous with bivalves and gastropods, preserved as shells and moulds; F7 collected near base, F8 near top.

F 6	1.7 metre	Buff weathering limestone, White colour when fresh. shell beds seen at 40-70 cm from the base. Scattered shells seen at other levels seem to be bivalves, forams *Operculina*.
	1.95 metre	friable grey shales with abundant gypsum veins.
F 5	0.15 metre	Reddish coloured hard marl, (dolomitic calcareous) with bivalves internal and external mould, and ostracodes.
	0.35 metre	Grey shales with lots of fibrous gypsum.
	0.7 metre	buff coloured dolomitic marl/limestone.
F 4	0.2 metre	Grey shales with lots of gypsum crystals. irregular base and top; contains lenses of buff coloured dolomitic marl /limestone.
F 3	0.95 metre	Buff coloured dolomitic marl/limestone, moderately hard, with shales in the lower part, gypsum crystals are present, as well as shell fragments.
F 2	0.4 metre	Grey marl, react with HCl, small lenses of shells, seen most of which seem to be ostracods; gypsum crystals are present.
F1	0.7 metre	Pale grey calcareous marl/limestone, moderately hard, probably dolomitic because only slightly react with HCl, No obvious fossils.

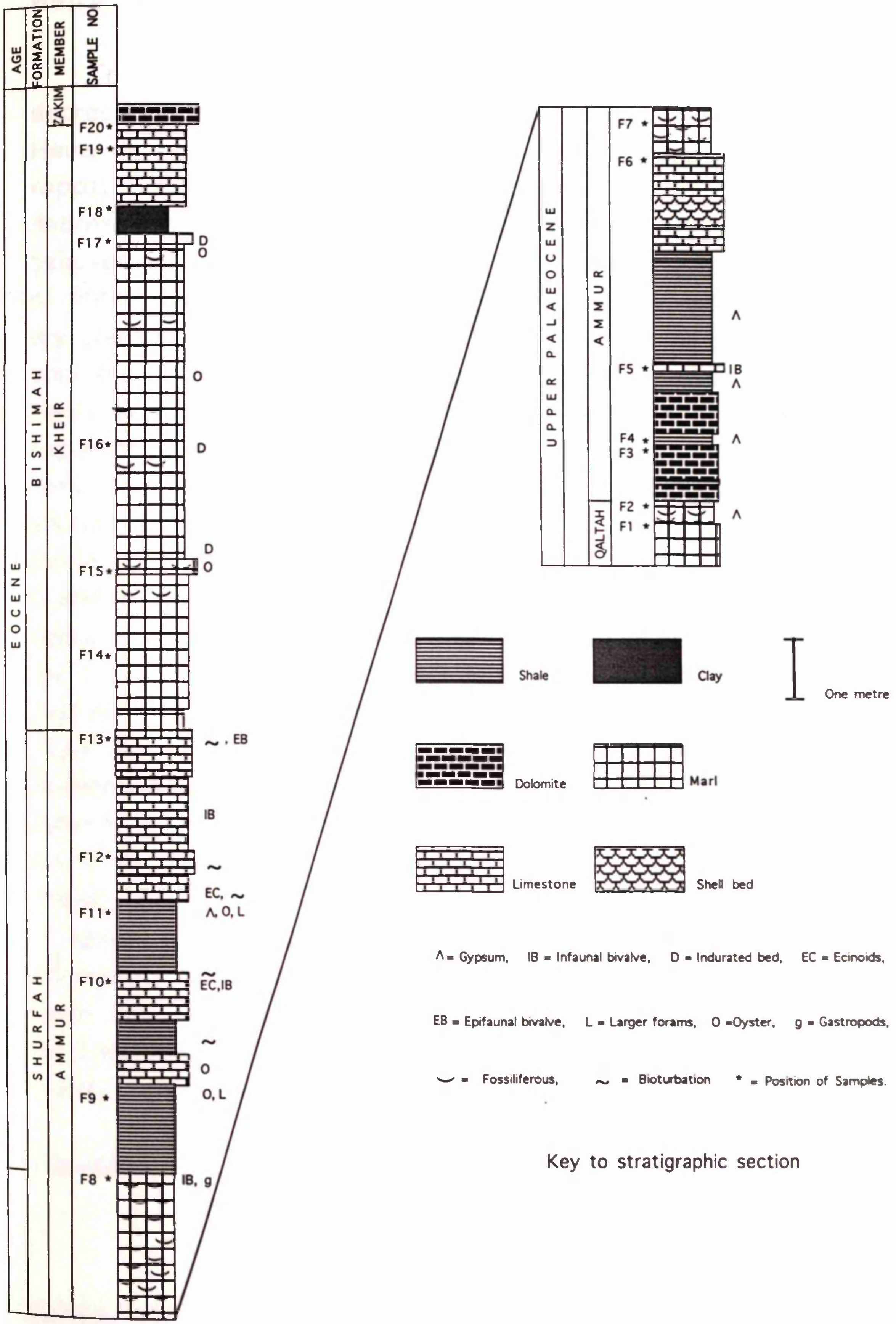


Figure 7.1 Geological section of El-Fogha area

Heira Section:

The Heira depression is one of a series of roughly circular depressions found in the region around El-Fogha. The geology of the Heira depression has previously been described by Brown (Internal report Esso oil company 1958) and Woller(1984). These depressions are named "Gararat" = depressions in Arabic; they are believed to have been formed in a semi-arid climate by weathering of rocks during more humid periods followed by eolian erosion in dry periods. Their location does not appear to be related to any geological structures such as gentle doming (Woller, 1984). The Heira depression was chosen for study because it is the largest exposing a succession from the late Cretaceous through to the early Eocene (Woller 1984). It was hoped to use this as a reference section to be correlated with subsurface sequences in the Sirt Basin. Unfortunately once in the field it was difficult to relate the sections given by Woller (1984) to the section observed. The sections measured have been related to prominent ledges seen in the depression formed by harder rocks (Fig. XX). The base of the section was taken at the lowest point where rocks could be observed, which were believed to be Upper Tar. However subsequent analysis leads to the belief that the measured section actually commenced in the Buras member. The section began in black to dark-grey shales which were not described by Woller (1984); the first hard layer, an echinoid-rich dolomitic limestone is taken to be the lowest part of the Qaltah member. It is interesting that Brown (1958 internal report Esso) described the Heira Shale at Heira, which includes shales similar to the ones at the base of the section measured here. The Heira Shale of Brown is mostly equivalent to the Shurfa Formation of Woller(1984).

Location S4:

Latitude 27° 33' 57" N
Longitude 16° 07' 63" E

Sample No Thickness Lithology

Bed-1

The top of this section is the flat surface at the top of the Qararah. The top 10 metre is formed of dolomitic shales and gypsum. the shales are frequently contorted and the gypsum brecciated. The basal 1-2 metre consists of brecciated gypsum.

Bed-2

4.5 metre Grey marl becoming increasingly dolomitic upwards.

The basal half of this bed is a grey coloured marl; thin lenses (0.5cm thick) of brown weathering dolomites { field appearance is as a siltstone} appear at about 2 metre from the base and become thicker upwards through the unit, becoming more continuos laterally, but still forming impersistant beds. From 3.60 metre from the base these dolomites are dominant, with subordinate marl. The top 30 cm is a well bedded laminated "siltstone", forming "flagstones"; some ripple marked bedding planes are present, with two types of horizontal trace fossils: 1cm thick tubular traces extending for 30 cm, and 0.5 cm meandering traces; Salt Pseudomorph (?) and rain pits(?)are present. the very top of this bed is bioturbated with 1 cm diameter burrows.

S5-5		30 cm at the top
S4-4		3.4 metre from the base unit.
S4-3		2 metre from the base is a prominent laminated10 cm . thick dolomite.
S4-2		1 metre above S4-1
Bed-3		
S4-1	30 cm	Indurated marl layer, pink weathering.
	2.35	metre grey marl

Location S3:

Latitude 27° 33' 83" N

Longitude 16° 07' 79" E

The top of this part of the section is a platform formed by 3 closely spaced prominent pink weathered hard beds with intervening softer beds. In detail the distinction between the hard and soft beds is not so clear as they grade into each other and the middle hard bed tends to be urecognisable in a clean unweathered section.

From the top:

	50 cm	Hard limestone with Spatangoid echinoides.
	30 cm	Cream coloured marl, much bioturbation; large bivalves.
S3-7	70 cm	Hard limestone, numerous Spatangoid echinoids.
S3-6	40 cm	Cream coloured marl, much bioturbation.
	70 cm	Hard cream coloured limestone with Spatangoids, sand dollars, abundant shell fragments.
S3-5	2.5 metre	Hard buff coloured dolomitic marl, weathering appears shale like.
S3-4	24 cm	Indurated layer with Myid bivalves in life position.
	55 cm	Green "Shales".
	10 cm	Oyster bed, with Ophiomorpha, Chondrites, and 1 cm diameter horizontal burrows (Thalassinoides ?).
S3-3	110 cm	Green "shale" .
S3-2	0-10cm	Pebble bed: Pebbles are small (.5 cm) , scattered { i.e matrix support}, black in colour (Phosphatic?), rounded; common Oyster shells both whole and fragmentary, plus other shell fragments, most shells are broken. The Oysters probably represent a reworked hard ground to which they were cemented. Pebbles are found in lenses, infilling erosional depression upto 10 cm thick pebbles are present in the basal 30 cm of the overlying shales.
S3-1	40	From marl below pebble bed. Section obscure for approximately 3 metre below this and the top limestone of S2

Location **S2:**

Latitude 27° 33' 49" N

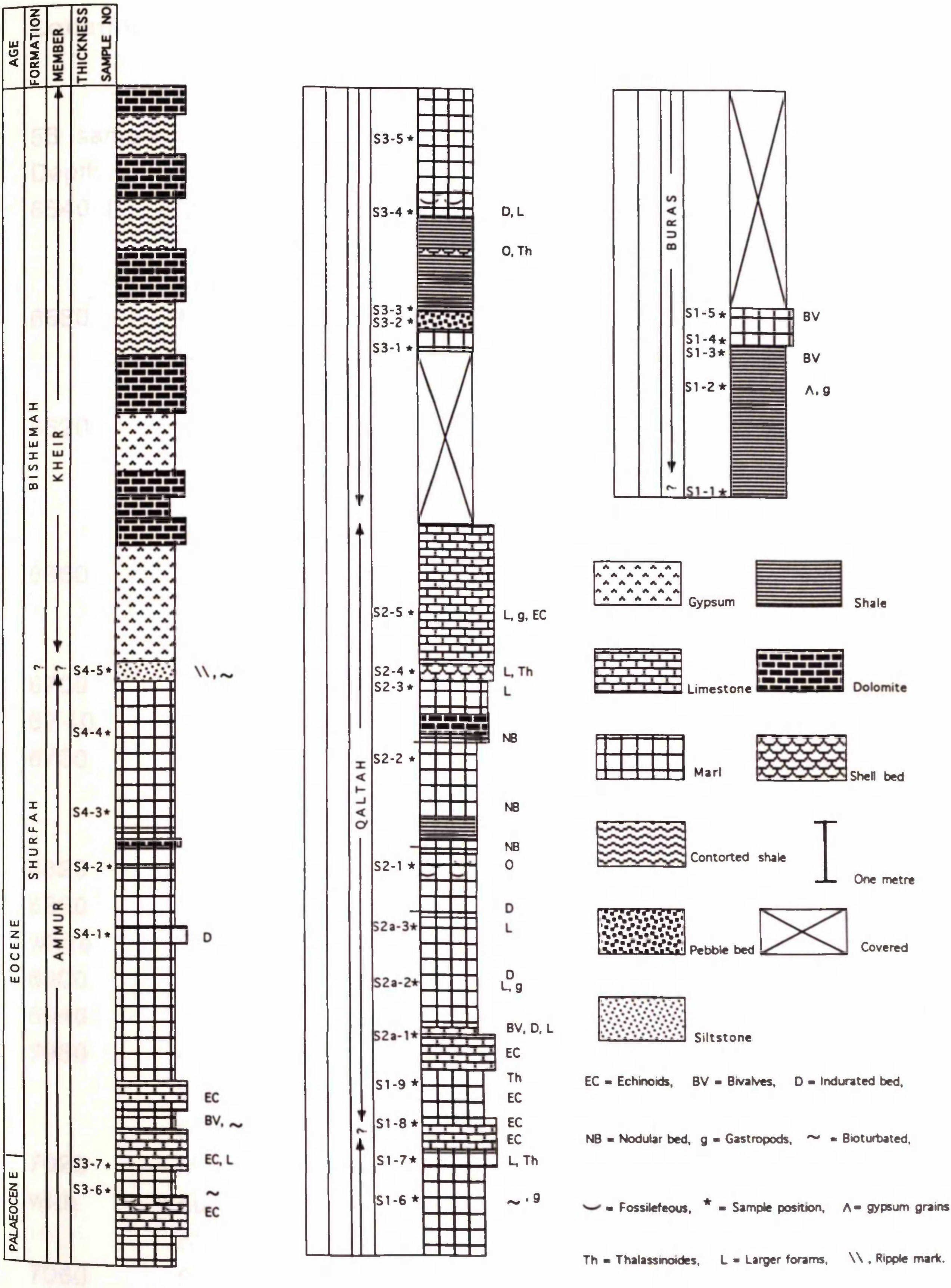
Longitude 16° 07' 60" E

Sample No	Thickness	Lithology
S2-5,4	2.7 metre	Limestone, pink when weathered, white when fresh; forms a prominent ledge The top of the ledge tending to appear rubbly due to weathering, very fossiliferous with Spatangoid echinoids, "sand dollars" internal moulds of gastropods; .5 cm diameter horizontal burrows systems.
S2-5		sample **5** from 1.5 metre from top. The basal S2-530 cm is sample **4** formed by a bed of broken shells which has small Thallassinoides burrows system.The section between the hard pink limestone consists of yellow grey marls which weathered to a friable "shaley" condition.Indurated nodular layers occurs at approximately 1 metre interval; from the top down wards:
S2-3	55 cm	Hard greenish- yellow- grey marl, grey marl with large (30-40) tabular dolomitic.
	15 cm	Nodule bed.
S2-2	110 cm	Grey marl.
	20 cm	Nodular bed.
	40 cm	Grey shale with nodules.
	20 cm	Nodule bed.
S2-1	9 cm	Light grey / yellow marl with a bed of shell lenses, lithified, mostly (oyster Plicatula?) shells are fragmentary as well as complete.
	20 cm	Indurated nodular layer.
S2a-3	90 cm	Grey marl.
	20	Indurated nodular layer.
S2a-2	90 cm	Grey marl.
S2a-1	5-10 cm	Indurated shell bed with bivalves.

Location S1:

	Latitude	27° 33' 47" N
	Longitude	16° 07' 36" E

Sample No	Thickness	Lithology
Bed 3	2.25 metre	
	60 cm	Hard pink limestone, with Spatangoids.
	30 cm	Marl with extensive Thalasonoides.
S1- 9	50 cm	Marl with Spatangoids.
S1- 8	15 cm	Rubbly limestone, also with Spatangoid echinoids
	45 cm	Hard prominent pink- weathering limetone form a ledge wih abundant Spatangoid echinoids
S1- 7	20-25 cm	From burrow infill Thalassinoides burrow systems forming a prominent 20-25 cm bed on the underside of limestone ledge; these occur in the top 20-25 cm of the underlying marl.
Bed 2	?6 metre	grey marl; basal 65 cm and top 1.5 metre is seen; sample **4** from the base, **5** from 65 cm, **6** at the top
Bed 1	2.6 metre	Black-grey organic rich(?) Shale with secondary gypsum; very friable and "shaley" when weathered, becomes less so when fresh, plastic texture, Bivalves present in the top part; this grades into the overlying grey marl.
S1- 3		at the top shells
S1- 2		2 metre from the base.
S1-1		at the base.



Key to stratigraphic section

Figure 7.2 Composite section of Heira

Location of well PP2- 6.

Latitude 29° 7' 59" N

Longitude 19° 50' 11" E

56 sample obtained as follows:

Depth	Lithology.
6540 ft	Mainly calcareous shale, light green to grey, soft, calcareous, gummy blocky, with trace of brown quartz grains.
6580	Mainly limestone pale yellow to brown, medium hard, with 20 % of calcareous shale, light grey to light green, and trace of anhydrite.
6620	Mainly argillaceous calcilutite, pale yellow to brown, vaggy, with trace of white soft chalky grains, light green shale, glauconite, and quartz grains, with fossil fragment i.e Nummulite.
6660	Mainly argillaceous calcilutite of creamy, pale yellow-brown highly fossiliferous, with 20 % of whites chalky, and trace of brown quartz grains.
6700	Similar to 6660.
6740	Similar to 6660.
6780	50 % Calcarentes, pale yellow, creamy, 30% Limestone, buff in colour, medium hard, 20% of white soft Chalky, with trace of grey shale.
6820	Similar 6780 with fossil fragment of Nummulite.
6860	Mainly Calcilutite, pale yellow to brown, with trace of
white	Chalk, with light grey Limestone, medium hard.
6900	Similar to 6860.
6940	Similar to 6860.
6980	Mainly Limestone, buff to light grey in colour, medium, fine crystalline, in parts, with 10% of Calcarenite, light grey, friable.
7020	Mainly Limestone, buff, light-dark grey, medium hard,
with	about 10 % of Calcarenite, whitish in colour, and trace of Quartz grains.
7060	Similar to 7020.
7100	Mainly Limestone, light grey in colour, medium hard, with trace of white soft Chalky, and grains of dark brown chert.

7140	Mainly Limestone, light to grey in colour, medium hard, with 10% of light grey to green shale, with trace of white soft Chalky, and fossil fragment of Bryozoan.
7180	Mainly Limestone, grey in colour, medium hard, 20% Calcarenite, light grey in colour, 10 % Shale, light grey to green in colour, fissile with trace of Quartz grains.
7720	Similar to 7180.
7260	80% Shale, light grey to Olive green, in colour, fissile, slightly Pyretic, 20 % Calcareous Limestone, light grey, medium hard, with trace of cherts and Quartz grains.
7300	Mainly shale light gery to olive in colour, with fossil fragment of Foraminefera and trace of calcareous limestone and quartz grians.
7340	Mainly shale light grey rarely dark grey, olive in colour, fissile, with trace of calcareous, light grey, medium hard.
7380	Mainly shale, grey to light green, in colour, fissile, soft, with trace of calcarenite, light grey in colour.
7420	Similar to 7380 with pyretic grains.
7460	Similar to 7380.
7500	Similar to 7380 with trace of grey limestone, very hard, highly fossiliferous i. e gastropods and Forams.
7540	Mainly shale, light to dark grey in colour, splintery, with trace of grey to light yellow grains of limestone, medium hard.
7580	Similar to 7540.
7620	Similar to 7540, with trace of calcilutite, buff in colour, and quartz grains.
7660	Similar to 7620.
7700	Similar to 7540, with pyretic grains.
7740	Similar to 7620.
7780	Similar to 7620, with trace of fossil fragments.
7820	Similar to 7540.
7860	Mainly shale, light to dark grey, fissile, splintery, with trace of limestone, light grey, medium hard, and calcilutites, buff to light yellow, friable, with pyretic grains and fossil fragments.
7900	Similar to 7860.

7940	Mainly shale, light to dark grey, fissile, splintery, with traces of limestone, light grey, medium hard, and trace of micritic limestone, yellowish to brownish in colour, very hard.
7980	Simialr to 7940 , with pyretic grains.
8020	Mainly shale, light to dark grey, light green to olive in colour, fissile, splintery, with trace of limestone, light green, medium hard.
8060	Similar to 8020
8100	Similar to 8020.
8140	Similar to 8020.
8180	Mainly shale, light to dark grey, fissile, splintery, with trace of limestone, light grey, medium hard, and grains of pyrite.
8220	Similar to 8180.
8260	Mainly shale light to dark grey, rarely green olive, fissile,splintery, with trace of limestone, light grey to grey in colour, very hard, calcilutites , buff to yellowish, medium hard, and pyritic grains.
8300	Similar to 8260.
8340	Similar to 8260, with bryozoan fragment.
8380	Similar to 8260.
8420	Similar to 8260, with foraminifera fragments.
8460	Similar to 8260, with quinqueloculina forams.
8500	Similar to 8260.
8540	Similar to 8260, with bryozoan fragment.
8580	Similar to 8260.
8620	Similar to 8260.
8660	Similar to 8260, with 10% of limestone, varied in colour, light grey to grey, hard, white yellowish micritic , medium hard.
8700	Similar to 8260, with 30% limestone, varied in colour, light grey to grey, hard, white yellowish micritic limestone, medium hard.
8740	60% limestone, grey to light grey in colour, medium hard, 40% shale , light grey to grey, fissile, calcareous.

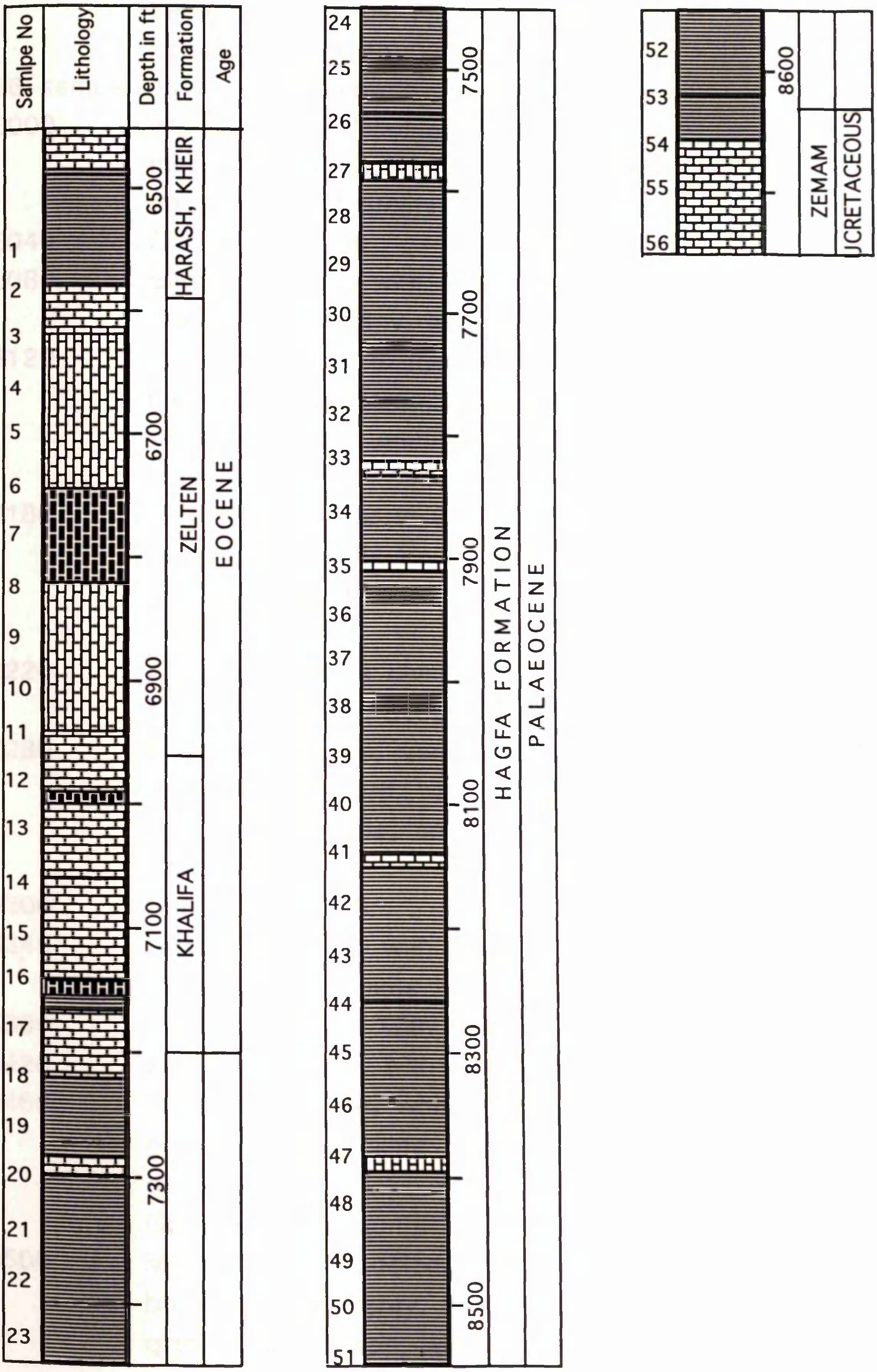


Figure 7.3 Stratigraphic section of the Early Tertiary in the Well PP2-6

Location of well YY1- 6.

Latitude 29° 04' 55" N

Longitude 19° 45' 09" E

56 sample obtained as follows:

6000	Argillaceous calcilutites, light tan to buff in colour, medium hard, with fossil fragments of forams, and trace of quartz grains and cherts.
6040	Similar to 6000.
6080	Similar to 6000, with 10% shale, light grey, grey to green, soft, gummy, and trace of pyritic grains.
6120	70% shale, light to medium grey, green to grey, soft, gummy,30% calcareous limestone, light grey to grey, white to yellow, medium hard, with trace of micritic limestone.
6180	40% shale similar to 6120, 20% limestone, grey, very hard, 40% argillaceous calcilutites, light grey, whitish, medium hard, with trace of quartz grains, and fossil fragment.
6220	40% argillaceous calcilutites, 40% limestone, 20% shale, similar to 6180.
6280	Mainly limestone, varied colour, white to buff, yellow, grey, medium hard, with traces of shale, light grey to light green, fissile, and white soft chalk, with fossil Borelis sp.
6300	Similar to 6280.
6340	Similar to 6280, with Coral fragments, Foraminifera fossil of Nummulites, and Quinqueloculina.
6380	Similar to 6280, with trace of glauconite.
6420	Similar to 6280, with Coral fragments.
6460	Mainly limestone, white, buff, yellowish, brownish, hard, microcrystalline, 10% shale, light grey to light green, fissile, 5% of quartz grains, and trace of Coral fragments.
6500	Microcrystalline dolomitic limestone, yellowish to brownish, lightgrey, hard, with traces of shale , light grey to light green, with fragment of Forams, and white soft chalk.
6540	Similar to 6500, with Coral fragment.

6580	Mainly limestone, buff, light grey to grey, hard, with microcrystalline calcite, 10% shale, light grey to light green, and trace of white soft chalk, and Quartz grains.
6620	Mainly limestone light grey to light green, hard, with 10% calcarenite whitish, medium hard, and trace of shale light grey to light green.
6660 30%	Mainly calcilutites, whitish to earthy, medium hard, limestone light grey to light brown, hard , with trace of shale and pyritic grains.
6700	Similar to 6660, with 10% of shale, light grey to light green, fissile.
6740	Similar to 6660.
6780	Similar to 6660.
6820	Similar to 6660, with coarse transparent quartz grains.
6900	Mainly calcareous limestone, light grey, medium hard, 30% shale, dark grey, splintery, fissile, with trace yellowish to transparent quartz grains.
6940	Similar to 6900, with Coral fragments and forams.
6980	Similar to 6900, with foraminifera faunas.
7020	Mainly shale , slightly grey to dark grey, partly brownish, fissile, splintery, with 20% argilaceous limestone, , light grey to dark grey, medium hard, with trace of white soft chalk, foraminifra faunas, and transparent quartz grains.
7060	Similar to 7020, with trace of pyrite.
7100	Similar to 7020, with pyritic grains.
7140	Mainly shale similar to 7020, 5% argillaceous limestone, similar to 7020.
7180	Similar to 7140.
7220	Similar to 7120.
7280	Similar to 7140.
7320	Mainly shale, light grey to dark grey, partly brownish, fissile, splintery, with 5% limestone, whitish to light grey, fossil fragment of Gastropods, and traces of pyritic grains.
7360	Similar to 7320, with trace of argillaceous calcilutites, whitish, moderately hard.
7400	Similar to 7320.

7440	Similar to 7320.
7480	Similar to 7320.
7580	Shale, grey to dark grey, splintery, fissile, partly brownish with trace of limestone, whitish to light grey, medium hard.
7620	Similar to 7580, with15% limestone, varies colour, whitish to light grey, brownish, very hard, with bivalves fossils and gastropods.
7660	Similar to 7620.
7700	Similar to 7620, with glauconites, trace of calcareous siltstone.
7740	Similar to 7620.
7780	Similar to 7620, with pyritic grains, and siltstone, light grey, fine grains, medium hard.
7820	Similar to 7780.
7860	Similar to 7780, with trace of siltstone, very fine to fine grains, whitish to light grey, medium hard, with glauconites .
7900	Similar to 7860.
7940	Similar to 7860.
7980	80% calcareous shale, light to dark grey, rarely brown, fissile, splintery, soft with, 10% siltstone, whitish, light grey to dark grey, medium hard, very fine to fine grains, with glauconites, grains, and 10% limestone, grey dark grey, brownish crystalline, very hard, and trace of fossil fragments and pyritic grains.
8020	Similar to 7980.
8060	Similar to 7980, with less amount of limestone.
8100	Similar to 7980.
8140	Similar to 7980.
8180	Simlar to 7980.
8280	Similar to 7980.
8320	Similar to 7880, with 20% limestone, whitish to yellowish, light grey to dark grey, medium hard.
8360	50% shale similar to 7980, 50% varies colour limestone, whitish yellowish, light grey to dark grey, medium hard,
8400	Similar to 8360.

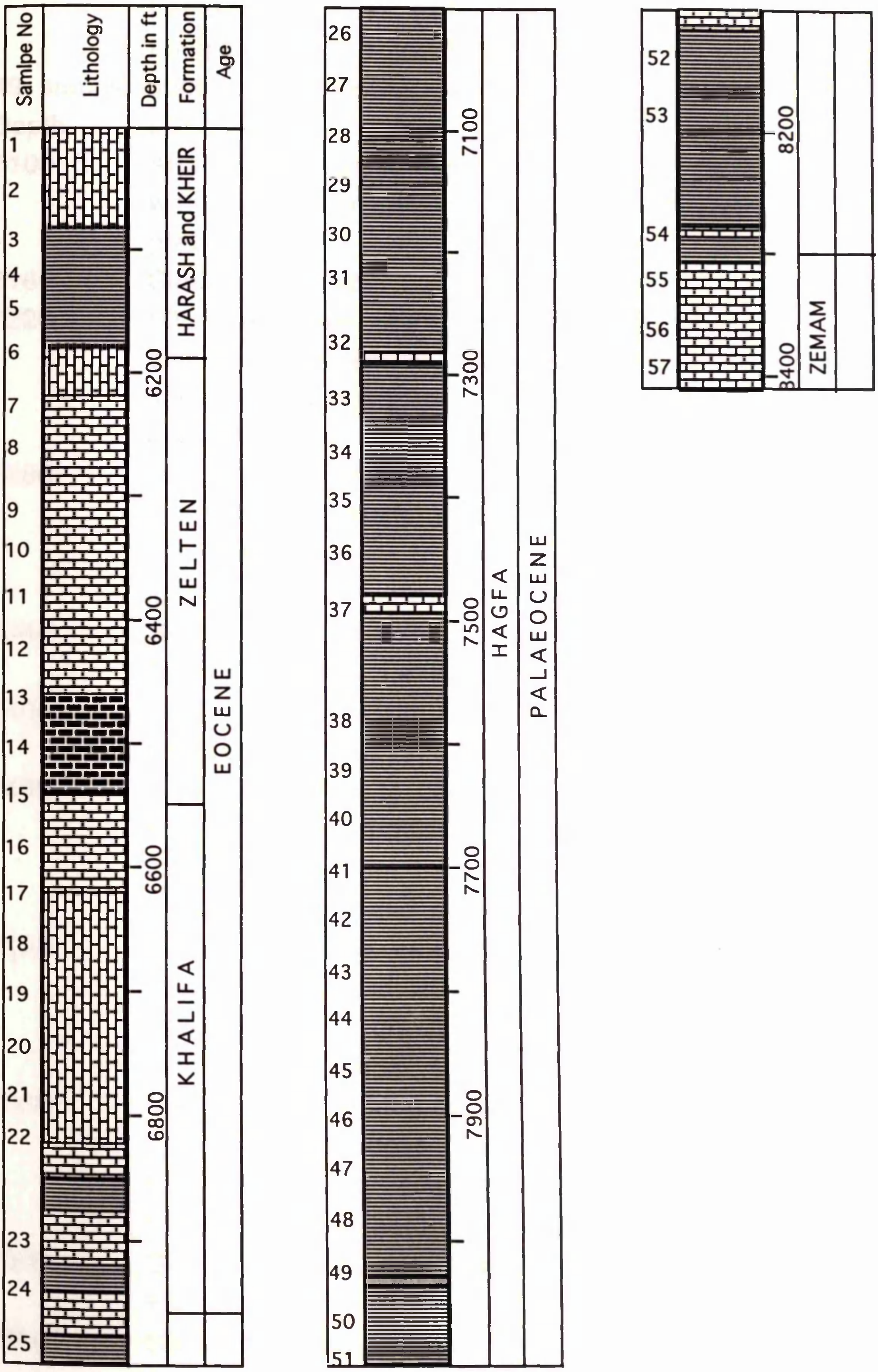


Figure 7.4 Stratigrahpic section early Tertiary Well YY1-6

Location of well 3H1- 6.

