LATE CRETACEOUS AND PALEOCENE OSTRACODS FROM THE WAHA AND HEIRA FORMATIONS OF THE SIRTE BASIN, LIBYA.

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Summary

The aim of the project is to study the taxonomy of the ostracods of the Upper Cretaceous (Waha Formation), and Lower Paleocene (Heira Formation) in the Sirte Basin, Libya, and to discover their value in correlation between wells in Libya, and between Libya and adjacent regions. No study has previously been carried out on the ostracods of these formations.

The material studied was mainly ditch cuttings with a few core chips from the Waha and the Heira Formations of wells E12, E46, and E57 in the Raguba Oil Field of the Sirte Basin, Libya.

Thirty-five genera, seventy-three species and two subspecies have been recorded among which twenty-five species are proposed as new; seventeen species have previously been described; thirteen can be closely compared with described species; and the remainder left under open nomenclature. Many of the species previously described have a wide range of distribution in the Upper Cretaceous and the Paleocene of North Africa, West Africa, and the Middle East.

Nine species make their first downhole appearance in the Waha Formation, of which only four species are previously described. *Cristaeleberis fornicata* Bassiouni is important because it is only known from the Maastrichtian in other areas. The presence of certain species such as *Paracosta pervinquieri* (Damotte & Donze) in the Heira Formation suggests that it is probably Early Danian in age.

A brief review of the palaeoecology and palaeobiogeography of the investigated ostracod taxa has been described.

The generic and specific composition of the overall fauna suggests deposition at mid-shelf depths. A brief review of Paleocene faunas for considering the palaeobiogeographical purposes is undertaken, and the need to take into account the presence of the Lower Paleocene hiatus in many localities in North Africa and the Middle East. In general the Paleocene ostracods show a relationship with other parts of North Africa as well as with West Africa, Jordan, and Saudi Arabia.

DECLARATION

I declare that the contents of this thesis are my own work carried out in the Department of Geology and Applied Geology, University of Glasgow from December 1988 to May 1991.

ALI ELSOGHER MOHAMED-SALEH

DR. M. C. KEEN

CHAPTER ONE

INTRODUCTION

Libya is situated on the central Mediterranean foreland of the African shield, between Egypt and Sudan to the east, Tunisia and Algeria to the west, and with Niger and Chad situated directly to the south. It covers about 1,800,000 km^2 and extends about 1,925 kms from east to west and 1,450 kms from north to south.

The areas studied in the present work are located in the Raguba Oil Field situated near the central part of the Sirte Basin, and cover the area of concession 20 (Fig. 1-1 & Tab. 1-1).

Table 1-1 Locality of the wells studied.

Well no.	Intervals	Latitude	Longitude
E12-20	4530'- 5610'	29° 5' 1.5"	19° 4' 19.4"
E46-20	4900'- 6121'	29° 2' 1.4"	19° 4' 19.2"
E57-20	5270'- 6187'	29° 8' 32.2"	19° 3' 51.5"

The material of cuttings and a few chips of cores was obtained from three oil wells drilled by Esso Sirte Inc. (northern part of the Raguba Field well E57-20, middle part of the field well E12-20, and southern part of the field well E46-20.)

The samples studied are from the Upper Cretaceous Waha Formation and from the Lower Paleocene Heira Formation. No previous work has been carried out on the Cretaceous ostracods nor the Paleocene ostracods of this area. This study attempts to fill the gap in basic ostracod research in Libya.

The stratigraphical terms used in this study are those which have been widely used in the Sirte Basin. The stage names of the Paleogene are those of Western Europe and are not always the same as more recently

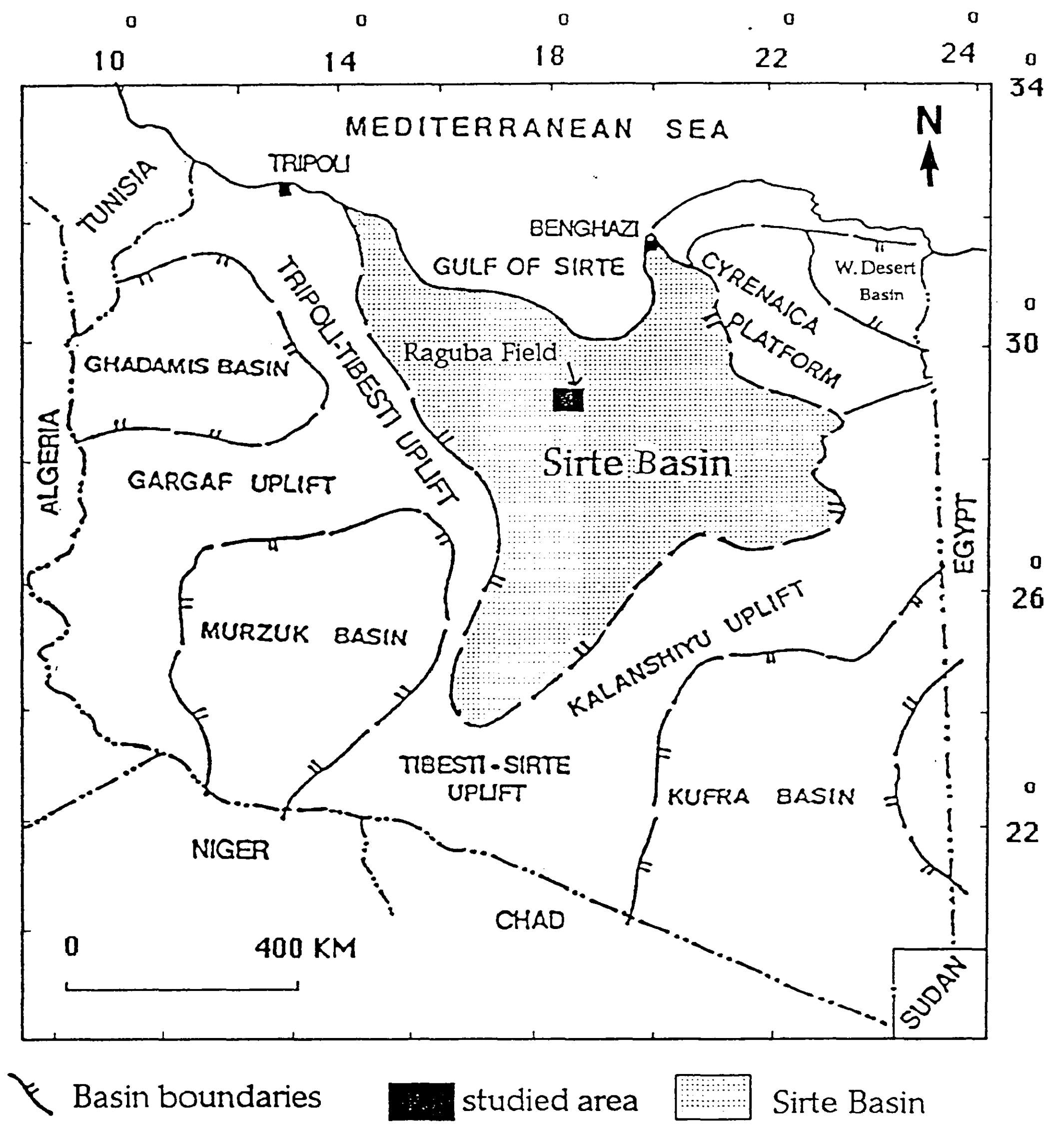

Fig. 1-1 Geographical location map of the area studied within the Sirte Basin, Libya.

accepted international stages. Thus Landenian is used for the Upper Paleocene rather than Thanetian.

Many of the species found appear to have a wide geographical distribution and are recorded from several west African countries (Nigeria, Senegal, Mali, Ivory Coast, etc.), as well as from north Africa (Tunisia, Egypt), and the Middle East (Saudi Arabia, Jordan, and Oman) Fig. 1-2.

The nature of the samples studied and the preservation of the ostracods present some problems. The ratio of carapaces to single valves is very great, so the internal features are rarely seen, lending an uncertainty to generic assignments. The state of preservation of the material, even when open valves are found, is frequently very poor. Finally, contamination of well cuttings leads to problems concerning species ranges.

The material is deposited in the Hunterian Museum in Glasgow University.

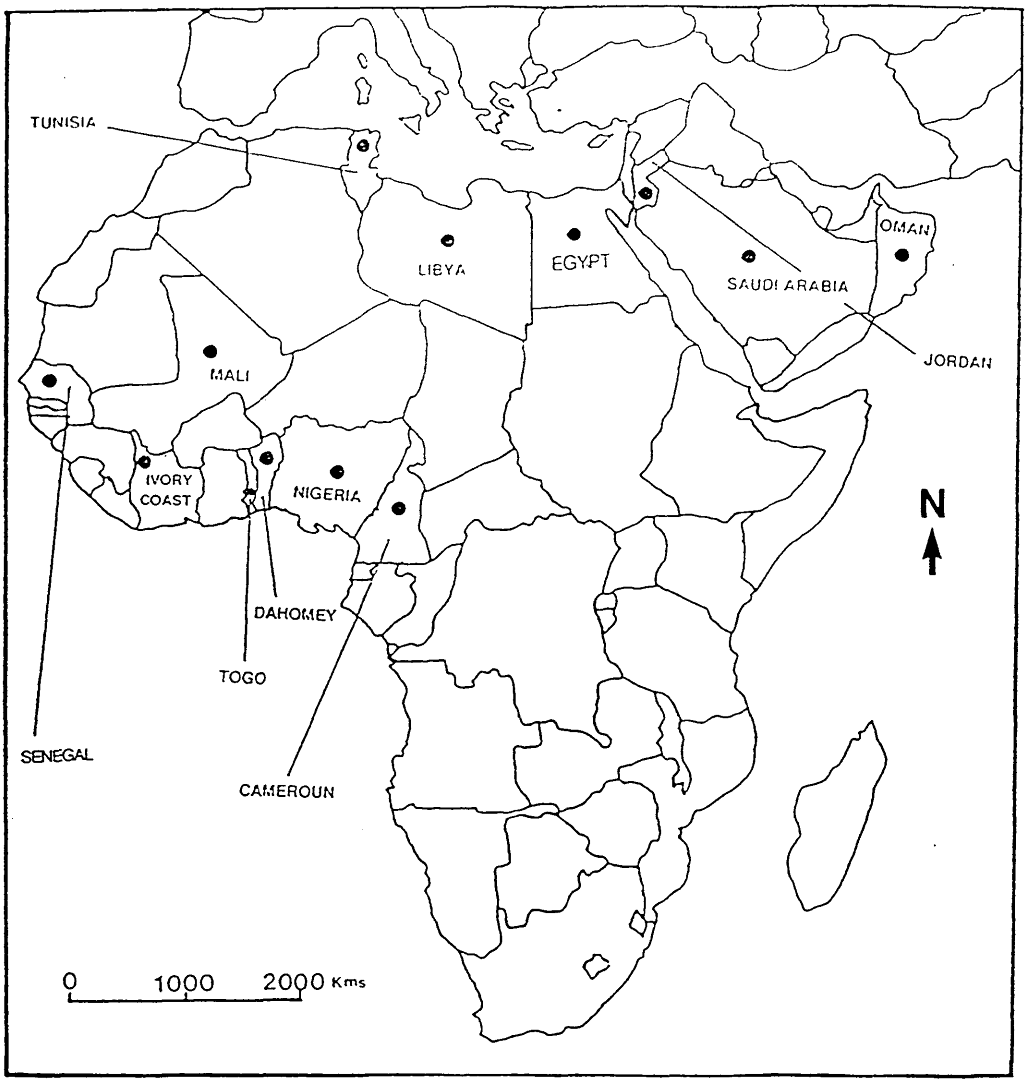

Fig. 1-2 Location of some important studies of Upper Cretaceous and Paleocene ostracods in north and west Africa and the Middle East.

CHAPTER TWO

PREPARATION TECHNIQUES FOR THE S.E.M.

Sample Techniques

1-Ditch cutting sample techniques

The samples were soaked in 20% hydrogen peroxide solution for 18-20 hours. The duration of soaking is dependent upon the strength of the specimens and thickness of the dirt particles. The residue was washed with hot water to remove the finer organic particles and sieved into three fractions: 500 μm, 250 μm, and 75 μm classified as coarse, medium, and fine. The three residues obtained were transferred to evaporating basins and dried in an oven at 150 ^{o}C. The dried residue was packed in labelled vials then picked under a binocular microscope using a fine moistened sable brush. Most of the adult ostracods species were obtained from the medium residue, although a few juvenile ostracods were found in the fine residue; very rare ostracods were obtained from the coarse residue.

2-Core chips sample techniques

The techniques used in the processing of the core chip samples was the sodium hydroxide preparation method used to extract carbonate material (e.g. ostracods, foraminifera, etc.) from shales, limestones, and clastics. The samples were broken down using a jaw crusher to fragments less than 1 cm^3. About 200gms of samples were placed in 400 ml of 30% hydrogen peroxide solution with 3-5 pellets of sodium hydroxide, and left overnight. The sediment was then boiled in hydrogen peroxide solution for about 3-4 hours, and washed and sieved.

Preparation Techniques

Cleaning methods for specimens

The following cleaning techniques were used for the specimens selected for examination under the scanning electron microscope:

A- Manual method

This method was used to clean out sediment within the specimens. The specimens were soaked in hydrogen peroxide (20%) for 15-20 minutes, placed on a slide with a drop of water to prevent the specimens from being lost when the remaining particles were removed with a sharp needle.

B- Ultrasonic Method

This method was used for cleaning specimens which could not be cleaned manually. The specimens were placed in a small glass vial quarter filled with water, then the vial was immersed for less than 3-4 second in the Ultrasonic field (some specimens took more time). This process was repeated again if required. After each cleaning, the specimens were examined under the microscope until they were clean. This method was used with great care because of damage, breakage and recrystallisation which destroys the ornamentation (as in Pl. 8, Fig. 3.)

Photography

The Cambridge Instruments S600, and S360 were used in this study. The specimens had to be mounted on an aluminium stub of one centimetre diameter by means of two different methods of adhesive:

1- Pritt stick

This type of adhesive is very easy to use, cheap, and quick drying. The glue is applied to the S.E.M. stub as a very thin film, the specimens are placed on the adhesive using a damp brush under a binocular microscope, then dried on the stub under a desk lamp for approximately 30 minutes. The surface of the dry adhesive was scratched for better conductivity between the stub and coated specimens and then coated with gold and examined under the S.E.M. The advantage of this method is that the specimens are easily removed from the stub by soaking in a drop of water using a wet brush. The disadvantage is that the electron beam causes outgassing from the adhesive which could contaminate an EDX detector (energy dispersive x-ray) .

2- Tempfix

A thermoplastic adhesive for mounting specimens, necessary for use with the more sophisticated S360 to prevent contamination of the chamber. Tempfix is a resin which does not contain any solvents and is stable in a high vacuum. It is not sticky at room temperature but becomes adhesive at around 40^{o}C and melts at 120^{o}C. An aluminium stub is warmed up on a hot plate to around 120^{o}C, and a thin layer of tempfix is applied to the stub. The tempfix is allowed to become slightly solidified, at about 40^{o}C, then the specimens are mounted onto it under a binocular microscope; when the tempfix is completely solidified, the specimens are coated with gold in a vacuum coating unit. The disadvantages in this method are as follows:

1- Specimens are difficult to removing from the tempfix, so this method is inadvisable if the total number of specimens available is very low.

2- Only a small number of specimens can be mounted on the stub because the tempfix cools rapidly.