	Latitude 29° 13' 24" N
	Longitude 20° 1' 27" E
49 sample	obtained as follows:
Depth	Lithology.
7100 ft	Argillaceous calcilutites, light brown to brown, soft, with trace of limestone, light grey, hard, and glauconites.
7160	Similar to 7100.
7220	50% calcareous shale, light grey, soft, fissile, 30% calcilutites whitish in colour, with glauconites, 20% limestone, light brown to light grey, hard with coarse crystalline.
7280	Mainly shale, light grey to dark grey, light green , partly brown, fissile splintery with trace of calcilutites, whitish to buff, medium hard, and limestone , light grey, hard, with pyritic grains.
7340	Similar to 7280, with trace of anhydrite and trace of fossil fragment. i.e Bivalves.
7400	Similar to 7280. with Gastropods fossils and trace of coarse calcite crystalline.
7460	50% shale, light to dark grey, brownish, fissile, splintery, 50% argillaceous calcilutites, whitish, to light grey, medium hard, with traces of limestone, dark grey, very hard. and pyrite grains.
7520	60% argillaceous calcilutites, whitish, light to dark grey, medium hard, 40% shale, varies colour, light to dark grey, light green, brownish, fissile, splintery, with pyritic grains.
7580	Mainly shale, light grey, rarely dark grey, fissile splintery, with traces of limestone, light grey very hard, and vaggy calcilutites and calcarenites, whitish, to grey, medium hard, with pyritic grains.
7640	Similar to 7580, with fossiliferous faunas i. e Foraminifera.
7700	Shale, light grey, rarely dark grey, light green, with traces of limestone, dark grey, very hard, and pyritic grains.

7760	Mainly limestone highly fossiliferous, buff, grey, light, light brown, crystalline very hard, with trace of whitish soft chalky, and vaggy calcilutites and calcarenites, whitish, medium hard, and 10% of shale, light grey to light green, fissile, splintery.
7820	50% shale, light grey to light green, fissile, splintery, 40% calcarenites, whitish to buff, medium hard, 10% limestone, light grey, to dark grey, crystalline, very hard.
7890	Mainly limestone, light brown, grey to buff, hard, and buff calcilutite to earthy calcareintes, medium hard, and 10% shale light grey to light green, fissile , splintery.
8940	Mainly limestone and argillaceous limestone, of varies colour, buff to light grey, light brown, medium hard, 10% shale, light grey to light green, fissile, splintery.
8000	Similar to 7940.
8060	Mainly limestone partly crystalline, pyritic, varies colour, light grey to dark grey, buff, hard, with 5%calcareous shale, light grey to grey, medium hard.
8120	50% shale, grey to dark grey, light green, fissile, splintery, partly calcareous, 50% limestone, varies colour, tan, grey to dark grey, medium hard, partly crystalline, traces of calcarenites of light to earthy , medium hard.
8180	Shale light grey to dark grey, light green, fissile, splintery, partly calcareous, pyritic, with fossil fragments.
8240	Similar to 8180.
8300	Similar to 8180.
8360	Similar to 8180, with Gastropods fossils.
8420	Shale, light grey to dark grey, partly calcareous, fissile, splintery, with trace of crystalline, limestone, whitish to dark grey, medium hard, with pyritic grains.
8480	Similar to 8420.
8540	Similar to 8420, with Quinqueloculina fossils.
8600	Similar to 8420.

8660	Similar to 8420, with bivalves and Gastropods fragments, and trace of limestone, coarsely crystalline, dark grey brownish, and sugary , medium hard.
8720	Similar to 8420, with trace of anhydrite.
8780	Similar to 8420.
8840	Similar to 8420.
8910	Similar to 8420, with traces of anhydrite, whitish in colour.
8960	Similar to 8420.
9020	Shale, light to dark grey, partly brownish, fissile, splintery, with trace of limestone, light grey to grey, medium hard, and grains of anhydrite, whitish to light grey, Calcilutites, light grey, and pyritic grains.
9080	Similar to 9020.
9140	Similar to 9020, without pyritic grains.
9200	Similar to 9020, without pyritic grains.
9260	Similar to 9020, without pyritic grains.
9320	Similar to 9020.
9380	Similar to 9020.
9440	Similar to 9040, with traces of calcareous siltstone, light grey, very hard.
9500	Similar to 9020.
9560	Similar to 9020, with gastropods fragments.
9620	Similar to 9020, with trace of quartz grains.
9680	Similar to 9020.
9740	Similar to 9020, shale partly blocky.
9800	Similar to 9020, shale partly blocky.
9860	Similar to 9020, shale partly blocky.
9920	Similar to 9020, shale partly blocky.
9980	40% argillaceous limestone, light grey, hard, 60% shale, light grey to dark grey, fissile, partly blocky.
10040	Mainly limestone, 80% argillaceous limestone, light grey, hard,15% calcareous siltstone, yellowish in colour, medium hard, with traces of anhydrite and quartz grains, 5% shale similar to 9020.

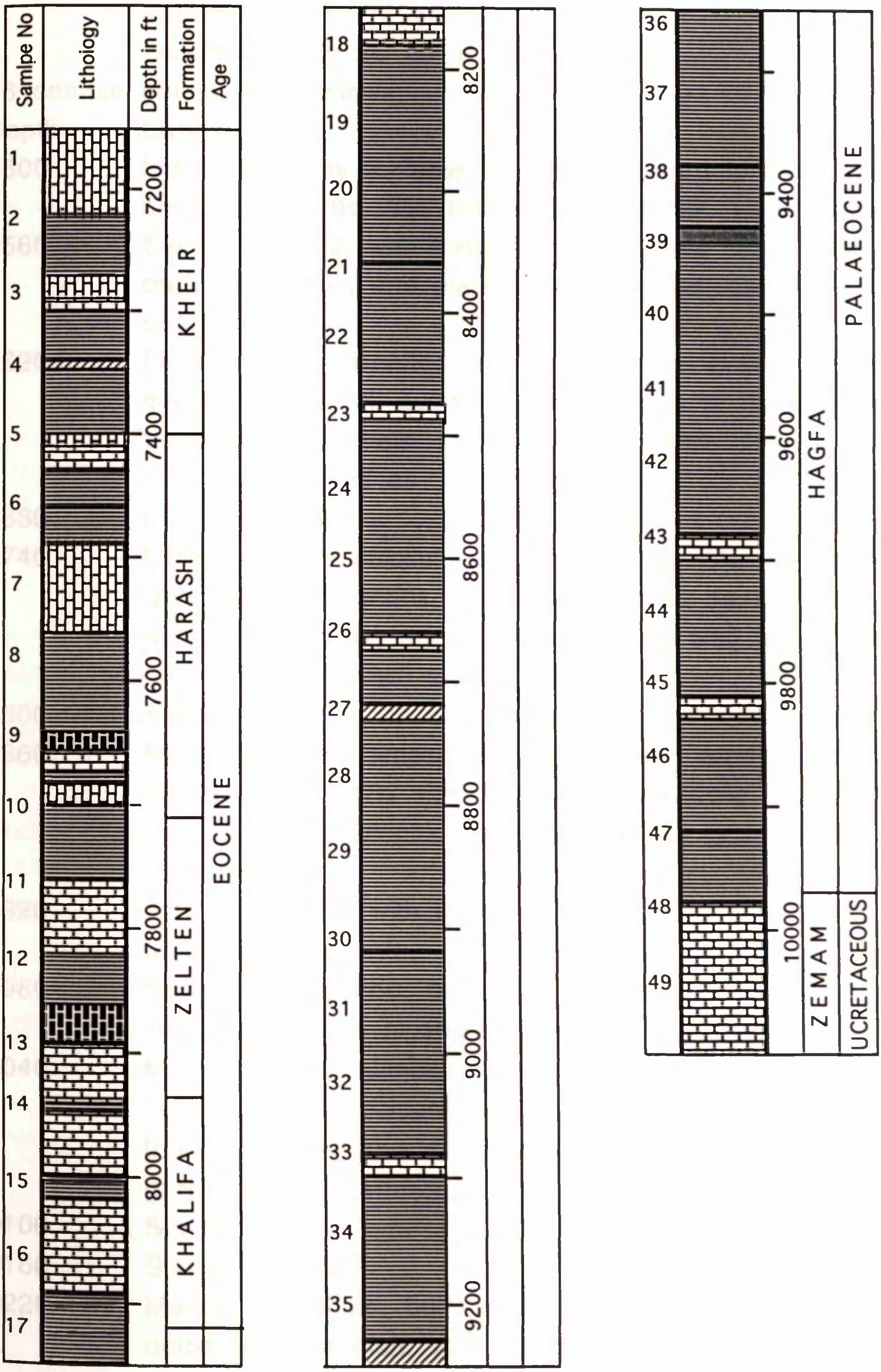


Figure 7.5 Stratigraphic section early Tertiary well 3H1-6.

Location of well KK1- 6.

	Latitude 29° 18' 39" N
	Longitude 20° 26' 49" E
76 sample	obtained as follows:
Depth	Lithology.
8500	Limestone, grey to brownish, medium hard to hard, with cherts fragments, and traces of glauconitic sand grains.
8560	Similar to 8500, with traces of green olive shale, and dark grey shale, and glauconitic limestone, as well quartz grains.
8620	Limestone calcarenites, whitish, buff, to medium grey, medium hard, 2% quartz grains, pinkies to transparent, traces of white chalk, and olive green shale, and glauconitic grains as well as pyrite.
8680	Similar to 8620.
8740	Limestone and calcilutites, grey to brownish, very hard, with sandstone grains, light grey, medium hard, glauconite, quartz, and pyritic grains as well as light green to light brown shale.
8800	Similar to 8740.
8860	Mainly dolomitic limestone, grey to light brown, hard to medium hard, 10% shale, green olive, fissile, 10% light grey, grains glauconitic sandstone coarse grained , medium hard.
8920	Similar to 8860, with traces of olive green shale, and bryozoan fragments.
8980	Dolomitic limestone, buff, light brown to light grey, hard, with traces of shale, olive green to brownish.
9040	Mainly dolomitic limestone, grey to light brown, buff, very hard, and calcarenites, whitish, medium hard, with traces of calcareous sandstone, glauconite, and olive green shale.
9100	Similar to 9040.
9160	Similar to 9040.
9220	Mainly calcilutites, buff, medium hard, with traces of dolomites, brownish, very hard, calcareous sandstone, and glauconite.
9280	Similar to 9220.

9340	Mainly limestone and calcarenites, buff to light brown, medium hard, with traces of dolomite dark brown, very hard.
9400	Mainly calcilutites, buff in colour, medium hard, with 10% dolomitic limestone, light brown to dark grey, hard, and traces of quartz coarse grains.
9460	Similar to 9400.
9520	Mainly calcarenites, light brown, medium hard, with traces of calcareous sandstone, and quartz coarse grains.
9580	Similar to 9520, partly whitish calcarenites and glauconitic grains.
9640	Similar to 9520, without quartz grains.
9700	Dolomitic limestone, pale yellow to brownish, rarely dark grey, medium hard.
9760	Similar to 9700, with traces of sandstone, light grey, medium hard.
9820	Similar to 9700, with traces of glauconitic grains.
9880	Similar to 9700, with traces of glauconitic sandstone, , olive green shale as well as quartz coarse grains.
9940	Similar to 9700, with traces of calcareous sandstone, coarse grains, light grey.
10000	Similar to 9700.
10060	Similar to 9700, with traces of light green to light grey, shale, fissile, and glauconitic grains.
10120	Dolomitic limestone, mainly light brown to brown, whitish, buff, medium hard to hard.
10180	Mainly limestone, buff to brownish, soft to medium hard, with 10% calcareous sandstone, light green, medium hard, 10% shale, light green fissile.
10240	Limestone, buff to light brown, soft medium hard, with traces calcareous sandstone, and green olive shale.
10300	Mainly limestone, buff to brownish, medium hard to hard, with 5% shale, light grey to light brown, rarely olive green, fissile, and traces of glauconite and pyrite grains.
10360	Similar to 10300.

10420	Mainly limestone, light brown, rarely buff in colour, medium hard to hard, with 15% shale, light grey to dark grey, brown, olive green, fissile, splintery, and traces of calcareous sandstone, glauconite and pyritic grains
10480	Mainly calcareous shale, light grey to light brown, fissile , splintery, 30% limestone, buff to brownish, hard to medium hard, with traces of calcareous sandstone, light grey.
10540	Mainly calcareous shale, light grey to grey, light brown, medium hard, fissile, with traces of limestone, light brown, medium hard, and quartz grains.
10600	Similar to 10540, with traces of olive green shale and glauconitic grains.
10660	Similar to 10540.
10720	Mainly calcareous shale, grey to dark grey, fissile, splintery, with 20% microcrystalline dolomites, light grey very hard.
10780	Similar to 10720, with traces of anhydrite, whitish to grey, and limestone, whitish , medium hard.
10840	Similar to 10720.
10900	Mainly limestone, tan to slightly brown, medium hard, with 20% shale, light grey, fissile, splintery.
10960	60% limestone, whitish light brown, highly fossiliferous, medium hard, 40% calcareous shale, light grey to dark grey, fissile splintery.
11020	Mainly calcareous shale, light grey to grey, fissile , splintery, partly blocky, with 40% limestone, whitish to light grey , brownish, highly fossiliferous, with traces of pyrite grains and quartz grain. pinkish, yellowish, transparent.
11080	Mainly calcareous shale, light to dark grey, rarely black, fissile, splintery, 20% limestone, whitish, light grey, brownish, rarely black, highly fossiliferous, medium hard, to hard, with traces of quartz and pyritic grains.
11140	Similar to 11o80, with quartz and glauconite grains.
11200	Similar to 11140.

11260	Calcareous shale, light grey to grey, rarely black, fissile, splintery, partly blocky, with traces of limestone, buff, brownish, light grey, very hard, and grains of quartz as well pyrite and fossil fragments i,e gastropods and forams.
11320	Similar to 11260.
11380	Shale, light grey to grey, black, fissile, splintery, partly blocky, with traces of limestone, white, light grey, brownish, medium hard.
11440	Similar to 11380, with varies colour of quartz grains, white, yellowish, brownish, and pyrite as well as fossil fragments, i. e forams.
11500	Similar to 11440.
11560	Similar to 11440.
11620	Calcareous shale, light grey to grey, rarely black, fissile, splintery, partly blocky, with traces of limestone, light grey, medium hard and pyritic grains.
11680	Similar to 11620, with traces of anhydrite grains, whitish in colour.
11740	Calcareous shale, light grey to grey, rarely black, fissile, splintery, partly blockty, with traces of limestone, varies colour, whitish, light grey, brownish, yellowish grains, as well as anhydrite and quartz grains.
11800	Similar to 11740.
11860	Similar to 11740, with pyrite grains.
11920	Similar to 11740, with pyrite grains and gastropods fragments.
11980	Similar to 11740, without quartz grains.
12040	Calcareous shale, light grey to grey, rarely black, fissile, splintery, partly blocky, with traces of limestone, grey, brownish, medium hard to hard, and anhydrite grains.
12100	Similar to 12040.
12160	Similar to 12040.
12220	Mainly calcareous shale, light grey to grey, rarely black, fissile, splintery, partly blocky.

12280	Similar to 12220, with traces of dark grey, brownish, limestone, quartz, pyrite, and anhydrite grains.
12340	Similar to 12220.
12400	Similar to 12220, with traces of dark grey, limestone, very hard.
12460	Similar to 12220, with traces of varies colour limestone, light grey, whitish, brownish, medium hard, quartz grains, yellowish to transparent and anhydrite.
12520	Similar to 12460.
12580	Similar to 12460, without quartz grains.
12640	Mainly calcareous shale, light grey to grey, rarely black, fissile, splintery, partly blocky.
12700	Similar to 12640, with traces of limestone, grey, buff, medium hard, and quartz grains as well as anhydrite, whitish to light grey.
12760	Similar to 12700.
12820	Similar to 12700, with pyritic grains.
12880	Similar to 12700.
12940	Mainly calcareous shale, light grey to grey, black, fissile, splintery, partly blocky, with traces of limestone, varies colour, whitish, buff, light grey, brownish, medium hard to hard, and traces of coarse subrounded quartz grains.
13000	Similar to 12940, with traces of anhydrite, whitish, greyish.
13060	Similar to 12940, with traces of anhydrite, brownish to greyish in colour.

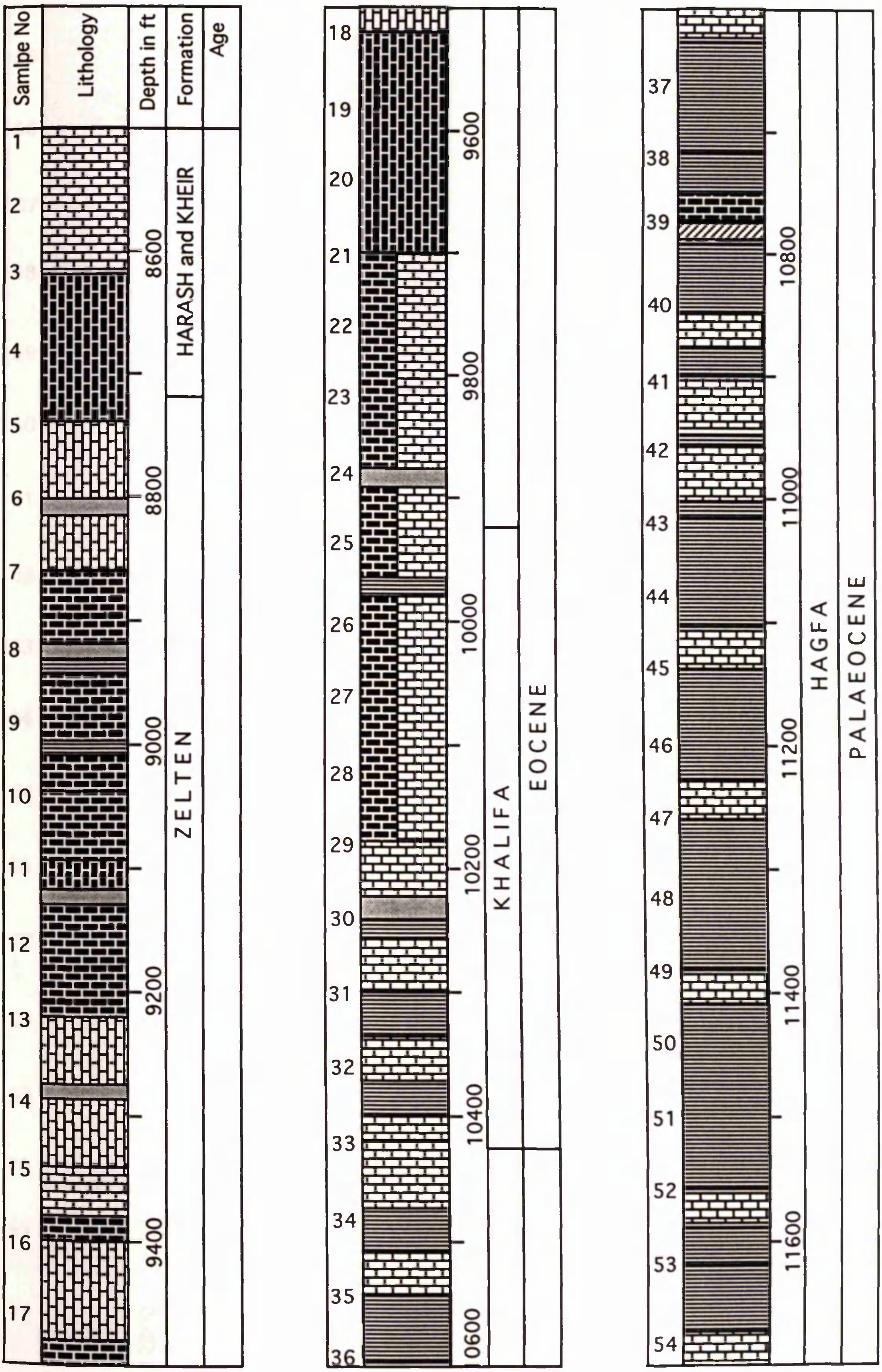
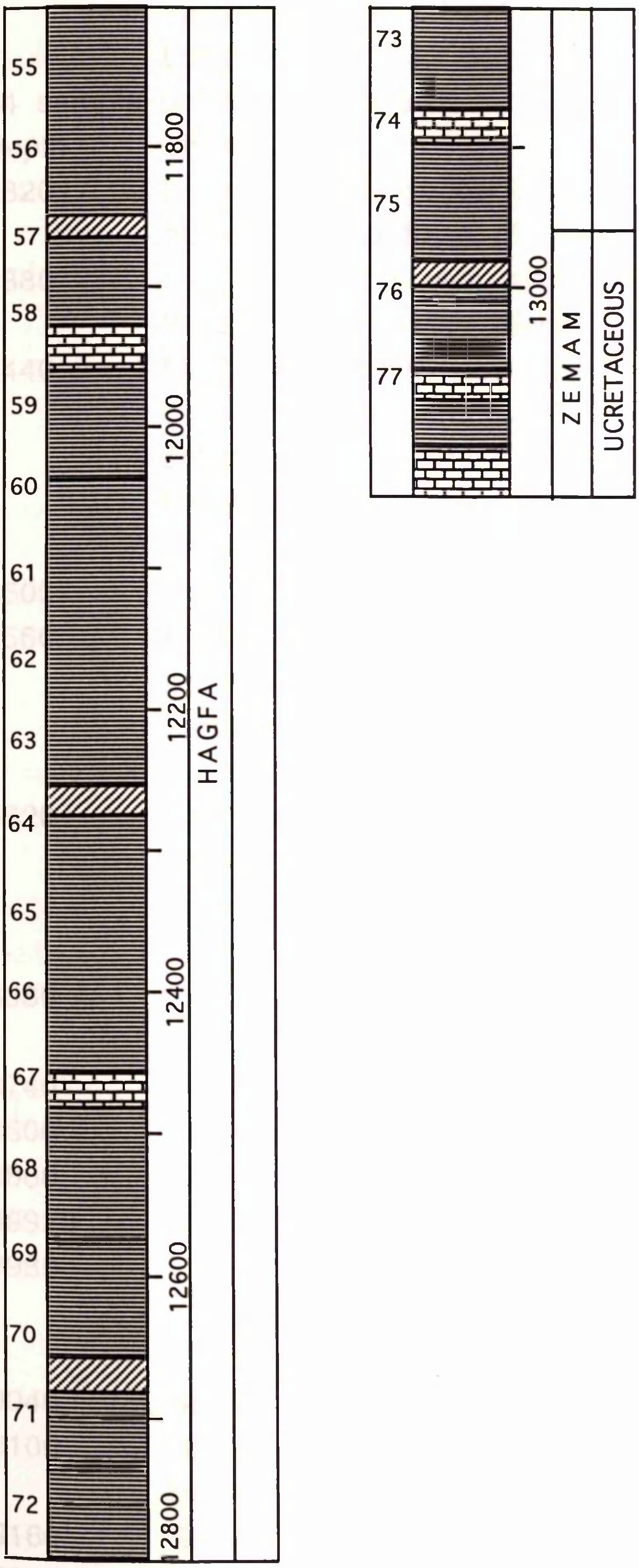


Figure 7.6 Stratigraphic section early Tertiary well KK1-6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HAGFA
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74
75
76
77
13000
ZEMAM
UCRETACEOUS

Location of well AA1- 6.

Latitude 29° 21' 27" N

Longitude 20° 33' 51" E

84 sample obtained as follows:

Depth	Lithology.
8320	Limestone pale yellow to brown, very hard, with glauconite and trace of shale, light grey, fissile.
8380	Similar to 8320, with trace of pyritic gains and Whitish to yellowish quartz grains.
8440	Mainly limestone, light grey to grey, yellowish, hard, crystalline, with traces of calcilutites, whitish in colour, medium hard, and chalk, whitish soft, as well fossils fragments i. e. Forams, and light grey fissile shale.
8500	Similar to 8440.
8560	Limestone, pale yellow, light grey to grey, slightly brownish, hard, and calcilutites, light yellow, medium hard, with traces of shale, light grey, fissile and transparent subrounded quartz grains, dark grey cherts.
8620	Calcilutites, buff to pale yellow, medium hard, 15% limestone, light grey to light brown, hard, with traces of light grey, shales, and quartz grains, dark grey cherts.
8680	Similar to 8620, with 20% dolomite, dark grey, very hard.
8740	Similar to 8620.
8800	Similar to 8620.
8860	Similar to 8620.
89920	Similar to 8620.
8980	Limestone, buff, medium hard, with traces of sandstone, whitish, coarse grained, and shale light green, with glauconites.
9040	Similar to 8980.
9100	Similar to 8980, with 5% of glauconitic sandstone and traces of quartz grains.
9160	Similar to 9100, with traces of pyritic grains.
9220	Limestone, pale yellow to light brown, medium hard, with traces of sandstone grains and dark grey cherts.

9280	Similar to 9220, with traces of glauconite and shale, light green, fissile.
9340	Similar to 9220, with traces of dolomite, brownish in colour, hard.
9400	Limestone, mainly calcilutites, buff in colour, medium hard, with 2% quartz subrounded coarse grains, varies in colour, pinkish, yellowish, brownish, and white, with traces of dolomitic dark grey.
9460	Similar to 9400, with traces of shale, light grey, fissile, and quartz grains yellowish pinkish in colour.
9520	Limestone, buff to pale yellow, brownish, medium hard, with traces of whitish, soft, chalk.
9580	Similar to 9520, with traces of sandstone grains and fossil fragments i. e. Foraminifera.
9640	Similar to 9520.
9700	Limestone, light grey to brownish, hard, partly argillaceous, with chert grains, and traces of fossil fragments.
9760	Similar to 9700.
9820	Similar to 9700, with traces of sandstone grains, light grey in colour.
9880	Similar to 9700.
9940	Similar to 9700.
10000	Mainly calcilutites, light grey to buff, medium hard, 10% brownish, limestone, medium hard.
10060	Similar to 10000.
10120	Limestone, buff, pale yellow, brownish, medium hard, with traces of quartz grains, pinkish, yellowish in colour, and traces of white, soft, chalk.
10180	Limestone, buff, pale yellow, brownish, medium hard, with traces of glauconites and sandstone, light grey, medium hard, and shale, light grey to light green, fissile.
10240	Limestone, buff, yellow, brownish, medium hard, with traces of shale, light grey, blocky.
10300	Mainly limestone, varied in colour, buff, light grey to dark grey, light brown to brown, medium hard, 10% shale light grey, fissile, with traces of quartz grains,

	yellow, transparent, and light grey coarse grain sandstone.
10360	50% limestone, buff, light grey to grey, brownish, medium hard, 50% shale, light brown, to grey, fissile, splintery, with traces of quartz and pyritic grains, and gastropods fragment.
10420	Similar to 10360, with light green, shale, and foraminifera faunas.
10480	70% shale, light grey to grey, light brown, light green, fissile splintery, 30% limestone, varies in colour, buff, light to dark grey, brown to dark brown, medium hard, with traces of sandstone, light grey to light green, medium hard, with glauconite and pyritic grains.
10540	80% shale, mainly light brown, rarely light grey to light green, fissile, partly blocky, 20% argillaceous limestone, buff, light brown, light grey, medium hard.
10600	70% limestone, buff, light grey to dark grey, rarely light brown, medium hard, to hard, 30% shale, light grey to grey, light green, fissile partly blocky, with traces of glauconitic sandstone, coarse grained, and quartz grains.
10660	70% mainly calcareous shale, light grey, blocky, light green olive, shale, fissile, splintery, 30% limestone, buff to light grey, medium hard.
10720	50% calcareous shale, light grey to light green, brownish, fissile, partly blocky, 40% limestone, buff to light grey, medium hard, and 10% sandstone, light grey whitish, friable.
11780	50% shale, dark grey, rarely light green, fissile, partly blocky, 50% argillaceous limestone, light to dark grey , medium hard.
10840	Similar to 10780, with traces of sandstone, whitish, friable.
10900	Mainly calcareous shale, light grey to dark grey, rarely light green, fissile, partly blocky, with 15% limestone, buff, light grey to grey, very hard, and traces of glauconitic sandstone, light grey to whitish in colour.

10960	50% limestone, tan to light brown, medium hard, 50% argillaceous shale, light to dark grey, light green, fissile, partly blocky, with cherts grains.
11020	Mainly calcareous shale, light grey to dark grey, fissile, splintery, partly blocky, 10% limestone, whitish to light grey, medium hard, 5% pyritic grains and traces of quartz and pyritic grains.
11080	Mainly calcareous shale, light grey to dark grey, fissile splintery, with 5% limestone, whitish to light grey, medium hard, and traces of quatrz and pyritic grains.
11140	Mainly calcareous shale, light to dark grey, fissile, splintery, partly blocky, with traces of limestone, buff to light grey, moderately hard, and traces of quartz and pyritic grains.
11200	Similar to 11140.
11260	Similar to 11140, with traces of limestone, dark grey, brown, buff, medium hard, fossil fragment, and anhydrite grains.
11320	Similar to 11140.
11380	Similar to 11140, with fossil fragments i. e foraminifera.
11440	Similar to 11140.
11500	Similar to 11140.
11560	Similar to 11140, with fossil fragments.
11620	Calcareous shale, light to dark grey, fissile, splintery, partly blocky, with traces of limestone, buff to light brown, medium hard.
11680	Similar to 11620.
11740	Calcareous shale, light grey to dark grey, partly light brown, fissile, splintery, with fossil fragment.
11800	Similar to 11740.
11860	Similar to 11740.
11920	Similar to 11740, with traces of pyritic and quartz grains.
11980	Similar to 11740, with traces of limestone, buff to grey, medium hard to hard.
12040	Similar to 11740, with traces buff to light grey, limestone, and quartz grains.

12100	Similar to 12040.
12160	Light grey to almostly dark grey, calcareous shale, fissile, splintery, partly blocky, with trces of limestone, whitish to light grey, and quartz grains.
12220	Similar to 12160, with traces of anhydrite, whitish in colour.
12280	Similar to 12160.
12340	Similar to 12160, without quartz grains.
12400	Similar to 12160, with traces of anhydrite grains.
12460	Similar to with varies colours traces of limestone, yellowish, light brown, whitish, medium hard, and glauconitic sandstone as well as anhydrite.
12520	Smilar to 12160, with traces of pyrite.
12580	Similar to 12160, with traces of pyrite.
12640	Light grey to dark grey, almostly calcareous shale, rarely brownish, fissile, partly blocky, with traces of of limestone of vareis colour, whitich, dark grey, light brown, very hard, and whitish to pinkish quartz grain, and anhydrie.
12700	Similar to 12640.
12760	Similar to 12640.
12820	Similar to 12640.
12880	Similar to 12640, with traces glauconitic sandsone.
12940	Similar to 12640, with traces of calcite crystalline.
13000	Light grey to almostly dark grey, calcareous shale, rarely brown, fissile, partly blocky.
13060	Similar to 13000, with traces of varies coloured limestone, light grey to grey, buff, whitish, hard, with quartz grains as well anhydrite.
13120	Similar to 13060, with traces of sandstone and pyritic grains.
13180	Similar to 13060.
13240	Mainly calcareous shale, light grey to dark grey, fissile, splintery, and partly blocky, with 15% limestone, light grey to dark grey, light brown, very hard, crystaliline, with traces of calcilutites, light grey, and gastropods fossils.
13300	Similar to 13240, with 40% of limestone.

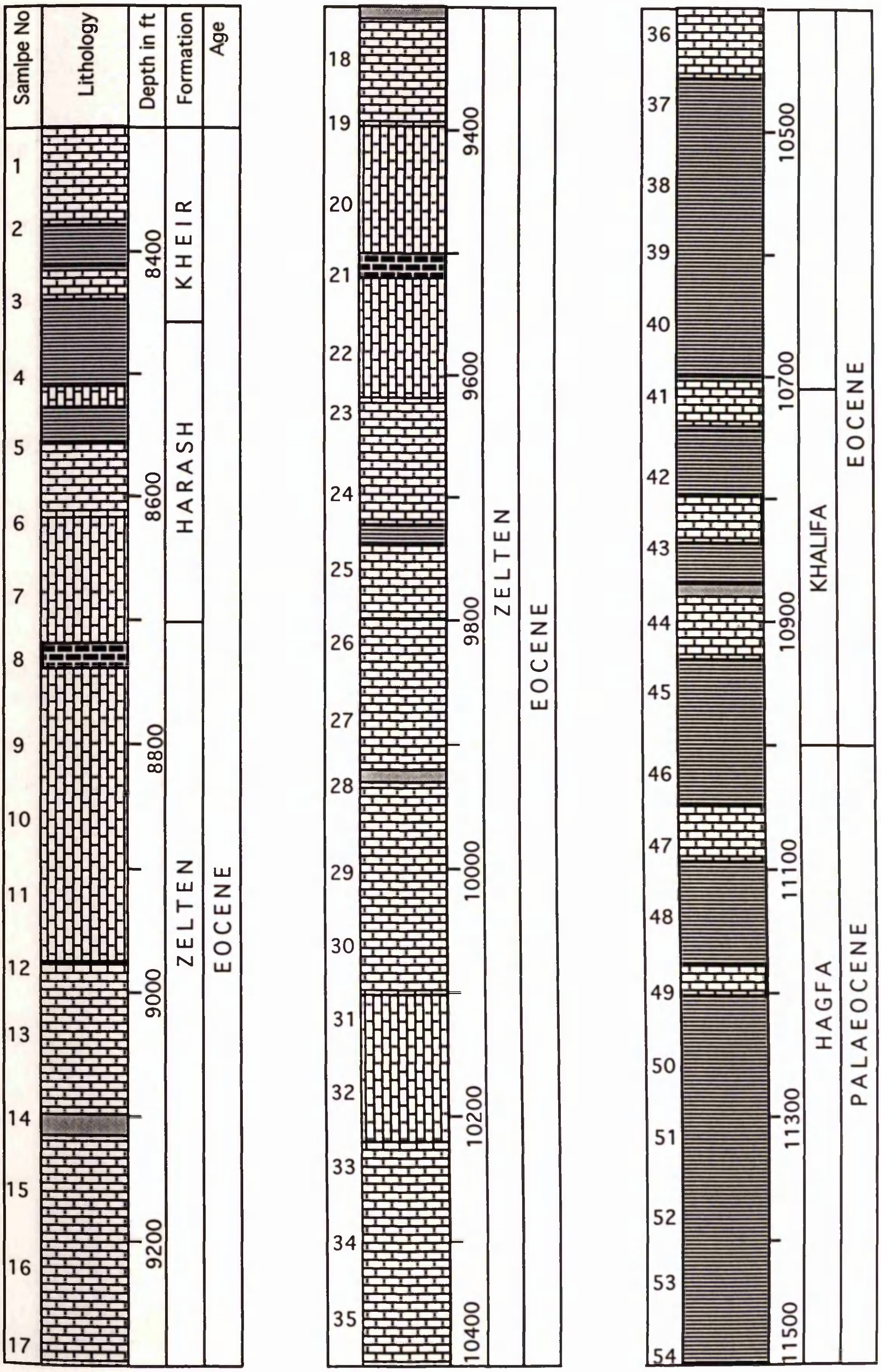
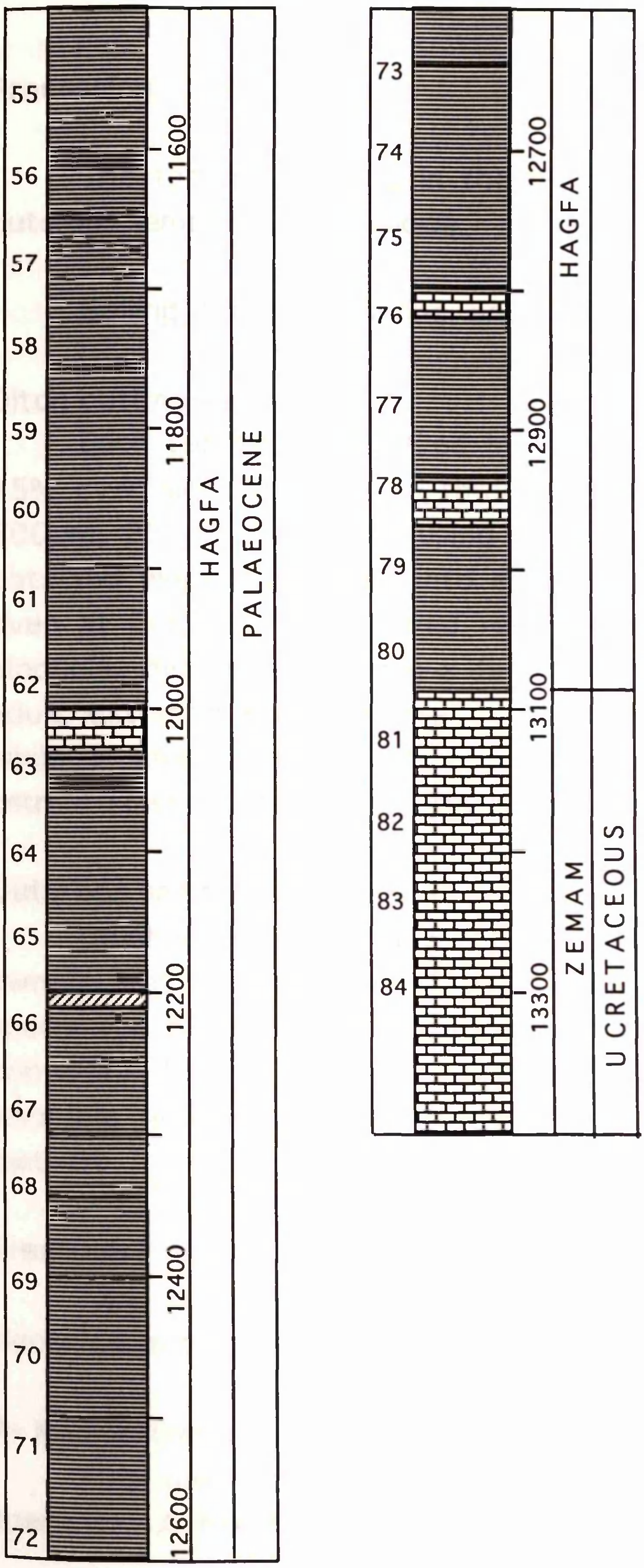


Figure 7.7 Stratigraphic section of early Tertiary in the Well AA1- 6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Appendix- 2

Processing:

The techniques used in the processing of ditch cutting and outcrops samples was as follows.

Boiling, Washing, sieving, and picking of the samples.

Ditch cutting samples:

Each sample was soaked in dilute hydrogen peroxide (H_2O_2) 15% over night then sieved through brass sieves with apertures of 500μm, 250μm and 75μm using tap hot water. The three residues obtained were transferred into evaporating basins and dried in an oven at 200 ^{o}C. These dried residues were then picked under a binocular microscope using a fine moistened sable brush. Most of adult ostracod species were obtained from the medium residue, while a few juvenile ostracods found in the fine residue; rare ostracods were obtained from the coarse residue.

Outcrops samples:

Crushed by manual method using pistol & mortar, then each sample was boiled in water using stainless steel bowl with two spoon full of sodium carbonate added to defloculent the sample, continuos boiling and stirring for about two hours until a few insoluble residue are remains then sieving and picking using former method.

Treatment of individual specimens:

The specimens selected for examination under scanning electronic microscope (S.E.M), were cleaned as follows.

A- Manual treatment:

This method was used to clean out sediments within the specimen. A fine tungsten needle mounted in a piece of wood and sable brush were used with a drop of hydrogen peroxide (15%) added to soften the sediment and to prevent the specimen from being lost when being touched by the needle.

B- Ultrasonic method:

This was used for cleaning specimens which could not be cleaned manually. The specimens were placed in a small glass vial half filled with water, then the vial was held in an ultrasonic instrument set at 50-55,000 cycles per second for two second or less. This was repeated if necessary, each time the specimen was examined under the microscope until the specimen was properly cleaned. When using this method, great attention has to be paid to delicate carapaces and valves which could have been broken during treatment

Photography:

Scanning electronic microscope Cambridge instruments S600 were used. The specimens to be photographed were mounted on an aluminium stub of 12 mm diameter. Carbon adhesive discs mounting medium were used to fixed the specimens onto the S.E.M. stubs as follows:

This type of adhesive is very cheap and its very easy to use, these electrically conductive double-sided adhesive discs of 12mm diameter are carbon based, they can pressed on S.E.M stubs and the specimens placed on the carbon adhesive discs under binocular microscope, the specimens is then coated with gold in vacuum gold unit.

Advantaged of this method are:

1- Ideal for examining uncoated small specimen.
2- very good for microanalysis.
3- Leave conductive carbon adhesive when backing material is removed.

PLATES

Plate 1

Cytherella saidi sp nov.

Fig. 1- Female stereoscopic paired photographs left carapace (Holotype); GLAHM 100867, X 70
Fig. 2- Female dorsal carapace; GLAHM 100868, X 67.5
Fig. 3- Female dorsal carapace; GLAHM 100869, X 67.5
Fig. 4- Female right carapace; GLAHM 100870, X 65.125
Fig. 5- Male left carapace; GLAHM 100871, X 75

Cytherella sorrensis El Sogher, 1991 M.S

Fig. 6- Female left carapace; GLAHM 872, X 77.5
Fig. 7- Male left carapace; GLAHM 100873, X 80
Fig. 8- Male ventral carapace; GLAHM 100874, X 75
Fig. 9- Female right carapace; GLAHM 100875, X 75
Fig. 10- Female right carapace; GLAHM 100876, X 75

Cytherella hateibensis El Sogher, 1991 M.S

Fig. 12- Female left carapace; GLAHM 100877, X 77.5
Fig. 11- Male left carapace; GLAHM 100878, X 75

PLATE 1

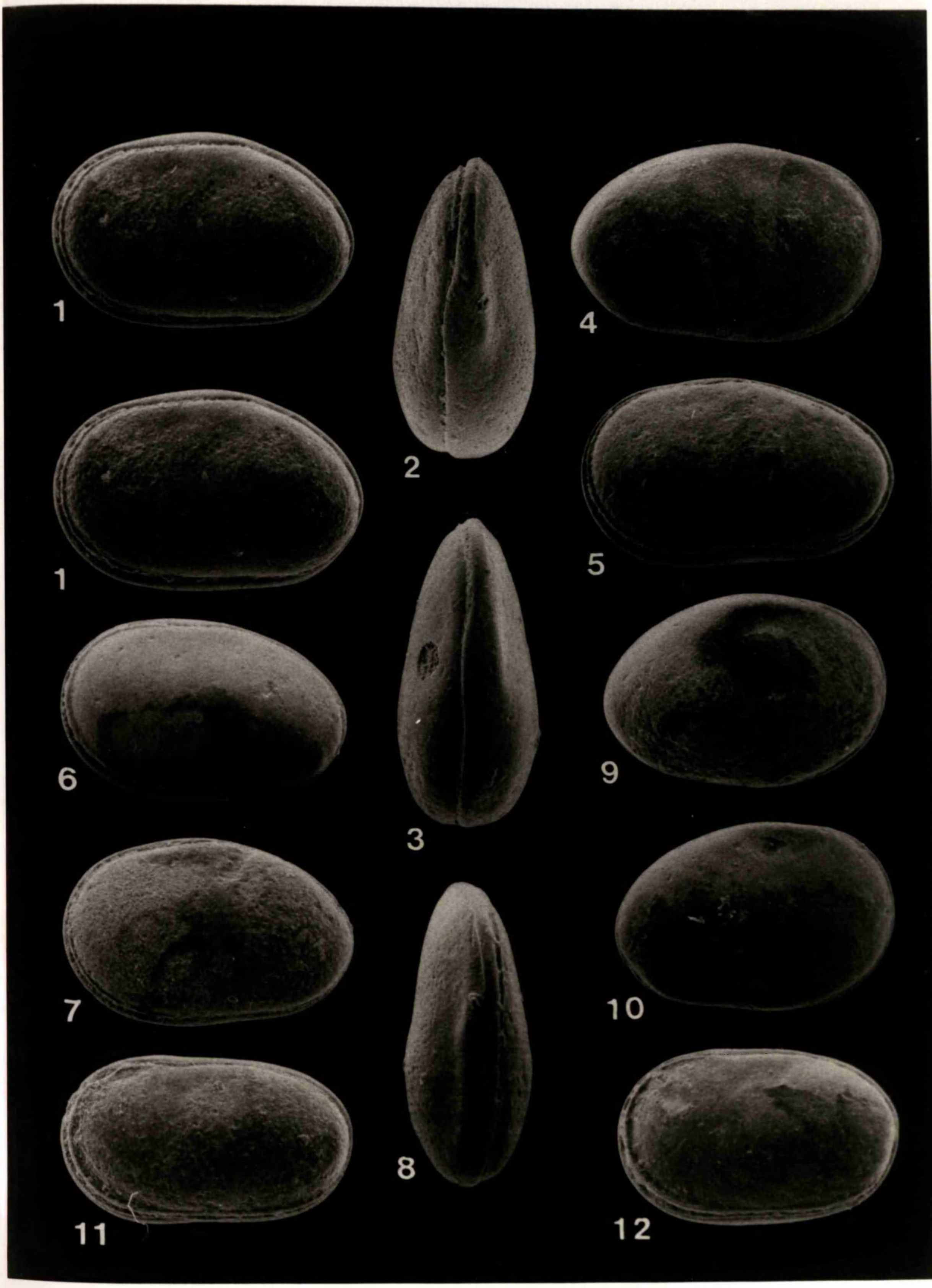


Plate 2

Cytherella hateibensis El Sogher, 1991 M.S

Fig. 1- Female right carapace; GLAHM 100879, X 77.5
Fig. 2- Female dorsal carapace; GLAHM 100880, X 72.5
Fig. 3- Male right carapace; GLAHM 100100881, X 70

Cytherella mohamedi sp nov.

Fig. 4- Male stereoscopic paired photographs left carapace; GLAHM 100882, X 65
Fig. 5- Female right carapace; GLAHM 100883, X 70
Fig. 6- Female right carapace; GLAHM 100884, X 77.5
Fig. 7- Female left carapace; GLAHM 100885, X 72.5
Fig. 8- Female ventral carapace; GLAHM 100886, X 75
Fig. 9- Female dorsal carapace; GLAHM 100887, X 72.5

Cytherella zaltanensis sp nov.

Fig. 10- Male left carapace; GLAHM 100888, X 72.5
Fig. 11- Juvenile left carapace; GLAHM 100889, X 90
Fig. 12- Female right carapace; GLAHM 100890, X 85
Fig. 13- Male right carapace; GLAHM 100891, X 80
Fig. 14- Female left carapace; GLAHM 100892, X 80

PLATE 2

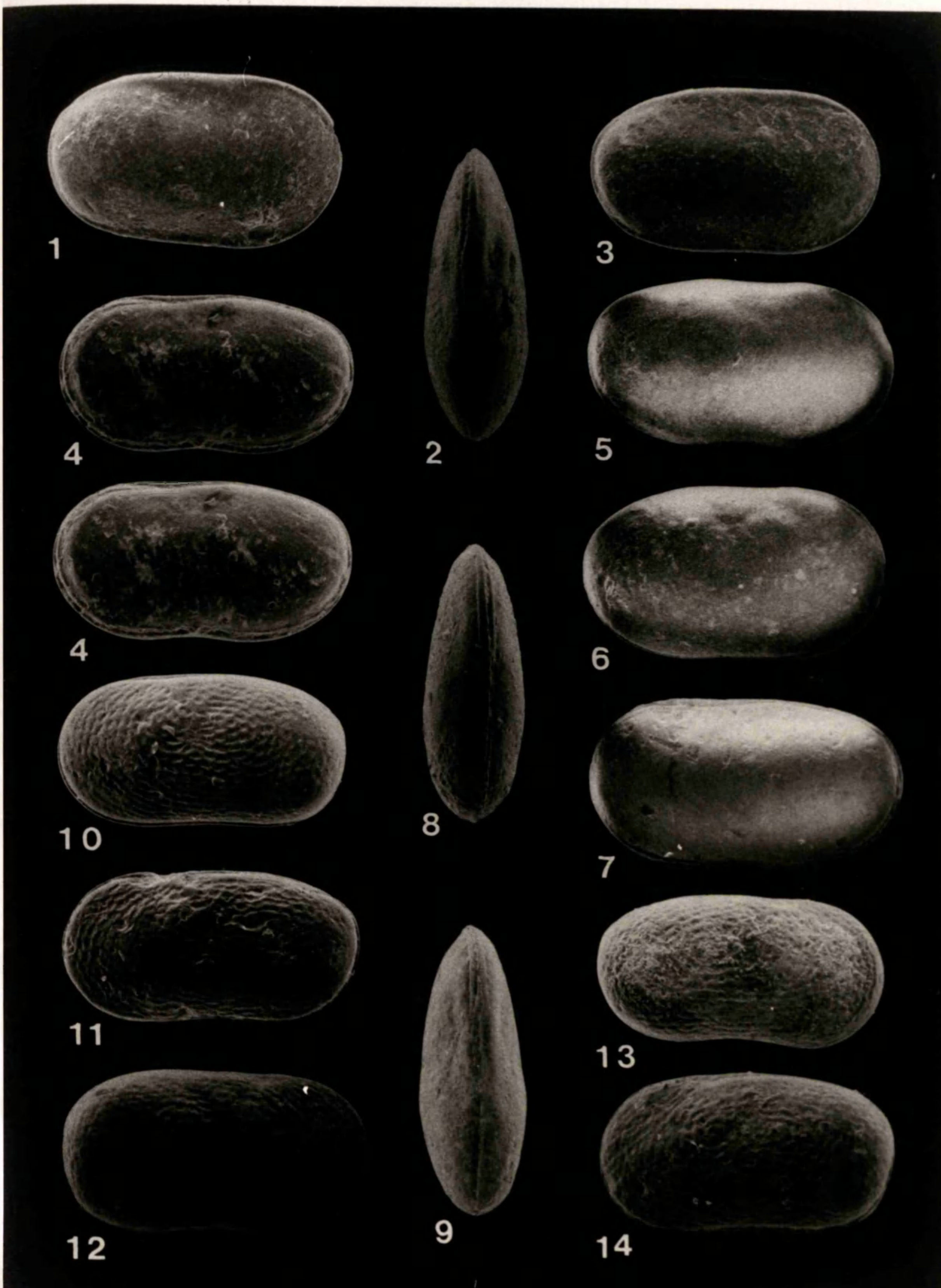


Plate 3

Cytherella mouzoghi sp nov

Fig. 1- Female stereoscopic paired photographs left carapace; GLAHM 100893, X 70
Fig. 2- Male stereoscopic paired photographs left carapace; GLAHM 100894, X 70
Fig. 3- Female right carapace; GLAHM 100895, X 75
Fig. 4- Male right carapace; GLAHM 100896, X 77.5
Fig. 5- Female dorsale carapace; GLAHM 100897, X 74

Cytherella zaltanensis sp nov.

Fig. 6- Male ventral carapace; GLAHM 100898, X 80
Fig. 7- Male dorsal carapace; GLAHM GLAHM 100899, X 82.5

Cytherella sp

Fig. 10- Female left carapace; GLAHM 100900, X 92.5
Fig. 11- Male left carapace; GLAHM 100901, X 80

Cytherelloidea musacea Carbonnel *et al*, 1990

Fig. 8- Female stereoscopic paired photographs right carapace; GLAHM 100902, X 85
Fig. 9- Female stereoscopic paired photographs left carapace; GLAHM 100903, X 80

PLATE 3

Plate 4

Cytherelloidea musacea Carbonnel *et al*,1990

Fig. 1- Male left carapace; GLAHM 100904, X 92.5
Fig. 2- Female dorsal carapace; GLAHM 100905, X 86. 25

Cytherelloidea sp.

Fig. 3- Stereoscopic paired photographs left carapace; GLAHM 100906, X 95

Cytherelloidea sp A.

Fig. 4- Stereoscopic paired photographs left carapace; GLAHM 100907, X 85

Isohabrocythere heiraensis sp nov.

Fig. 5- Male stereoscopic paired photographs right carapace; GLAHM 100908, X 90
Fig. 6- Female right carapace; GLAHM 100909, X 85
Fig. 7- Male left carapace; GLAHM 100910, X 86.25
Fig. 8- Male ventral carapace, GLAHM 100911, X 85
Fig. 9- Female dorsal carapace; GLAHM 100912, X 90

Isohabrocythere teiskotensis Apostolescu, 1961

Fig. 10- Female left carapace; GLAHM 100913, X 85
Fig. 11- Female right carapace; GLAHM 100914, X 95
Fig. 12- Male right carapace; GLAHM 100915, X 77.5

PLATE 4

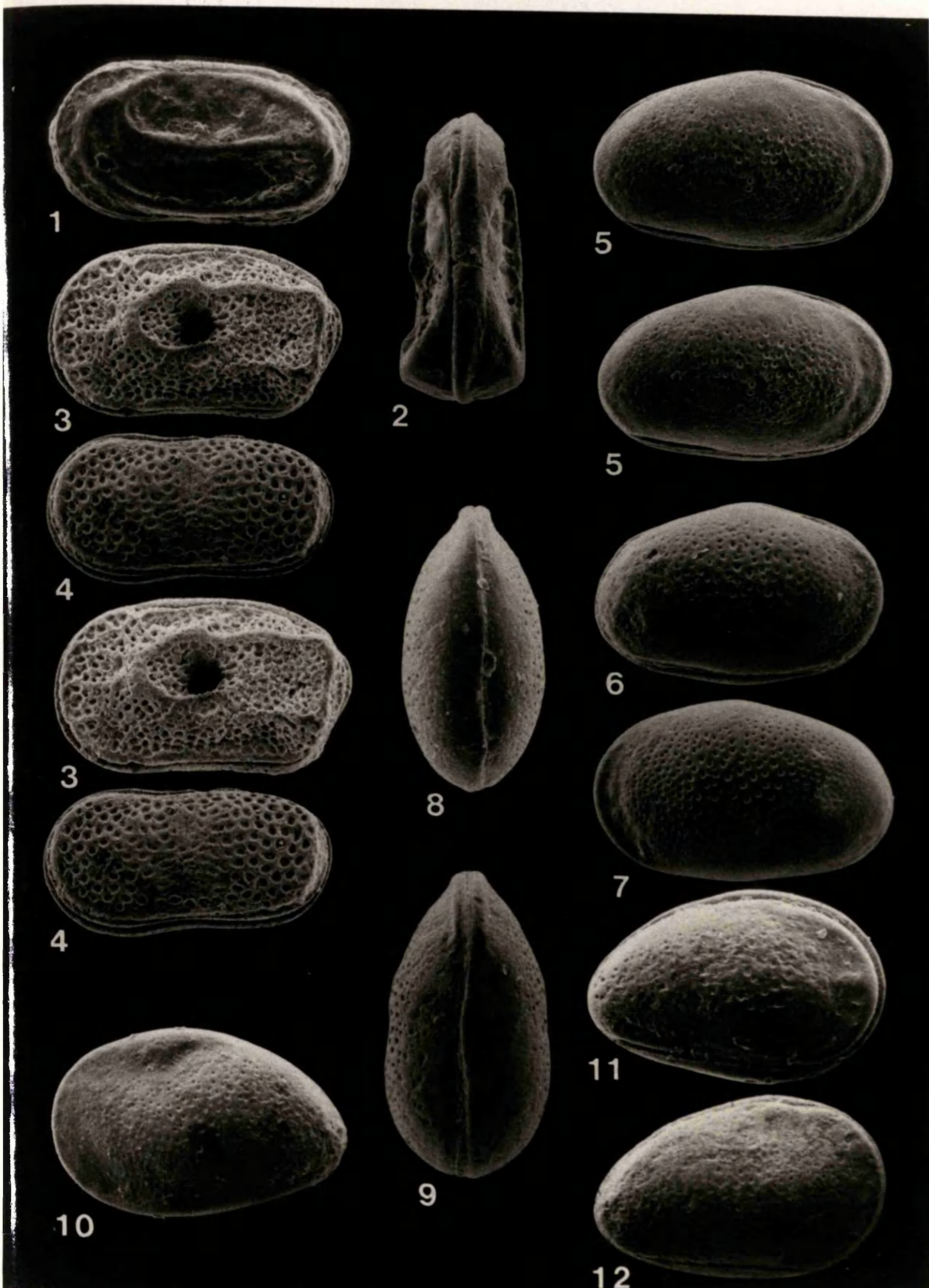


Plate 5

Isohabrocythere teiskotensis Apostolescu, 1961.

Fig. 5- Dorsal carapace; GLAHM 100916, X 80

Bairdia gp *ilaroensis* Reyment &Reyment, 1959

Fig. 1- Male right carapace; GLAHM 100917, X 59
Fig. 2- Female left carapace: GLAHM 100918, X 57.5
Fig. 3- Female right carapace; GLAHM 100919, X 48.5
Fig. 4- Male dorsal carapace; GLAHM 100920, X 57

Bairdia aff *B buisae* El-Waer, 1992

Fig. 6- Right carapace; GLAHM 100921, X 65

Bairdia cf *B septentrionalis* Bonnema, 1941

Fig. 7- Right carapace; GLAHM 100922, X 34

Bairdia libyaensis sp nov.

Fig. 8- Left carapace; GLAHM 100923, X 37
Fig. 9- Right carapace; GLAHM 100924, X 36.5
Fig. 10- Right carapace; GLAHM 100925, X 35.6
Fig. 11- Right carapace; GLAHM 100926, X 36.5
Fig. 12- Left carapace; GLAHM 100927, X 41
Fig. 13- Dorsal carapace; GLAHM 100928, X 44

PLATE 5

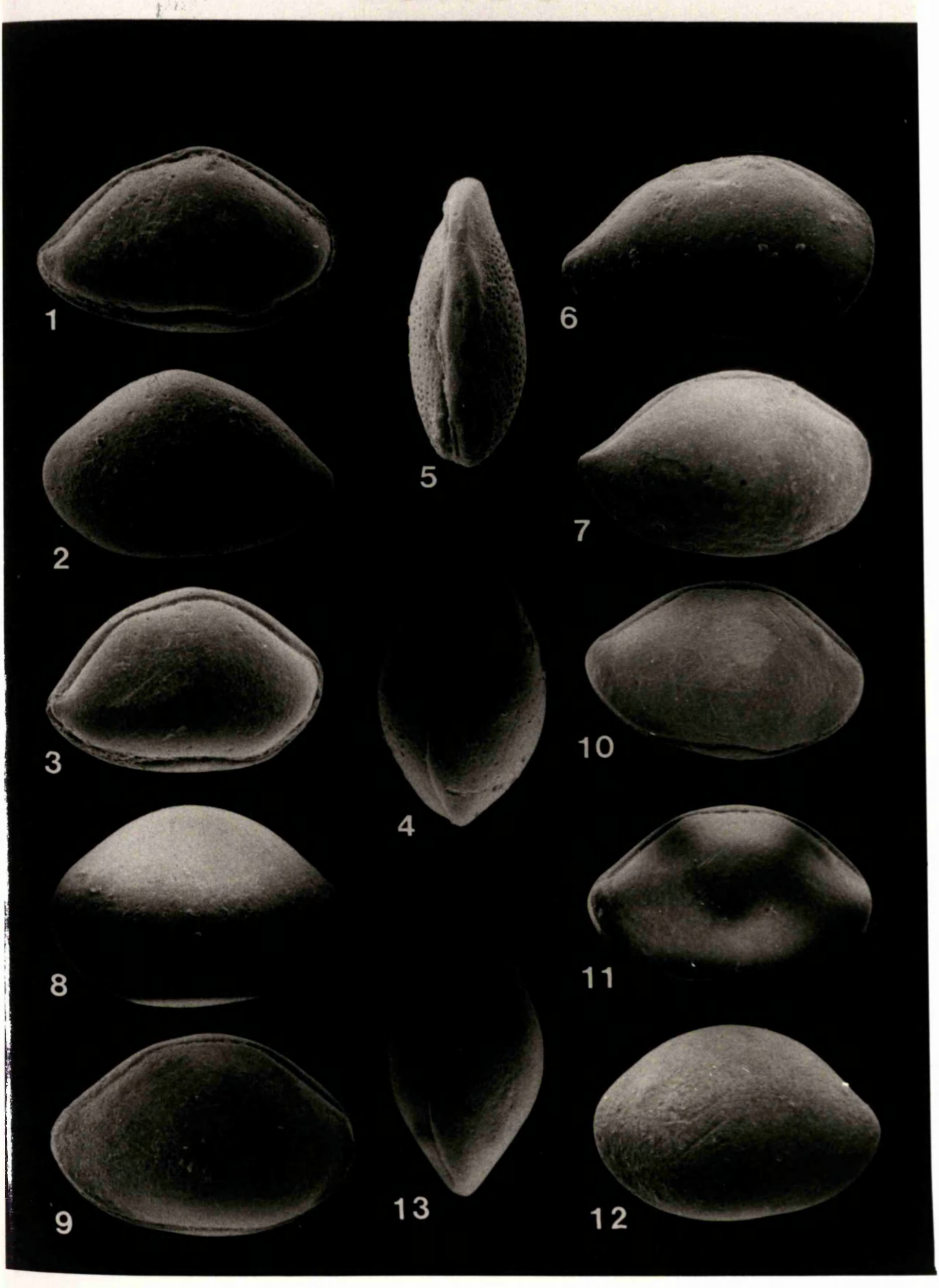


Plate 6

Bairdia sp.

Fig. 1- Right carapace; GLAHM 100929, X 100
Fig. 2- Left carapace; GLAHM 100930, X 94
Fig. 3- Dorsal carapace; GLAHM 100931, X 94

Bairdia libyaensis sp nov

Fig. 4- Ventral carapace; GLAHM 100932, X 36

Bairdia sp A.

Fig. 5- Right carapace; GLAHM 100933, X 39
Fig. 6- Left carapace; GLAHM 100934, X 38
Fig. 7- Right carapace; GLAHM 100935, X 39.5
Fig. 8- Dorsal carapace; GLAHM 100936, X 41

Bairdoppilata magna Alexander, 1927

Fig. 9- Right carapace; GLAHM 100937, X 62.5
Fig. 10- Left carapace; GLAHM 100938, X 63
Fig. 11- Right carapace; GLAHM 100939, X 58
Fig. 12- Right carapace; GLAHM 100940, X 58.5
Fig. 13- Left carapace; GLAHM 100941, X 62

PLATE 6

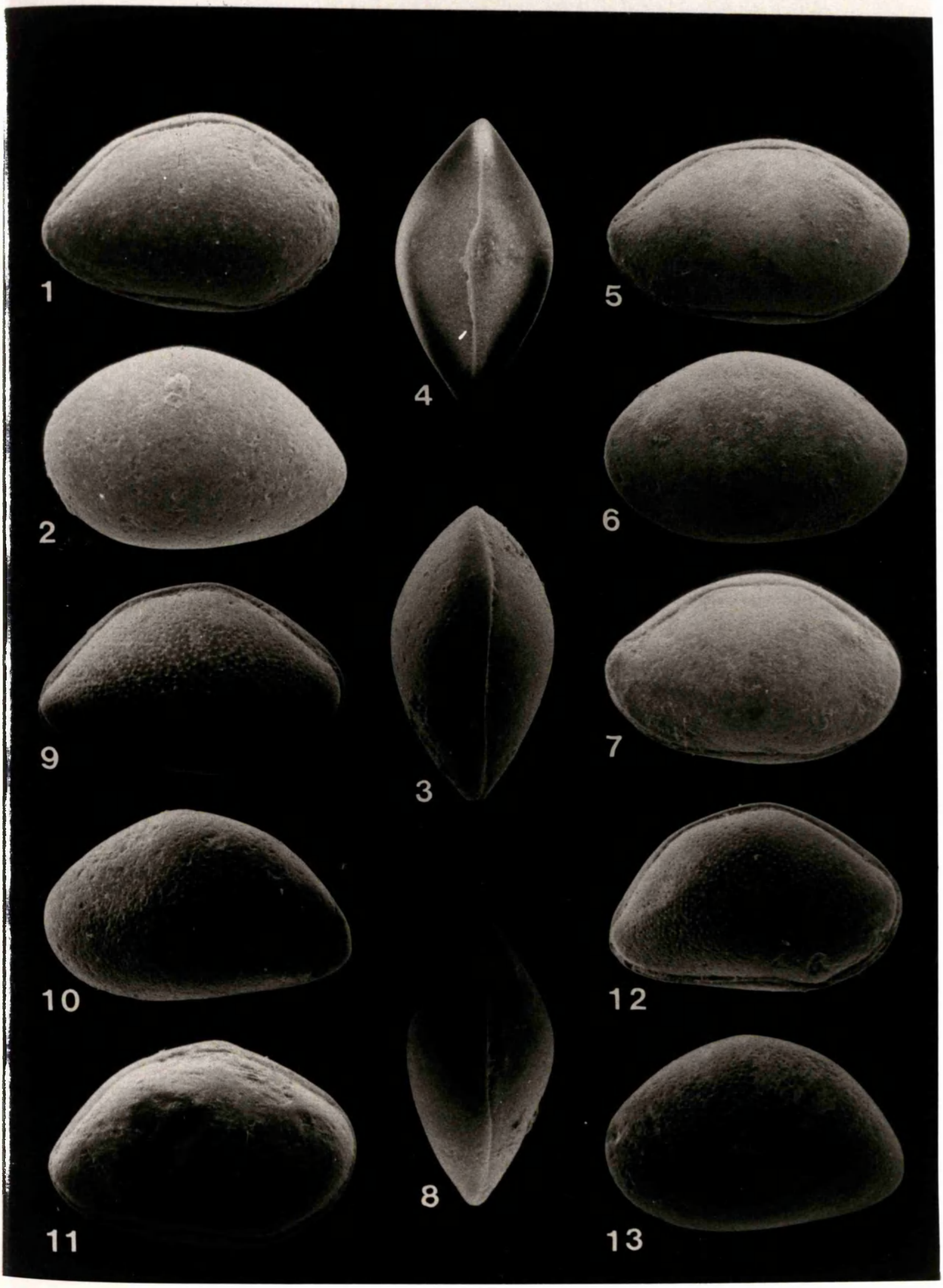


Plate 7

Bairdoppilata magna Alexander, 1927

Fig. 9- Dorsal margin, GLAHM 100942, X 63

Bairdoppilata sp

Fig.1- Female right valve; GLAHM 100943, X 65
Fig. 2- Female right carapace; GLAHM 100944, X 66
Fig. 3- Male right carapace; GLAHM 100945, X 67.5
Fig. 4- Male right valve; GLAHM 100946, X 66

Bythocypris ajdabiyaensis sp nov

Fig. 5- Left carapace; GLAHM 100947, X 50
Fig. 6- Right carapace; GLAHM 100948, X 52.5
Fig. 7- Stereoscopic paired photographs right carapace; GLAHM 100949, X 52
Fig. 8- Dorsal carapace; GLAHM 100950, X 54

Bythocypris n sp 1 Salahi, 1966

Fig. 10- Right carapace; GLAHM 100951, X 76
Fig. 11- Right carapace; GLAHM 100952, X 80
Fig. 12- Right carapace; GLAHM 100953, X 97.5
Fig. 13- Juvenile right carapace; GLAHM 100954, X 120

Bythocypris curryi sp nov.