CHAPTER THREE

GENERAL GEOLOGY

Geology and structure of Libya

Structurally, Libya is divided into five sedimentary basins, separated from one another by intervening uplifted arches (Conant & Goudarzi, 1967). These are the Ghadamis, Murzuk, Kufra, Western Desert and Sirte Basins, Fig 1-1. Several orogenies, from Early Palaeozoic to Cretaceous have occurred and resulted in the present day tectonic framework of the country. The Caledonian Orogeny, dated as near the end of the Silurian, resulted in several northwest-southeast trending structural elements of uplifts and troughs Fig. 3-1. In the Late Palaeozoic (Devonian and extending through the Carboniferous and Permian) the Hercynian orogeny occurred, resulting in northeast-southwest trending structures Fig. 3-2 approximately perpendicular to the Caledonian (Early Palaeozoic) tectonic trends Fig. 3-3; in northern Libya, these younger structural elements are trending east-west Fig. 3-2. The Cretaceous Period is characterised by the opening of the Sirte Basin, dominated by the formation of northwest-southeast trending horsts and grabens Fig. 3-3.

Since the Early Palaeozoic, the country has been the site of several transgressions and regressions by the sea, which has resulted in the accumulation of extensive sheets of a wide variety of continental and marine sediments. A major transgression of the sea during the Early Silurian, resulted in the accumulation of thick deep marine shales which mark the onset of the Silurian. A general regression of the sea over most of the country occured as a result of the Hercynian Orogeny, since when the southern two basins, Murzuk and Kufra, were never flooded again.

During the Triassic the northwestern and northeastern corners (Nefusa uplift, Ghadamis Basin and northern Cyrenaica) of the country were covered by the sea. Terrigenous clastics, carbonates and evaporites were deposited unconformably over the Palaeozoic rocks. During the Jurassic, marine areas did not change very much in the northwest, whilst

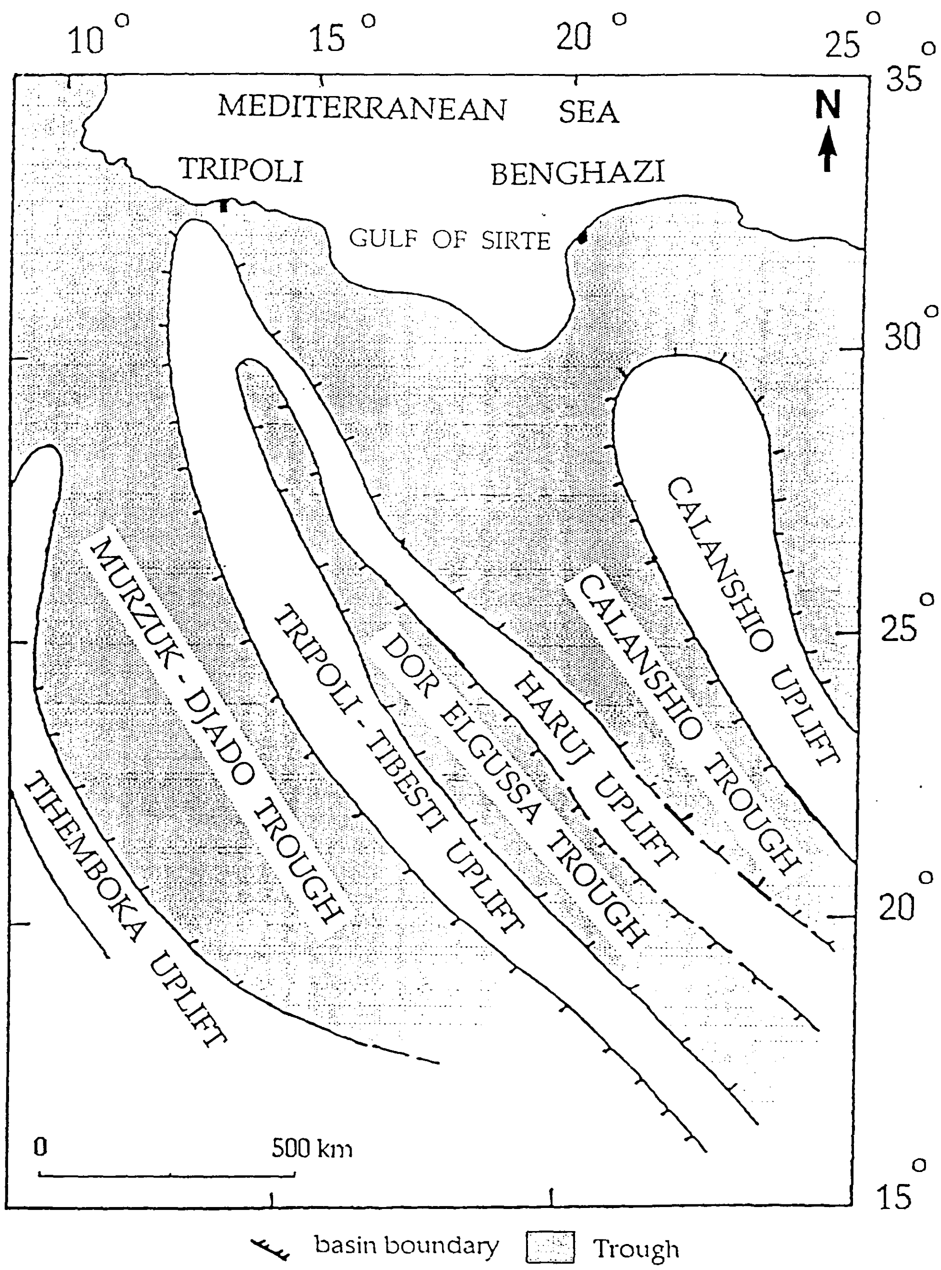

Fig. 3-1 Map showing the major structural elements of the central Sahara in Early Palaeozoic times (after Klitzsch, 1971). The structures are aligned NW-SE.

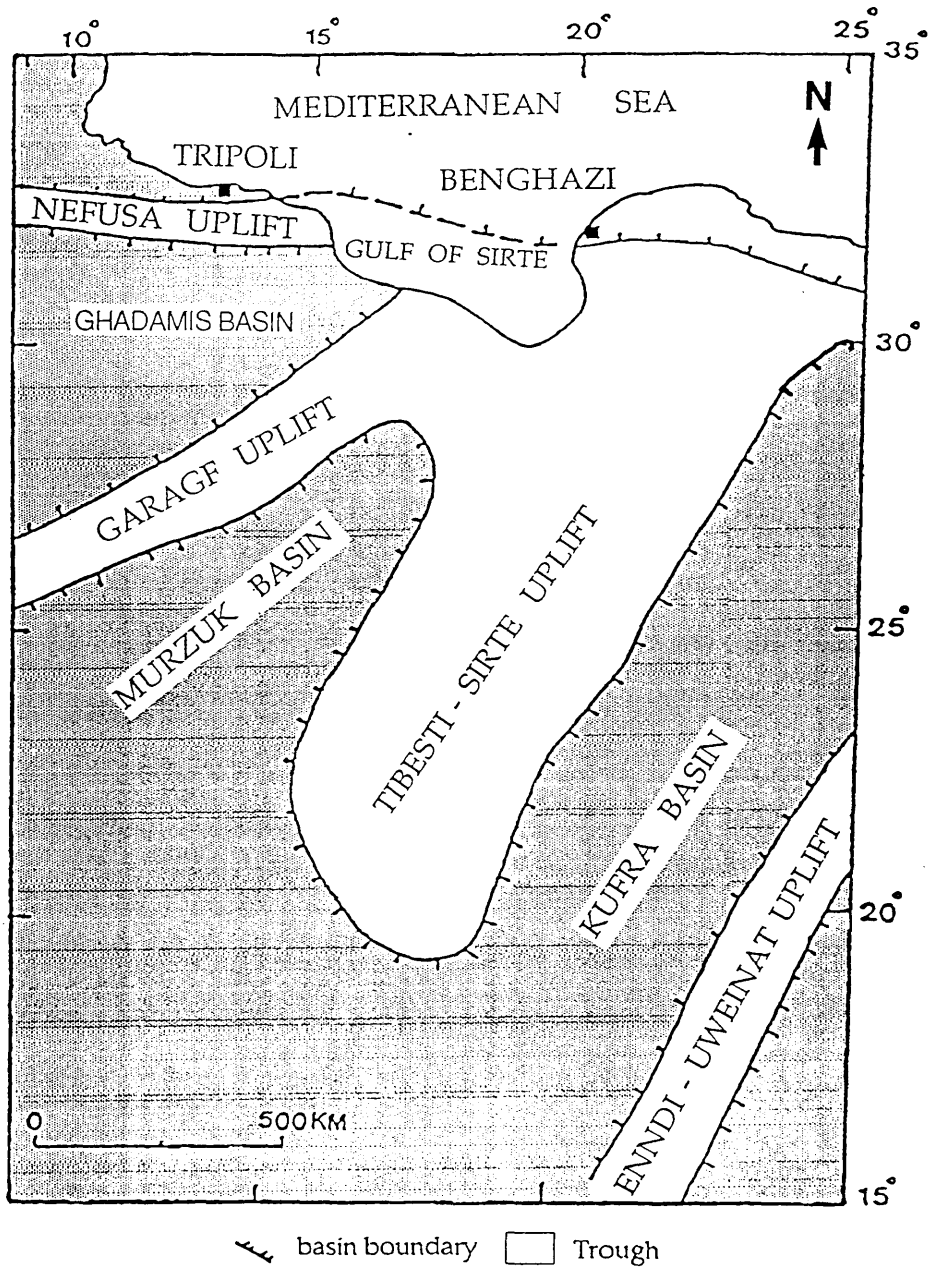

Fig. 3-2 Map showing the major structural elements of the central Sahara in Late Palaeozoic and Mesozoic times (after Klitzsch, 1971). The structures are aligned NE-SW.

in northern Cyrenaica the sea extended farther to the south. Shallow water carbonates and clastics were deposited to the south and deeper marine sediments accumulated in the north. During the Early Cretaceous a regression took place in north western Libya, where only continental sediments are recorded, whilst northern Cyrenica was still covered by a shallow sea.

The beginning of the Late Cretaceous (Cenomanian) was characterised by major tensional events which created the Sirte Basin. Only the major horsts in the Sirte Basin and the Cyreniaca Platform remained emergent. Throughout the Late Cretaceous the sea continued to advance southwards. By the end of the Maastrichtian only a few scattered horst crests remained above the sea as isolated islands (Duronio & Colombi, 1983).

The Tertiary section rests conformably on the Upper Cretaceous, and is composed entirely of marine sediments. Conditions appear to have remained stable throughout the Tertiary, even though there was continued rejuvenation of the horst/graben system in the Sirte Basin. During the Late Early Paleocene (Danian), or latest Maastrichtian, the last of the extensive transgressions began which is particularly evident in Late Paleocene times.

Regional geology and structural setting of the Sirte Basin

The Sirte Basin is a northwest - southeast trending basin, covering an area of approximately 300,000 km^2 and contains a total of 16 oil and gas fields. It is bounded by the Hun graben to the west, the Antalat fault which separates the basin from the Cyrenica platform to the east, the Mediterranean Sea to the north, and by the major Tibesti-Sirte uplift to the south Fig. 1-1.

The Sirte Basin was probably initiated in the Early Cretaceous, and by the Early Late Cretaceous (Cenomanian time) the basin was formed and a series of northwest-southeast trending horsts and grabens was developed

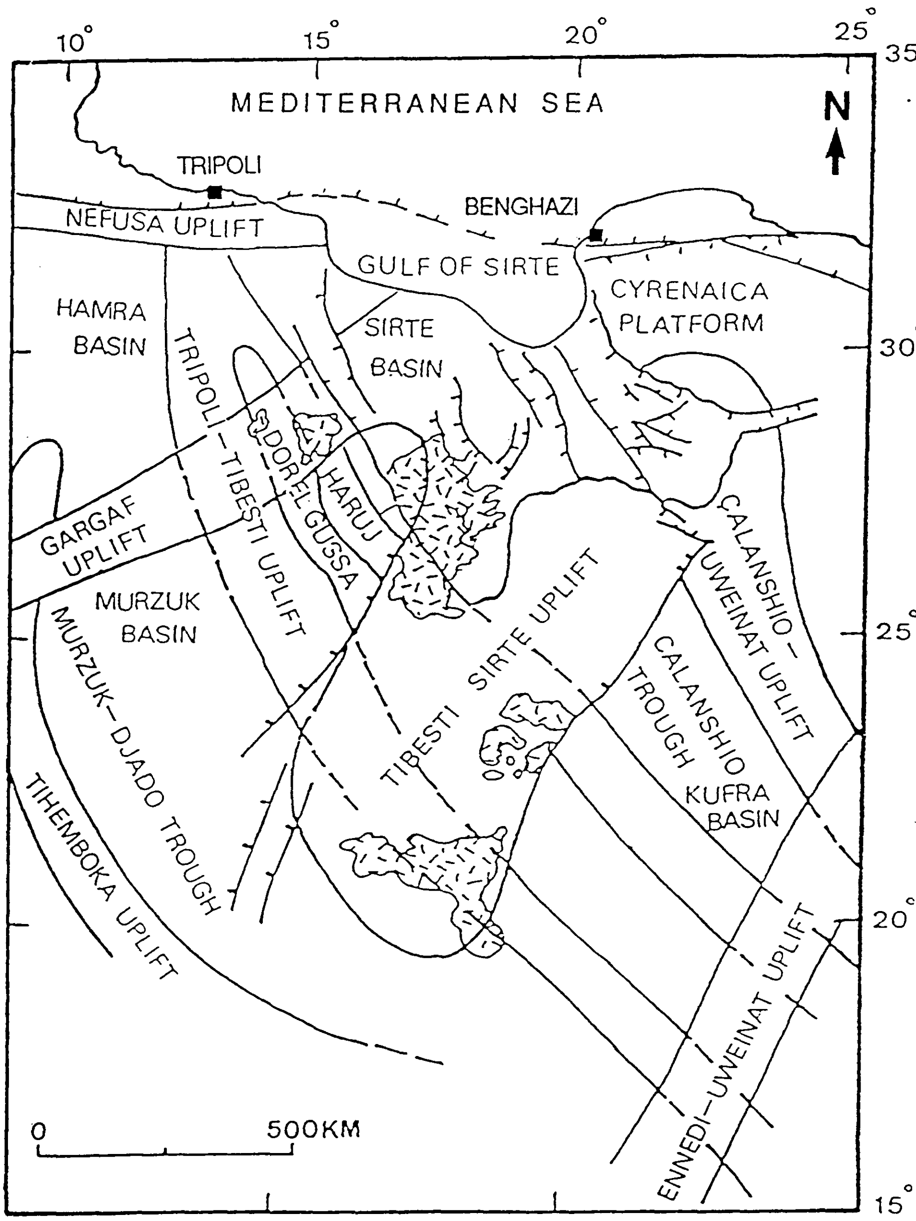

Fig. 3-3 Schematic map of the major structural elements, of the central Sahara. This shows the combined effects of the two structural regimes shows in Figs. 3-1 & 3-2 (after Klitzsch, 1971).

.Fig. 3-4. The basin formed as a result of crustal extension and the collapse of the Palaeozoic eroded basement uplift (the Tibesti-Sirte uplift, Fig. 3-2). However, only meagre Palaeozoic sediments (predominantly Cambro-Ordovician) have been formed in this basin, whereas thick sequences of predominantly marine Late Mesozoic and Tertairy sediments have accumulated in the deeper parts of the basin.