Fig. 14- Female dorsal carapace; GLAHM 100955, X 70

PLATE 7

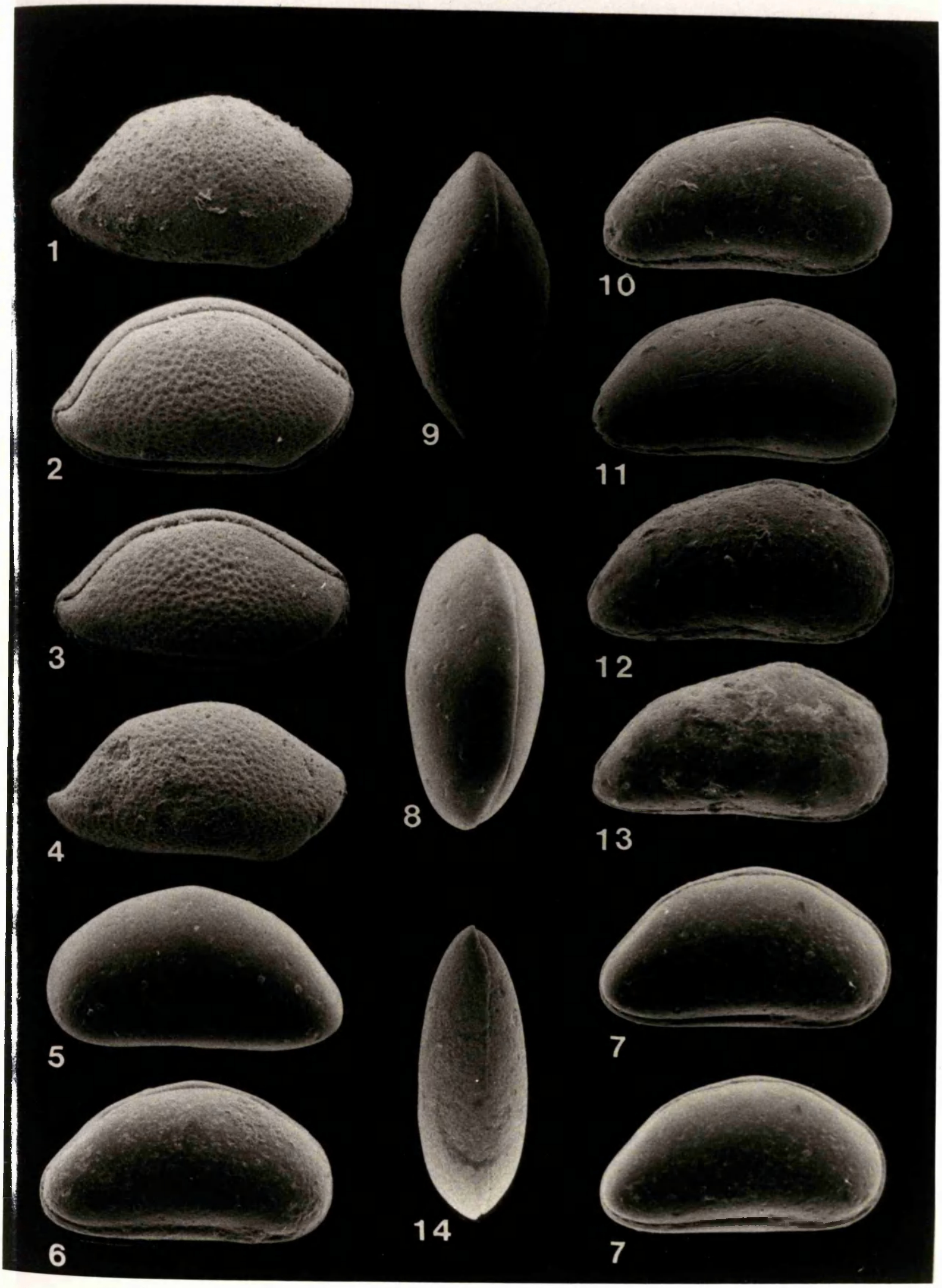


Plate 8

Bythocypris curryi sp nov.

Fig. 1- Female right carapace; GLAHM 100956, X 67.5
Fig. 2- Female left carapace; GLAHM 100957, X 67.5
Fig. 3- Male dorsal carapace; GLAHM 100958, X 70
Fig. 4- Male right carapace; GLAHM 100959, X 71
Fig. 5- Male left carapace; GLAHM 100960, X 70

Bythocypris elsogheri sp nov.

Fig. 6- Female right carapace; GLAHM 100961, X 48.5
Fig. 7- Female left carapace; GLAHM 100962, X 48
Fig. 8- Male dorsal carapace; GLAHM 100963, X 45
Fig. 9- Female ventral carapace; GLAHM 100964, X 43.6
Fig. 10- Male right carapace; GLAHM 100965, X 49
Fig. 11- Male left carapace; GLAHM 100966, X 47.4

Paracypris keeni sp nov.

Fig. 12- Female stereoscopic paired photographs right carapace; GLAHM 100967, X 45
Fig. 13- Male stereoscopic paired photographs right carapace; GLAHM 100968, X 44

PLATE 8

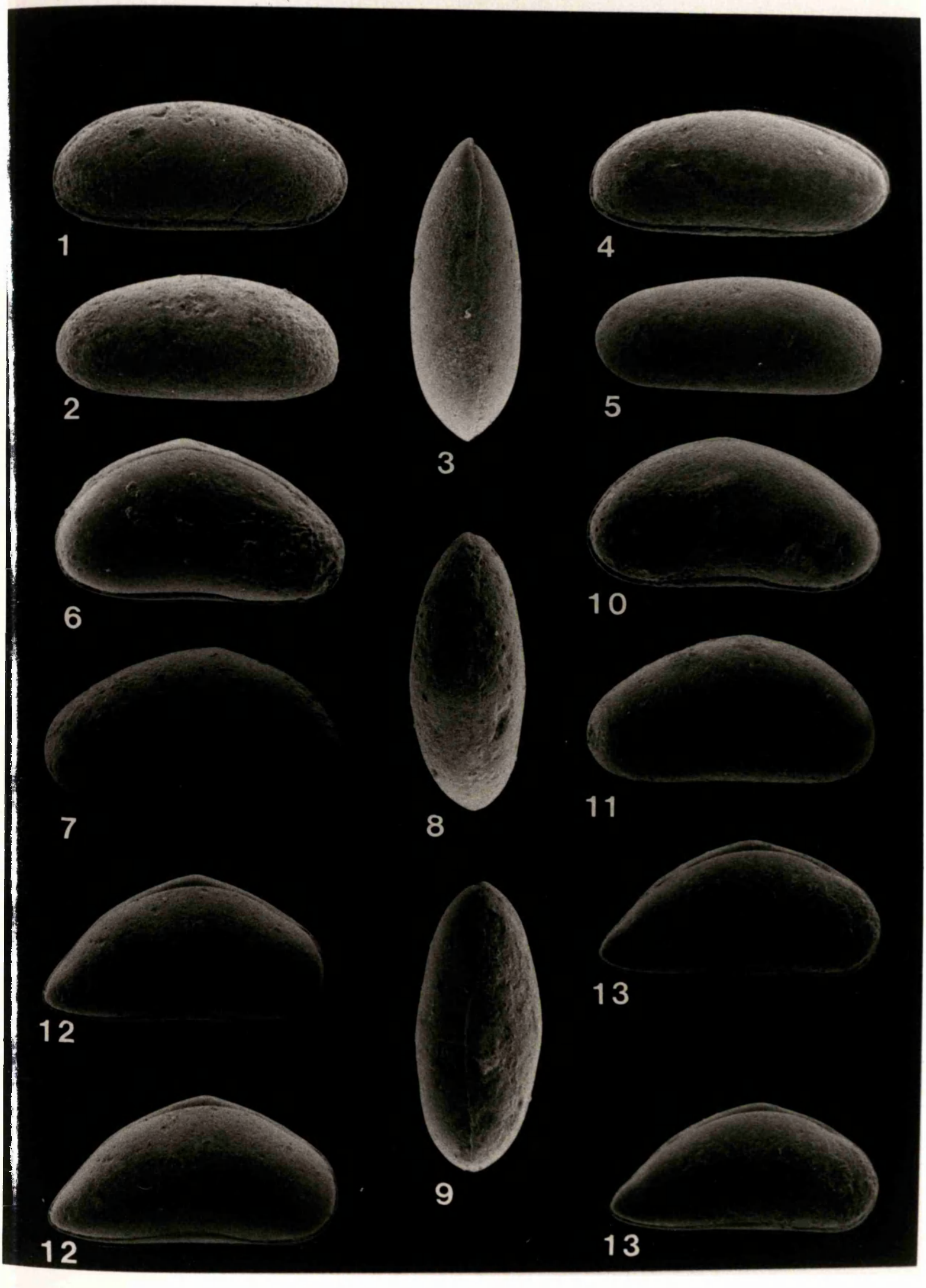


Plate 9

Paracypris keeni sp nov.

Fig. 1- Male left carapace; GLAHM 100969, X 47.5
Fig. 2- Female left carapace; GLAHM 100970, X 42.5
Fig. 3- Juvenile right carapace; GLAHM 100971, X 75
Fig. 4- Female ventral carapace; GLAHM 100972, X 49
Fig. 5- Male dorsal carapace; GLAHM 100973, X 47

Paracypris tripoliensis sp nov

Fig. 6- Female stereoscopic paired photographs right carapace; GLAHM 100974, X 54.5
Fig. 7- ?Female stereoscopic paired photographs left carapace; GLAHM 100975, X 56
Fig. 8- Male left carapace; GLAHM 100976, X 61
Fig. 9- Juvenile right carapace; GLAHM 100977, X 71
Fig. 10- Dorsal carapace; GLAHM 100978, X 58

Paracypris khawlai sp nov.

Fig. 11- Male left carapace; GLAHM 100979, X 45
Fig. 12- Female stereoscopic paired photographs right carapace; 100980, X 45
Fig. 13- Male stereoscopic paired photographs right carapace; GLAHM 100981, X 45
Fig. 14- Female left carapace; GLAHM 100982, X 43.5
Fig. 15- Male left carapace; GLAHM 100983, X 44

PLATE 9

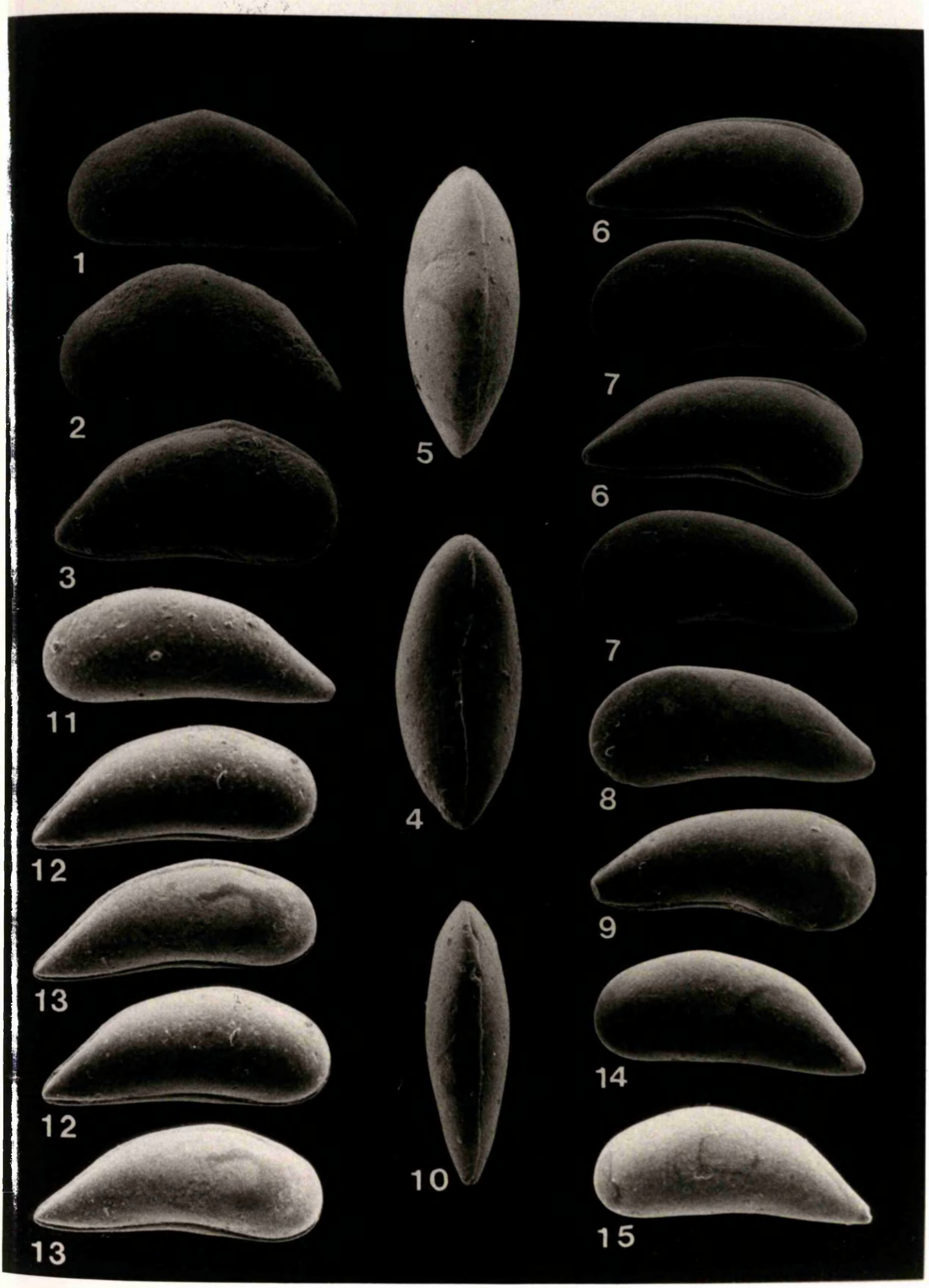


Plate 10

Paracypris sirtensis sp nov.

Fig. 1- Female stereoscopic paired photographs right carapace; GLAHM 100984, X 47.5
Fig. 2- Male stereoscopic paired photographs right carapace; GLAHM 100985, X 47.5
Fig. 3- Male left carapace; GLAHM 100986, X 45
Fig. 4- Female right carapace; GLAHM 100987, X 50
Fig. 5- Female left carapace; GLAHM 100988, X 46.25
Fig. 6- Male dorsal carapace; GLAHM 100989, X 54

Paracypris khawlai sp nov.

Fig. 7- Female dorsal carapace; GLAHM 100990, X 43.6
Fig. 8- Male dorsal carapace; GLAHM 100991, X 44

Paracypris hagfaensis sp nov.

Fig. 9- Female stereoscopic paired photographs right carapace; GLAHM 100992, X 49
Fig. 10- Male stereoscopic paired photographs right carapace; GLAHM 100993, X 47.5
Fig. 11- Female left carapace; GLAHM 100994, X 46
Fig. 12- Female left carapace; GLAHM 100995, X 45

Paracypris sp A.

Fig. 13- Left carapace; GLAHM 100996, X 55

PLATE 10

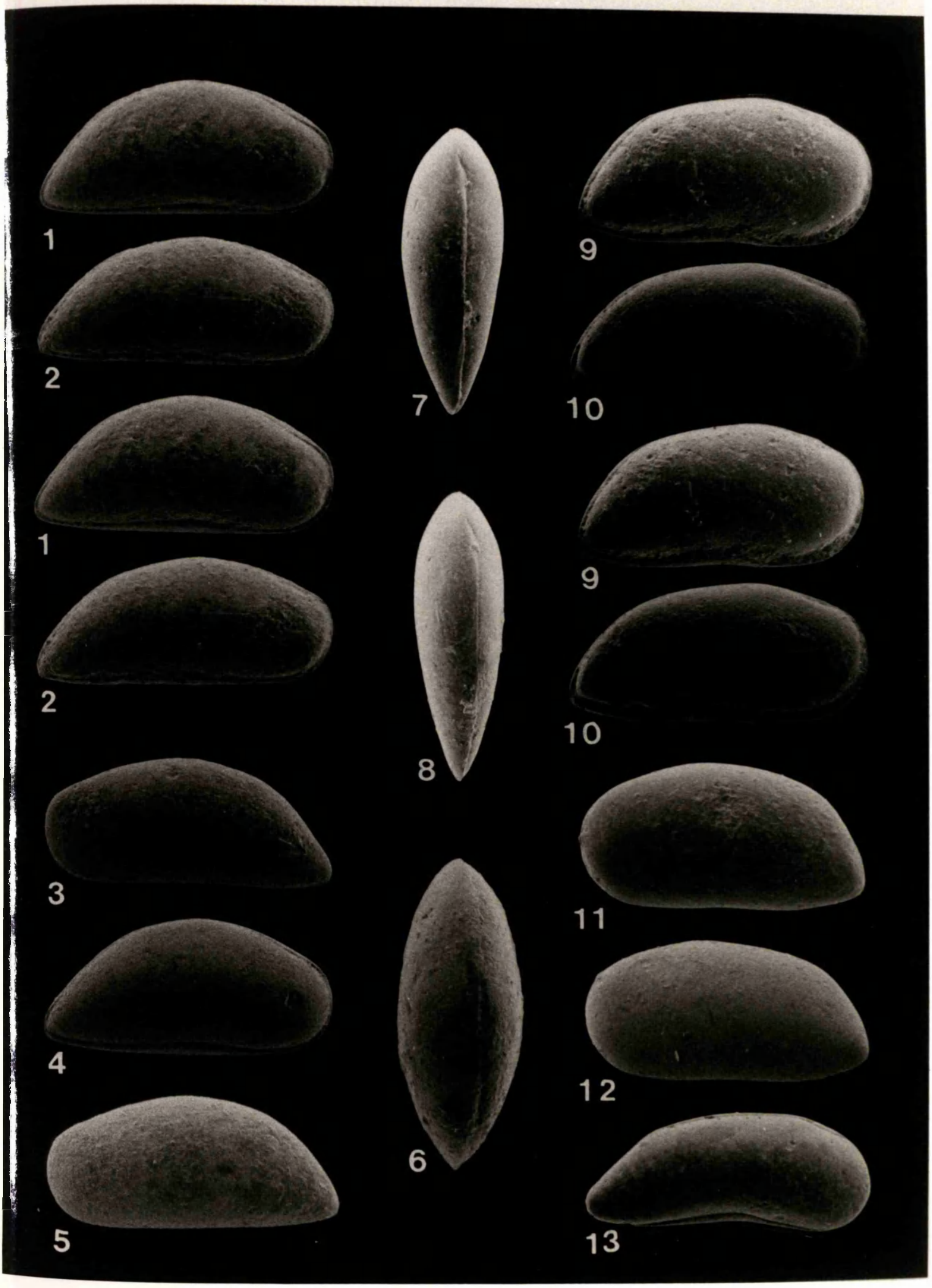


Plate 11

Paracypris sp B.

Fig. 1- Right carapace; GLAHM 100997, X 46
Fig. 2- Right carapace; GLAHM 100998, X 51.25

Pontocyprella sp.
Fig. 3- Stereoscopic paired photographs right carapace; GLAHM 100999, X 70

Pontocyprella recurva Esker, 1968

Fig. 4- Female stereoscopic paired photographs right carapace; GLAHM 101000, X 66
Fig. 5- Female left carapace; GLAHM 106001, X 64
Fig. 6- Male right carapace; GLAHM 106002, X 64
Fig. 7- Female dorsal carapace; GLAHM 106003, X 78

Paracypris hagfaensis sp nov.
Fig. 8- Dorsal carapace; GLAHM 106004, X 54

Paracypris sirtensis sp nov.
Fig. 9-Female ventral carapace; GLAHM 106005, X 50

Propontocypris triangulata sp nov.
Fig. 10- Female left carapace; GLAHM 106006, X 103
Fig. 11- Female right carapace; GLAHM 106007, X 95
Fig. 12- Male left carapace; GLAHM 106008, X 108
Fig. 13- Male right carapace; GLAHM 106009, X 112
Fig. 14- Juvenile left carapace; GLAHM 106010, X 122

Propontocypris aff *tarabulusensis* El-Waer.
Fig. 15- Left carapace; GLAHM 106011, X 80

PLATE 11

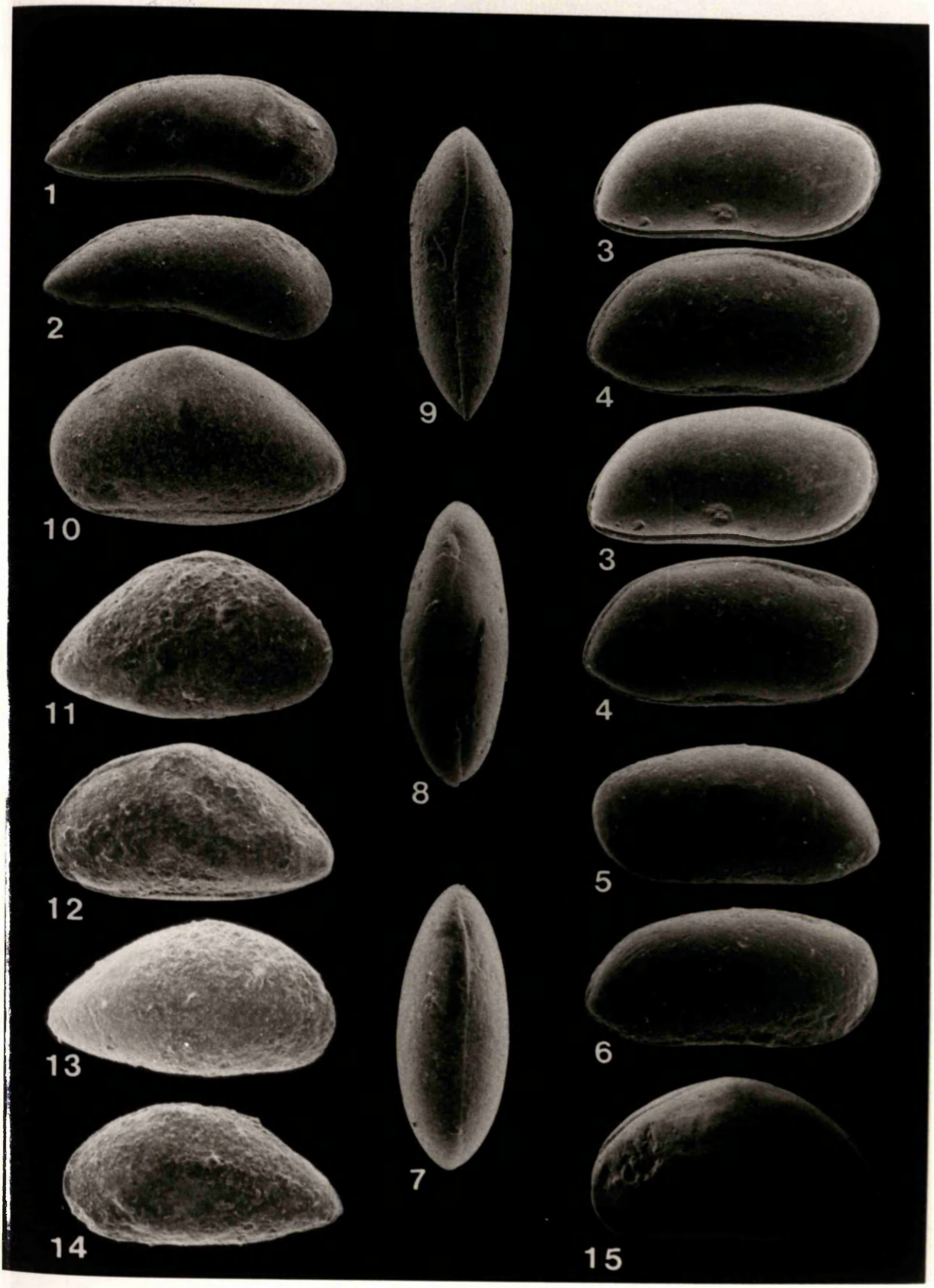


Plate12

Propontocypris triangulata sp nov.

Fig.6- Male dorsal carapace; GLAHM 106012, X 111

Brachycythere spinosa sp nov

Fig. 1- Stereoscopic paired photographs right carapace; GLAHM 106013, X 75
Fig. 2- Stereoscopic paired photographs right carapace; GLAHM 106014, X 77.5
Fig. 3- Stereoscopic paired photographs left carapace; GLAHM 106015, X 74
Fig. 4- Right carapace, GLAHM 106016, X 80
Fig. 5- Dorsal carapace; GLAHM 106017, X 74

Dahomeya alata Apostolescu, 1961

Fig. 7- Stereoscopic paired photographs right carapace; GLAHM 106018, X 95
Fig. 8- Left carapace; GLAHM 106019, X 95
Fig. 9- Dorsal carapace; GLAHM 106020, X 95

Pterygocythereis tarabulusensis El-Waer, 1992

Fig. 10- Right carapace; GLAHM 106021, X 107.5
Fig. 11- Right carapace; GLAHM 106022, X 106

PLATE 12

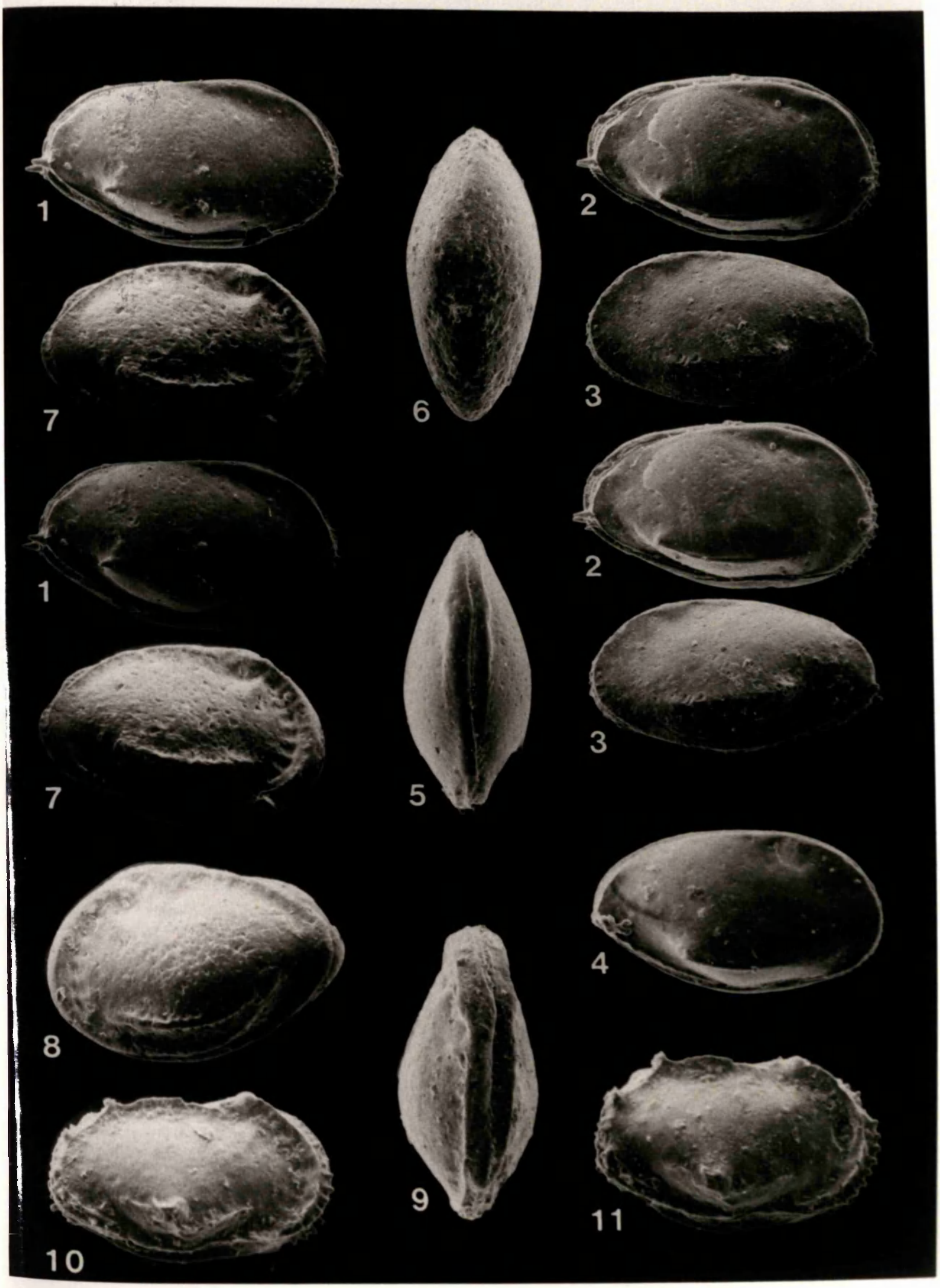


Plate 13

Bythoceratina sp.

Fig. 1- Female stereoscopic paired photographs left carapace; GLAHM 106023, X 67.5
Fig. 2- Male right carapace; GLAHM 106024, 67.5

Monoceratina gaziryi El Sogher, 1991 M.S

Fig. 3- Male stereoscopic paired photographs right carapace; GLAHM 106025, X 94
Fig. 4- Female left carapace; GLAHM 106026, X 77.5
Fig. 5- Female right carapace; GLAHM 106027, X 85
Fig. 6- Female ventral carapace; GLAHM 106028, X 84
Fig. 7- Female dorsal carapace; GLAHM 106029, X 85
Fig. 8- Juvenile left carapace; GLAHM 106030, X 97.5
Fig. 9- Male left carapace; GLAHM 106031, X 90

Monoceratina salemi sp nov.