The Sirte Basin consists of a series of depositional troughs separated by platform areas Fig. 3-4. The sea covered both types of structure, characteristically with shale deposition in the troughs and carbonates on the platforms. This leads to a complex stratigraphy with lateral facies changes. Superimposed on to this complexity, a further complication arises from the practice of the Oil Companies in using their own stratigraphical nomenclature within their concessions.

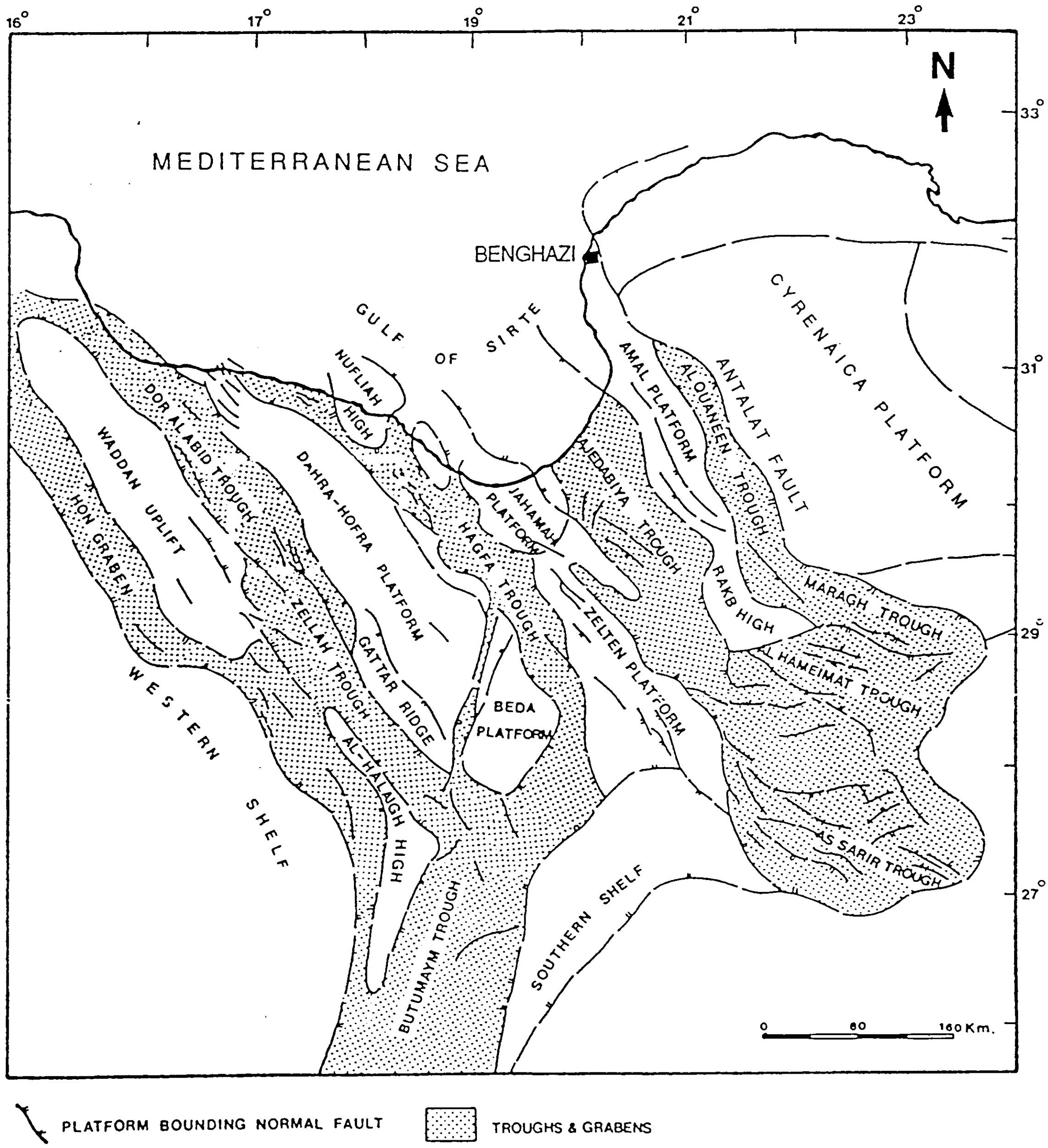

Fig. 3-4 Map showing the structural elements of the Sirte Basin (after Mouzoghi & Taleb, 1980)

CHAPTER FOUR

STRATIGRAPHY

General geology of the Upper Cretaceous

The Upper Cretaceous-Tertiary strata in Libya are exposed from the Tropic of Cancer in the south to the Mediterranean coast in the north, and continue in an E-W direction beyond the international borders to form part of the north African-Arabian platform deposits. These rocks have only recently been systematically studied. The early scattered information on these rocks was compiled by Desio (1943), and the main results of the intensive geological exploration from 1955 to 1970 were compiled by Burollet (1960); Hecht *et al.* (1963), Conant & Goudarzi (1964, 1967); Klilzsch (1970), Goudarzi (1970), Barr & Wegar (1972).

The Upper Cretaceous rocks outcrop on the surface as well as being present in the subsurface Sirte Basin. The nature of the Cretaceous-Tertiary boundary is well known throughout much of Libya. In the Sirte Basin, both Maastrichtian and Danian sediments are exceptionally well developed, although exposures of their contact are found only along the western margin of the basin (Jordi & Lonfat, 1963; Gohrbandt, 1966; and Barr & Weegar, 1972).

The Maastrichtian-Danian contact in the Sirte Basin has been penetrated by hundreds of wells. In the deeper parts of the basin there appears to be no interruption of deposition at the end of the Cretaceous. Often, however, there is an abrupt lithological change at this contact, reflecting a widespread and sudden change in depositional environments. This is a result of a shallowing of the Late Maastrichtian seas, bringing the Cretaceous to a close, followed by a strong transgressive phase at the beginning of the Danian (Barr, 1972a ; Baar & Berggren, 1980).

Previous studies of the Waha Formation in the Sirte Basin

Many studies have been conducted on the various aspects of the Waha Formation. Hea (1971) introduced the name Waha Sandstone with an inadequate description, deriving its name from the Waha Oil Field in the south central Sirte Basin. It was formally introduced by Barr & Weegar (1972) as the Waha Limestone as a subsurface formation with its type section located in the Oasis A29-59 Well (28^{o} 18′′ 45′′′N : 19^{o} 53′ 45′′E) at a drill depth of 1819.35 to 1842.21m. They pointed out that it consists predominantly of a tan to white, granular skeletal calcarenite; lime mud forms 15-35% of the rock. The grains consist mainly of fossil debris, including fragments of rudistids, other molluscs, echinoids, algae and benthonic foraminifera. Quartz grains are common in the basal part. The Waha Limestone varies in thickness from a few feet to a maximum of about 300 ft., and is restricted to the region of the Waha and Defa Oil Field and adjacent areas.

The lower boundary is conformable with the Cretaceous continental sandstones (Bahi Formation) or the igneous basement, and the upper boundary is conformable with the Maastrichtian Kalash limestone or the Lower Paleocene (Danian) Defa Limestone of Baar & Weegar (1972) (Fig. 4-1). Laterally the Waha Limestone is a facies equivalent of the Kalash Limestone.

In addition to molluscan and echinoid fragments, the large benthonic foraminifera *Omphalocyclus macroporus*, *Siderolites calcitrapoides* and *Orbitopides media* are some of the most common and diagnostic fossils in this formation. These species indicate a Maastrichtian age and a very shallow marine environment of deposition. The Waha Limestone is the principal reservoir in the Waha and Defa Oil Fields and is also an important reservoir in the Raguba Oil Field.

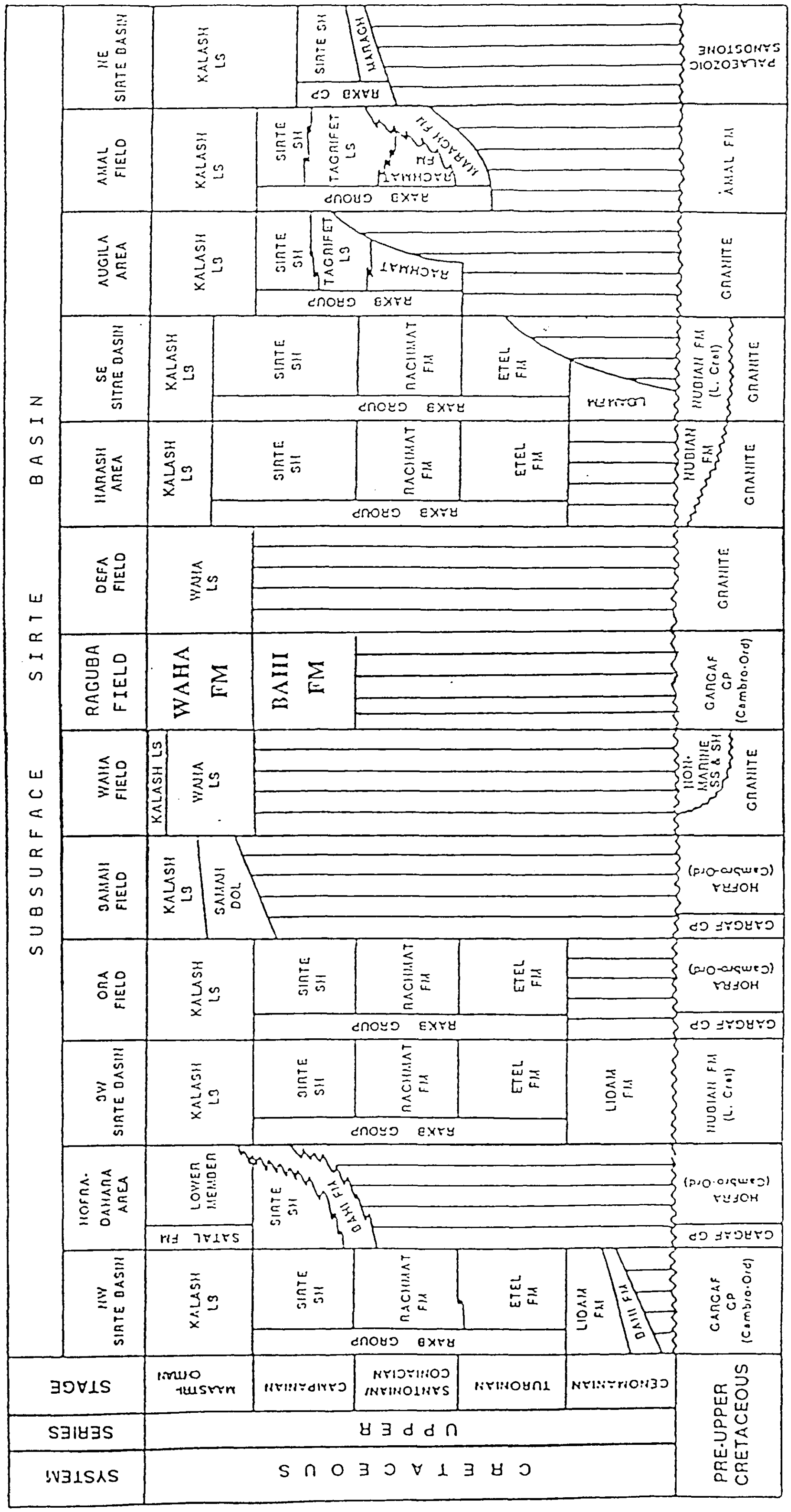

Fig. 4-1 Correlation chart of the Upper Cretaceous in the Sirte Basin (after Baar & Weegar, 1972).

Previous studies of the Waha Formation in the Raguba Field

The Raguba Field is located on a pronounced structural high near the western edge of the Hagfa trough Fig. 3-4. This feature remained positive during the deposition of some Tertiary formations. It acted as a barrier, separating the deeper water marine sediments of the Hagfa trough in the north-east from the shallow marine sediments on the south west shelf. The stratigraphical succession of the field is shown in Fig. 4-5. The Waha Formation constitutes the upper and major reservoir unit in the Raguba Field. The Waha Formation thickens towards the south west and south. The maximum thickness exceeds 800 feet in the west and towards the southern area of the field. In the eastern part of the field the formation does not exceed 400 feet. The Waha Formation gradually pinches out on the flanks of the Gargaf dome which forms the basement of the field.

The Waha Formation in the Raguba Field is interpreted as being deposited by waves and tidal or shoreline currents in a high energy environment. The salinity of the water is commonly normal marine, well oxygenated, having good circulation but not hospitable to marine life due to constant shifting of the sea floor sediments. (Abogars, 1989). Foraminifera, dasycladacean algae, worms and abraided coquinas have been reported.

The Waha Formation is present in most of concession 20 around the flanks of the old Menzella-Raguba Ridge and is absent on the crests of these structural features which were, presumably, not invaded by the sea. The Waha Formation grades into the Socna Formation in the Hagfa trough.

Abogars (1989) studied the Waha Formation in the Raguba Field, and divided the formation into three lithofacies:

A- Calcareous sandstone facies: shallow water winnowed platform-edge sands forming a belt around the Menzella-Raguba Ridge. The sands have rounded grains and are fairly well sorted grainstones. Bioclasts (shell hash), dasycladacean algae, and foraminifera are present.

B-Mainly skeletal sandy limestones: representing a transition between facies A and C. They were deposited near normal wave base and are composed of interbedded skeletal sandy limestone and calcareous sand facies.

C- Skeletal sandy limestone (calcarenites): This is composed of skeletal debris of benthonic and other bioclasts, dasycladacean algae and foraminifera similar to those found in the calcareous sand facies. This facies was deposited near to, or slightly below, normal wave base.

By definition, the Waha Formation is composed of quartzoze sandstone, grading to a pure skeletal limestone, characterised by fossil debris. It represents a shallow water, high energy, beach type deposit.

Waha Formation in the studied area

The Waha Formation in the studied area increases in thickness towards the south. It is 164 ft. in Well E57-20 located in the northern part of the field, 373 ft. in Well E12-20 located near the centre of the field, and 448 ft. in Well E46-20 located in the southern part of the field.

The sediments penetrated by the Wells differ slightly from those described by Barr & Weegar; the majority of the succession consists of limestone and sandstone with fossil fragments (see sample description).

General geology of the Paleocene in the Sirte Basin

The general subsidence continued from the Cretaceous, and a thick sequence of shales and carbonates was deposited throughout the Paleocene, during which time almost all the topographic highs were buried. This sequence illustrates many characteristics of deposition in the Sirte Basin.

During the Early Paleocene, transgression was continuous on the southern and south western margin of the Sirte basin and persisted into the Late Paleocene.

The Paleocene rocks outcrop on the surface as well as being present in the subsurface. They crop out nearly continuously along the south western and western margin of the Sirte Basin (Fig. 4-2) and extend from Wadi Faregh in southern Dor el Gussa northward to the Hon Graben (Fürst, 1964) and westward beyond the Sirte Basin over a large area of the Hamra platform (Jordi & Lonfat, 1963; Conant & Goudarzi, 1964).

Lower Paleocene rocks are similar in surface outcrop and subsurface wells. Deposition usually continued without break from the Maastrichtian into the Paleocene; some possible exceptions are discussed below (Lehmann, 1964).

The Danian, Montian and Landenian stages are all represented with lithologies consisting of alternating open marine calcareous shales and shallow water carbonates. The total thickness and lithology of the sediments are a function of sea level changes controlled by the major structural elements of the basin.

The maximum marine transgression took place during the Danian. The basal shale unit of the Paleocene, the Hagfa Formation, was deposited in separate areas of the Hagfa trough (see Fig. 3-4) in a moderately deep water environment surrounding shallower water environments of the upper Satal Formation, and covered the Beda, Dahra-Hofra, Jahama and Zelten platforms (Fig. 3-4). The Hagfa Formation is equivalent to the Heira Formation in the Raguba Field of the Sirte Basin and consists mainly of shale with limestone. It overlies the Kalash Formation conformably, and in turn is conformably overlain by the Beda Formation (Fig. 4-3). Planktonic Danian species are common especially in its lower part and include *Globoconusa daubjergensis*, *Globorotalia compressa*, and *Globigerina pseudobulloides*.

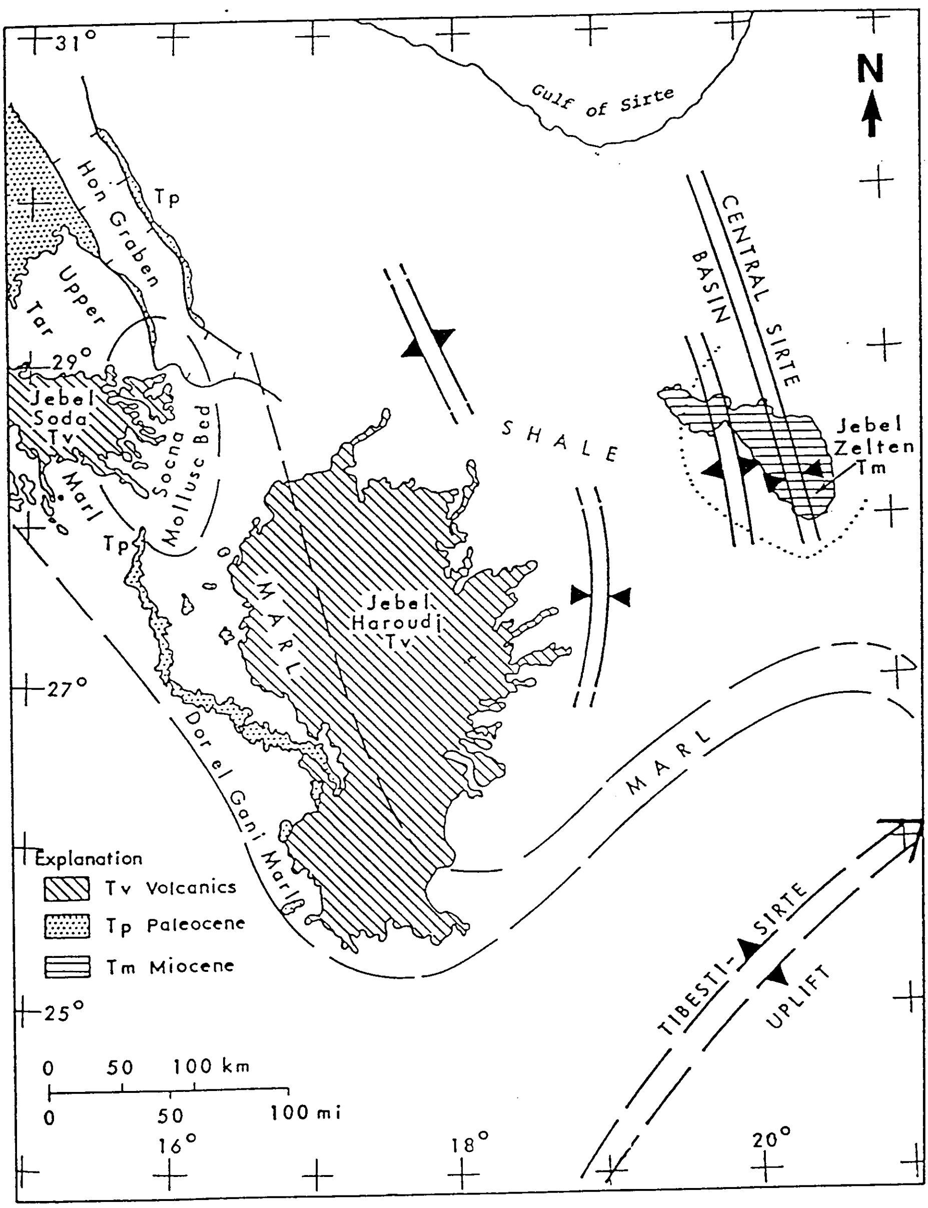

Fig. 4-2 Map showing the Paleocene outcrops at the western and southwestern margins of the Sirte Basin (after Conley, 1971).

During the Montian a carbonate sequence of the Beda Formation was deposited in the western part of the Sirte Basin. This consists mainly of limestone interbedded with dolomite and calcareous shale. The Beda Formation overlies the Hagfa Formation conformably and is conformably overlain by the Dahra Formation. The fossil content indicates a variety of shallow marine environments.

During Landenian times, a thick sequence of carbonates was deposited, represented by the Dahra, Zelten, Harash and Kheir Formations (Fig. 4-3).

Previous study of the Heira Formation in the studied area

The Heira Formation was originally described by R. Brown (1958). The type section is located in the El-Heira depression where it consists mainly of shales, grey to green or black in colour, fissile to blocky, with some beds of limestone, and is very fossiliferous.

The Heira Formation changes facies vertically and laterally producing three separate carbonate members: the Mabruk, Ora, and Meem members. The Mabruk and Meem members are present in the Raguba Field. The Heira Formation is laterally equivalent to the Hagfa shale (Barr & Weegar, 1972), which is present in many locations in the Sirte Basin.

Heira Formation in the studied area

The Heira Formation in the studied area increases in thickness towards the south of the field. It is 1513 ft. thick in well E57-20, 1511 ft. in well E12-20, and 1780 ft. in well E46-20. It consists of a sequence of alternating shales and carbonate rocks (Fig. 4-4).
In this study the data available are from the Heira Formation just below the Mabruk member.

Several authors (Conley, 1969; Jordi *et al.*, 1963) have attributed this alternation of shale and carbonate to repeated transgressive and regressive

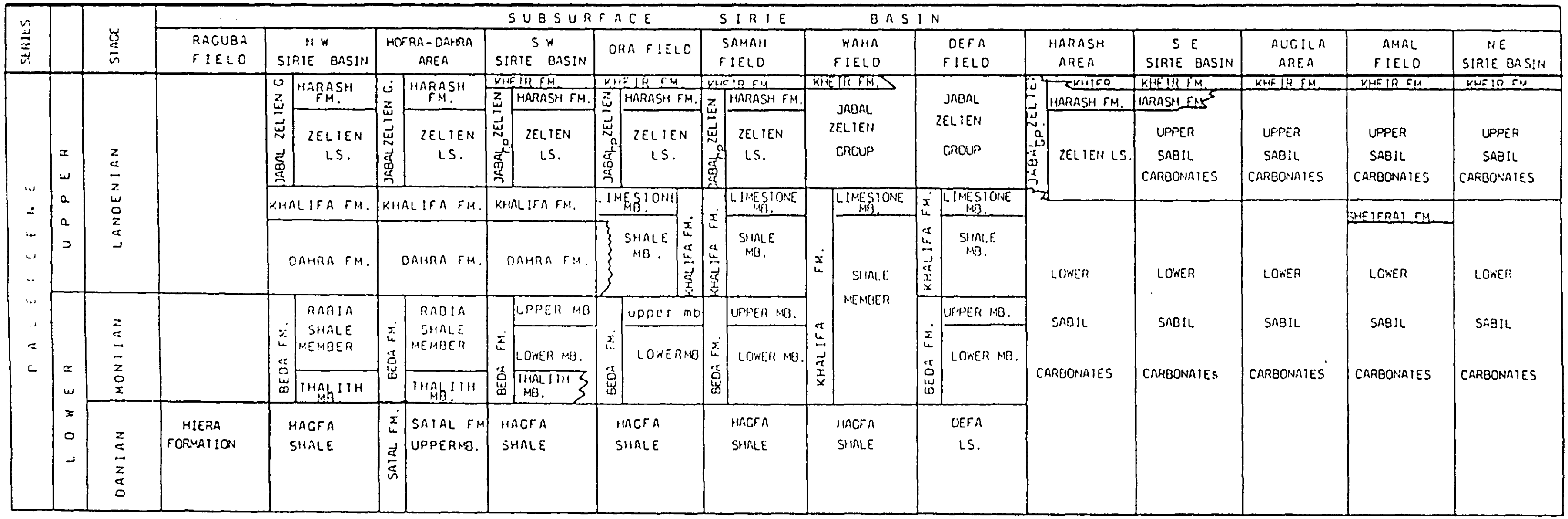

Fig. 4-3 Correlation chart of the Paleocene in the Sirte Basin (after Barr & Weegar, 1972).

cycles. Fürst (1964), suggested that the alternations of Paleocene shale and carbonate rocks in outcrop are sedimentation cycles reflecting transgressive and regressive tendencies.

The well logs show shale/limestone cycles which could be accounted for in several ways (Conley, 1971)

1- Major changes occurred in the supply of fine terrigenous clastics to the basin from the north.

2- Temporary reactivation of old highs or faults altered the bathymetry sufficiently to initiate flourishing reef and bank growth and also to prevent currents from spreading fine clastics widely.

3- Subsidence was temporarily more rapid in the basin centre allowing trapping of great volumes of fine clastics.

Figure 4-4 illustrates the stratigraphical correlation between the three wells, using both wireline log responses (e.g. spontaneous potential (sp) and resistivity log), and lithological description from ditch cutting samples and, where available, core samples. This cross-section clearly shows that the Heira Formation overlies the Waha Formation conformably and consists mainly of thick shale intervals with thin carbonates. The Waha Formation consists of calcareous sandstone in the lower part and limestone in the upper part.

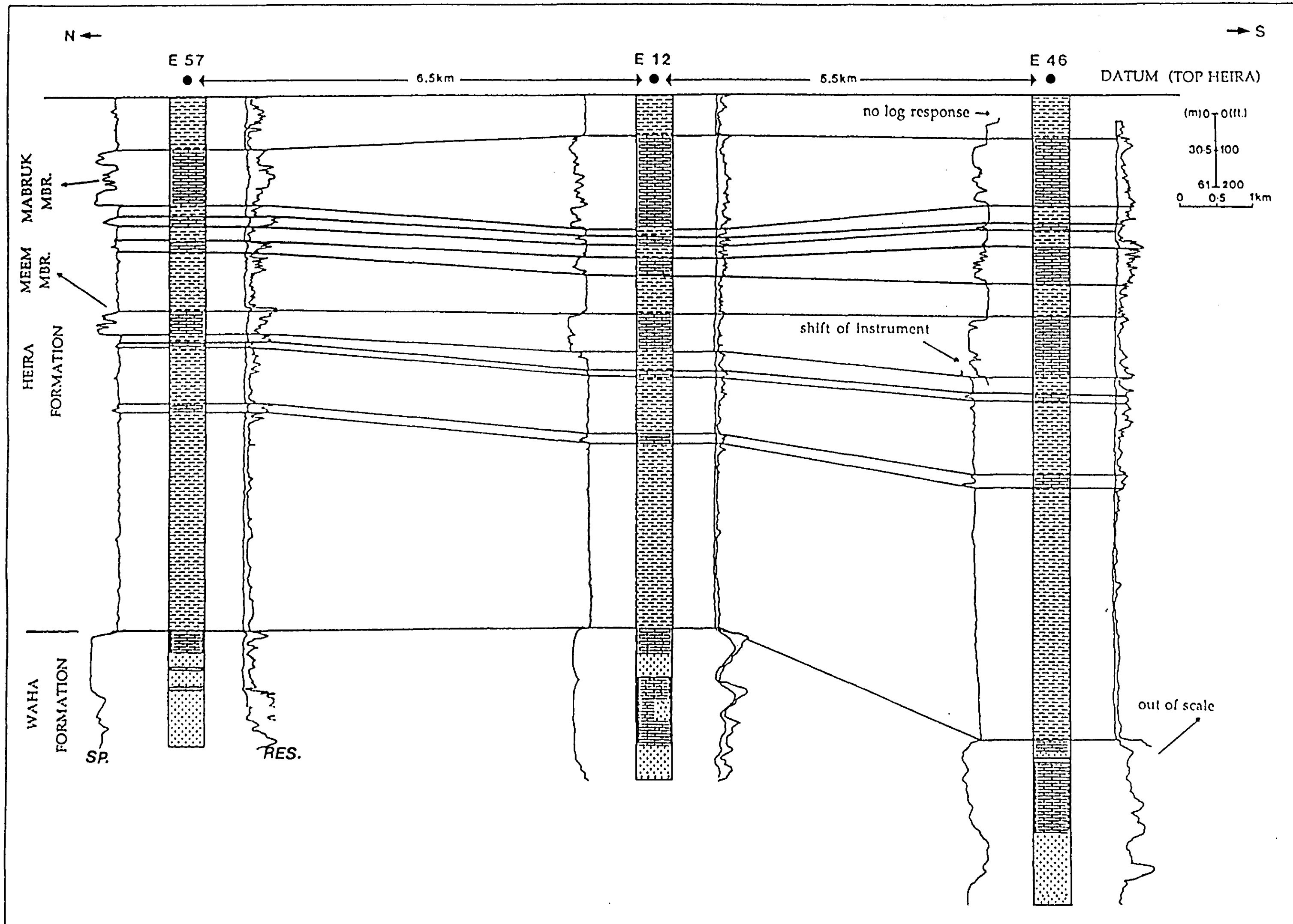

Fig. 4-4 Correlation between wells (E12, E46, and E57), using sp. curve, and resistivity logs, showing the Upper Cretaceous - Tertiary contact, the Mabruk, and Meem members, and the thin beds of limestones within the shale association.