Fig. 10- Dorsal carapace; GLAHM 106032, X 135
Fig. 11- Stereoscopic paired photographs right carapace; GLAHM 106033, X 120
Fig. 12- Stereoscopic paired photographs left carapace; GLAHM 106034, X 121

PLATE 13

Plate 14

Krithe gp *kalambainaensis* Reyment, 1981

Fig. 1- Male right carapace; GLAHM 106035, X 80
Fig. 2- Female right carapace; GLAHM 106036, X 82
Fig. 3- Male left carapace; GLAHM 106037, X 77.5
Fig. 4- Male left carapace; GLAHM 106038, X 74
Fig. 5- Female dorsal carapace; GLAHM 106039, X 87.5

Krithe echolsae Esker, 1968

Fig. 6- Female right carapace; GLAHM 106040, X 70
Fig. 7- Female left carapace; GLAHM 106041, X 71
Fig. 8- Male right carapace; GLAHM 106042, X 67
Fig. 9- Female left carapace; GLAHM 1106043, X 73

Krithe barsottii sp nov

Fig. 10- Stereoscopic paired photographs right carapace; GLAHM 106044, X 84
Fig. 11- Stereoscopic paired photographs left carapace; GLAHM 106045, X 85
Fig. 12- Right carapace; GLAHM 106046, X 86
Fig. 13- Left carapace; GLAHM 106047, X 82.5
Fig. 14- Dorsal carapace; GLAHM 106048, X 90
Fig. 15- Ventral carapace; GLAHM 106049, x 93

PLATE 14

Plate 15

Parakrithe crolifa Bassiouni, 1990

Fig. 1- Female right carapace; GLAHM 106050, X 92
Fig. 2- Male right carapace; GLAHM 106051, X 91
Fig. 3- Male left carapace; GLAHM 1106052, x 90
Fig. 4- Male dorsal carapace; GLAHM 106053, X 91

?*Parakrithe* sp

Fig. 5- Stereoscopic paired photographs right carapace; GLAHM 106054, X 72.5
Fig. 6- Stereoscopic paired photographs left carapace; GLAHM 106055, X 70
Fig. 7- Dorsal carapace; GLAHM 106056, X 67.5

Cytheropteron sp cf *C lekefense* Esker, 1968

Fig. 8- Female stereoscopic paired photographs right carapace; GLAHM 106057, X 153
Fig. 9- Male stereoscopic paired photographs right carapace; GLAHM 106058, X 145

Cytherura n sp 1 Salahi, 1966

Fig. 10- Right carapace; GLAHM 106059, X 122
Fig. 11- Left carapace; GLAHM 106060, X 118
Fig. 12- Dorsal carapace; GLAHM 106061, X 128

PLATE 15

Plate 16

Cytheretta aff *C* n sp 1 Salahi, 1966
Fig. 1- Right carapace; GLAHM 106062, X 94

Loculicytheretta cf *L cavernosa* (Apostolescu & Magne, 1956)
Fig. 2- Right valve; GLAHM106063, X 53

Cytheropteron sp
Fig. 3- Stereoscopic paired photographs right carapace; GLAHM 106064, X 142

Pterygocythereis sp
Fig. 4- Stereoscopic paired photographs right valve; GLAHM 106065, X 59

?*Eucytherura* sp
Fig. 5- Right carapace; GLAHM 106066, X 105

Paijenborchellina sp
Fig. 6- Female right carapace; GLAHM106067, X 92.5
Fig. 7- Female left carapace; GLAHM 106068, X 93
Fig. 8- Male right carapace (broken); GLAHM 106069, X 94

Semicytherura elfoghaensis sp nov
Fig. 9- Female right carapace; GLAHM 106070, X 97
Fig. 10- Male right carapace; GLAHM 106071, X 89
Fig. 11- Male left carapace; GLAHM 106072, X 93
Fig. 12- Female dorsal carapace; GLAHM 106073, X 92.5
Fig. 13- Female ventral carapace; GLAHM 106074, X 94

Uromuellerina sinhai sp nov
Fig. 14- Female ventral carapace; GLAHM 106075, X 81

PLATE 16

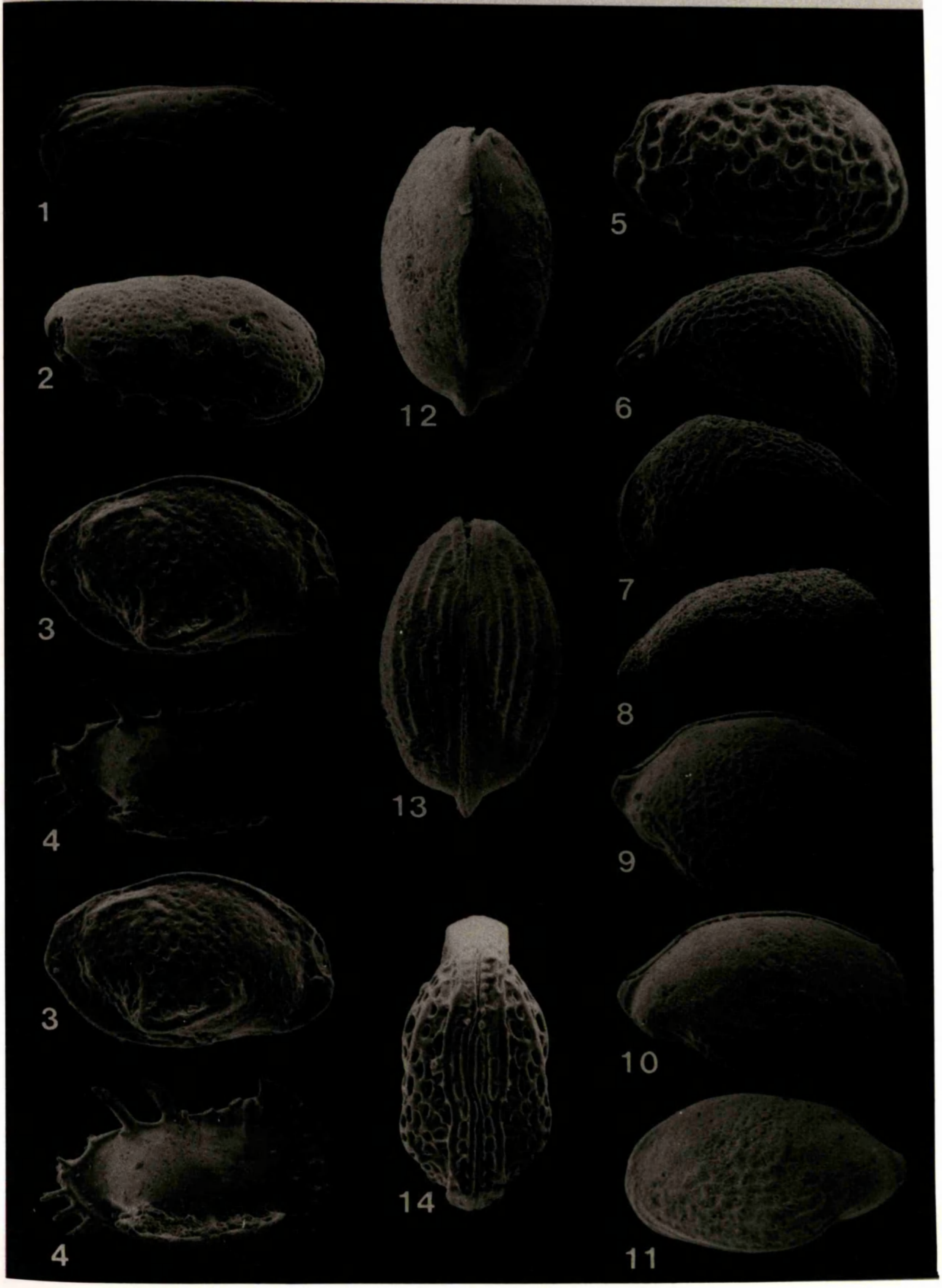


Plate 17

Uromuellerina sinhai sp nov

Fig. 1- Male stereoscopic paired photographs right carapace; GLAHM 106076, X 72.5
Fig.3- Female right carapace; GLAHM 106077, X 87.5
Fig.4- Male left carapace; GLAHM 106078, X 72.5
Fig.5- Female left carapace; GLAHM 106079, X 80
Fig.6- Female dorsal carapace; GLAHM 106080, X 82.5

Leguminocythereis lokossaensis Apostolescu, 1961

Fig. 2- Female stereoscopic paired photographs right carapace; GLAHM 106081, X 82.5
Fig. 7- Female right carapace; GLAHM 106082, X 81
Fig. 8- Male right carapace; GLAHM 106083, X 74
Fig. 9- Female ventral carapace; GLAHM 106084, X 102

Loxoconcha burtoni sp nov

Fig. 10- Dorsal carapace; GLAHM 106085, X 121
Fig. 11- Stereoscopic paired photographs right carapace; GLAHM 106086, X 120
Fig. 12- Stereoscopic paired photographs left carapace; GLAHM 106087, X 118

PLATE 17

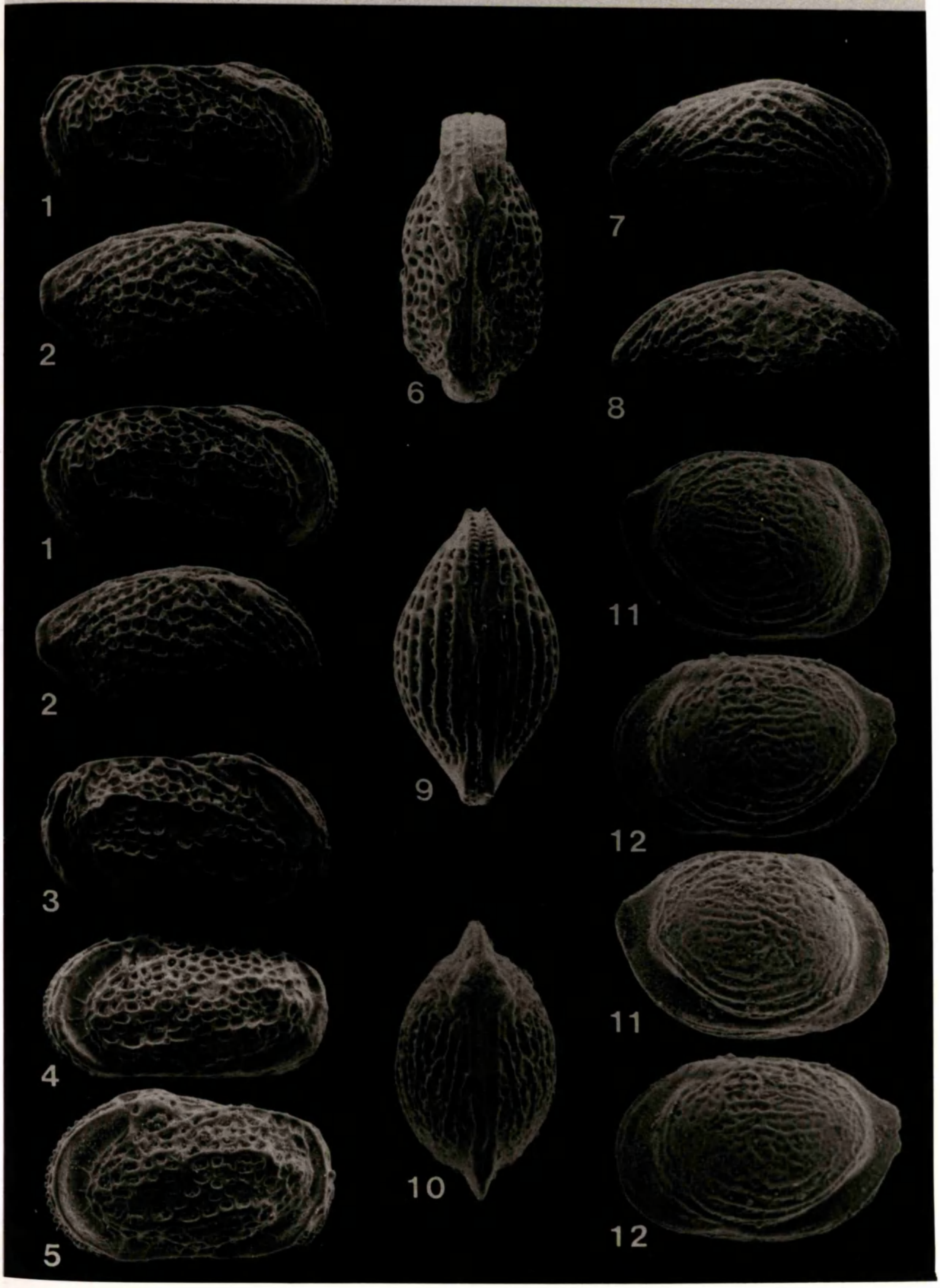


Plate 18

Loxconcha aff *L marionensis* Salahi, 1966

Fig. 1- Female right carapace; GLAHM 106088, X 85
Fig. 2- Male left carapace; GLAHM 106089, X 86
Fig. 3- Male right carapace; GLAHM 106090, X 84

Loxoconcha sp

Fig. 4- Right carapace; GLAHM 106091, X 82.5
Fig. 5- Left carapace; GLAHM 106092, X 88
Fig. 6- Right carapace; GLAHM 106093, X 84.5
Fig. 7- Ventral carapace; GLAHM 106094, X 82.5
Fig. 8- Dorsal carapace; GLAHM 106095, X 85
Fig. 9- Left carapace; GLAHM 106096, X 82.5

Schisocythere qaltahensis sp nov.

Fig. 10- Female right carapace; GLAHM 106097, X 112.5
Fig. 11- Female left carapace; GLAHM 106098, X 106
Fig. 12- Male right carapace; GLAHM 106099, X 98
Fig. 13- Female left carapace; GLAHM 106100, X 102.5
Fig. 14- Female left carapace; GLAHM 106101, X 106
Fig. 15- Female dorsal carapace; GLAHM 106102, X 107. 5

PLATE 18

Plate 19

Paijenborchella sp

Fig. 1- Stereoscopic paired photographs right carapace; GLAHM 106103, X 135

Mauritsina coronata (Esker, 1968)

Fig. 2- Stereoscopic paired photographs right carapace; GLAHM 106104, X 58

Fig. 3- Left carapace; GLAHM 106105, X 68

Trachyleberis modesta Apostolescu, 1961

Fig. 4- Female right carapace; GLAHM 106106, X 75

Fig. 5- Male left carapace; GLAHM 106107, X 66

Fig. 6- Male dorsal carapace; GLAHM 106108, X 64

Fig. 7- Male right carapace; GLAHM 106109, X 67

Trachyleberis teiskotensis Apostolescu, 1961

Fig. 8- Male stereoscopic paired photographs right carapace; GLAHM 106110, X 59

Fig. 9- Female stereoscopic paired photographs right carapace; GLAHM 106111, X 68

Fig. 10- Male left carapace; GLAHM 106112, X 58

Fig. 11- Female left carapace; GLAHM 106113, X 67

Fig. 12- Juvenile dorsal carapace; GLAHM106114, X 80

Fig. 13- Male dorsal carapace; GLAHM 106115, X 65

PLATE 19

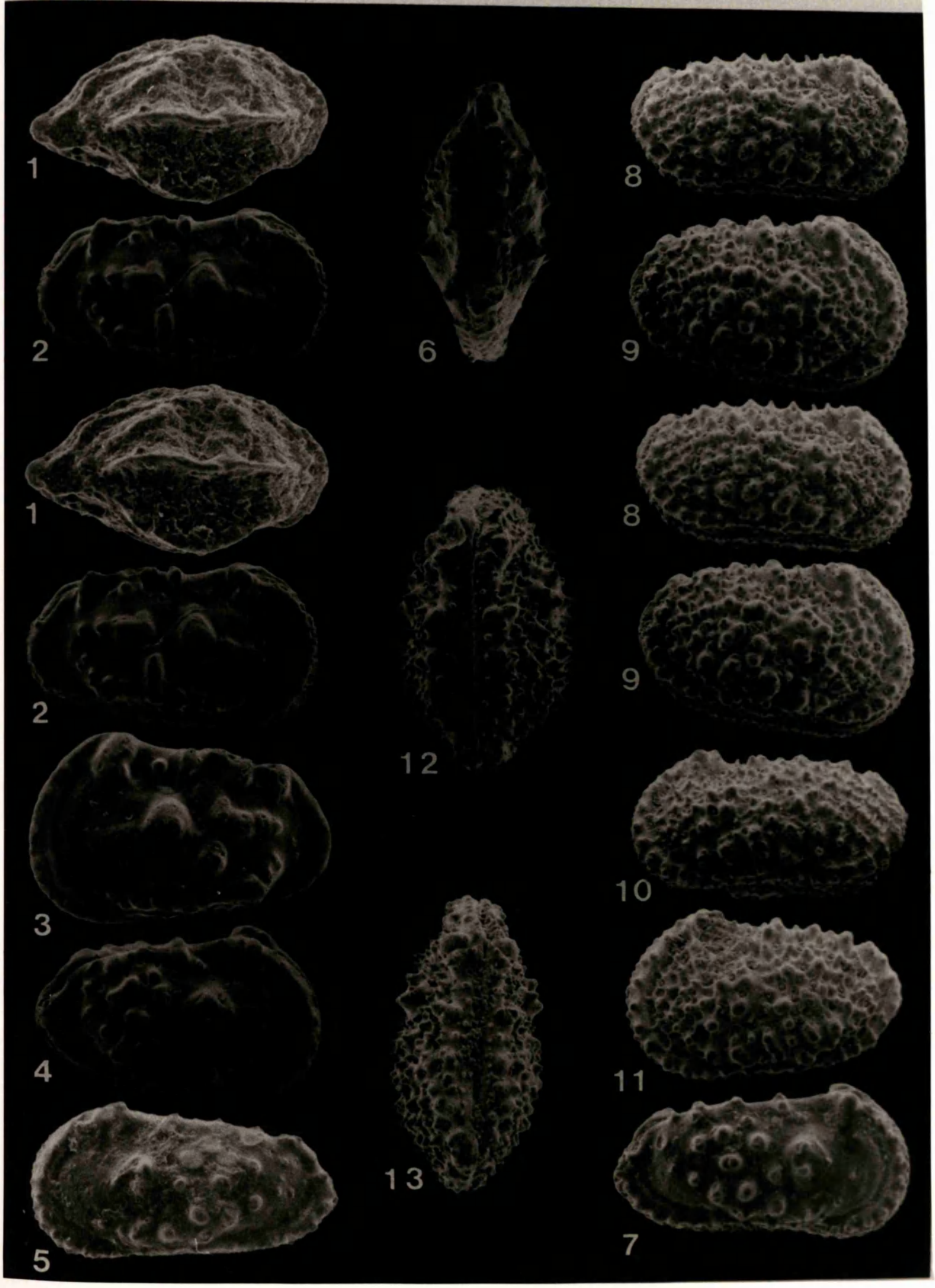


Plate 20

Actinocythereis joshensis sp nov.

Fig. 1-Male right carapace; GLAHM 106116, X 58
Fig. 2-Female left carapace; GLAHM 1106117, X 69
Fig. 3-Male left carapace; GLAHM 106118, X 63.5
Fig. 4-Female right carapace; GLAHM 106119, X 68.5
Fig. 5-Female dorsal carapace; GLAHM 106120, X 75
Fig. 6-Female right carapace; GLAHM 106121, X 73

Acanthocythereis Stymatuora libyaensis sub sp nov

Fig. 7-Male right carapace; GLAHM 106122, X 66
Fig. 8-Male left carapace; GLAHM 106123, X 67
Fig. 9-Male right carapace; GLAHM 106124, X 65
Fig. 10-Male dorsal carapace; GLAHM 106125, X 71 (upside down)

Buntonia sp cf *B tichittensis* Apostolescu, 1961

Fig. 11-Female right carapace; GLAHM 106126, X 113
Fig. 12-Male right carapace; GLAHM 1106127, X 102
Fig. 13-Female right carapace; GLAHM 106128, X 115
Fig. 14-Female dorsal carapace; GLAHM 106129, X 120

Buntonia tatteuliensis (Apostolescu, 1961)

Fig. 15-Female right carapace; GLAHM 106130, X 68
Fig. 16-Female left carapace; GLAHM 106131, X 72.5

PLATE 20

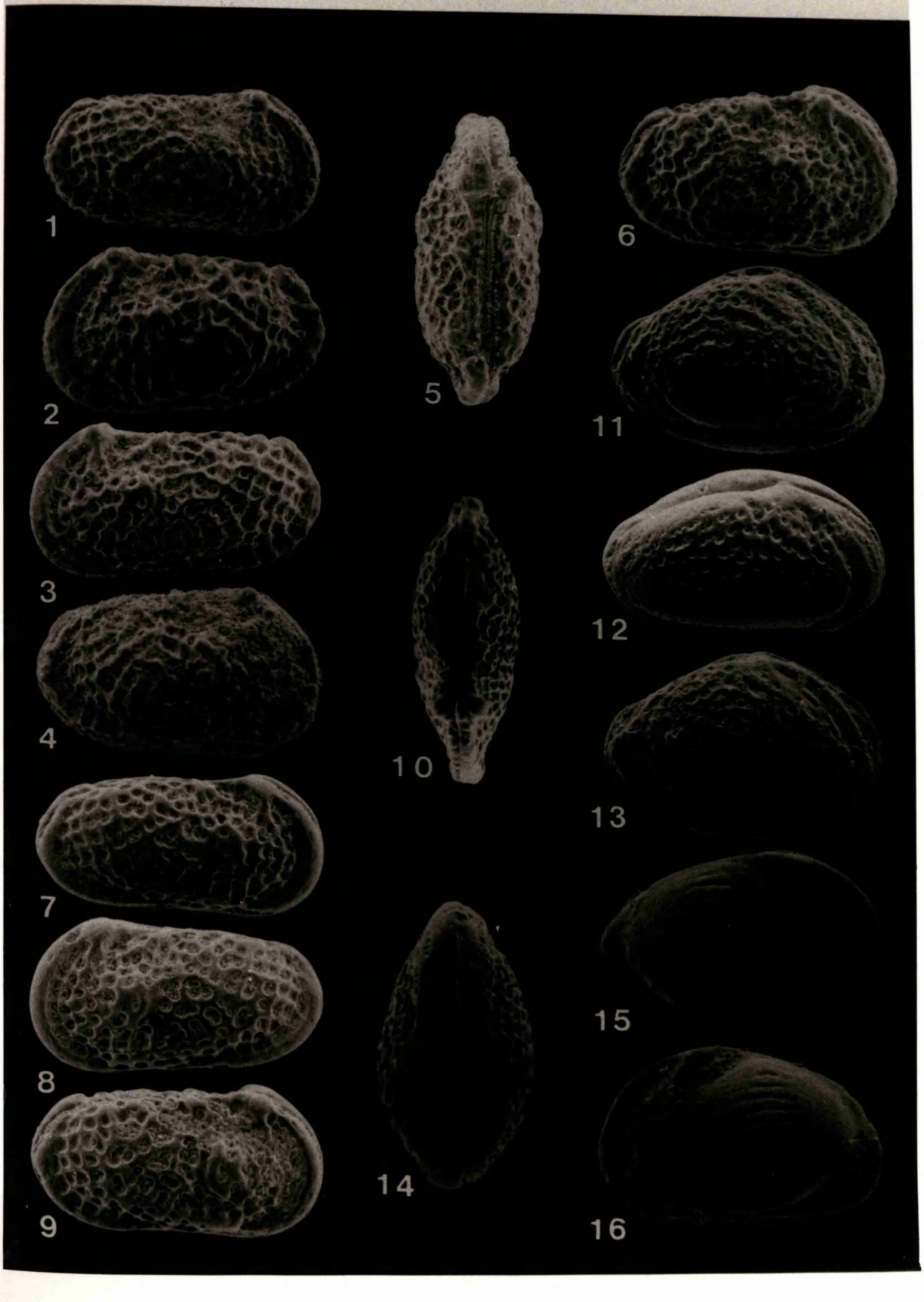


Plate 21

Buntonia tatteuliensis (Apostolescu, 1961)

Fig. 1-Male right carapace; GLAHM 106132, X 61
Fig. 2-Male left carapace; GLAHM 106133, X 62
Fig. 3-Juvenile right carapace, GLAHM 106134, X 81.5
Fig. 4-Female ventral carapace; GLAHM 106135, X 65.5
Fig. 5-Male dorsal carapace; GLAHM 106136, X 60

Buntonia (*B*) *salahii* sp nov.

Fig. 6-Female left carapace; GLAHM 106137, X 102
Fig. 7-Male right carapace; GLAHM 106138, X 89
Fig. 8-Male left carapace; GLAHM 106139, X 89
Fig. 9-Female left carapace; GLAHM 106140, X 106.5

Buntonia fortunata Apostolescu, 1961

Morphotype A

Fig. 10-Female right carapace; GLAHM 106141, X 82
Fig. 11-Male right carapace, GLAHM 106142, X 63
Fig. 12-Female left carapace; GLAHM 106143, X 85

Morphotype B

Fig. 13-Male left carapace; GLAHM 106144, X 60
Fig. 14-Female left carapace; GLAHM 106145, X 76
Fig. 15-Male right carapace; GLAHM 106146, X 61

Morphotype C

Fig. 16-Female right carapace; GLAHM 106147, X 80
Fig. 17-Male left carapace; GLAHM 106148, X 64

PLATE 21

Plate 22

Buntonia harashensis sp nov.

Fig. 1-Female left carapace; GLAHM 106149, X 66.5
Fig. 2-Male right carapace; GLAHM 106150, X 66
Fig. 3-Female left carapace; GLAHM 106151, X 70
Fig. 4-Male left carapace; GLAHM 106152, X 66
Fig. 5-Female right carapace; GLAHM 106153, X 70.5
Fig. 6-Female right carapace; GLAHM 106154, X 71
Fig. 7-Female ventral carapace; GLAHM 106155, X 75
Fig. 8-Female dorsal carapace; GLAHM 106156, X 78

Cythereis teiskotensis (Apostolescu, 1961)

Fig. 9-Male left carapace; GLAHM 106157, X 69
Fig. 10-Female right carapace; GLAHM 106158, X 66
Fig. 11-Female left carapace; GLAHM 106159, X 66.5
Fig. 12-Male right carapace; GLAHM 106160, X 57.5
Fig. 13-Female dorsal carapace; GLAHM 106161, X 69

Cythereis sp cf *C teiskotensis* (Apostolescu, 1961)

Fig. 14- Male stereoscopic paired photographs right carapace; GLAHM 106162, X 55.5
Fig. 15- Female stereoscopic paired photographs right carapace; GLAHM 106163, X 55

PLATE 22

Plate 23

Cythereis sp cf *C teiskotensis*.(Apostolescu, 1961)

Fig. 1-Male left carapace; GLAHM 106164, X 55.5
Fig. 2-Female left carapace; GLAHM 106165, X 58.5
Fig. 6- Female dorsal carapace; GLAHM 106166, X 61

Cythereis kheirensis sp nov

Fig. 3- Male stereoscopic paired photographs right carapace; GLAHM 106167, X 73
Fig. 4- Female stereoscopic paired photographs left carapace; GLAHM 106168, X 77
Fig. 5-Male right carapace; GLAHM 106169, X 78

Occultocythereis confirmatus El Sweify, 1983

Fig. 7-Male right carapace; GLAHM 106170, X 112
Fig. 8-Female right carapace; GLAHM 106171, X 121
Fig. 9-Male left carapace; GLAHM 106172, X 109
Fig. 10-Male dorsal carapace; GLAHM 106173, X 119

Occultocythereis sp

Fig. 11- Stereoscopic paired photographs right carapace; GLAHM 106174, X 62

Protobuntonia nakkadii Bassiouni, 1970

Fig. 12- Male stereoscopic paired photographs right carapace; GLAHM 106175, X 50
Fig. 13- Female dorsal carapace; GLAHM 106176, X 63.5

PLATE 23

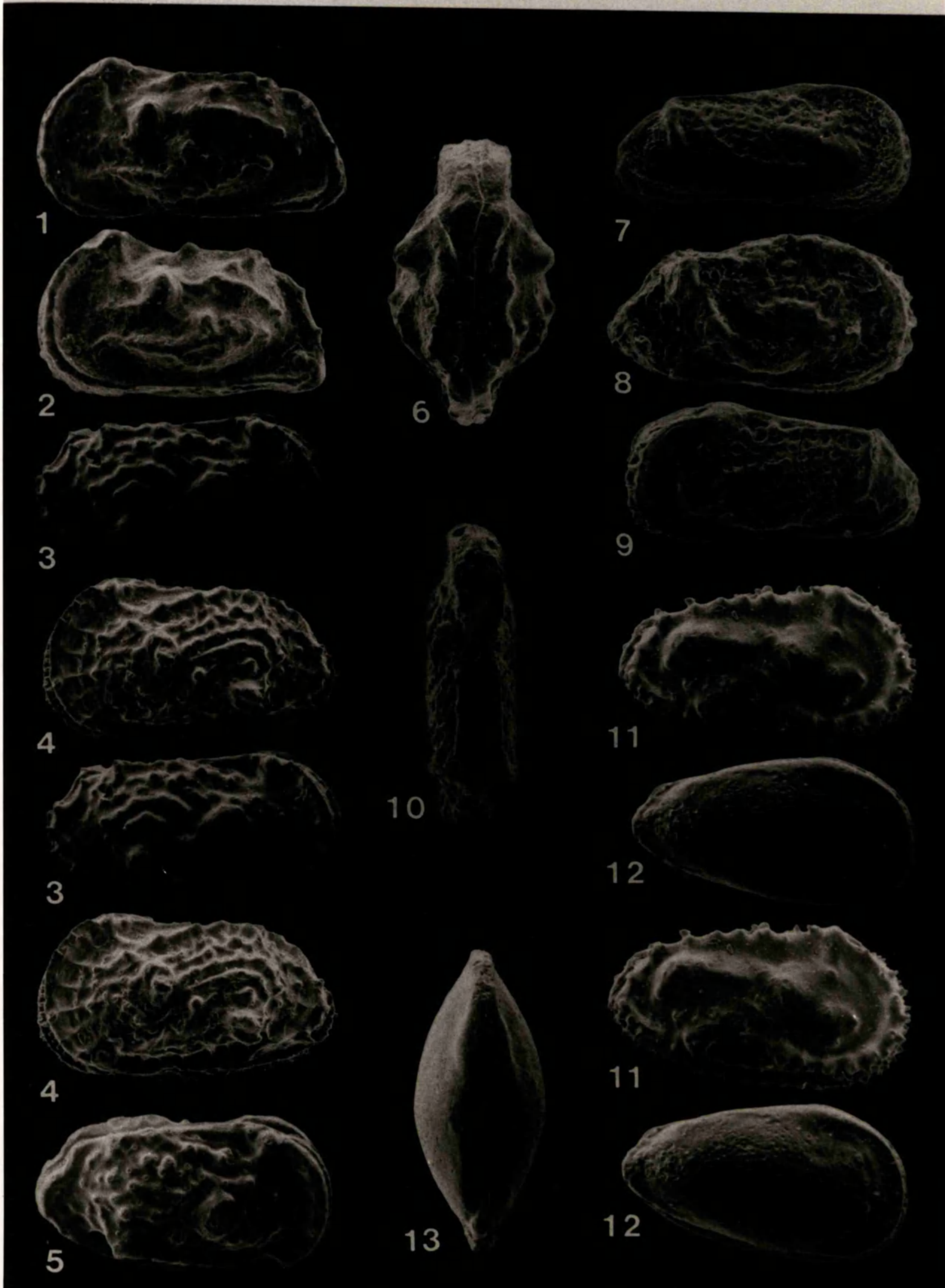


Plate 24

Protobuntonia nakkadii Bassiouni, 1970

Fig. 1- Female stereoscopic paired photographs right carapace; GLAHM 106177, X 60.5
Fig. 3- Female left carapace; GLAHM 106178, X 59

Protobuntonia sp B El Sogher, 1991 M.S

Fig. 2- Stereoscopic paired photographs right carapace; GLAHM 106179, X 94

Protobuntonia spinosa sp nov

Fig. 4- Male right carapace; GLAHM 106180, X 82
Fig. 5- Male left carapace; GLAHM 106181, X 84
Fig. 6- Female right carapace; GLAHM 106182, X 88
Fig. 7- Female left carapace; GLAHM 106183, X 86
Fig. 8- Female right carapace; GLAHM 106184, X 115
Fig. 9- Male dorsal carapace; GLAHM 106185, X 88
Fig. 10- Female ventral carapace;GLAHM 106186, X 95

Quadracythere kaoensis Carbonnel *et al*, 1990

Fig. 11- Female right carapace; GLAHM 106187, X 87
Fig. 12- Female left carapace; GLAHM 106188, X 90.5
Fig. 13- Male right carapace; GLAHM 106189, X 92
Fig. 14- Male left carapace; GLAHM 106190, X 96.5
Fig. 15- Female ventral carapace; GLAHM 106191, X 98

PLATE 24

Plate 25

Quadracythere kaoensis Carbonnel *et al*, 1990

Fig. 13- Female dorsal carapace; GLAHM 106192, X 97.5

Hornibrookella episcelis Al-Furaih, 1984

Fig. 1- Female right carapace; GLAHM 106193, X 70
Fig. 2- Female left carapace; GLAHM 106194, X 65
Fig. 3- Male right carapace; GLAHM 106195, X 67.5
Fig. 4- Female left carapace; GLAHM 106196, X 68

Hornibrookella heiraensis sp nov

Fig. 5- Female right carapace; GLAHM 106197, X 70.5
Fig. 6- Male right carapace; GLAHM 106198, X 68
Fig. 7- Female stereoscopic paired photographs left carapace; GLAHM 106199, X 72.5
Fig. 8- Male stereoscopic paired photographs right carapace; GLAHM 106200, X 72.5
Fig. 9- Male left carapace; 106201, X 67.5
Fig. 10- Female right carapace; GLAHM 106202, X 72.5
Fig. 11- Female dorsal carapace; GLAHM 106203, X 81
Fig. 12- Female ventral carapace; GLAHM 106204, X 76

PLATE 25

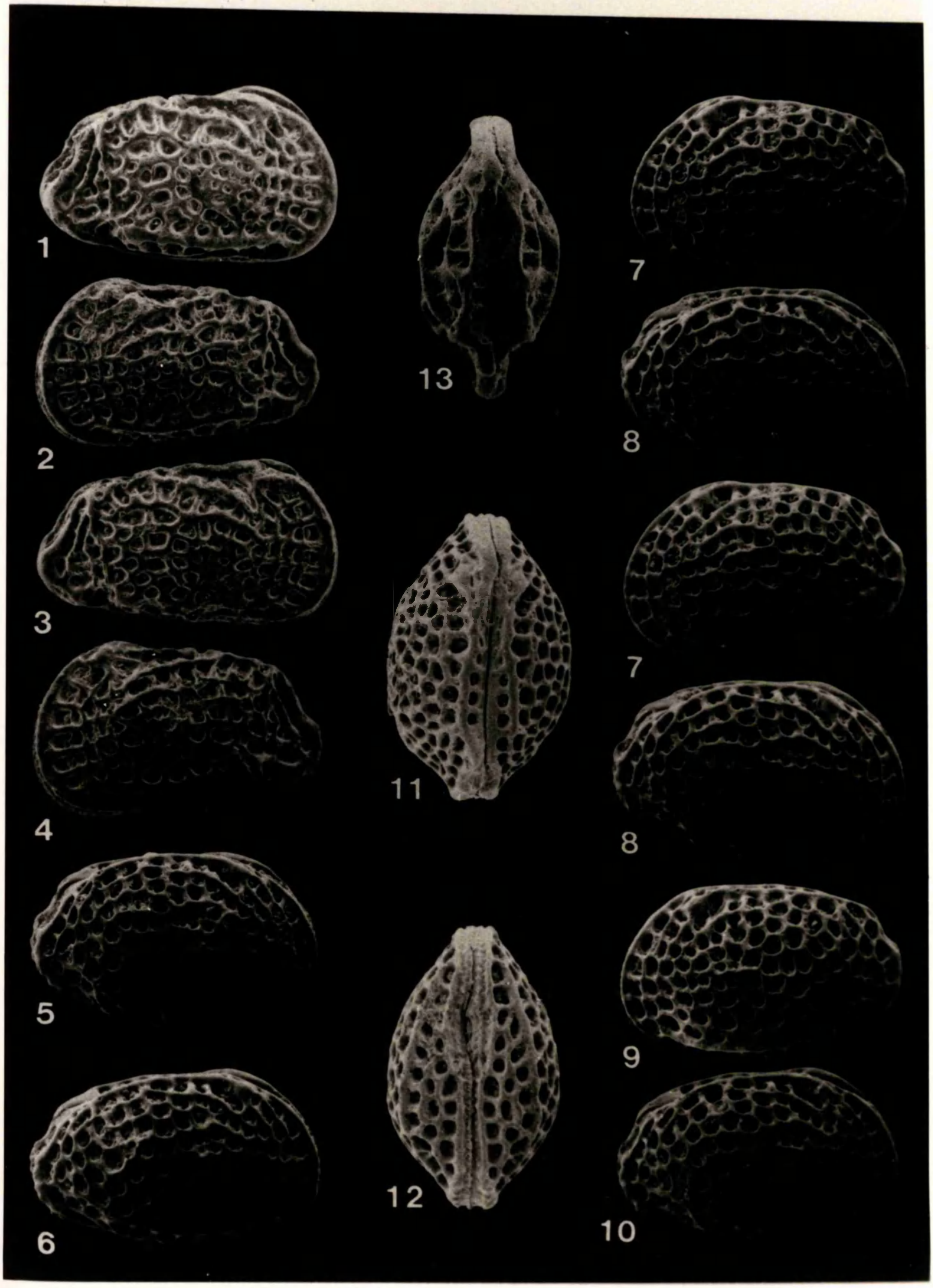


Plate 26

Oertliella heiraensis sp nov

Fig. 1- Male stereoscopic paired photographs right carapace; GLAHM 106205, X 86
Fig. 2- Female stereoscopic paired photographs left carapace; GLAHM 106206, X 92.5
Fig. 3- Male left carapace; GLAHM 106207, X 85
Fig. 4- Female left carapace; GLAHM 106208, X 98
Fig. 5- Female ventral carapace; GLAHM 106209, X 95
Fig. 6- Female dorsal carapace; GLAHM 106210, X 100.3

?*Ordoniya* (*O*) *burmaensis* (Bassioni, 1970)

Fig. 7- Right carapace; GLAHM 106211, X 79
Fig. 8- Left carapace; GLAHM 106212, X 77.5

Soudanella ghanienis sp nov

Fig. 9- Male stereoscopic paired photographs right carapace; GLAHM 106213, X 68.5
Fig. 10- Female stereoscopic paired photographs right carapace; GLAHM 106214, X 73.5
Fig. 11- Male left carapace; GLAHM 106215, X 71
Fig. 12- Female left carapace; GLAHM 106216, X 77.5
Fig. 13- Male dorsal carapace; GLAHM 106217, X 69

PLATE 26

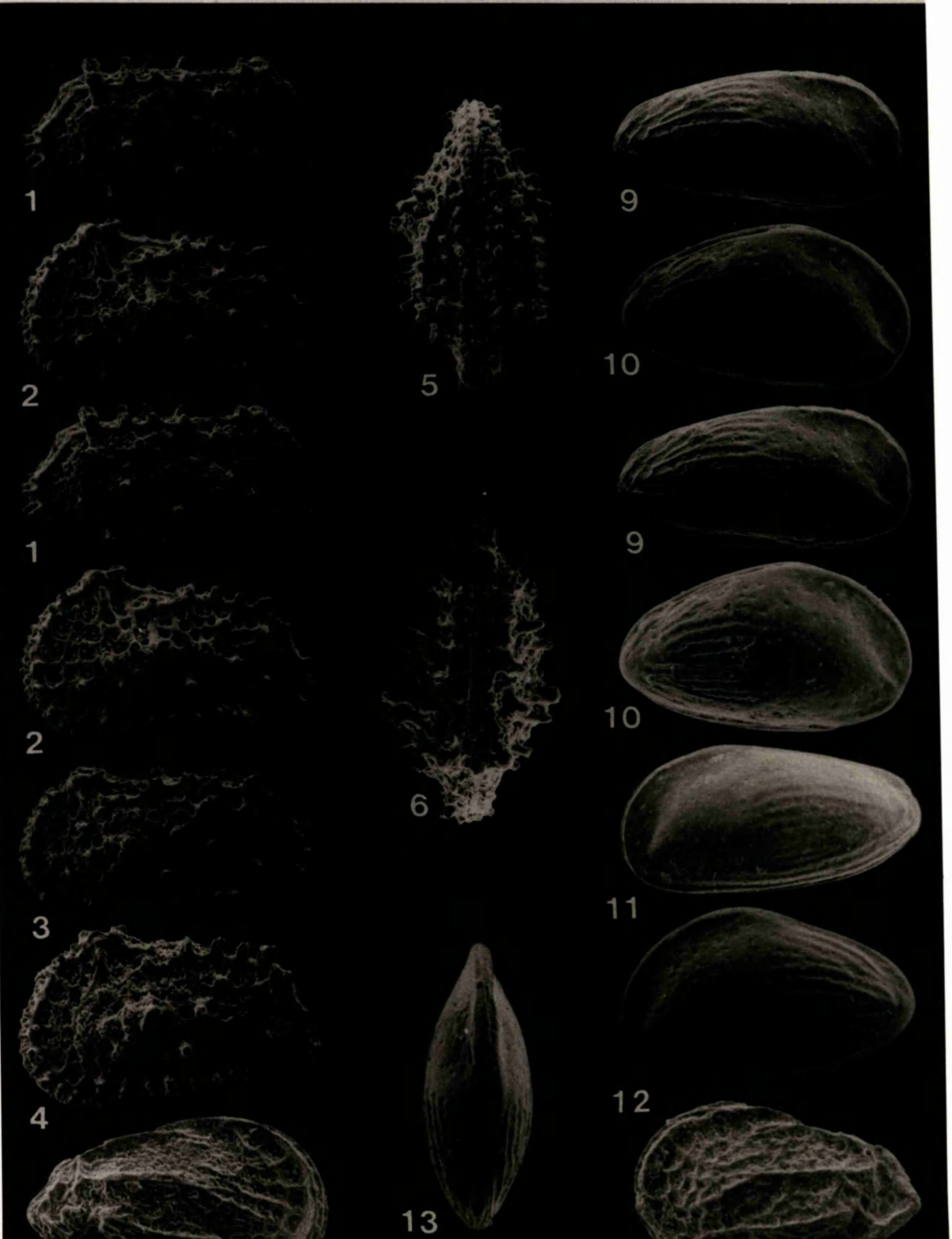


Plate 27

Soudanella ghaniensis sp nov

Fig. 9- Female ventral carapace; GLAHM 106218, X 74

Soudanella sp cf *S ioruba* Reyment, 1961

Fig. 1- Male right carapace; GLAHM 106219, X 72.5
Fig. 2- Female left carapace; GLAHM 106220, X 73
Fig. 3- Male right carapace; GLAHM 106221, X 67.5

Paragrenocythere gravis Al-Furaih, 1980

Fig. 4- Male left carapace; GLAHM 106222, X 65
Fig. 5- Female right carapace; GLAHM 106223, X 70
Fig. 6- Male left carapace; GLAHM 106224, X 62.5
Fig. 7- Female left carapace; GLAHM 106225, X 69
Fig. 8- Female dorsal carapace; GLAHM 106226, X 67.5

Paragrenocythere neoponticulata El Sogher, 1991 M.S

Fig. 10- Male left carapace; GLAHM 106227, X 56.5
Fig. 11- Female right carapace; GLAHM 106228, X 57.5
Fig. 12- Male right carapace; GLAHM 106229, X 56.5
Fig. 17- Female ventral carapace; GLAHM 106230, X 56.4

Phalcocythere jebelensis El Sogher, 1991 M.S

Fig. 13- Female left carapace; GLAHM 106231, X 75
Fig. 14- Female right carapace; GLAHM 106232, X 76
Fig. 15- Female left carapace; GLAHM 106233, X 73
Fig. 16- Female left carapace; GLAHM 106234, X 90

PLATE 27

Plate 28

Phalcocythere ralahensis El Sogher, 1991

Fig. 1- Right carapace; GLAHM 106235, X 87.5
Fig. 2- Left carapace; GLAHM 106236, X 84
Fig. 3- Right carapace; GLAHM 106237, X 83
Fig. 4- Dorsal carapace; GLAHM 106238, X 91

Phalcocythere hagfaensis sp nov

Fig. 5- Stereoscopic paired photographs left carapace; GLAHM 106239, X 60
Fig. 6- Stereoscopic paired photographs right carapace; GLAHM 106240, X 59
Fig. 7- Right carapace; GLAHM 106241, X 62.5
Fig. 8- Left carapace; GLAHM 106242, X 65
Fig. 9- Dorsal carapace; GLAHM 106243, X 67.5
Fig. 10- Ventral carapace; GLAHM 106244, X 64

Paracosta palaeomokattamensis Bassiouni & Luger, 1990

Fig. 11- Male left carapace; GLAHM 106245, X 75
Fig. 12- Male stereoscopic paired photographs right carapace; GLAHM 106246, X 70
Fig. 13- Female stereoscopic paired photographs right carapace; GLAHM 106247, X 84

PLATE 28

Plate 29

Paracosta palaeomokattamensis Bassiouni & Luger, 1990

Fig. 1- Female left carapace; GLAHM 106248, X 86
Fig. 2- Female dorsal carapace, GLAHM 106249, X 77.5
Fig. 3- Female ventral carapace; GLAHM 106250, X 82.5

Paracosta bensoni Damotte & Donze, 1982

Morphotype A

Fig. 4- Male right carapace; GLAHM 106251, X 72.5
Fig. 5- Female left carapace; GLAHM 106252, X 78
Fig. 6- Female right carapace; GLAHM 106253, X 78
Fig. 7- Female left carapace; GLAHM 106254, X 75.5
Fig. 8- Male right carapace; GLAHM 106255, X 67.5

Morphotype B

Fig. 9- Female left carapace; GLAHM 106256, X 75
Fig. 10- Male right carapace; GLAHM 106257, X 72
Fig. 11- Female right carapace; GLAHM 106258, X 72.5
Fig. 12- Female right carapace; GLAHM 106259, X 77

Paracosta warriensis (Reyment, 1960)

Fig. 13- Male left carapace; GLAHM 106260, X 58
Fig. 14- Female left carapace; GLAHM 106261, X 66
Fig. 15- Female dorsal carapace; GLAHM 106262, X 62.5

PLATE 29

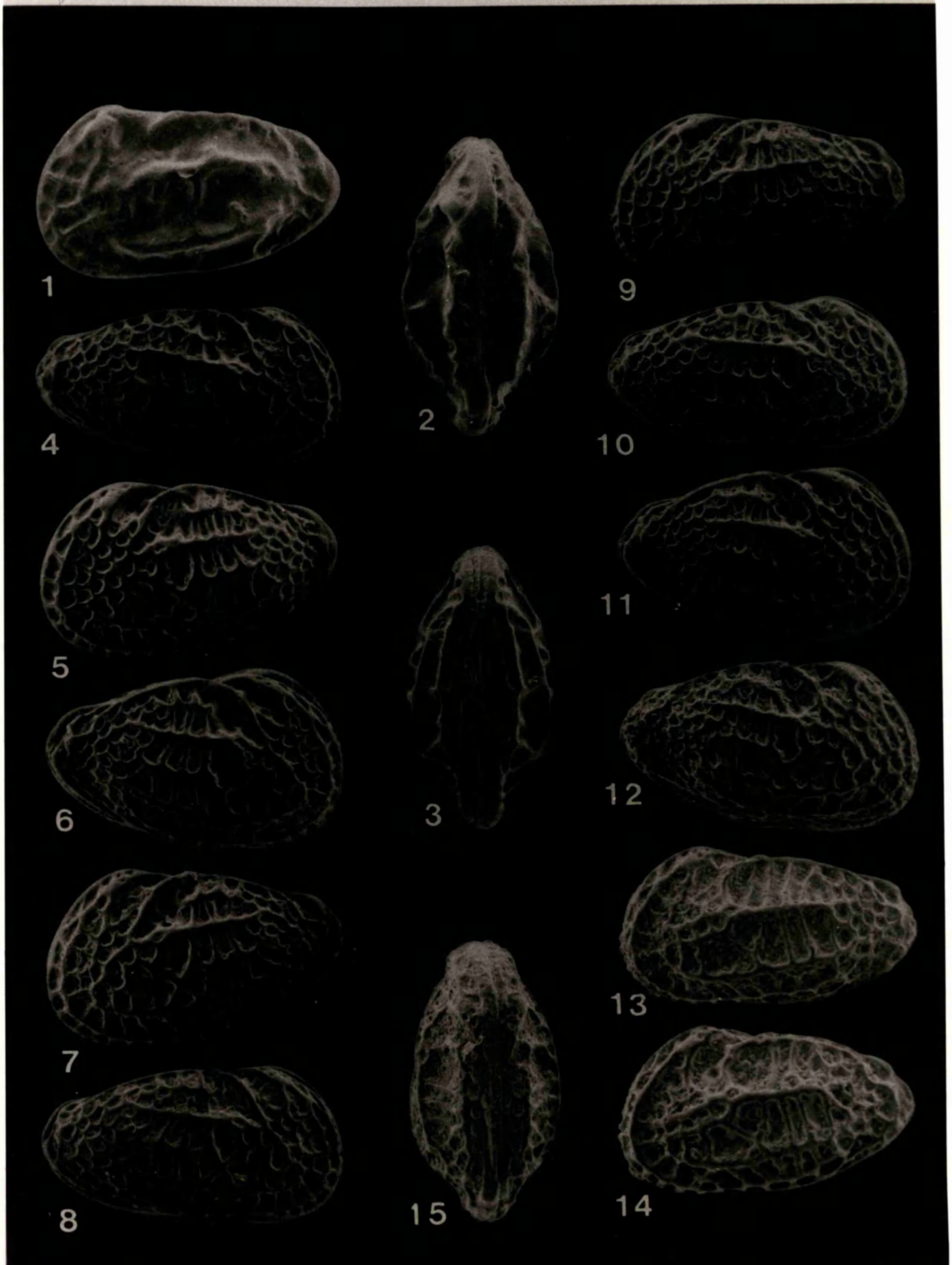


Plate 30

Paracosta warriensis (Reyment, 1960)

Fig. 1- Male right carapace; GLAHM 106263, X 54
Fig. 2- Female right carapace; GLAHM 106264, X 63
Fig. 3- Female ventral carapace; GLAHM 106265, X 63.5

Paracosta gp *bopaensis* Apostolescu, 1961

Fig. 4- Female right carapace; GLAHM 106266, X 64
Fig. 5- Female left carapace; GLAHM 106267, X 57.5
Fig. 6- Male right carapace; GLAHM 106268, X 53.5
Fig. 7- Male left carapace; GLAHM 106269, X 53
Fig. 8- Male dorsal carapace; GLAHM 106270, X 56.5
Fig. 9- Male ventral carapace; GLAHM 106271, X 57

Reticulina proteros (Bassiouni,1969b)

Fig. 10- Female left carapace; GLAHM 106272, X 62.5
Fig. 11- Female stereoscopic paired photographs right carapace; GLAHM 106273, X 60
Fig. 13- Male right carapace; GLAHM 106274, X 58.5

Reticulina sangalkamensis (Apostolescu, 1961)

Fig. 12- Female stereoscopic paired photographs right carapace; GLAHM 106275, X 54
Fig. 14- Female left carapace; GLAHM 106276, X 55
Fig. 15- Male right carapace; GLAHM 106277, X 56.5

PLATE 30

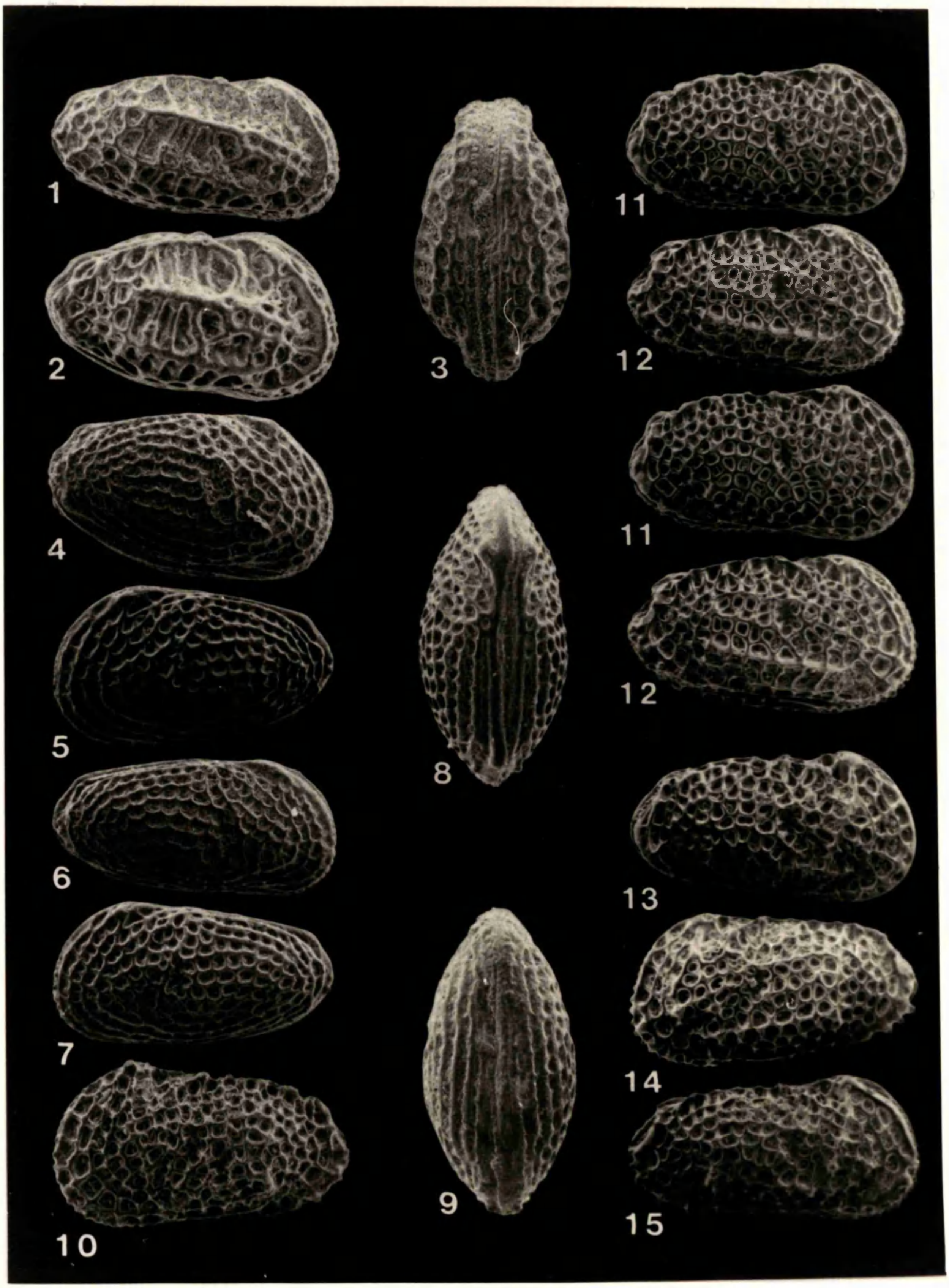


Plate 31

Reticulina sangalkamensis (Apostolescu, 1961)

Fig. 6- Male dorsal carapace; GLAHM 106278, X 57.5

Reticulina cf *proteros* (Bassiouni,1969b)

Fig. 1- Female stereoscopic paired photographs right carapace; GLAHM 106279, X 65.5
Fig. 2- Male stereoscopic paired photographs right carapace; GLAHM 106280, X 54
Fig. 3- Female right carapace; GLAHM 106281, X 58.5
Fig. 4- Female ventral carapace; GLAHM 106282, X 62.5
Fig. 5- Male dorsal carapace; GLAHM 106283, X 51

Schizoptocythere sp

Fig. 8- Stereoscopic paired photographs right carapace; GLAHM 106284, X 84

Asymmetricythere sp

Fig. 9- Male stereoscopic paired photographs right carapace; GLAHM 106285, X 85
Fig. 10- Female left carapace; GLAHM 106286, X 97.5

Asymmetricythere ahmedi sp nov

Fig. 11- Male right carapace; GLAHM 106287, X 70
Fig. 12- Female left carapace; GLAHM 106288, X 77
Fig. 13- Female left carapace; GLAHM 106289, X 79

Asymmetricythere sp A

Fig. 14- Right carapace; GLAHM 106290, X 66.5

PLATE 31

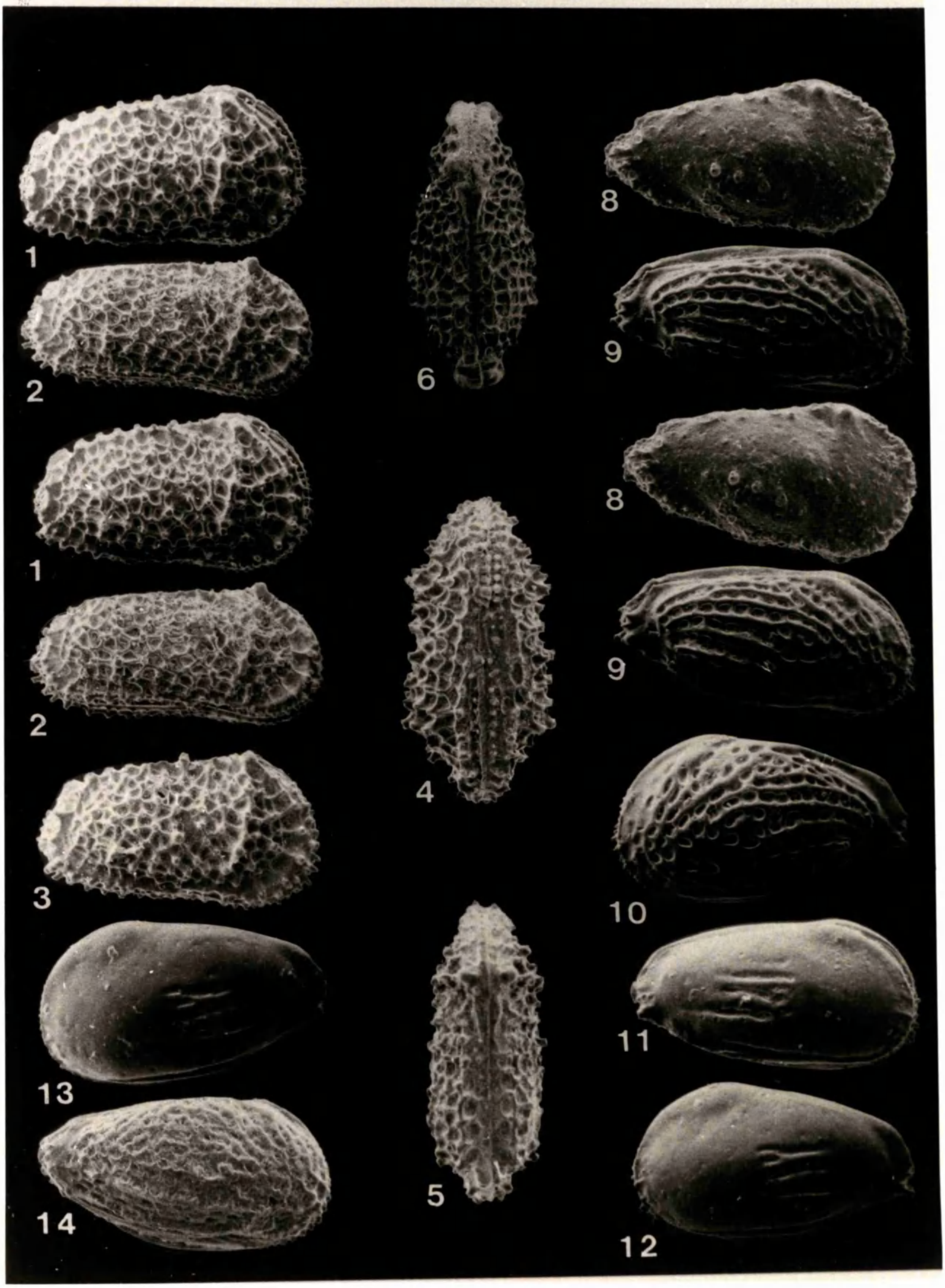


Plate 32

Asymmetricythere ahmedi sp nov

Fig. 1- Female stereoscopic paired photographs right carapace; GLAHM 106291, X 71
Fig. 2- Female stereoscopic paired photographs left carapace; GLAHM 106292, X 71
Fig. 3- Female dorsal carapace; GLAHM 106293, X 75
Fig. 4- Female ventral carapace; GLAHM 106294, X 74

Xestoleberis tripoliensis El Sogher, 1991 M.S

Fig. 5- Female right carapace; GLAHM 106295, X 81
Fig. 6- Female left carapace; GLAHM 106296, X 77.5
Fig. 7- Female right carapace; GLAHM 106297, X 80
Fig. 8- Male right carapace; GLAHM 106298, X 78.5
Fig. 9- Female ventral carapace; GLAHM 106299, X 86

? *Paracypris harashensis* sp nov

Fig. 10- Female right carapace; GLAHM 106300X 86
Fig. 11- Male right carapace; GLAHM 106301, X 81.5
Fig. 12- Male left carapace; GLAHM 106302, X 87.5
Fig. 13- Female left carapace; GLAHM 106303, X 83.5

PLATE 32

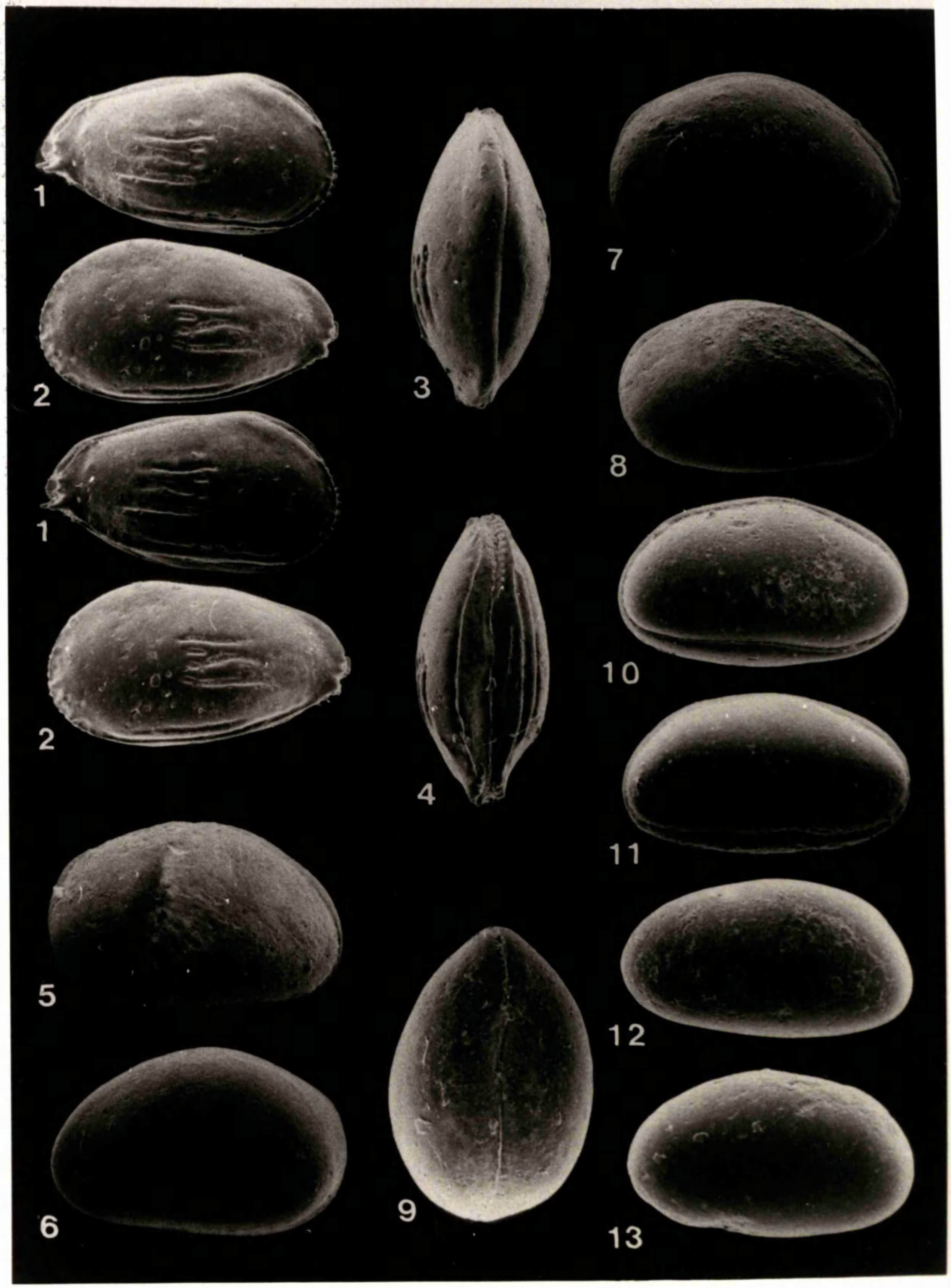


Plate 33

? *Paracypris harashnsis* sp nov

Fig. 5- Female dorsal carapace; GLAHM 106304, X 89

Xestoleberis sp cf *X kiseibaensis* Bassiouni & Luger, 1990

Fig. 1- Male right carapace; GLAHM 106305, X 96
Fig. 2- Female right carapace; GLAHM 106306, X 97.5
Fig. 3- Female left carapace; GLAHM 106307, X 103
Fig. 4- Female dorsal carapace: GLAHM 106308, X 117.5