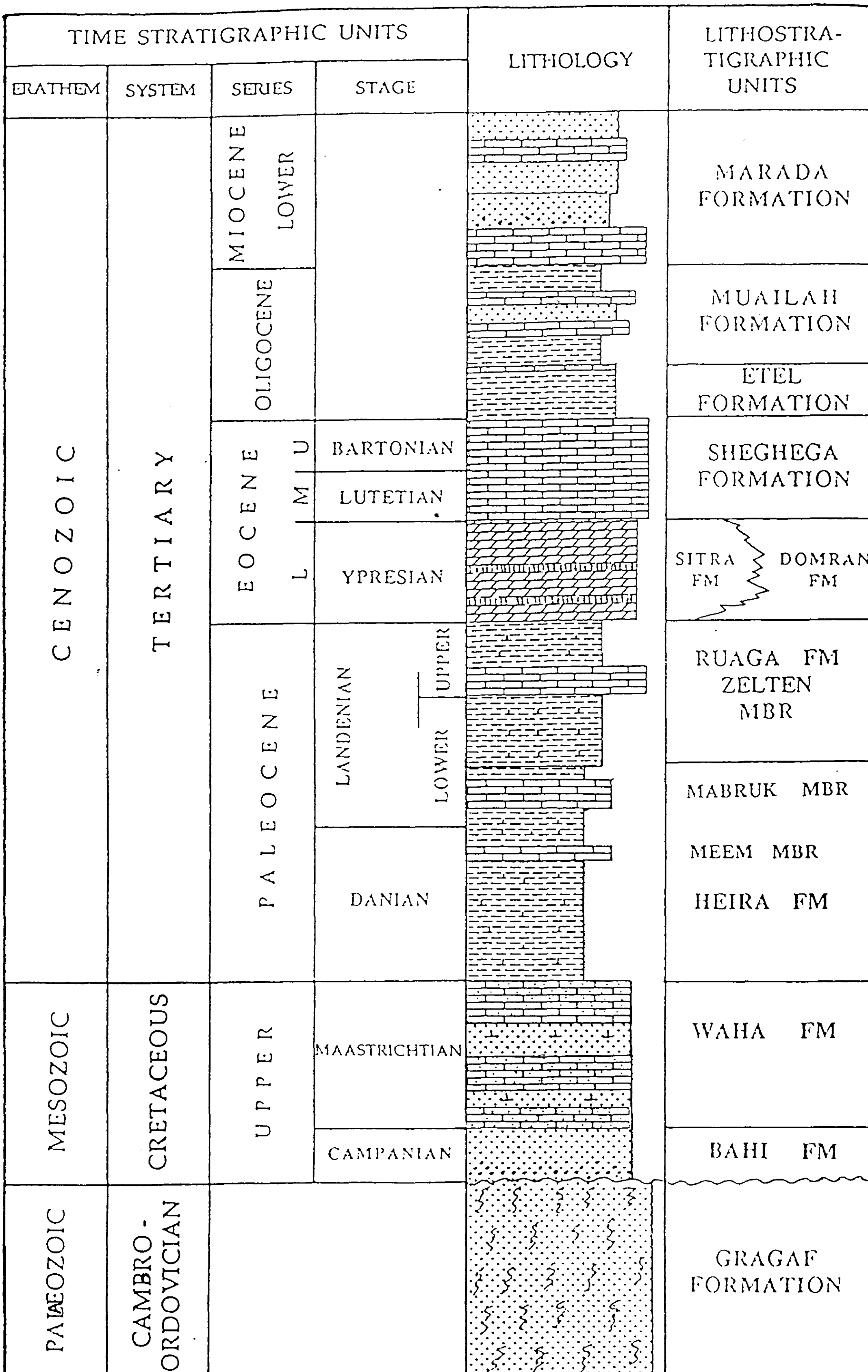

Fig. 4-5 Generalized columnar section of concessions 16 and 20,showing stratigraphical terms in use in the field. (Landenian probably equals Thanetian).

Lithological description of samples

Ditch cutting samples and a few core chips were examined from the three wells E12-20, E46-20, and E57-20 drilled by Esso Sirte Inc. (now Sirte Oil Company, Libya) from the Raguba Field in northern central part of the Sirte Basin. A total of 84 unprocessed samples was obtained. 22 samples from well E12-20 (Fig. 4-6), 35 samples from well E46-20 (Fig. 4-7), and 27 samples from well E57-20 (Fig. 4-8). Note that the description of missing intervals is given in the sections based on well logs.

Well E12-20

22 samples were obtained as follows:

DEPTH (ft.)	LITHOLOGY
4530	Mainly shale: grey to light grey in colour, splintery, fissile, soft to medium hard, slightly silty, calcareous.With limestone: whitish, microcrystalline, argillaceous with fossil fragments.
4660	70% limestone similar to depth 4530 with abundance fossil fragments. 30% shale similar to depth 4530.
4700	Mainly shale similar to depth 4530 with traces of limestone.
4780	Mainly limestone: brown to light brown in colour,micritic, soft to medium hard, highly argillaceous, abundance fossil fragments.
4840	50% limestone: similar to depth 4780. And 50% shale: similar to depth 4700.
4880	50% limestone similar to depth 4780, 50% shale similar to depth 4700.
4900	Mainly shale: grey to light grey, greenish, splintery, fissil, soft to medium hard, very calcareous, occasionally silty.

4940	Similar to depth 4900.
5100	Mainly shale similar to depth 4900 with traces of limestone.
5140	Similar to depth 5100.
5180	Mainly shale: grey to light grey in colour, occasionally dark grey, fissile, occasionally blocky, medium hard, calcareous. With traces of limestone brown to light brown in colour, microcrystalline, medium hard, argillaceous, traces of fossil fragments.
5220	Similar to depth 5180.
5260	Similar to depth 5180.
5290	Mainly limestone: whitish, brown to light brown in colour, crypto-crystalline to microcrystalline, skeletal, very sandy, medium hard, occasionally pyritic. With traces of shale similar to depth 4900.
5320	Mainly limestone similar to depth 5290 with fossil fragments.
5340	Mainly limestone similar to depth 5290 becoming more sandy.
5450	Mainly limestone : light brown, occasionally light grey, micritic, skeletal, very sandy, medium hard, some fossil fragments. With loose sand grains, fine to medium grained, subrounded to subangular.
5480	Similar to depth 5450.
5550	Mainly limestone similar to depth 5450.
5580	Mainly limestone similar to depth 5550.
5610	Similar to depth 5580.

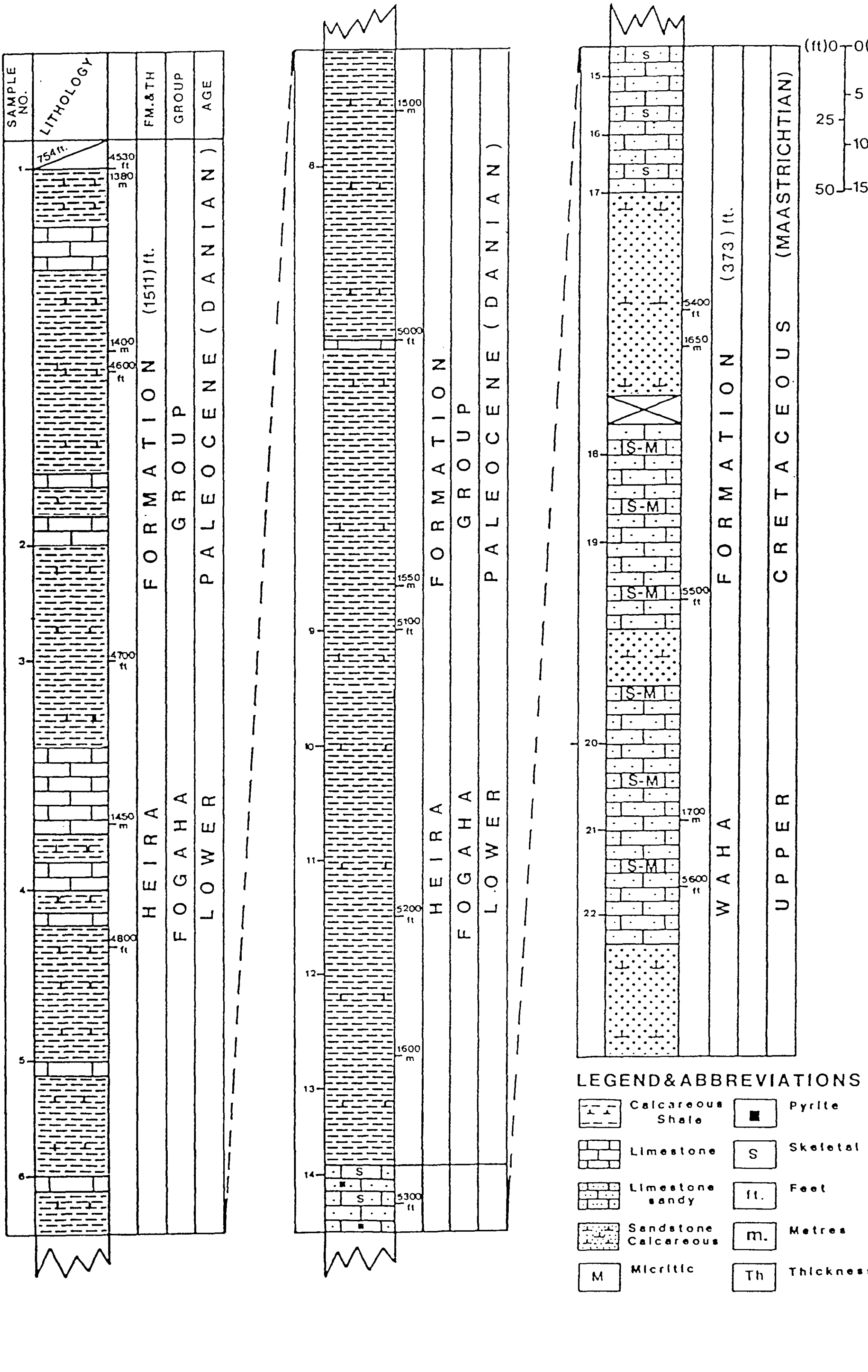

Fig. 4-6 Stratigraphic section of the Waha & Heira Formations in well E12-20.

Well E46-20

35 samples were obtained as follows:

Depth (ft.)	Lithology
4900	Mainly shale: grey to light grey in colour, splintery, fissile, occasionally blocky, soft to medium hard, slightly silty, calcareous.
4930	70% limestone: brownish in colour, occasionally whitish chalky in parts, soft to medium hard, argillaceous, with abundance fossil fragments. 30% shale similar to depth 4900 but becoming very calcareous.
4960	40% limestone, 60% shale both similar to depth 4930.
4990	mainly shale similar to depth 4900.
5020	Mainly limestone: brown to light brown in colour, micritic, soft to medium hard, highly argillaceous, abundance fossil fragments.
5050	Mainly shale: grey to light grey in colour, occasionally greenish, fissile, splintery, soft to medium hard, very calcareous.
5080	Mainly shale: similar to depth 5050.
5110	Mainly shale similar to depth 5050.
5140	50% limestone: similar to depth 5020. And 50% shale similar to depth 5050.
5170	Similar to depth 5140.
5200	Mainly shale similar to depth 5050.
5230	75% shale: light grey in colour, occasionally blocky, splintery, fissile, soft, very calcareous 25% limestone brown to light brown

in colour, occasionally whitish, micritic, chalky in parts, highly argillaceous, with fossil fragments.

5260 Similar to depth 5230 with less percentage of limestone.

5290 Mainly shale: similar to depth 5230.

5320 Similar to depth 5290.

5350 Mainly shale with limestone similar to depth 5230.

5380 Similar to depth 5350.

5410 Mainly shale similar to depth 5230.

5440 Mainly limestone: whitish in colour, light grey, chalky in parts with abundance fossil fragments, traces of shale.

5470 Mainly shale similar to depth 5230 with traces of limestone.

5500 Mainly limestone similar to depth 5440 with rich in fossils.

5540 Mainly limestone: whitish, occasionally light brown, chalky in parts, soft to medium hard, highly argillaceous, with very rich in fossils.

5560 Mainly shale: very light grey in colour, fissile, splintery, soft, very highly calcareous.

5590 Mainly shale: similar to depth 5560.

5620 Mainly shale: similar to depth 5560.

5650 Similar to depth 5560.

5680 Mainly limestone: whitish, very light brown, cryptocrystalline to microcrystalline, micritic, very fine sandy, soft to medium hard, occasionally calcite veins, glauconitic, slightly pyritic, with traces of shale.

5920 Similar to depth 5890.

5950 Mainly limestone: light brown to dark brown, occasionally light grey, micritic, sandy, medium hard, glauconitic.

5980 mainly sandstone: light grey, fine to medium grained, subrounded to subangular, very calcareous, soft to medium hard.

6010 Mainly limestone similar to depth 5950.

6040 Mainly sandstone similar to depth 5980.

6070 Similar to depth 6040.

6100 similar to depth 6040.

6121 Mainly sandstone similar to depth 6040 with less calcareous.

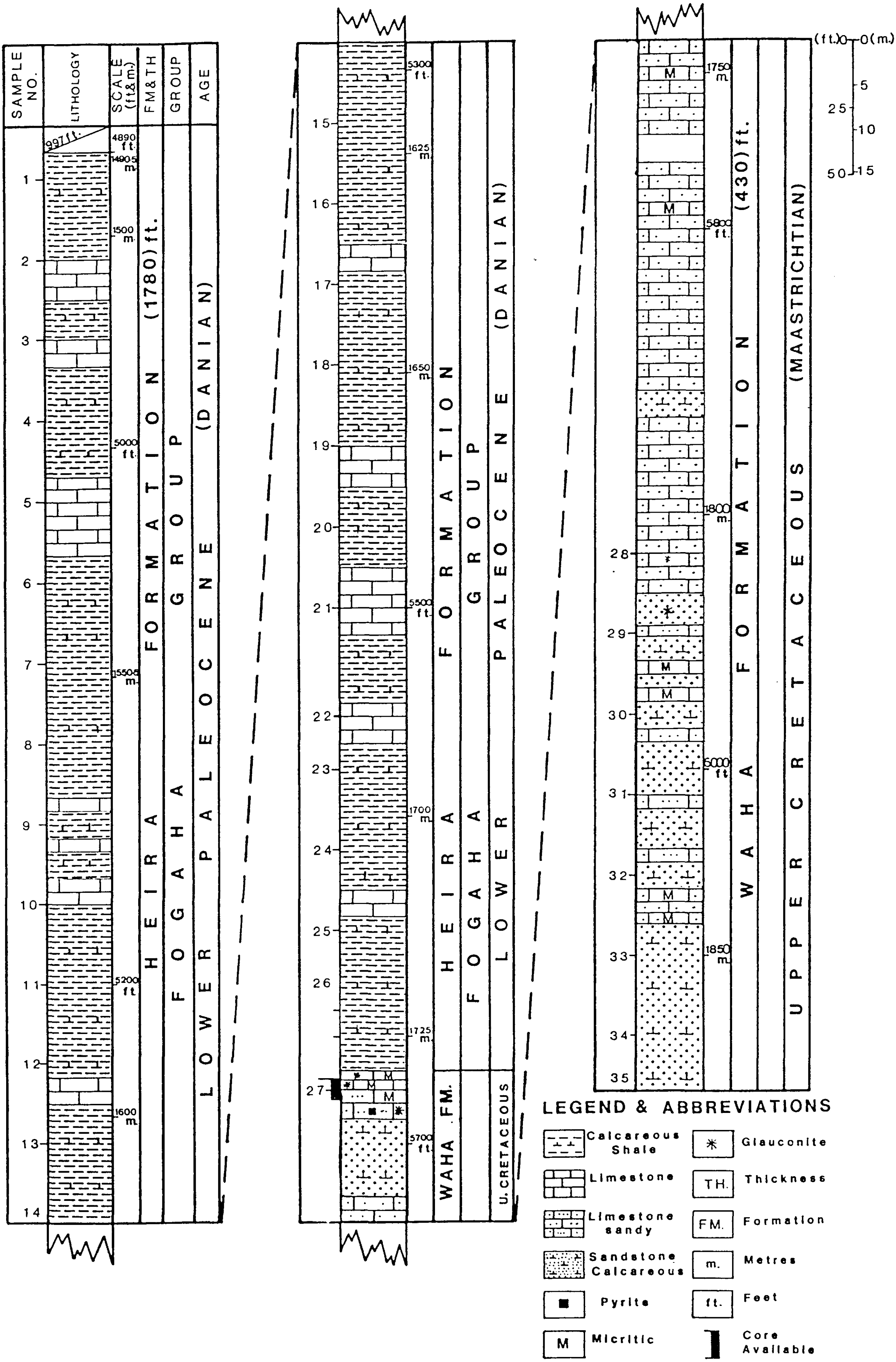

Fig. 4-7 Stratigraphic section of the Waha & Heira Formations in well E46-20.