Uroleberis Oculata libyaensis sp nov

Fig. 6- Female left carapace; GLAHM 106309, X 97.5
Fig. 7- Male left carapace; GLAHM 106310, X 104
Fig. 8- Male right carapace; GLAHM 106311, X 109
Fig. 9- Male left carapace; GLAHM 106312, X 104
Fig. 10- Female left carapace; GLAHM 106313, X 95
Fig. 11- Female left carapace; GLAHM 106314, X 98
Fig. 12- Female right carapace; GLAHM 106315, X 97.5
Fig. 13- Female left carapace; GLAHM 106316, X 101.5
Fig. 14- Male ventral carapace; GLAHM 106317, X 106

PLATE 33

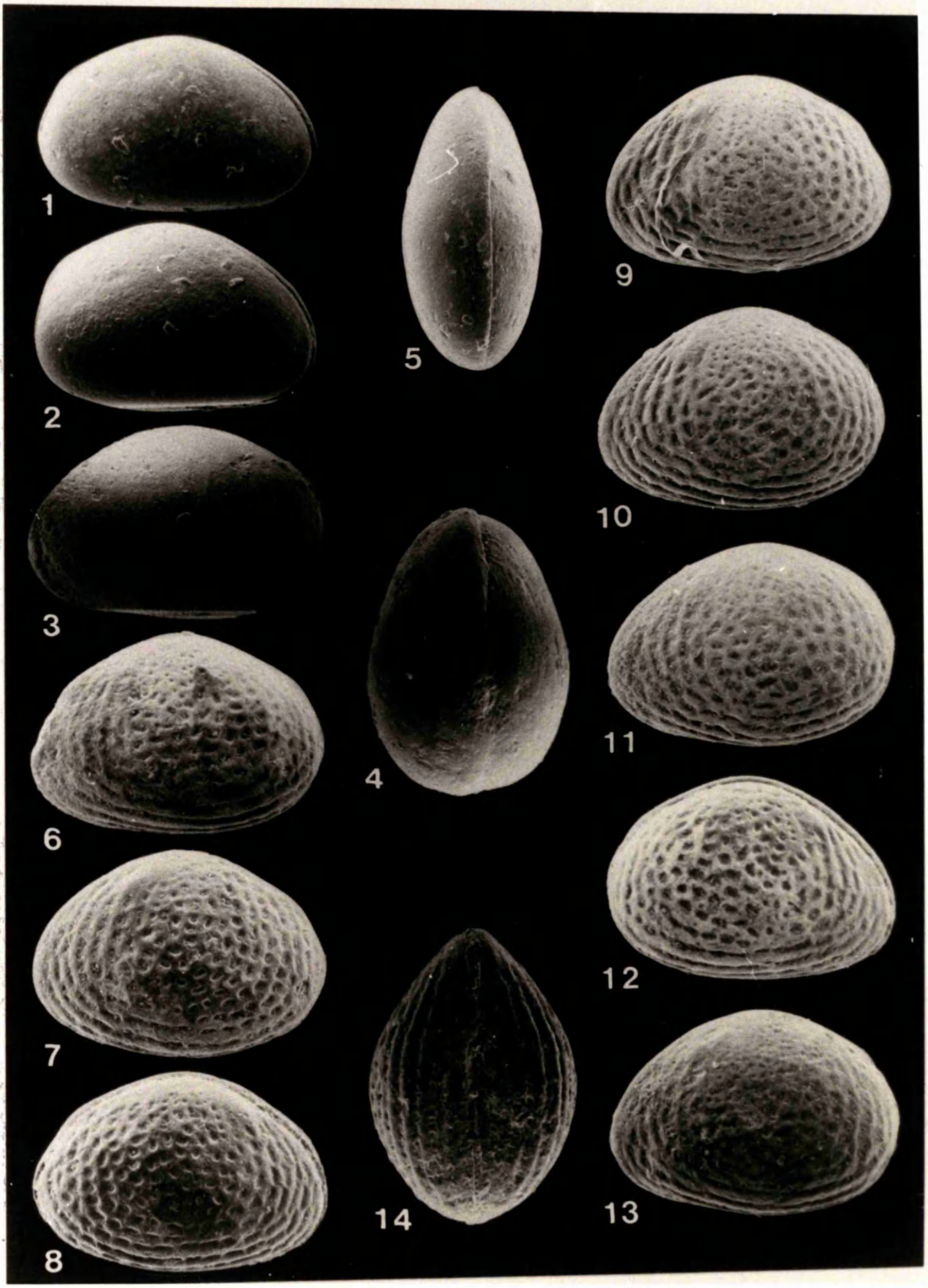


Plate 34

Uroleberis oculata libyaensis sp nov

Fig. 1- male dorsal carapace; GLAHM 106318, X 116
Fig. 2- Female ventral carapace; GLAHM 106319, X 100
Fig. 3- Female dorsal carapace; GLAHM 106320, X 95

Uroleberis cf *glabella* Apostolescu, 1961

Fig. 4- Stereoscopic paired photographs right carapace; GLAHM 106321, X 93.75
Fig. 5- Left carapace; GLAHM 106322, X 99

Uroleberis sp

Fig. 6- Stereoscopic paired photographs right carapace; GLAHM 106323, X 91

?*Exophthalmocythere* sp

Fig. 7- Female right carapace; GLAHM 106324, X 66.5
Fig. 8- Male left carapace; GLAHM 106325, X 65
Fig. 9- Male right carapace; GLAHM 106326, X 63.5
Fig. 10- Juvenile left carapace; GLAHM 106327, X 71.5
Fig. 11- Juvenile right carapcae; GLAHM 106328, X 68.5

Ruggieria sp

Fig. 12- Female stereoscopic paired photographs right carapace; GLAHM 106329, X 79
Fig. 13- Male right carapace; GLAHM 106330, X 66

PLATE 34

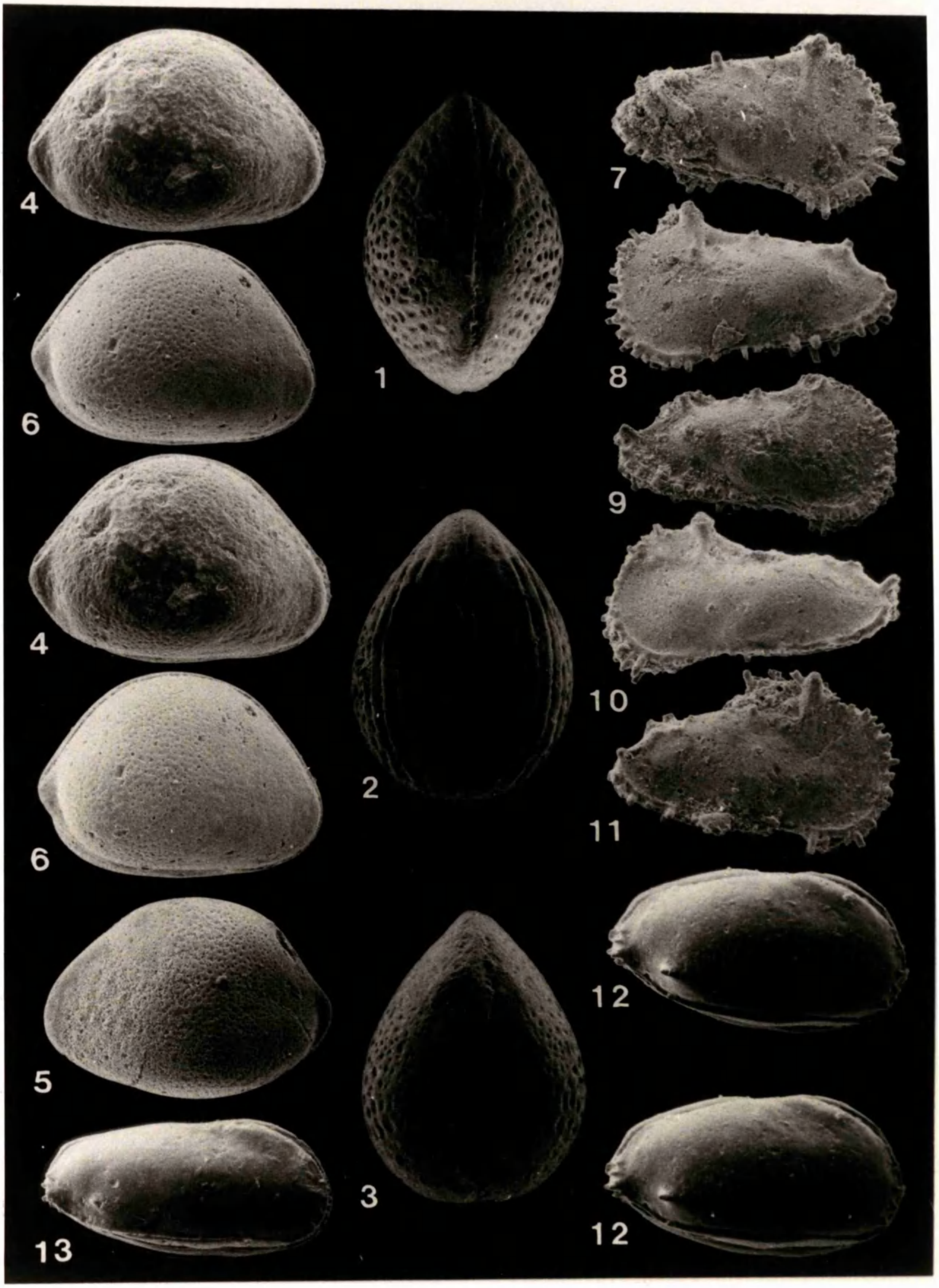


Plate 35

Bythocypris tripoliensis Gammudi & Keen, 1993
Fig. 1- Female right carapace, X 56

Cytheridea joshensis Gammudi & Keen, 1993
Fig. 2- Male right carapace, X 73

Cyamocytheridea idrisi (Gammudi in press)
Fig. 3- Female right carapace, X 69
Fig. 4- Male left carapace, X 64

Cyprideis maradaensis Gammudi & Keen, 1993
Fig. 5- Right valve, X 61.5

Leguminocythreis cirtaensis Apostolescu & Magné, 1956
Fig. 6- Dorsal carapace; GLAHM 106331, X 77.5
Fig. 7- Right carapace; GLAHM 106332, X 83.5
Fig. 8- Left carapace; GLAHM 106333, X 82.5

Loxoconcha n sp 2 Salahi, 1966
Fig. 10- Male dorsal carapace, X 104
Fig. 11- Male ventral carapace, X 105
Fig. 12- Female left carapace, 102
Fig. 13- Male right carapace, X 95

Neomonoceratina miocaenica El-Waer, 1988
Fig. 14- Male right carapace, X 88.5

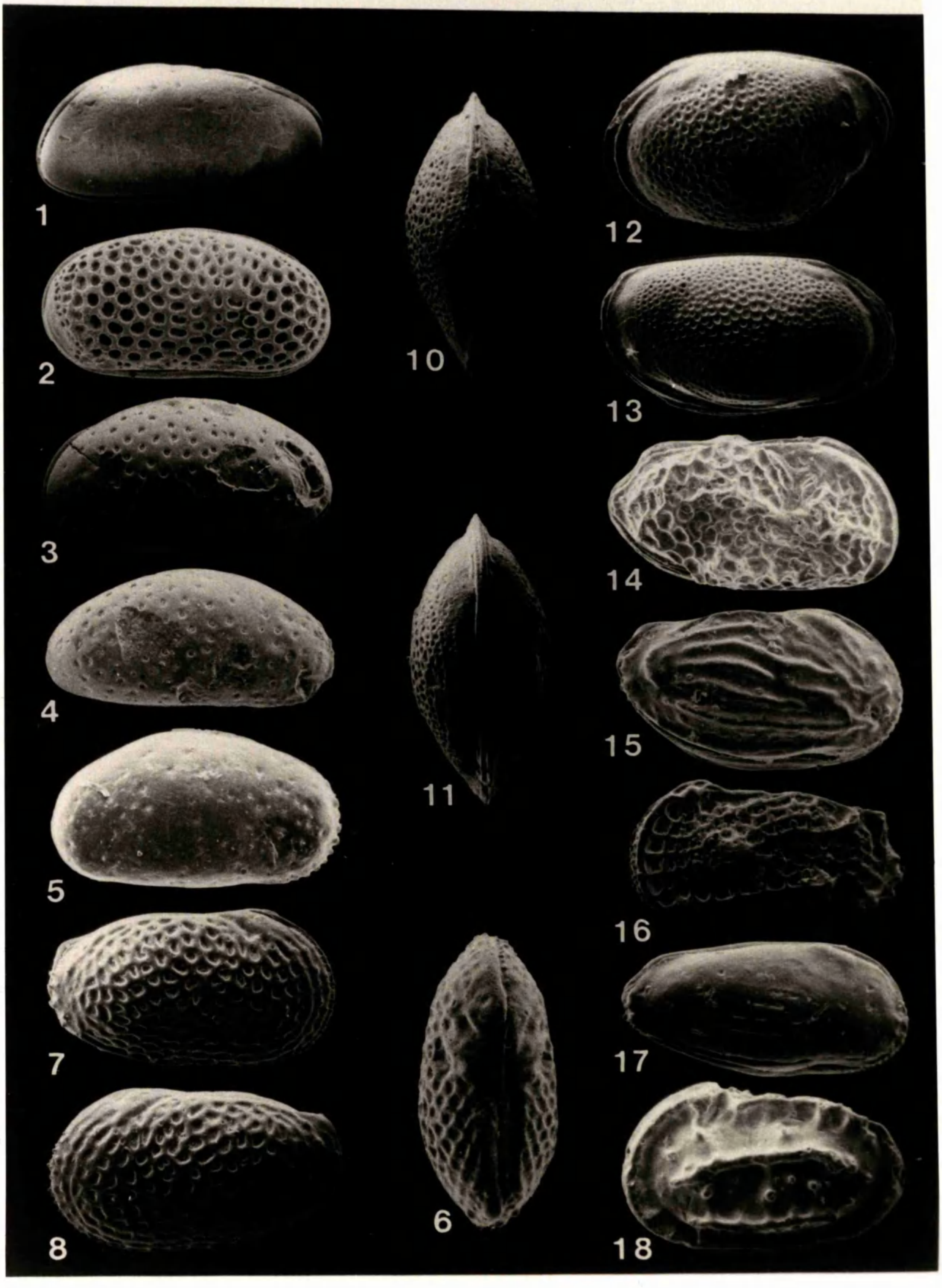
Buntonia cf *tellilae* El-Waer, 1992
Fig. 15- Right carapace, x 66

Hermanites n sp 1 (Salahi, 1966)
Fig. 16- Male left carapace, X 62.5

Keijella aff *k hodgii* (Brady, 1866)
Fig. 17- Male right carapace, X 53.5

Costa n sp 3 (Salahi, 1966)
Fig. 18- Left carapace, X 82.5

PLATE 35



Species / Sample No	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F15	F16	F17	F18	F19	20
Buntonia tatteuliensis Apostolescu	R		VA	VA	VA	R	R	R		VA		C	VA	VA				R	
Buntonia fortunata Apostolescu	R																		
Hornibrookella heiraensis sp nov	C	R	C	C	VA	C	R	R	VA	VA	C	A		R		R			
Uroleberis (O) libyaensis sp nov	VA		A	C	VA	R		C	VA	VA	R	VA	VA	VA		VA	VA	R	
Bairdia gp *ilaroensis* Rey&Rey	R	R	R	C	A	R			VA	R			C						
Bairdoppilata magna Alexander	R		R		C			R	R	R			VA						
Bairdoppilata sp	R				R	R		R					R						
Cythereis sp cf *C teiskotensis*		R		VA	R	R			VA		VA			VA				R	
Trachyleberis modesta Apostolescu		A		VA	R	R		R	VA	R	C		A	R	C	R			
Paracypris sirtensis sp nov		A	C	VA	A				VA		VA			R	VA				
Isohabrocythere teiskotensis Apos		R		VA	A	R			C	R		R	C	R		R			
Bairdia libyaensis sp nov		C		VA		R			VA		R	R	C	C					
Oertliella heiraensis sp nov		R		R					VA		R								
Krithe barsottii sp nov		VA		VA	VA	C		C	VA	VA	A	VA	VA	VA	R	VA			
Paracosta bensoni Damotte&Donze		C	R	R	C	VA		R											
Quadracythere kaoensis Carbonnel		R	R	VA	R				VA	R	R		R	R					
Cytherella sorrensis El Sogher		R								R	A	R			R				
Dahomey alata Apostolescu		C		C		R			VA	R	VA		R		R				
Cytherella mouzoghii sp nov		R						R	R										
Soudanella ghanienis sp nov		R																	
Paragrenocythereis gravis El-Fur			R		R				R				R	C					
Cytherella saidi sp nov				C					C	R				R	R		R	R	
Paragrenocythere neoponticulata				VA	R			R			VA		R	VA		R			
Cytherura n sp 1 salahi				R	R				VA		R			R					
Occultocythereis confirmatus El Sw				R					R										
Trachyleberis teiskotensis Aposto					R				VA	R			R	R					
Xestoleberis tripoliensis El sogher					R				VA	R	C								
Cytherelloidea sp					R														
Cytherelloidea musacea Carbonnel								R				R	R						
Paracosta warriensis Reyment									C	C	VA		R	VA	C				
Cythereis teiskotensis Apostolescu									A										
Bythocypris curryi sp nov									R		R								
Bythocypris elsogheri sp nov									C	R	R	R	C						
Propontocypris triangulata sp nov									C										
Loxoconcha burtoni sp nov									R										
Pterygocythereis sp									C										
Semicytherura elfoghaensis sp nov									A		VA		R		R				
Uroleberis cf *glabbella* Apostlescu									R	R									
Buntonia (B) salahii sp nov									C					C					
Loxoconcha sp									R		C		R						
Monoceratina salemi sp nov									R										
?*Exphothalmocythere* sp										R									
Schisocythere qaltahensis sp nov										R	R		R	R					
Uroleberis sp										R									
Buntonia sp cf *B tichittensis* Aposto											VA			C	C	C			R
Cytherella sp														R		R			
Paijenbochellina sp																	R	A	

Table 3.8 Ostracoda distribution chart in the El-Fogha section

Species / Sample No	S1-1	S1-2	S1-3	S1-4	S1-5	S1-6	S1-7	S1-8	S1-9	S2a -1	S2a -2	S2a -3	S2 -1	S2 -2	S2 -3	S2 -4	S2 -5	S3 -1	S3 -2	S3 -3	S3 -4	S3 -5	S3 -6	S3 -7	S4 -1	S4 -2	S4 -3	S4 -4	S4 -5
Cythereis sp cf *C teiskotensis*			VA	A	VA			C	A	VA	C	VA	R	R	R							R							
Trachyleberis modesta Aposto			VA		VA			R			VA	VA	VA																
Paracypris sirtensis sp nov			VA		VA		C	R	R	VA		VA	C		C							R	R						
Buntonia sp cf *B tichittensis* Apost			A		R					R																			
Buntonia fortunata Apostolescu			VA	A	VA		R						R																
Isohabrocythere teiskotensis Apost			R		VA			R	A	VA	R	VA				R							R	A					
Isohabrocythere heiraensis sp nov			R	VA	R		R																						
Paracosta warriensis Reyment			VA	R	VA			R									R												
Cytherella saidi sp nov			VA	R	A		R	C	R	VA	C	VA	C		R		R						R						
Bairdia libyaensis sp nov			VA				C	VA	VA	C	R	VA		R	R	R		A				R	R	R	R				
Paragrenocythere neoponticulata			VA	VA	VA																	R		R					
Oertiella heiraensis sp nov			R	R	VA		R		VA	R	R	VA																	
Krithe barsottii sp nov				VA	R		R	VA	VA		R	VA	VA		VA		C					A	VA	VA	A				
Cythereis teiskotensis Apostolescu				R	VA		R		A	R																			
Bythocypris curryi sp nov					VA	R	C					R	R																
Cytherura n sp 1 *salahi*					R				R				R											R					
Occultocythereis confirmatus El Sw					A			R	R				R																
Paragrenocythereis gravis Al-Fur					A			R	A	R					R														
Cytherella mouzoghii sp nov					C	R		R			R	R										R							
Soudanella sp cf *S ioruba* Reyment					R																								
Paracosta bensoni Damotte&Donze							VA		VA	VA	VA	VA	VA	R	R			VA						A					
Hornibrookella heiraensis sp nov							VA	VA	R				R	C		C	R	VA				C	R	R					
Quadracythere kaoensis Carbonnel							C	VA	VA	C	R	R	A			R	R					R							
Cytherella sorrensis El Sogher							C			A			R																
Buntonia tatteuliensis Apostolescu							R	VA	VA	C			R			R	A					C		VA	R				
Cytherelloidea sp A								R																					
? *Exophthalmocythere* sp								R	C								R												
Uroleberis (*O*) *libyaensis* sp nov								VA	VA	R				R		R	A					R	VA	VA	A				
Bairdia aff *B buisae* El-waer								C	C		R																		
Bairdia gp *ilaroensis* Reyment								VA	VA			VA	R		R	C		R											
Monoceratina salemi sp nov									R																				
Dahomeya alata Apostolescu										VA		VA	C		R						R			R					
Cytherella hateibensis El Sogher											R																		
Bairdoppilata magna Alexander																R	R	R					C	A					
Bairdoppilata sp																	C	R											
Xestoleberis tripoliensis El Sogher																	R							R					
Cytherelloidea sp																							R						
Cytherelloidea musacea Carbonnel																								R	R				
Schisocythere galtahensis sp nov																								C	R				
Bythocypris elsogheri sp nov																						R		R					

Table 3.8 Ostracoda distribution chart of the Heira section

Species / Depth in feet	7160	7220	7280	7340	7400	7460	7520	7580	7640	7700	7760	7820	7890	7940	8000	8060	8120	8180	8240	8300	8360	8420	8480	8540	8600	8660	8720	8780	8840	8910	8960	9020	9080	9140	9200	9260	9320	9380	9440	9500	9560	9620	9680	9740	9800	9860	9920	9980	10040
Xestoleberis sp cf X kiseibaensis		R		R	R	R		A	R	C	R	C				C	VA	C	R		VA	VA	VA	VA	C	C	C	R	C	R	C	R	C	R	R	R	R	C	C	C	C		A	R	R	R	R		
Leguminocythreis lokossaensis Apos		R																																															
Cytherella sorrensis El Sogher		R	R	R	R		R	C		R				R		C	VA	C	R	VA	A	A	VA	A	C	C	VA	R	R	R	R	R	R	R	R			R		R	R	R	R	R	R	R	R	R	
Krithe barsottii sp nov				R	C	A	R	R	R	R	R	R			R	C	R			R	R	C	VA	A	A	C	R	R		R			C	C			R	R	R	C			R		R		R		
Reticulina sangalkamensis Aposto				R	R							R																																					
Cytherella saidi sp nov				R	C		R	R		R		R	R			R	C	R	C	VA	VA	C	A	R	C	VA	A	C	R	R		R	A	C	R		R			R	R		R		R	R			
Paracosta warriensis Reyment					R				R								R	VA	C	C	A	C	R	R	R	R	R	R				R	R	R					R			R						R	R
Cythereis sp cf C teiskotensis Apost					R	R	R	R			R	R					R	R			C	R	R	R	R	R	R	R	R		R					R					R		R				R		
Buntonia sp cf B tichittensis Apost					R				R													R	R		R	C	R																						
Bairdia sp					R												R	C	R	R																													
Eucytherura sp						R																																											
Brachycythere spinosa sp nov						R																																											
Hornibrookella episcelis Al-Furaih						R	R	R				R																	R																				
Buntonia (B) salahii sp nov						R											R	C	R	R	R	C		C	A	A	R			R	R					R						R			R		R		
Reticulina proteros Bassiounoni						R															R				C	VA	R				R												R	R					
Bairdia libyaensis sp nov						R											R	R	R	R	R	R	R	C	R	R		R							R			R											
Paragrenocythere neoponticulata							R										R	C	C	C	A	C		R	C	R						R	R			R	R	R	R			R	R				R		
Isohabrocythere teiskotensis Apos								R									R			R	R			R	R					R	R	R		R		R	R										R		
?Paracypris harashensis sp nov										R																																							
Uroleberis (O) libyaesis sp nov															R		VA	VA	VA	VA	VA	VA	VA	VA		R	C	C	R	C	R	R	C	R		C	R						R	R			R		
Buntonia tatteuliensis Apostolescu																R	VA	A	A	VA	VA	A	VA	VA	C	R	C	R	R	C	C	R	R	C	R		R		R				R		R		R		
Krithe gp kalambainaensis Reyment																R		R		R	R	R	R	A	C	R	R	R	R	R		R	A			R				R	R	R	R						
Pontocyprella recurva Esker																R																					R												
Bythocypris curryi sp nov																R	C	C	C	R	VA	VA	VA	A	R		R	R	R	C	R		R	R	R		R	R	C			R	R	R					
Cytherella hateibensis El sogher																R	C			C	C		R	R			R			R	C	R	R												R				
Buntonia fortunata Apostolescu																R	A	VA	R	C	VA	C	R	R		C		R	R	R	R	R	R	R	R		R					R	R						
Paracypris sirtensis sp nov																	A	C	C	VA	VA	VA	VA	VA	VA	R	C	C	R	A	C	R	C	C		R	R		R	R	R	R		R				R	
Bythocypris elsogheri sp nov																	R			R		R	R	R	R		R							R	R	R			R	R				R					
Paracypris keeni sp nov																	C	R		R		R		R					R							R													
Paracota gp bopaensis Apostolescu																	R	VA	A	VA	VA	VA	VA	A	VA	A	VA	C	R		R	C	C	C	R			R	R	R			C	R	R	R			
Paracosta bensoni Damotte&Donze																	R	C	R	R		R	R	R	VA	C	R	R	R	R			R		R	R	R					R			R				
Paragrenocythereis gravis Al-Furaih																	R	R									R			R										R			R						
Isohabrocythre heiraensis sp nov																	R		R	C	C		R	A	A	R				R		R	R	R				R				R							
Propontocypris triangulata sp nov																	R				R			R																									
Cytherura n sp1 Salahi																	R	R																															
Phalcocythere ralahensis El Sogher																	R							R			R																						
Acanthcythereis (s) libyaensis sp nov																	R																								R	R							
Krithe echolsae Esker																		R																															
Trachyleberis modesta Apostolescu																		R		R	C	C	C	R	C	R		R	R		R		R	R			R		R				R				R		
Soudanella sp cf S ioruba Reyment																		R	R	R			R									R													R				
Phalcocythere jebelensis El Sogher																		R	R					C																									
Actinocythereis joshensis sp nov																		R		R	R	R																											
Soudanella ghaniensis sp nov																			R	R																													
Schizoptocythere sp																			R																														
Cythereis teiskotensis Apostolescu																			R	R		R		R																									
Uroleberis cf glabella Apostolescu																				R																													
Cytherella mohamedi sp nov																				R		C	R					R			R																		
Cytherella zaltanensis sp nov																				R																													
Xestoleberis tripoliensis El Sogher																					R			VA	C	R	R			R	R	C	R		R				R	R	R		R				R		
Paracypris khawlai sp nov																					R	C	R	R	R	R		R		R	R	R	R	R		R				R	R		R	R					
Paracypris hagfaensis sp nov																					R																												
Bairdia gp ilaroensis Reym & Reym																					R		R	C	R	R	R			R			R		R	R		R	R			R	R				R		
?Parakrithe sp																						R		R	R			R													R								
Monoceratina gazirvi El Sogher																							R					R			R																		
Buntonia harashensis sp nov																							R	R																									
Protobuntonia nakkadii Bassiouni																										R														R									
Parakrithe crolifa Bassiouni																														R	R	R	R					R	R	R	R	R			R		R		
Cytheropteron sp																															R										R								
Cytherella mouzoghii sp nov																															R																		
Cytherelloidea mucacea Carbonnel																																R																	
Phalcocythre hagfaensis sp nov																																													R				

Table 3.3 Ostracoda distribution chart well 3H1-6

Species / Depth in feet	6540	6580	6620	6660	6700	6740	6780	6820	6860	6900	6940	6980	7020	7060	7100	7140	7180	7220	7260	7300	7340	7380	7420	7460	7500	7540	7580	7620
Cythereis sp cf C teiskotensis	R	R					R								R						R	R	C	C	C	R	R	R
Buntonia sp cf B tichittensis	R	R			R										R		R	R				R						
Krithe barsottii sp nov	R	C	C	R	R		R		R	R	R		C			C	A	C	R	A	R	R	A	VA	R	A	R	R
Xestoleberis sp cf X kiseibaensis	R	R	R			R							R				R		C	A	C	A			R	C	C	
Cytherella sorrensis El Sogher	R	5	R		R								R			R	R			R		C	C	C	C	VA	R	C
Dahomeya alata Apostolescu		R	R	R			R	R							R		R											
Buntonia tatteuliensis		R									R						R	R			R	VA	VA	VA	VA	VA	VA	VA
Bairdia sp				R								R	R					R	R	R				R				R
?Ordoniya (O) burmaensis Al-Sheikhly					R																							
Leguminocythereis lokossaensis							R										R											
Isohabrocythere teiskotensis							R	R		R	R											R	R		C	A	A	C
Pontocyprella recurva Esker													R					R	R				R					
?Paracypris harashensis sp nov														R			R	R	R	C	R		R	R				
Cytherella hateibensis El Sogher														R			R					C	R	R	C	C		R
Bairdia libyaensis sp nov														R		R				R		R	R	C	R		R	
Cytherella saidi sp nov														R			R	R	R	R	R	C	C	A	VA	VA	VA	VA
Parakrithe crolifa Bassiouni															R		C	C	C	VA					R			
Bythocypris n sp 1 salahi																	R			A			R					
Leguminocythereis cirtaensis																	R				R							
Krithe echolsae Esker																		R	R	A	R							
Xestoleberis tripoliensis El Sogher																		R	C	C					R	A	A	C
Bythocypris curryi sp nov																		R	C		R	C	VA	C	A	VA	VA	VA
Paracypris sirtensis sp nov																		R	R	R		VA	VA	VA	VA	VA	VA	VA
Paracypris hagfaensis sp nov																			R									
Bairdoppilata magna Alexander																				A					R			
Bairdia aff B buisae El-Waer																				R								
Bythocypris ajdabiyaensis sp nov																				A	R		R			R		
Paracypris tripoliensis sp nov																				R	R							
Acanthocytheis (S) libyaensis sp nov																				C								
Pontocyprella sp																				R				R				
Paracypris sp B																				R								
Buntonia fortunata Apostolescu																					R	A	C	VA	VA	VA	VA	A
Paragrenocythereis gravis Al-Furaih																					R	C	C	A	C	A	R	R
Trachyleberis modesta Apostolescu																					R	A	R	R		R	C	C
Bythocypris elsogheri sp nov																						R	R	R	R	C	R	R
Paracypris keeni sp nov																						C	R	R		R	R	R
Paragrenocythereis neoponticulata																						VA	VA	VA	VA	VA	VA	A
Uroleberis (O) libyaensis sp nov																						VA	VA	VA	VA	VA	VA	VA
Paracosta gp bopaensis																						R	VA	A	VA	VA	VA	VA
Soudanella sp cf S ioruba																						R						R
Paracosta warriensis																						A	VA	VA	VA	A	C	A
Oertliella heiraensis sp nov																						R	R					
Krithe gp kalambainaensis																						R			C	VA	C	A
Paracosta bensoni Damotte & Donze																						R	A	R	R	R	R	VA
Buntonia (B) salahii sp nov																						R			C	R	R	
Cythereis teiskotensis Apostolescu																							R			C	R	R
Isohabrocythere heiraensis sp nov																							R	C	C	A		VA
Bairdia gp ilaroensis Reym& Reym																									R	C	R	R
Propontocypris triangulata sp nov																									R			
Monoceratina gazirvi El Sogher																										R		R
Phalcocythere ralahensis El sogher																										R	R	R
Actinocythereis ioshensis sp nov																										R	R	
Phalcocythere hagfaensis sp nov																										R		
Cytherella zaltanensis sp nov																											R	
Cytherella mohamedi sp nov																												R
Cytherelloidea musacea Carbonnel																												
Paracosta paleomokattamensis Bas																												
Protobuntonia nakkadii Bassiounni																												
Reticulina sangalkamensis																												
Mauritsina coronata Esker																												
Cytherura n sp 1 Salahi																												
Paracypris sp A																												
Phalcocythere jebelensis El Sogher																												