Well E 57-20

27 samples were obtained as follows:

Depth (ft.)	**Lithology**
5270	Mainly shale: light grey to grey in colour, splintery, firm to medium hard, very slightly silty, very calcareous traces of lime stone: light grey in colour, off white hard, chalky in parts, some fossil fragments.
5290	Mainly shale: as above with some shale grey to dark grey in colour. Traces of limestone: similar to depth 5270.
5330	Similar to depth 5290.
5370	60% limestone: white, off white, occasionally brown to light brown in colour, occasionally micritic, hard, chalky in parts, argillaceous, abundant fossil fragments, intercalation of clay. 40% shale: light grey in colour, splintery, fissile, soft to medium hard, very calcareous, pyritic in parts.
5420	Mainly limestones similar to depth 5370 with shale: grey to light grey in colour, occasionally dark grey in colour, splintery, fissile,firm to medium hard, very calcareous.
5450	Mainly shale: similar to depth 5420 with traces of limestone.
5490	Mainly shale: similar to depth 5450 with traces of fossil fragments.
5530	Mainly shale: similar to depth 5490 with traces of limestone: whitish, light grey, occasionally brown in colour, hard, chalky in parts, argillaceous, with traces of fossil fragments
5560	Mainly shale: similar to depth 5530. With trace of limestone similar to depth 5530.

5600 Mainly shale : similar to depth 5560 becoming more calcareous with trace of limestone similar to 5560.

5640 Mainly shale: similar to depth 5600 with traces of fossil fragments

5670 Mainly shale: similar to depth 5640. with limestone similar to depth 5530 and some limestone of brown in colour.

5700 80% limestone: whitish, grey to light grey in parts, microcrystalline, hard, argillaceous, rich in fossil fragments. 20% shale: light to very light grey in colour, splintery, fissile, medium hard, very highly calcareous.

5750 50% limestone: similar to 5700. With 50% shale: similar to 5700.

5790 95% shale: light grey, occasionally green, splintery, fissile, medium hard,very calcareous. with 5% limestone similar to depth 5750 with fossil fragments.

5830 Mainly shale: similar to depth 5790. with limestone similar to depth 5790.

5870 Mainly shale: similar to depth 5790 with traces of fossil fragments.

5910 Mainly shale: similar to depth 5870

5950 Mainly shale: light grey to very light grey, fissile, splintery, medium hard, very highly calcareous. with traces of limestone similar to depth 5790.

5990 Mainly shale: similar to depth 5950 becoming very highly calcareous. with limestone: similar to depth 5790.

6010 Similar to depth 5990.

6040 Mainly limestone: whitish, occasionally light grey in colour, cryptocrystalline to microcrystalline, occasionally skeletal, micritic, sandy, friable quartz grains, soft to medium hard, occasionally chalky in parts, with fossil fragments, slightly pyritic, with traces of shale

6070 Mainly limestone: similar to depth 6040.

6100 Mainly sandstone: whitish, occasionally light grey, medium to coarse grained, subrounded, medium hard, friable, very calcareous with traces of limestone similar to depth 6040 with increase of sand grains, traces of fossil fragments.

6130 Mainly sandstone: similar to depth 6100 with traces of fossil fragments.

6160 60% limestone similar to depth 6040.
40% sandstone similar to depth 6130.

6187 Mainly sandstone similar to 6100

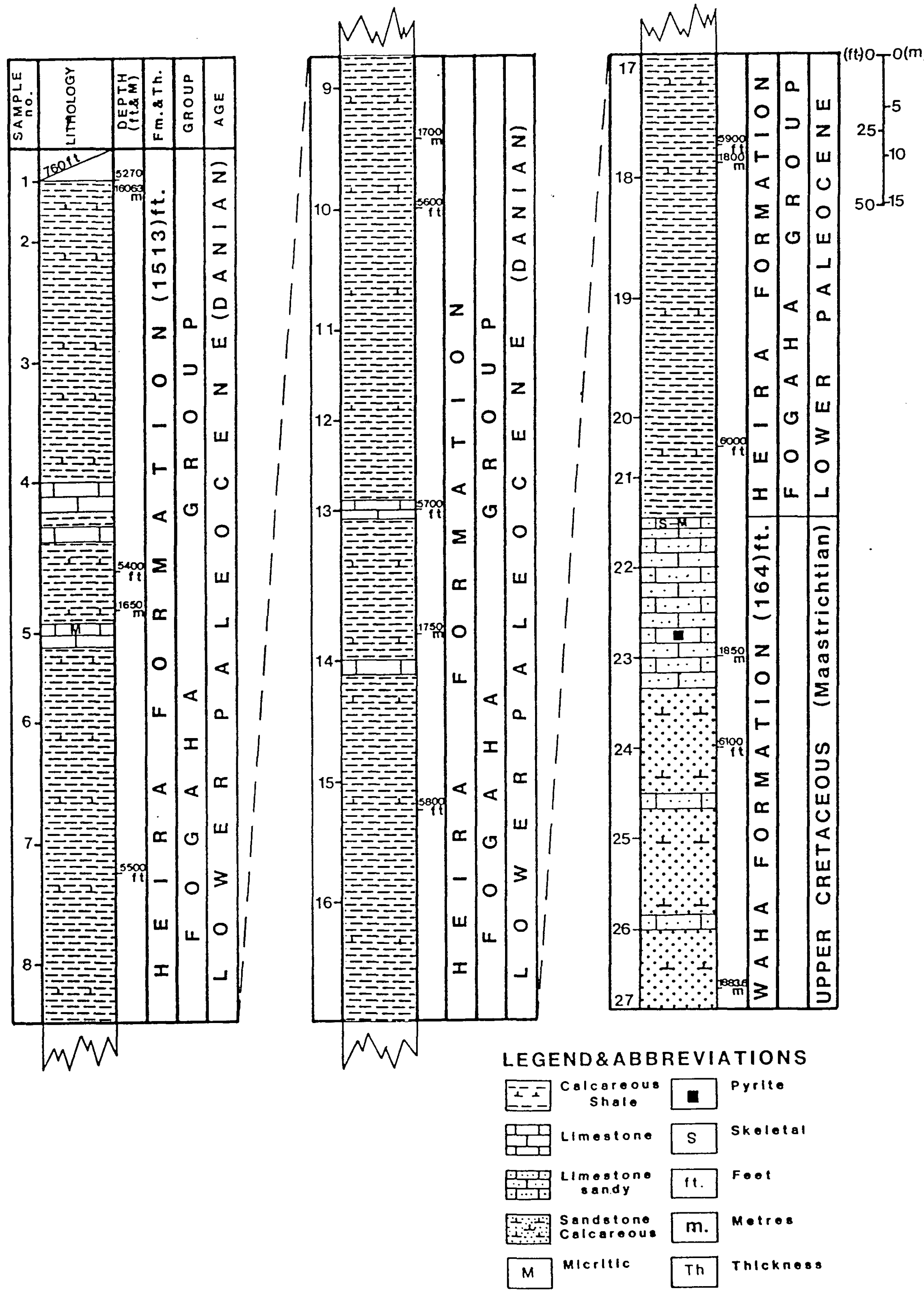

Fig. 4-8 Stratigraphic section of the Waha & Heira Formations in well E57-20

CHAPTER FIVE

SYSTEMATIC DESCRIPTIONS

The classification used follows that of the Treatise On Invertebrate Palaeontology (Q Arthropoda 1961); genera described subsequently have been placed in the family designated by the author.

Subclass Ostracoda Latreille, 1806.
Order Podocopida Müller, 1894.
Suborder Platycopa Sars, 1866.
Family Cytherellidae Sars, 1866.
Genus *Cytherella* Jones, 1849.
***Cytherella bassiouni* sp. nov.**
Plate 1, Figures 9-13, 16-17

1990, *Cytherella piacabucuensis* Neufville; Bassiouni & Luger, non Neufville 1979, P. 777, Pl. 1, Figs. 7-12.

Derivation of name: In honour of Dr. M. A. Bassiouni who first found this species in Egypt.

Diagnosis:

A species of *Cytherella* with horizontal oriented dorsal depression situated in a position close to the anterior position.

Holotype: Carapace, HM-A 12766; Pl. 1, Fig. 10.

Type Locality: Raguba Field well E 12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4780′

Stratigraphic range: Maastrichtian - Danian.

Catalogued specimens: HM-A 12761-767

Material:

Morphotype A: Forty carapaces and three valves recorded from the Heira Formation in well E46-20, at different levels; and from the Heira and Waha Formation in wells E12-20, and E57-20, at different levels.

Morphotype B: Four hundred and sixty seven carapaces and eight valves recorded from the Heira and Waha formations, at different levels in the studied wells.

Two distinct Morphotypes can be recognized which differ in ornament:

Morphotype A

Plate1, Figures 9, 11-13, 16

Description:

Carapace, subrectangular in lateral outline with nearly symmetrically broadly rounded posterior and anterior margins, anterior and posterior marginal rims are clearly seen; the surface of the carapace is ornamented with punctations except the central area which appears smooth. A dorsal depression lies in the central dorsal area, which is horizontally oriented, and situated in a position close to the anterior; the dorsal margin of the left valve is slightly concave in the middle but is convex in the right valve; the ventral margin is nearly straight. Greatest length passes through the mid-height, greatest height just before the middle towards the posterior.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12761	662	400	-
Left carapace, HM-A 12762	555	333	-
Right carapace, HM-A 12763	680	426	-
Left carapace, HM-A 12764	666	440	-
Dorsal view, HM-A 12765	680	-	320

Morphotype B

Plate 1, Figures 10, 17

Slightly larger in size, and the surface of the carapace is completely smooth.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12766 (holotype)	757	457	-
Ventral view, HM-A 12767	728	-	342

Discussion:

This is identical to the material described and illustrated by Bassiouni & Luger (1990) as *Cytherella piacabucuensis* Neufville (1979). Neufville described the species from the Paleocene of the Sergipe-Alagoas Basin, northeastern Brazil, while Bassiouni & Luger's material came from the Middle Paleocene to Early Eocene of Egypt. *Cytherella bassiouni* sp. nov. differs from *Cytherella piacabucuensis* in outline, being less "humped" in the posterior half of the dorsal margin, but more importantly differs in the dorsal depression. This has a vertical orientation in *Cytherella piacabucuensis* while it is horizontal in *Cytherella bassiouni* sp. nov.; the depression is situated in a position close to the highest point in *Cytherella piacabucuensis* rather than the more anterior position in *Cytherella bassiouni* sp. nov.

Cytherella sp. aff. *Cytherella bullata* Alexander, figured and illustrated by Bertels (1973) from the Lower Paleocene (Early Danian) of the Roca Formation of Argentina is a similar smooth species, but is larger and differs slightly in general outline.

Two distinct morphotypes can be recognised, a smooth form and a punctate form which otherwise are identical in shape. Bassiouni & Luger also recognised this feature. This phenomena is well known in species of *Cytherella*, (see Keen 1982).

Occurrence:

The species was recorded from the Middle Paleocene to Early Eocene of Egypt by Bassiouni & Luger (1990). In the present material it occurs in the Heira (Danian), and Waha (Maastrichtian) formations in the studied wells.

Cytherella hateibensis **sp. nov.**
Plate, 1 ; Figures 6-8, 15

Derivation of Name:
After the Hateiba Gas Field in concession six in Sirte Basin.

Diagnosis:

A species of *Cytherella* with unornamented surface; there is a clear anterior rim on the left valve, extending from the antero-dorsal area, along the whole ventral margin, terminating at a point on the posterior margin.

Holotype: Carapace, HM-A 12757; Pl.1, Fig. 6.

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Waha Formation (Maastrichtian), depth of 5580′.

Stratigraphic Range: Maastrichtian-Danian.

Catalogued specimens: HM-A 12758 - 760.

Material:

Total number of specimens one hundred and ninety two: Well E12-20, sixty specimens recorded from the Heira Formation at different level, eighteen specimens were recorded from the Waha Formation; well E46-20, forty specimens from the Heira Formation, thirty two specimens from the Waha Formation recorded at different levels; well E57-20, thirty one specimens recorded from the Heira Formation, and eleven specimens from the Waha Formation at different levels.

Description:

Carapace ovate in lateral view; anterior margin even and broadly rounded, posterior margin even and slightly less narrow than anterior. An anterior rim on the left valve extends from the antero-dorsal area, running along the whole ventral margin and terminating at a point on the posterior margin; a clear rim is present on the anterior and postero-ventral margins of the right valve; dorsal margin straight to slightly convex at central dorsal area. Ventral margin straight. The surface of the carapace is smooth, with a marked dorso-central depression; the right valve overlaps the left nearly on the whole margins.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12757 (Holotype)	770	414	-
Right carapace, HM-A 12758	666	373	-
Right carapace, HM-A 12759	755	414	-
Ventral view, HM-A 12760	784	-	292

Discussion:

Cytherella hateibensis sp. nov. differs from *Cytherella bassiouni* sp. nov. in shape and general outline, the carapace of *Cytherella hateibensis* sp. nov. tapering slightly towards the posterior.

Cytherella barpatharensis (female dimorph form Pl. 40, Fig. 12) Neale & Singh (1985) from the Middle Eocene of Assam differs from this species in general outline and being smaller in size, and in having fine pitting posteriorly.

Occurrence:

Occurs through the Heira and Waha formations in the studied wells.

Cytherella ragubaensis **sp. nov.**

Plate, 1; Figures 1-5, 14

Derivation of name: After the Raguba Oil Field in concession 20 in the Sirte Basin.

Diagnosis:

A species of *Cytherella* with caudal process in right valve, giving markedly different lateral outline for each valve.

Holotype: Carapace, HM-A 12751; Pl. 1, Fig.1.

Type locality: Raguba Field well E 12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 5100′

Stratigraphic range: Maastrichtian-Danian

Catalogued specimens: HM-A 12752 - 756

Material:

One hundred and sixty carapaces and six valves recorded from the Heira Formation (Danian), and Waha Formation (Maastrichtian) in wells E12-20, first appearance at drilling depth 5100′, last appearance at 5610′; E46-20, first appearance at drilling depth 5110′, last appearance at 6100′; and E57-20, first appearance at drilling depth 5600′, last appearance at 6187′.

Description:

The two valves have very different lateral outlines; the larger right valve has a prominent caudal process, more conspicuous when the carapace is viewed from the right side, convex dorsal and ventral margins, with the greatest height in the posterior half; the smaller left valve has a more typical *Cytherella* outline, with a concave dorsal margin, highest point towards the posterior, and a straight ventral margin. There is strong overlap around the whole margin. Surface smooth or with fine puncti; a smooth depression is present in the left valve in the central-dorsal area; there is a small submarginal ridge parallel to the anterior margin in the left valve. The internal features have been observed in a single right valve (Plate 1, Fig. 14) but are indistinct because of matrix covering part of the valve; the hinge is poorly preserved, the selvage is prominent; the muscle scars are not clear.

Dimensions of figured specimens in µm:

	L	H	W

Left carapace, HM-A 12751 (Holotype)	662	400	-
Left carapace, HM-A 12752	637	387	-
Right carapace, HM-A 12753	714	428	-
Left carapace, HM-A 12754	625	400	-
Ventral view, HM-A 12755	658	-	283
Right valve, HM-A 12756	625	362	-

Discussion:

This species is distinguished from others by the outline of the right valve, especially the posterior caudal process. A similar species has been illustrated by Grosdidier (1973) from the Cenomanian-Albian age of the coastal Fars Province of Iran, and referred to as *Cytherella* IR C6 (Pl.1, Fig. 3b). Grosdidier's species differs in having a caudal process more centrally placed on the posterior margin and in being oriented to point slightly postero-ventrally, whereas the caudal process in *Cytherella ragubaensis* sp. nov. points in a postero-dorsal direction.

Cytherella ragubaensis sp. nov. also shows some similarities to *Cytherella* IR K14 (Pl.1, Fig.5 a-b) Grosdidier (1973) from the Albian of the coastal Fars Province of Iran, but the latter has more equal-sized valves, a much less prominent caudal process, and nearly straight dorsal and ventral margins.

Occurrence:
Occurs in the Heira and Waha formations throughout the studied wells.

Cytherella sorrensis sp. nov.

Plate, 2; Figures 1 - 8

Derivation of name: After the Sorra Oil Field in concession six in the Sirte Basin.

Diagnosis:

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

Holotype: Male carapace, HM-A 12769; Pl. 2; Fig.2.

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Waha Formation (Maastrichtian), depth of 5490′

Stratigraphic range: Maastrichtian - Danian.

Material:

Five hundred and five specimens recorded throughout the Heira and Waha Formations in the studied wells.

Description:

Carapace ovate in lateral outline, tapered towards posterior. Sexual dimorphism is distinct, males more elongate than females. Anterior margin broadly rounded with weak rim on both valves; the posterior margin is narrower and is obliquely rounded, in some specimens with weak rim in the postero-ventral area; the dorsal margin is moderately convex; the ventral margin is slightly convex to nearly straight. Maximum height near centre; maximum width lies behind the mid-point. The surface is smooth in the female and weakly punctate in the male. There is a depression in the central-dorsal area.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Male right carapace, HM-A 12768	680	413	-	1.64
Male left carapace, HM-A 12769 (Holotype)	693	440	-	1.57
Female right carapace, HM-A 12770	510	340	-	1.50
Female left carapace, HM-A 12771	487	341	-	1.42
Female dorsal view, HM-A 12772	510	-	230	-
Female ventral view, HM-A 12773	510	-	230	-
Male dorsal view, HM-A 12774	625	-	275	-
Male ventral view, HM-A 12775	625	-	287	-

Discussion:

The female of this species is similar in general outline to *Cytherella sergipensis* Neufville (1979) (Neufville 1979, Pl.1, Fig.1a) from the Danian-Early Eocene of the Sergipe-Alagoas Basin, northeastern Brazil. *Cytherella sergipensis* differs in lacking the central-dorsal depression. The male of *Cytherella sergipensis* however has a different lateral outline from the male of *Cytherella sorrensis* sp. nov., being more elongate and lacking the tapered posterior.

Occurrence:

Known so far from the Waha and Heira Formations in the studied wells.

Genus *Cytherelloidea* Alexander, 1929

***Cytherelloidea libyaensis* sp. nov.**

Diagnosis:

A species of *Cytherelloidea* with a prominent ridge running parallel to anterior, ventral, and posterior margins, and a longitudinal median ridge joining the marginal ridge at the posterior and curving upward to join margin ridge at the antero-dorsal area.

Description:

Carapace sub-rectangular in lateral outline; anterior margin evenly and broadly rounded. The surface ornament consists of a prominent rib running from an antero-dorsal position parallel to the anterior, ventral, and posterior margins, ending in a postero-dorsal position; a prominent longitudinal median ridge joins the marginal ridge at the posterior and curves upwards at the anterior to join the marginal ridge near the antero-dorsal angle. Greatest length passes through the mid-height, greatest height at anterior fourth. Right valve larger than left, extending over the left around the entire margin, strongest overlap along the ventral margin.

Discussion:

Two subspecies are recognised which differ in ornament and lateral outline. The marginal ridge is much closer to the margin of the valves in *Cytherelloidea libyaensis libyaensis* compared with *Cytherelloidea libyaensis punctata,* the surface of the carapace between the ridges is smooth in *C. libyaensis libyaensis* but has coarse pitting or fine reticulation in *C. libyaensis punctata.* The lateral outline also differs, especially the ventral margin which is almost straight in *C. libyaensis libyaensis,* but strong concave in *C. libyaensis punctata;* the postero-dorsal margin is more obliquely rounded in *C. libyaensis punctata* so that the posterior margin appears more tapered. It is not certain how important the differences noted above are. The taxa described may represent two distinct species or two morphs of a single species; the solution adopted here is a compromise between these two views.

This species shows some similarity to *Cytherelloidea aazourensis* Bischoff (1964) from the Cretaceous of Lebanon in outline but it differs in shape and details of ornamentation and in being smaller in size.

***Cytherelloidea libyaensis libyaensis* subsp. nov.**
Plate 2, Figures 9-11, 16

Derivation of name: After Libya

Diagnosis:

A subspecies of *Cytherelloidea libyaensis* with smooth ornament between ridges, marginal ridge close to margins, ventral margin straight.

Holotype: Carapace, HM-A 12776, Pl. 2, Fig. 9.

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4900´

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: 12776 - 779

Material:

Total number of specimens sixteen: well E12-20: Ten specimens have been recorded from the Heira Formation, first appearance, at 4660′, last appearance at 5140′, four specimens from the Waha Formation, first appearance, at drilling depth 5290′, last appearance at 5610′; well E57-20, two specimens from the Heira Formation, at drilling depth 5870′.

Dimensions of figured specimens in μm:

	L	H	W
Left carapace, HM-A 12776 (Holotype)	527	294	-
Right carapace, HM-A 12777	609	353	-
Left carapace, HM-A 12778	625	362	-
Dorsal view, HM-A 12779	536	-	178

Occurrence:

Known so far from the Waha and Heira Formations in well E12-20; and from the Heira Formation in well E57-20.

***Cytherelloidea libyaensis punctata* subsp. nov.**

Plate 2, Figures 12-15

Derivation of name: related to surface ornamentation.

Diagnosis:

A subspecies of *Cytherelloidea libyaensis* with punctate or reticulate ornament between ridges, marginal ridge not close to margin, ventral margin strongly concave.

Holotype: Carapace, HM-A 12780, Pl. 2, Fig. 12

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4840′.

Catalogued specimens: HM-A 12781-783

Material:

Total number of specimens seven: All have been recorded from the Heira Formation in, well E12-20: two carapaces, at drilling depth 4840′; well E46-20: one carapace, at drilling depth 5200′; and well E57-20: four specimens, first appearance, at drilling depth 5330′, last appearance, at drilling depth 5830′.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12780 (holotype)	523	298	-
Right carapace, HM-A 12781	551	302	-
Dorsal view, HM-A 12782	526	-	173
Ventral view, HM-A 12783	536	-	187

Occurrence:

Occurs in the Heira Formation in the studied wells.

Cytherelloidea sp. A.
Plate 3; Figures 1-4

Figured specimens: HM-A 12784

Material:

Only one carapace has been found so far from the Waha Formation in well E12-20, at drilling depth 5550′.

Description:

Carapace subrectangular in lateral view; anterior margin evenly rounded, antero-marginal rim prominent; posterior end truncated ventrally; dorsal margin almost straight; ventral margin concave; greatest length slightly above mid-height. Surface ornamentation consists of three strong longitudinal ridges; the dorsal ridge is irregular, extending from the posterior marginal ridge towards the anterior where it appears to bifurcate; the median ridge is the shortest bifurcating at the posterior; the ventral ridge is parallel to the ventral margin and joins the posterior marginal ridge. The surface between the ridges, and possibly on the ridges, may have been punctate; however, well developed puncti are only clearly seen beneath the ventral ridge, and along the underside of the median and dorsal ridges; this is probably due to preservation.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12784	658	361	258

Discussion:

Cytherelloidea pachycosmata Al-Abdul-Razzaq (1981) from the *Cenomanian? -Turonian* of Kuwait resembles the present species in shape, outline and ornamentation. The Kuwaiti species differs in being smaller, and having the entire surface of the carapace covered by fine to medium-sized reticulation, and having less prominent ridges. Another similar species is *Cytherelloidea* IR D26 figured by Grosdidier (1973) from the Lower Aptian of the coastal Fars Province of Iran.

Occurrence:

This species has only been found in well E12-20, in the Waha Formation.

Family Cytherideidae Sars, 1825
Subfamily Cytherideinae Sars, 1825
Genus *Isohabrocythere* Apostolescu, 1961
Isohabrocythere teiskotensis Apostolescu, 1961
Plate 3, Figures 5-9

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. teskotensis* Apostolescu; Salahi, P.14, Pl.2, Fig.20.

1976, *Isohabrocythere teskotensis* Apostolescu; Ficcarelli, P.734, Pl.90, Fig. 8.

1980, *Isohabrocythere teiskotensis* Apostolescu; Reyment & Reyment Pl.1, Fig.1.

1983, *Isohabrocythere teiskotensis* Apostolescu; Foster, Swain, & Petters P.113, Pl.3, Figs. 11-13; Pl.8, Figs. 1-2.

1981, *Habrocythere teiskotensis* (Apostolescu); Reyment, P.57, Pl. 1, Figs. 13-14; Pl. 3, Fig. 1.

1990, *Isohabrocythere teiskotensis* Apostolescu; Bassiouni & Luger, P. 794, Pl. 6, Figs. 1-2, 4-5, 7-8.

Figured specimens: HM-A 12785-789

Material:

One hundred and five specimens have been recorded from the Heira Formation in the studied wells, at different levels.

Diagnosis:

A small carapace, subelliptical in lateral outline, anterior marginal rim prominent, anterior margin broad and evenly rounded and compressed, posterior margin varies from bluntly rounded to more pointed; eye tubercle present as a swelling near mid-dorsal margin; surface weakly punctate along margins becoming strongly punctate in the central area of the carapace.

Dimensions of figured specimens in μm:

	L	H	W
Left carapace, HM-A 12785	618	278	-
Right carapace, HM-A 12786	583	380	-
Left carapace, HM-A 12787	582	365	-
Dorsal view, HM-A 12788	623	-	305
Ventral view, HM-A 12789	588	-	305

Discussion:

The specimens studied here are the same as that figured by Reyment & Reyment (1980) as *Isohabrocythere teiskotensis* from the Paleocene of Libya. However, there are some differences between the Libyan species and those from Mali (Apostolescu, 1961) and Nigeria (Foster *et al.*, 1983). The outline of the posterior margin is more pointed in their figures, the dorsal margin is more rounded, and the ornamentation is much weaker. The Nigerian specimens also appear to lack the eye tubercle.

Occurrence:

This species is known from the Paleocene of Mali, Dahomey - Togo, Ivory Coast, Nigeria, Mali, and Egypt; in this study it occurs in the Lower Paleocene (Danian).

Family Schizocytheridae Mandelstam, 1960

Genus *Schizocythere* Triebel, 1950

Genus cf. *Schizocythere*? sp.

Plate 3, Figs. 10-11

Figured specimen: HM-A 12790

Material:

Only one carapace has been found from the Heira Formation in well E12-20, at drilling depth 4530′

Description:

Small subquadrate carapace, Dorsal and ventral margins almost straight and subparallel. Surface coarsely reticulate; a prominent rib runs parallel to the anterior margin, a weak rib parallel to the dorsal margin in the central-dorsal area has a row of 4 small reticulae between it and the dorsal margin. Valves almost equal in size; eye tubercle prominent .

Dimensions of figured specimens in µm:

	L	H
Right carapace, HM-A 12790	485	276
Same left carapace,	485	276

Discussion:

This species shows some similarity to *Schizocythere sellarius* described and illustrated by Al-Furaih (1980) from the Lower Paleocene of Saudi Arabia in general appearance, including the weak dorsal ridge and 4 reticulae. It differs in outline, and details of ornament, and is slightly larger in size. As only one carapace has been found the generic assignment is uncertain.

Occurrence:
It occurs in the Heira Formation (Danian) in well E12-20.

Suborder Podocopina Sars, 1866.
Superfamily Bairdiacea Sars, 1888.
Family Bairdiidae Sars, 1888.
Genus *Bairdia* McCoy, 1844.
***Bairdia* sp. aff. *Bairdia ilaroensis* Reyment & Reyment, 1959**
Plate 4; Figures 1-5

Figured specimens: HM-A 12791-795
Material:

One hundred and thirty specimens recorded from the Heira Formation in the studied wells.

Description:

Anterior symmetrically rounded, posterior acuminate, dorsal margin highly arched, ventral margin moderately convex in left valve and nearly straight to slightly concave in the middle in the right valve. Maximum height centrally, left valve larger than right in size with overlapping around all margin. Valve surface with small puncti.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12791	800	507	-
Right carapace, HM-A 12792	755	503	-
Right carapace, HM-A 12793	735	485	-
Dorsal view, HM-A 12794	769	-	430
Ventral view, HM-A 12795	769	-	415

Discussion:

This species is very similar in general outline to *Bairdia ilaroensis* Reyment & Reyment, (1959), (see also Reyment, 1981), recorded from the Maastrichtian of Ghana; it differs slightly in the antero-ventral margin, and in having finer punctation over the surface of the valve. It is also larger, a fact also described by Reyment & Reyment (1980) who believed there was a size-cline in this species from west Africa to north Africa. *Bairdia ilaroensis* is also recorded from the Late Paleocene of Nigeria by Foster *et al.* (1983).

Bairdia ilaroensis Reyment figured and illustrated by Bassiouni & Luger (1990) from the Late Paleocene of Egypt differs from the present species in being larger in size (L 1027, H 860 cf. L 800, H 507) and the surface of the carapace being almost smooth.

Occurrence:

Occurs in the Heira Formation (Danian) in the studied wells.

Bairdia sp. A

Plate 4; Figures 6-10

Figured specimens: HM-A 12796-800

Material:

Twenty carapaces have been recorded from the Heira Formation in well E46-20; two carapaces found in well E12-20, from the Heira and Waha Formations; and twenty-four carapaces recorded from the Heira and Waha Formations in well E57-20 at different levels.

Description:

Shell subtriangular to sublanceolate in lateral view, anterior margin rounded, extended above, subtruncated below; posterior margin acuminate; dorsal margin moderately to strongly convex, ventral margin nearly straight. Maximum length occurs below the mid-height, Maximum height at third length from anterior margin. Left valve larger than right. Surface of the shell smooth.

Dimensions of figured specimens in μm:

	L	H	W
Left carapace, HM-A 12796	769	461	-
Right carapace, HM-A 12797	833	500	-
Left carapace, HM-A 12798	611	352	-
Dorsal view, HM-A 12799	755	-	355
Ventral view, HM-A 12800	742	-	342

Discussion:

This species has a very characteristic lateral outline; the anterior margin is very obliquely rounded with its anterior-most point towards the dorsal margin; the posterior margin has a typical bairdiid outline; the dorsal margin does not have a prominent highest point. No other species are known with which to compare it.

Occurrence:

Occurs in the Heira Formation (Danian) in the studied wells; and in the Waha Formation (Maastrichtian) in wells E12-20, and E57-20.

Bairdia sp. B
Plate 4; Figures 11-15

Figured specimens: HM-A 12801-805

Material:

Ninety two specimens have been recorded at different levels from the Heira and Waha Formations in the studied wells.

Description:

The carapace is rather elongate to subtriangular in lateral aspect and elongate ellipsoid in dorsal aspect. Antero-dorsal and antero-ventral margins are straight, anterior end rounded, postero-dorsal margin slightly concave, postero-ventral margin curved, posterior extremity narrowly rounded to bluntly pointed. dorsal margin highly arched at central-dorsal, ventral margin straight in left valve, and concave in the middle at the right valve. Maximum height at centre. Left valve larger than right. Surface of carapace is clearly ornamented with small puncti.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12801	742	457	-
Right carapace, HM-A 12802	714	414	-
Right carapace, HM-A 12803	728	475	-
Dorsal view, HM-A 12804	728	-	371
Ventral view, HM-A 12805	714	-	414

Discussion:

This species has a very characteristic dorsal outline which is highly arched with a straight antero-dorsal margin. The surface is punctate. *Bairdia* sp. from the Paleocene of Senegal (Diop *et al.*, 1982) has a somewhat similar lateral outline but is smooth and larger in size.