Species / Depth in feet	7660	7700	7740	7780	7820	7860	7900	7940	7980	8020	8060	8100	8140	8180	8220	8260	8300	8340	8380	8420	8460	8500	8540	8580	8620	8660	8700	8740
Cythereis sp cf C teiskotensis	R	R	R	R		R	R										R										R	
Buntonia sp cf B tichittensis																												
Krithe barsottii sp nov	VA	VA	A	A	C	R	R	R	R					R			R	R	R		R	R		R		R		R
Xestoleberis sp cf X kiseibaensis																												
Cytherella sorrensis El Sogher	C	VA	C	C	A	R	C	C	C	R	R	R		R		R	R	R	R	R				R	R	R		C
Dahomeya alata Apostolescu																												
Buntonia tatteuliensis	VA	VA	C	R	R	R	R	R	R	R	C	R	R		R	R	R	R	C	R	R			R	R	R	R	R
Bairdia sp	R	R			R		R	R		R					R	R		R										R
?Ordoniya (O) burmaensis Al-Sheikhly																										R		
Leguminocythereis lokossaensis																												
Isohabrocythere teiskotensis	C	R		R	R	R			R			R				R		R	R									
Pontocyprella recurva Esker																												
?Paracypris harashensis sp nov	R	R																										
Cytherella hateibensis El Sogher	C	R		R	R							R																
Bairdia libyaensis sp nov									R																			
Cytherella saidi sp nov	VA	VA	A	C	C	C	C	R	C	R	R	R	R	R	R		R		C		R	R			R	R		R
Parakrithe crolifa Bassiouni																												
Bythocypris n sp 1 salahi																												
Leguminocythereis cirtaensis																												
Krithe echolsae Esker																												
Xestoleberis tripoliensis El Sogher	VA	VA		VA	A	R	C	R	R		R					R	R	R	R	R					R	R	R	R
Bythocypris curryi sp nov	VA	A	A	C	C	R	R		R		R	R	R	R		C	C	C	R				R	R	R	R		
Paracypris sirtensis sp nov	VA	VA	VA	C	A	R	C	R	R	R	A	R	R	R		VA	C	R	R	R	R			R	R	R	R	R
Paracypris hagfaensis sp nov											R																	
Bairdoppilata magna Alexander																												
Bairdia aff B buisae El-Waer																												
Bythocypris ajdabiyaensis sp nov	R							R																		R		
Paracypris tripoliensis sp nov	R																											
Acanthocytheis (S) libyaensis sp nov			R	R	R		R					R																
Pontocyprella sp																												
Paracypris sp B																												
Buntonia fortunata Apostolescu	R	R	R			R	R				R	R				R	R	R								R		
Paragrenocythereis gravis Al-Furaih		R	R	R		R			R				R		R		R										R	
Trachyleberis modesta Apostolescu	C		R	R			R									R								R				
Bythocypris elsogheri sp nov	R	R	R	R	R	R				R					R													
Paracypris keeni sp nov					R	R																		R				
Paragrenocythereis neoponticulata	C	C	C	R			C	R	R	R			R		R								R					R
Uroleberis (O) libyaensis sp nov	C	A	R	R	R	C	A			R	R			R	R	C	R	C	R	R	R	R	R	R	R	R	R	R
Paracosta gp bopaensis	VA	A	R	VA	C	VA	A	C	R	R	R			R	C		R				R	R	R					R
Soudanella sp cf S ioruba	R	R	R	R				R																				
Paracosta warriensis	C	R	C	R	R	R								R			R			R	R	R	R				R	
Oertliella heiraensis sp nov			R											R														
Krithe gp kalambainaensis	VA	VA	VA	VA	A	C	A	R	R	R	R			R	R	C	R	R	R							R		
Paracosta bensoni Damotte & Donze	R	R	R	R	A	C	R	R	R	R						R		R	R				R					
Buntonia (B) salahii sp nov	R	R	R	R	C		R	R						R		R			R									
Cythereis teiskotensis Apostolescu		R	R			R											R	R			R							
Isohabrocythere heiraensis sp nov	A	R	R	R	R	R	R		R		R				R	R			R	R	R		R					
Bairdia gp ilaroensis Reym& Reym			R				R	R								R	R											
Propontocypris triangulata sp nov																						R						
Monoceratina gazirvi El Sogher	R			R																								
Phalcocythere ralahensis El sogher								R							R								R		R	R		
Actinocythereis ioshensis sp nov			R		R		R									R		R										
Phalcocythere hagfaensis sp nov								R							R								R					
Cytherella zaltanensis sp nov	R			R		R	R												R									
Cytherella mohamedi sp nov			R	R	R	R			R							R			R									
Cytherelloidea musacea Carbonnel		R				R																					R	
Paracosta paleomokattamensis Bas				R				R																				
Protobuntonia nakkadii Bassiounni									R		R	R																R
Reticulina sangalkamensis																R	R											
Mauritsina coronata Esker																							R					
Cytherura n sp 1 Salahi																											R	
Paracypris sp A																												R
Phalcocythere jebelensis El Sogher																												R

Table 3.2 Ostracoda distribution chart well PP2-6

Species / Depth in feet	6000	6040	6080	6120	6140	6180	6220	6260	6300	6340	6380	6420	6460	6500	6540	6580	6620	6660	6700	6740	6780	6820	6900	6940	6980	7020	7060	7100	7140	7180	7220	7280	7320	7360	7400	7440	7480	7580	7620	7660	7700	7740	7780	7820	7860	7900	7940	7980	8020	8060	8100	8140	8180	8280	8320	8360
Costa n sp 3 salahi	R																																																							
Propontocypris aff P tarabulusensis	R																																																							
Asymmetricythere sp Bass	R	R								R				R																																										
Ruggeria sp	R	R	R		R				R					R	R									R															R								R									
Brachycythere spinosa sp nov	C		R	R	R	C		R		R	R		R	R	R	R			C		R																																			
Leguminocythereis cirtaensis	R		R	R	R									R	R					R					R																															
Asymmetricythere ahmedi sp nov	C	R		R	R		R			R	R		R						R	R	R	R		R	R	R																														
Reticulina cf R proteros Bassiouni	R	R		R	R									R					R		R																																			
Bythocypris tripoliensis G & Keen	C	R		R														R			R																																			
Bairdia sp	R	R	R		R	R	R	R		R	R				R	R			R		R	R		R	R		C	R	C	R									C	C	C	R	C		R	R					R				R	
Uromuellerina sinhai sp nov	R				R					R															R																															
Xestoleberis sp cf X kiseibaensis	R	R	R	C		R		R	R	R						R	R	R	R	C	R	R	R	R	C		R	C	VA	VA	VA	A	C	C	C	R	R	R		R	R	R	R				R		R			R	R	R	R	
Loxoconcha aff L marioensis Salahi	R			R	R			R		R	R		R	R																																R										
Loxoconcha n sp 2 Salahi	C			R	C								R	R		R					R																																R			
Bairdia libyaensis sp nov			R	R		C			R				R					R					R	R	R	R	VA	A	VA	C	C	R		R	R		R	R		R					R	R	R	R	R	R		R	R			R
Leguminocythereis lokossaensis				R	R													R																												R										
Krithe barsottii sp nov				R		VA	R	C	R		R	R		C	R	R	R	R	R		R				R	R	R	C	VA	VA	VA	VA	VA	VA	VA	C	VA	R	C	C	R					R	A		R	R		R	R		R	
Buntonia sp B tichittensis Apost					R	VA	R	R		R		R		C	R	R		R	R		R	R							R	R				R			R																			
Cythereis sp cf C teiskotensis Apost					R	R	R							R	R			R	R						R	R	R	C	C	C	C	C	C		R	R		R		R	R	R					R	R	R	R	R					
Cythreis kheirensis sp nov					R				R				R																																											
Reticulina proteros Bassiouni					R	R													R				R		R																															
Bairdia sp A					R	R																R	R	R		R				R	R	R	R	R	R		R		R		R	R				R		R								
Isohabrocythere teiskotensis Apost						C			R			R		R	R				R	R					R	C	R	R	VA	VA	VA	VA	A	C	C	R	R	R	R			R	R			R	R	C	R		R		R			
Cytherella mouzoghii sp nov						C		R	R													R		R	C	C	A	VA	VA	VA	A	C	VA	VA	R	C	R	R					R		R	R	R	R	C	R	R	R				
Cytherella sorrensis El Sogher						C				R						R		R		R	C		R	R	VA	A	A	VA	VA	VA	VA	VA	C	VA	A	VA	C	A	C				R	R	R	R	C	C	C	C	C	R	C	R		
Bythocypris curryi sp nov							R																		C	A	VA	VA	VA	VA	VA	VA	VA	A	VA	C	C	R	R	R	R	C		R	C		R	C	C		R	R	R	R		R
Hermanites n sp 1 Salahi								R	R				R																																											
Pterygocythereis tarabulusensis										R				R										R																																
?Paracypris harashensis sp nov											R												R		R	R	R																											R		
Bairdia aff B buisae El-Waer													R																																											
Buntonia tatteuliensis Apost													R	R										R	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	A	A	C	A	R	R	C	R	C	C	C	C	A	C	R	C	R	C		R	R
Uroleberis cf glabella Apostolescu																		R																																						
?Ordoniya (O) burmaensis Al-Sheikhly																				R	R		R																																	
Cytherella hateibensis El Sogher																					R				C	R	R	R	VA	R	R	R	C	R	R				R	R	R		R						R			R	R			
Parakrithe crolifa Bassiouni																					R	R		R		R	R	R							R					R				R	R						R	R	R			
Trachyleberis modesta Apost																					R				C	VA	C	VA	VA	VA	VA	C	R	R	R			R				R	R		R		C	R	R	R						
Paracypris hagfaensis sp nov																						R	R	R		R	R																													
Bythocypris n sp 1 Salahi																							R	R		R	R																													
Paracosta bensoni Damotte & Donze																							R		R		R	VA	R		C	C		R		C	R	R	R	VA	VA	VA	R	C	R		R	R	R	R		R	R			
Bairdia cf B septentrionalis Bonne																								R																																
Paracypris sirtensis sp nov																								R	C	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	A	VA	A	C	R	C	R	R	R	C	A	C	C	VA	C	R	R	R		R	
Propontocyprella recurva Esker																								R																								R								
Cytherella saidi sp nov																									VA	A	C	VA	VA	VA	VA	VA	VA	VA	A	A	C	R	C	R	C	R	R	R	C	R	R	R	C	R	C	R	R	R		R
Isohabrocythere heiraensis sp nov																									R	R	R	A	VA	VA	VA	VA	R	VA	R	R		R			R			R					R							
Buntonia fortunata																									C	A	VA	VA	VA	VA	R	A	R		R									R	R		R		R			R				
Uroleberis (O) libyaensis sp nov																									R	VA	VA	VA	VA	VA	VA	VA	VA	VA	A	A	R	R	R	R	R	R		R	R	R	R	VA	VA	C	R	R		R		
Paracosta warriensis																									R	VA	VA	VA	VA	VA	VA	A	R	R	R	R	C	R	R			R				R	R	R	C	R	R	R			R	
Krithe gp kalambainaensis Reyment																									VA	VA	R	VA	VA	VA	VA	A	VA	VA	VA	A	C	R	R	R			R	R			C	R	C	R	R		R			
Paragrenocythereis gravis Al-Fura																									C	VA	VA	A	A	VA		R		R		R				R						R	R		R							
Paracypris keeni sp nov																									R	R	C	C	C	R		C	R	C	R	R												R			R					
Oertliella heiraensis sp nov																									C	R	R																													
Reticulina sangalkamensis																									R	R		R																												
Paragrenocythereis neoponticulata																										R	A	VA	VA	VA	VA	VA	VA	VA	C	R	A	R	C	R	R	R		R		R		R	R				R			
Bythocypris elsogheri sp nov																										R	C	A	A	A	A	A	VA	C	C	R	R		R							R	R	R		R						
Propontocypris triangulata sp nov																										R	R	R		R				R	R					R								R				R				
Phalcocythere hagfaensis sp nov																										R		R	C	R				R								R														
Cytherura n sp 1 Salahi																										R						R					R				R															
Occultocythreis confirmatus																										R		R	R	R		R	R																							
Paracypris tripoliensis sp nov																										R							R																							
Cythreis teiskotensis Apostolescu																											R	R	C	C	C	R		R			R				R	R	R					R		R	R	R				
Bythocypris aidabiyaensis sp nov																											R																													
Paracosta gp bopaensis																											VA	VA	VA	VA	VA	VA	VA	VA	R	C	VA	C	C		R	VA	VA	C	A	C	VA	VA	C	R	C	R	C		R	R
Krithe echolsae Esker																											R																													
Cytherella mohamedi sp nov																												R	R	R	C			R			R				R	R	R		R											
Buntonia (B) salahii sp nov																												R	R	C	R	A	C	R	R			R	R	R	C	C		R			R	R	R						R	
Mauritsina coronata Esker																												R																												
Pontocyprella sp																												R																												
Schizoptocythere sp																													R																											
Actinocythereis joshensis sp nov																													R	R		R	R																							
Bairdia gp ilaroensis																													VA	C	A	VA	VA	A	A	C	C	C					R	R	R		R	R		R		R				
Soudanella sp cf S ioruba Apostolescu																													R	R	R	R	R	R		R	R	R		R		R					R						R			
Phalcocythere ralahensis																													R		R	R	R			R																				
Monoceratina gaziryi El Sogher																														R		R	R		R									R	R											
Acanthocythereis (S) libyaensis sp nov																														C	R	R		R				R			R								R							
? Parakrithe sp																															R		R	R	R																					
Xestoleberis tripoliensis El Sogher																															R	VA	VA	A	A	A	R	R	R				R		R		R						R			
Paracypris khawlai sp nov																															R		C												R		R			R						
Phalcocythere jebelensis El Sgher																																C	R					R																		
Cytherella zaltanensis sp nov																																R							R										R		R					
Bairdoppilata magna Alexander																																	R																							
Paijenborchella sp																																	R	R																						
Soudanella ghaniensis sp nov																																		R		R	R																R			
Protobuntonia nakkadii																																							R		R				R				R	R						
Paracosta paleomokattamensis																																								R	R	R	R	R	R											
Cytheropteron sp																																											R													

Table 3.1 Ostracoda chart Well YY1-6

Species / Depth in feet	8500	8560	8620	8680	8740	8800	8860	8920	8980	9040	9100	9160	9220	9280	9340	9400	9460	9520	9580	9640	9700	9760	9820	9880	9940	10000	10060	10120	10180	10240	10300	10360	10420	10480	10540	10600	10660	10720	10780	10840	10900	10960
Krithe echolsae Esker			R																													R				R						
Bythocypris curryi sp nov			R														R																									
Cyamocytheridea idrisi Gammudi						R		R																					R													
Loculicytheretta cf *L cavernosa*							R																																			
Asymmetricythere ahmedi sp nov							R						F																													
Neomonoceratina miocaenca El-War									R																																	
Cytheridea joshensis Gam & Keen										R	R	R	F					R	R														R									
Bairdia sp										R											R											R										
Keijella punctigibba Capeder																		R											R			R										
Paragrenocythere neoponticulata																		R																								
Xestoleberis sp cf *X kiseibaensis* Bass																											R															
Uroleberis cf *glabella*																											R															
Parakrithe crolifa Bassiouni																																		R		R		R				
Paracypris sirtensis sp nov																																				R						
?Paracypris harashensis sp nov																																				R	R	R	R			
Bairdia libyaensis sp nov																																					R		R			
Cytherella sorrensis El Sogher																																						R		R		
Paracosta gr *bopaensis*																																										
Paracosta bensoni Damtte & Donze																																										
Cytheropteron sp cf *C lekefense* Esker																																										
Buntonia fortunata																																										
Cythereis teiskotensis Apostolescu																																										
Reticulina proteros Bassiouni																																										
Cytherella hateibensis El Sogher																																										
Reticulina sangalkamensis																																										
Krithe barsottii sp nov																																										
Krithe gr *kalambainaensis*																																										
Trachyleberis modesta Apostolescu																																										
Isohabrocythere heiraensis sp nov																																										
Isohabrocythere teiskotensis																																										
Bythocypris elsogheri sp nov																																										
Buntonia tatteuliensis Apostolescu																																										
Uroleberis (O) libyaensis sp nov																																										
Buntonia (B) salahii sp nov																																										
Cytherella mouzoghii sp nov																																										
Cythereis sp cf *C teiskotensis*																																										
Paracypris keeni sp nov																																										
Cytherella saidi sp nov																																										
Paracosta warriensis																																										
Paragrenocythere gravis Al-Furaih																																										
Cytherura n sp 1 *salahi*																																										
Buntonia harashensis sp nov																																										
Phalcocythere ralahensis El sogher																																										
Protobuntonia spinosa sp nov																																										
Acanthocythere (S) libyaensis subsp nov																																										
Xestoleberis tripoliensis El Sogher																																										
Paracypris khawlai sp nov																																										
Monoceratina gazirvi El Sogher																																										
Bairdia gr *illaroensis*																																										
Cytherella mohamedi sp nov																																										
Paracosta paleomokattamensis Bas																																										
Protobuntonia nakkadii Bassiouni																																										
Paijenborchella sp																																										
Oertliella heiraensis sp nov																																										
Bythocypris aidabiyaensis sp nov																																										
Pontocyprella sp																																										
Bythoceratina sp																																										

Species / Depth in feet	11020	11080	11140	11200	11260	11320	11380	11440	11500	11560	11620	11680	11740	11800	11860	11920	11980	12040	12100	12160	12220	12280	12340	12400	12460	12520	12580	12640	12700	12760	12820	12880	12940	13000
Krithe echolsae Esker																				C	R	R	R		R			R			R		R	
Bythocypris curryi sp nov		R	A	VA	R	R	C	VA	VA	A	A	C	R	A	C	R	C	R	R	R		R	R	R	R	R	R		R	R				R
Cyamocytheridea idrisi Gammudi																																		
Loculicytheretta cf *L cavernosa*																																		
Asymmetricythere ahmedi sp nov																																		
Neomonoceratina miocaenca El-War																																		
Cytheridea joshensis Gam & Keen																																		
Bairdia sp		R				C	VA	VA		C	VA		R			A	C			R	R									R		R	R	
Keijella punctigibba Capeder																																		
Paragrenocythere neoponticulata			VA	VA	C	C	C	A			R	R	R				R																	
Xestoleberis sp cf *X kiseibaensis* Bass		R	VA	C	C	C	C	VA	VA	VA	VA	C	C		VA	A	A			C	R		R	R		R								R
Uroleberis cf *glabella*																																		
Parakrithe crolifa Bassiouni	R	R												VA		R	R			C	C		R	R	R	R	R	R	R	R	R	R		
Paracypris sirtensis sp nov	R	R	VA		VA	VA	A	VA	C	R	C	R	R	C	A		R	R	R	R	R	R					R					R		
?Paracypris harashensis sp nov				R				VA														R												
Bairdia libyaensis sp nov			VA	VA	VA	VA	VA	VA	VA	A	VA	R	C		C		R	R		R					R			R						
Cytherella sorrensis El Sogher			R	C	R		C	VA	VA		VA	R	R	R	R	R	R	R	R	R		A				R	R	R				R	R	
Paracosta gr *bopaensis*	C	C	VA	VA	VA	VA	VA	VA	VA	VA	VA	A	A	VA	A	VA	VA		R	R	R				R						R	R	R	R
Paracosta bensoni Damtte & Donze	R	R	R	A	C	R	C	A		C	C			C		R	R					R												
Cytheropteron sp cf *C lekefense* Esker	R							R		R	R	R		R	R	R																		
Buntonia fortunata	R	R		A	A	VA	VA	VA	VA	VA	VA	C	C	VA	C	VA	C	R		R		R		R	R							R	R	
Cythereis teiskotensis Apostolescu	R			R	R			R																					R					
Reticulina proteros Bassiouni	R	A	C			C	VA	VA	VA	C	C	R	R	R	R	C	C					R					R							R
Cytherella hateibensis El Sogher	R	R	R		R	C	R	A		VA	C	A		R		R	R		R	R		R										R	R	
Reticulina sangalkamensis	R		R						VA	C	R				R										R									
Krithe barsottii sp nov		VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	A	VA	C	VA	A	C	C	A	R	R	R	R		R	R						R	R
Krithe gr *kalambainaensis*		C						VA	VA	C	A	C		R		A				R														
Trachyleberis modesta Apostolescu		R		C	R	R	R	VA	R	R	R			R			R																	
Isohabrocythere heiraensis sp nov		R		R		R	R	VA	C	R	C					R					R								R					
Isohabrocythere teiskotensis		R	R	R	R	VA	VA	VA	VA	C	A	R	R	C	R	C	R	R	R															
Bythocypris elsogheri sp nov		R	A	A	R	R	R	C	R						R								R											
Buntonia tatteuliensis Apostolescu		R	VA	VA	VA	VA	VA	VA	VA	A	VA	A	C	A	C	R	C	R	R	R	R	R	R			R	R	R		R	R		R	
Uroleberis (O) libyaensis sp nov		C	VA	VA	VA	VA		VA	VA	A	A	R	C	VA	R	C	A	R					R					R						
Buntonia (B) salahii sp nov		C	R	C	R	C	R	VA	VA	VA	VA	A	C	A	C	VA	C	R			R	R	R			R								
Cytherella mouzoghii sp nov		R	R	C	C	A	VA	VA	VA	VA	VA	C	VA	A	A	A	R		R	A		A					R	R						
Cythereis sp cf *C teiskotensis*		R	A	VA	A	A	A	VA	VA	VA	VA		C	C		R	R																	
Paracypris keeni sp nov			A	C	C	C	R	C	R	R	R		R		R	R	R		R	R				R										
Cytherella saidi sp nov			R	R		A	VA	VA	R	R	C	R		R		R	R	R																
Paracosta warriensis			A	VA	A	A	R	A	C	R	A	C		R	R	R												R						
Paragrenocythere gravis Al-Furaih			R	A	R					R	R		R	R																				
Cytherura n sp 1 *salahi*				R						R	R	R		C		R																		
Buntonia harashensis sp nov				R		R		A			R	R	R		R																			
Phalcocythere ralahensis El sogher				R	R	R																												
Protobuntonia spinosa sp nov					R			C		R						R																		
Acanthocythere (S) libyaensis subsp nov					R						R																							
Xestoleberis tripoliensis El Sogher						R	VA		A	C	VA	C	C	C	C	C	R					R				R	R	R		R				R
Paracypris khawlai sp nov							C	VA	VA	C	VA	R	R	R	R	A	C			R					R									
Monoceratina gazirvi El Sogher								C	R	R	R																							
Bairdia gr *illaroensis*								R																										
Cytherella mohamedi sp nov								R												R														
Paracosta paleomokattamensis Bas									A	C	C	R		C		R	R																	
Protobuntonia nakkadii Bassiouni										R				R	C		R				R		R											
Paijenborchella sp										R																								
Oertliella heiraensis sp nov										R	R																							
Bythocypris aidabiyaensis sp nov												R																						
Pontocyprella sp															R																			
Bythoceratina sp																					R													

Table (3, 6) Ostracoda distribution chart Well KK1-6.

Species / Depth in feet	8320	8380	8440	8500	8560	8620	8680	8740	8800	8860	8920	8980	9040	9100	9160	9220	9280	9340	9400	9460	9520	9580	9640	9700	9760	9820	9880	9940	10000
Asymmetricythere ahmedi sp nov				R																									
Asymmetricythere sp					R					R																			
Leguminocythereis lokossaensis							R	R							R														
Cytheridea joshensis Gammudi & Keen								R																					
Neomonoceratina miocaennca												R																	
Cyprideis maradaensis Gammudi&Keen												R																	
Xestoleberis sp cf X kiseibaensis												R				R								R					
Buntonia sp cf B tichittensis Apost																													
Asymmetricythere sp A																													
Hermanites n sp 1 Salahi																													
Cythreis kheirensis sp nov																													
Brachycythere spinosa sp nov																													
Occultocythereis sp																													
Phalcocythere ralahensis El Sogher																													
Bairdoppilata magna Alexander																													
Bairdia libyaensis sp nov																													
?Paracypris harashensis sp nov																													
Parakrithe crolifa Bassiouni																													
Krithe barsottii sp nov																													
Bythocypris curvi sp nov																													
Krithe echolsae Esker																													
Reticulina proteros Bassiouni																													
Cythereis sp cf C teiskotensis Apost																													
Buntonia fortunata																													
Paracypris haqfaensis sp nov																													
Pontocyprella sp																													
Bythoceratina sp																													
Paracosta gp bopaensis Apostolescu																													
Cytherella mouzoghii sp nov																													
Isohabrocythere teiskotensis Aposto																													
Paracypris sirtensis sp nov																													
Reticulina sangalkamensis Bassiouni																													
Krithe gp kalambainaensis																													
Buntonia (B) salahii sp nov																													
Cytherella sorrensis El Sogher																													
Cytherella hateibensis El Sogher																													
Trachyleberis modesta Apostolescu																													
Buntonia tatteuliensis Apotolescu																													
Bythocypris elsogheri sp nov																													
Cytherella saidi sp nov																													
Protobuntonia sp B																													
Paragrenocythere neoponticulata																													
Cythereis teiskotensis Apostolescu																													
Paracosta bensoni Damotte& Donze																													
Acanthocythereis (S) libyaensis sub sp nov																													
Uroleberis (O) libyaensis sp nov																													
Xestoleberis tripoliensis El Sogher																													
Paracypris keeni sp nov																													
Isohabrocythere heiraensis sp nov																													
Paragrenocythere gravis Al-Furaih																													
Actinocythereis joshensis sp nov																													
Paracosta warriensis																													
Buntonia harashensis sp nov																													
Soudanella ghaniensis sp nov																													
Paracypris tripoliensis sp nov																													
Paracypris khawlai sp nov																													
Protobuntonia nakkadii																													
Paracosta paleomokattamensis																													
Pontocyprella recurva Esker																													

Species / Depth in feet	10060	10120	10180	10240	10300	10360	10420	10480	10540	10600	10660	10720	10780	10840	10900	10960	11020	11080	11140	11200	11260	11320	11380	11420	11500	11560	11620
Asymmetricythere ahmedi sp nov																											
Asymmetricythere sp								R																			
Leguminocythereis lokossaensis																											
Cytheridea joshensis Gammudi & Keen																											
Neomonoceratina miocaennca																											
Cyprideis maradaensis Gammudi&Keen																											
Xestoleberis sp cf X kiseibaensis	R				R							R		R			VA		A	VA			R	R	R	R	
Buntonia sp cf B tichittensis Apost			R																								
Asymmetricythere sp A			R																								
Hermanites n sp 1 Salahi						R																					
Cythreis kheirensis sp nov							R																				
Brachycythere spinosa sp nov								R																			
Occultocythereis sp								R																			
Phalcocythere ralahensis El Sogher									R											R							
Bairdoppilata magna Alexander										R	R																
Bairdia libyaensis sp nov										R	R	R	R				R		R	VA	C	C	C	C	R		
?Paracypris harashensis sp nov											R	R		R	R								R				
Parakrithe crolifa Bassiouni											R						VA	C	R								
Krithe barsottii sp nov											R		R	R		R		C	R	VA	A	VA	C	R	R	R	
Bythocypris curvi sp nov															R		C	A	C	R	R	C	R	C	C		R
Krithe echolsae Esker																R											
Reticulina proteros Bassiouni																R	C	C	C	R		C	R	R	R	R	R
Cythereis sp cf C teiskotensis Apost																	R	R	R	R	R	C		R	R	R	R
Buntonia fortunata																	R	C	R	C	R	C	C	R	R	R	R
Paracypris haqfaensis sp nov																	R										
Pontocyprella sp																	R										
Bythoceratina sp																	R										
Paracosta gp bopaensis Apostolescu																		R	C	A	R	VA	A	VA		C	R
Cytherella mouzoghii sp nov																		R	R			R	R				
Isohabrocythere teiskotensis Aposto																		R	C	R	R		R	R	R	R	R
Paracypris sirtensis sp nov																		R	C	A	C	A	A	R	R	R	
Reticulina sangalkamensis Bassiouni																		R									
Krithe gp kalambainaensis																		VA	VA	VA	VA	VA	A	C	R		
Buntonia (B) salahii sp nov																		R	R	R	R	C	C	R	R	R	R
Cytherella sorrensis El Sogher																		R					R	R	R	R	
Cytherella hateibensis El Sogher																		R		R	R			R			R
Trachyleberis modesta Apostolescu																		R			R						
Buntonia tatteuliensis Apotolescu																			C	VA	VA	C	R	R	R		
Bythocypris elsogheri sp nov																			R	R	R	R			R		
Cytherella saidi sp nov																			R	R	A	R	R	R	R	R	R
Protobuntonia sp B																			R								
Paragrenocythere neoponticulata																			R		R						
Cythereis teiskotensis Apostolescu																			R	R	R						
Paracosta bensoni Damotte& Donze																			R	C	R	R	R		R		
Acanthocythereis (S) libyaensis sub sp nov																			R								
Uroleberis (O) libyaensis sp nov																			C	VA	A	C	C	R	R		
Xestoleberis tripoliensis El Sogher																			R	R	R			R	R		
Paracypris keeni sp nov																				R	R	R		R			R
Isohabrocythere heiraensis sp nov																				R	R			R			
Paragrenocythere gravis Al-Furaih																				R	R						
Actinocythereis joshensis sp nov																					R						
Paracosta warriensis																						R					
Buntonia harashensis sp nov																						R	R	R	R		
Soudanella ghaniensis sp nov																						R					
Paracypris tripoliensis sp nov																							R	R			
Paracypris khawlai sp nov																									R		
Protobuntonia nakkadii																											R
Paracosta paleomokattamensis																											
Pontocyprella recurva Esker																											

Species / Depth in feet	11680	11740	11800	11860	11920	11980	12040	12100	12160	12220	12280	12340	12400	12460	12520	12580	12640	12700	12760	12820	12880	12940	13000	13060	13120	13180	13240	13300
Asymmetricythere ahmedi sp nov																												
Asymmetricythere sp																												
Leguminocythereis lokossaensis																												
Cytheridea joshensis Gammudi & Keen																												
Neomonoceratina miocaennca																												
Cyprideis maradaensis Gammudi&Keen																												
Xestoleberis sp cf X kiseibaensis	R			R	R	R	R	R		R	R		R	R			R	R		R				R				
Buntonia sp cf B tichittensis Apost																												
Asymmetricythere sp A																												
Hermanites n sp 1 Salahi																												
Cythreis kheirensis sp nov																												
Brachycythere spinosa sp nov																												
Occultocythereis sp																												
Phalcocythere ralahensis El Sogher																												
Bairdoppilata magna Alexander																												
Bairdia libyaensis sp nov	R	R			R	R		R				R	R	R	R		R				R		R					
?Paracypris harashensis sp nov														R				R					R					
Parakrithe crolifa Bassiouni	R		R				R	R	R	R	R		R	R				R	R			R	R	R	R		R	
Krithe barsottii sp nov	R	R					R	R		R				R		R		R				R	R	R		R		
Bythocypris curvi sp nov				R	R				R						R		R	R	R						R			R
Krithe echolsae Esker																	R							R	R			R
Reticulina proteros Bassiouni		R	R				R			R				R						R								
Cythereis sp cf C teiskotensis Apost				C		R									R		R											
Buntonia fortunata				R								R		R						R							R	
Paracypris haqfaensis sp nov													R															
Pontocyprella sp					R																							
Bythoceratina sp																												
Paracosta gp bopaensis Apostolescu					R			R	R	R	R	R	R	R		R	R		R		R		R				R	
Cytherella mouzoghii sp nov					R					R	R	R	R			R	R	R	R					R				
Isohabrocythere teiskotensis Aposto														R					C			C						
Paracypris sirtensis sp nov				R			R	R	R			R		R							R		R	R				
Reticulina sangalkamensis Bassiouni				R													R											
Krithe gp kalambainaensis	R	R	R	R			R	R	R	R				R		R			R		R							
Buntonia (B) salahii sp nov	R	R	R					R	R											R			R	R		R	R	
Cytherella sorrensis El Sogher	R	R				R	R	R	C			C						R	R	R			R		R			R
Cytherella hateibensis El Sogher																						R						
Trachyleberis modesta Apostolescu																												
Buntonia tatteuliensis Apotolescu									R					R						R			R					R
Bythocypris elsogheri sp nov					R																							
Cytherella saidi sp nov	R			R			R	R														R						
Protobuntonia sp B																												
Paragrenocythere neoponticulata								R																				
Cythereis teiskotensis Apostolescu																												
Paracosta bensoni Damotte& Donze																			R									
Acanthocythereis (S) libyaensis sub sp nov																												
Uroleberis (O) libyaensis sp nov						R				R	R					R	R	R	R	R					R			
Xestoleberis tripoliensis El Sogher					R	R																						
Paracypris keeni sp nov																												
Isohabrocythere heiraensis sp nov				R																								
Paragrenocythere gravis Al-Furaih																												
Actinocythereis joshensis sp nov																												
Paracosta warriensis																												
Buntonia harashensis sp nov																												
Soudanella ghaniensis sp nov																												
Paracypris tripoliensis sp nov																												
Paracypris khawlai sp nov																												
Protobuntonia nakkadii	R					R	R	R	R		R		R											R				
Paracosta paleomokattamensis	R											R																
Pontocyprella recurva Esker																						R		R		R		

Table (3,8) Ostracoda chart well AA1- 6