Occurrence:
Known from the Heira and Waha Formations in the studied wells.

Genus *Bairdoppilata* Coryell, Sample & Jennings, 1935
***Bairdoppilata magna* (Alexander, 1927)**
Plate 4; Figures 16-17; Plate 5; Figures 19-20

1927, *Bairdia magna* Alexander; P. 32, Pl.6; Figs. 5,7,8

1963, *Bairdoppilata magna* (Alexander); Barsotti; P. 1524, Pl.1, Fig.1.

non 1976, *Bairdia magna* Alexander; Ficcarelli, P. 733, Pl. 90, Figs. 1-2.

Figured specimens: HM-A 12806 - 809

Material:

Total number of specimens sixty nine; twenty carapaces have been recorded from the Heira and Waha Formations in well E12-20, at different levels; forty nine carapaces were recorded from the Heira Formation in wells E46-20, and E57-20, at different levels.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12806	784	507	-
Right carapace, HM-A 12807	666	440	-
Dorsal view, HM-A 12808	769	-	400
Ventral view, HM-A 12809	784	-	415

Discussion:

This species was originally described from the Late Cretaceous and Paleocene deposits of the United States (Alexander 1927) and subsequently recorded from the Paleocene of El-Fogaha and Well A1/85 from Libya by Barsotti (1963). The specimens described here are similar to Barsotti's specimens, and the identification is based upon Barsotti's interpretation of the species. No internal details have been observed, so the generic placement is not certain.

Ficcarelli (1976) placed *B. ilaroensis* Reyment & Reyment in the synonymy of *B. magna;* although the illustrations are inadequate, it is most likely that Ficcarelli's species is the same as Reyment's species. This is not the same as the Libyan *Bairdoppilata magna.*

Occurrence:

Known so far from the Paleocene of El-Fogaha, Sirte Basin, Libya Barsotti (1963); According to Barsotti from Late Cretaceous and Paleocene deposits of the United States Alexander (1927); Paleocene of northwest Nigeria Ficcarelli (1976). In the present material it occurs in the Heira Formation in wells E46-20 and E57-20 and in the Waha Formation in well E12-20.

Genus *Bythocypris* Brady, 1880
***Bythocypris* sp. A**
Plate 5; Figures 1-6

Figured specimens: HM-A 12810-815

Material:

One hundred and fifty four specimens have been recorded from the Heira and Waha Formations in the studied wells at different levels.

Description:

Carapace elongate-ovate in lateral outline. Sexual dimorphism present, females larger and less elongate than males. Anterior end narrower than posterior in lateral view, anterior margin evenly rounded; posterior margin obliquely truncated. Dorsal margin convex; ventral margin straight. Greatest length slightly below mid-height; greatest height to the posterior of centre. Left valve overlaps right valve around margin. Surface smooth. In dorsal view carapace compressed and elongate elliptical; greatest width in the middle.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Female left carapace, HM-A 12810	717	317	-	2.26
Female right carapace, HM-A 12811	742	314	-	2.36
Male left carapace, HM-A 12812	673	263	-	2.50
Male right carapace, HM-A 12813	650	262	-	2.48
Male dorsal view, HM-A 12814	666	-	240	-
Female dorsal view, HM-A 12815	714	-	300	-

Discussion:

Bythocypris sp. Esker (1968) recorded from the Danian of Tunisia differs from this species in having a more arched dorsal margin. *Bythocypris olaredodui* Reyment (1963) from the Paleocene of Nigeria, is similar, but is higher than the Libyan species (L:747, H.364). *Bythocypris adunca* Esker (1968) from the Maastrichtian-Danian of Tunisia differs in having a convex ventral margin and more tapered posterior.

Occurrence:
Occurs in the Heira and Waha Formations in the studied wells.

Bythocypris sp.
Plate 5; Figures 7-10

Catalogued specimens: HM-A 12816-819

Material:

Twenty one specimens have been recorded from the Heira and Waha Formations in the studied wells, at different depths.

Description:

Shell elongate subreniform in lateral view. Anterior end is less high than the posterior in lateral view, anterior margin somewhat tapered;

posterior margin more broadly rounded and higher than anterior. Dorsal margin strongly convex with a pointed highest point in left valve, right valve rounded; ventral margin concave. Greatest length about one-third of height; greatest height to posterior of centre. Left valve larger than right. The entire surface of the carapace is smooth with very fine pits.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12816	1000	533	-
Right carapace, HM-A 12817	1000	520	-
Dorsal view, HM-A 12818	980	-	440
Ventral view, HM-A 12819	1000	-	440

Discussion:

Bythocypris sp. resembles *Bythocypris* sp. B. illustrated by Reyment (1981) from the Paleocene of Nigeria, but differs in being larger in size and having a less concave ventral margin.

Occurrence:

Occurs in the Heira and Waha Formations of wells E12-20, and E57-20; and in the Heira Formation in well E46-20.

Superfamily Cypridacea Baird, 1845
Family Paracyprididae Sars, 1923
Genus *Paracypris* Sars, 1866
***Paracypris* sp. aff. *Paracypris* sp. A. Esker (1968)**
Plate 5; Figures 15-18

Figured specimens: HM-A 12824-827

Material:

Six hundred and ninety specimens have been recorded from the Heira and Waha Formations at different levels in the studied wells.

Description:

Carapace elongate in lateral view. Anterior margin broadly rounded; posterior margin tapered. Dorsal margin slightly arched; ventral margin nearly straight in the left valve and slightly concave in the right valve. Left valve larger than right and overlapping all around margin. Surface of carapace smooth.

Dimensions of figured specimens in μm:

	L	H	W
Left carapace, HM-A 12824	728	357	-
Right carapace, HM-A 12825	714	328	-
Dorsal view, HM-A 12826	728	-	300
Ventral view, HM-A 12827	728	-	300

Discussion:

This is similar in outline to *Paracypris* sp. *A* of Esker (1968), and Donze *et al.* (1982) from the Maastrichtian-Danian of Tunisia, but is much smaller in size (728 cf. 1060).

Occurrence:

Occurs in the Heira and Waha Formations of the studied wells.

Paracypris sp. A

Plate 5; Figures 11-14

?1968 *Paracypris jonesi* Bonnema; Esker; Pl.1; Fig.13.

Figured specimens: HM-A 12820-823

Material:

Sixty specimens were recorded from the Heira and Waha Formations in the studied wells, at different levels.

Description:

Carapace elongate-subrectangular in lateral outline. Anterior margin obliquely rounded; posterior margin strongly tapered. Dorsal margin convex; ventral margin strongly concave at the middle. Greatest height occurs at anterior. Left valve larger than right and overlapping nearly all around margin. Surface smooth.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12820	742	285	-
Right carapace, HM-A 12821	769	323	-
Ventral view, HM-A 12822	753	-	230
Dorsal view, HM-A 12823	769	-	246

Discussion:

This is very similar to *Paracypris jonesi* Bonnema, 1941 illustrated by Esker (1968) from the Danian of Tunisia, but differs in having a more concave ventral margin and being much larger in size if Esker's Plate explanations are correct.

Paracypris n. sp.2. of Salahi (1966) from the Eocene of Libya is very similar but is larger (L: 1.00mm, H: 37mm, W: 0.27mm).

Occurrence:

Recorded from the Heira and Waha Formations of the studied wells.

Paracypris sp. B
Plate 6, Figures 1-3

Figured specimens: HM-A 12828

Material:

Only one carapace has been found from the Heira Formation in well E57-20, at drilling depth 5950′

Description:

Carapace elongate to subtriangular in lateral outline; anterior margin bluntly rounded; posterior margin tapered; dorsal margin arched with prominent highest point, ventral margin nearly straight. Greatest height near centre of carapace. The surface of the carapace is smooth. Internal features not known.

Dimensions of figured specimen in μm:

	L	H	W
Right carapace, HM-A 12828	536	305	-
Same left carapace,	536	305	-
Same dorsal carapace,	536	-	255

Discussion:

The generic affinity and definition of this species remains questionable since internal details such as hinge and muscle scar pattern could not be observed and only one specimen has been found. However, on the basis of its lateral outline it seems to be related to the genus *Paracypris*.

Paracypris sp. B is identical to forms illustrated by El-Khoudary *et al.* (1981) from the Upper Eocene Apollonia Formation of N.W. Jabal Akhdar, N.E. Libya and described as *Eucythere*? aff. *triordinis* Schmid although it differs in being larger.

Occurrence:
Known so far from the Heira Formation in well E57-20.

Superfamily Cytheracea Baird, 1850
Family Bythocytheridae Sars, 1862
Genus *Monoceratina* Roth, 1928
***Monoceratina gaziryi* sp. nov.**
Plate 6; Figures 4-10

Derivation of Name: In honour of the late Dr. Wahid Gaziry University of Garyounis, Benghazi-Libya, who died in 1989.

Diagnosis:

A smooth species of *Monoceratina* with 4-5 weakly developed small ventral ridges. A shallow groove runs parallel to the anterior margin.

Holotype: Female carapace, HM-A 12829; Pl. 6, Fig.4.

Type Locality: Raguba Field well E46-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4900′.

Catalogued specimens: HM-A 12830-835

Material:

Total number of specimens seven; four carapaces have been recorded from the Heira Formation in well E46-20, at drilling depths 4900′-4930′, and 4990′; three specimens from the Heira Formation in well E57-20, at drilling depths 5270′, and 5370′.

Description:

In lateral outline sexual dimorphism is distinct; males being more elongate than females. The dorsal margin is almost straight in the male, female has a slight concavity in posterior half; ventral margin convex. Anterior margin broadly rounded; posterior margin tapered in male, almost quadratic in females. Greatest length passes through the dorso-central area; greatest height central. Valves almost equal in size, left slightly over-reaching right at antero-dorsal angle. The surface is smooth. The valves are prominently swollen, especially towards the ventral margin; a slight dorsal depression divides the swelling into anterior and posterior; the anterior, posterior, and postero-ventral area are compressed, so emphasising the swelling; the anterior edge of the swelling is curved parallel to anterior margin in the male, but has a dorsal concavity in the female. 3-4 longitudinal ventral ridges are present parallel to the ventral margin. Eye tubercles present but not prominent.

In dorsal and ventral view carapace oval, with greatest width at middle. Both ends appear compressed in this view, posterior end being more drawn out than anterior.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Female right carapace, HM-A 12829 (Holotype)	666	426	-	1.56
Female left carapace, HM-A 12830	625	400	-	1.56
Male right carapace, HM-A 12831	658	361	-	1.82
Male left carapace, HM-A 12832	487	263	-	1.85
Male dorsal view, HM-A 12833	495	-	247	-
Female ventral view, HM-A 12834	600	-	294	-
Female dorsal view, HM-A 12835	637	-	312	-

Discussion:

In this species there is a variation in size in the male dimorph (L.487, H.263 - L.658, H.361) which may be due to the presence of different moult stages.

This species is placed in the genus *Monoceratina* on the basis of the shape of the carapace. *Monoceratina gaziryi* sp. nov. is similar in general outline to *Monoceratina* IR p11, figured by Grosdidier (1973) from the Albian of the Coastal Fars Province of Iran, but the latter differs in lacking the small ventral ridges, the surface of the carapace is pitted or reticulate, and the dorsal margin is slightly convex in the middle.

Occurrence:

Known so far from the Heira Formation (Danian) in wells E46-20, and E57-20.

Subfamily Krithinae Mandelstam in Bubikan, 1958
Genus *Krithe* Brady, Crosskey & Robertson, 1874
***Krithe* cf. *kalambainaensis* (Reyment, 1981)**
Plate 6; Figures 11-14

? 1981, *Bythocypris kalambainaensis*, Reyment, P.56, Pl. 1, Fig. 2-3
1990, *Parakrithe? kalambainaensis* (Reyment); Bassouni & Luger, P.797, Pl. 7, Figs. 1-4.

Figured specimens: HM-A 12836-839

Material:

Two hundred and forty two specimens have been recorded in different levels from the Heira and Waha Formations in the studied wells.

Diagnosis:

A species of *Krithe* in which the surface of the carapace is completely smooth; anterior margin broadly and evenly rounded; posterior end obliquely truncated, longest ventrally. Dorsal margin straight; ventral margin faintly concave at the middle.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12836	594	285	-
Right carapace, HM-A 12837	566	277	-
Dorsal view, HM-A 12838	714	-	328
ventral view, HM-A 12839	689	-	303

Discussion:

This species is very similar to that described by Reyment (1981) as *Bythocypris kalambainaensis* (Pl. 1, Fig. 2-3 µm) from the Kalambaina Quarry (Paleocene of Northwestern Nigeria). The Libyan specimens show more overlap along the dorsal, ventral and posterior margins, and are also rather large (566-769 cf. 530-540). The specimens studied here are also identical with those described and figured by Bassiouni & Luger (1990) who observed the muscle scars and selvage which rule out *Bythocypris* and suggest *Parakrithe* rather than *Krithe.*

Krithe autochthona Lyubimova & Guha (1978) from the Lower Miocene of Jamnagar (India) is also similar to this species in shape and outline but differs in being much larger in size.

Occurrence:

Known so far from the latest Paleocene (?) or basal Eocene of Egypt. In the present material it occurs in the Heira and Waha Formations throughout the studied wells.

Family Cytheruridae G. W. Müller, 1894

Genus *Cytherura* Sars, 1866

***Cytherura zeltensis* sp. nov.**

Plate 7; Figures 1-9

Derivation of name: After the Zelten Oil Field in the Sirte Basin.

Diagnosis:

A reticulate species of *Cytherura* with well developed longitudinal ventral ridges; eye tubercle broad and flat, the posterior margin with a relatively short caudal process.

Holotype: Female carapace, HM-A 12842; Pl. 7, Fig. 3.

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4840′.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 12840 - 848

Material:

Total number of specimens seventeen: nine carapaces were recorded from the Heira and Waha Formations in well E12-20, first appearance at drilling depth 4660′, last appearance at drilling depth 5450′; eight specimens from the Heira Formation in well E57-20, first appearance at drilling depth 5290′, last appearance at drilling depth 5870′.

Description:

Carapace elongate, subrectangular in lateral outline. Sexual dimorphism is very strong, the females are less elongate than the males. Anterior margin broadly rounded; posterior margin with a relatively short but prominent caudal process. The dorsal margin is nearly straight in the female, but slightly concave in the central dorsal area of the male; the ventral margin also differs between females and males, in the female it is straight to slightly convex, while in the male is nearly straight to slightly concave in the middle. Greatest length passes through the mid-height, greatest height at anterior third. Valves almost equal in size, left valve of male is very slightly larger than the right. The surface of the carapace is ornamented with rounded to subrounded medium-sized reticulation; there are 3-4 longitudinal ridges parallel to the ventral margin with development of reticulation between them, extending from central-anterior area and ending in the postero-ventral area. A prominent depression lies behind the eye tubercle running approximately parallel to the anterior margin and ending in the antero-central area. Subcentral tubercle not observed; eye tubercle weakly developed but clearly discernible.

In dorsal view, maximum width occurs at posterior third, anterior is compressed. In ventral view, the carapace is strongly flattened to produce a broad surface with shallow depression in the centre.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Male right carapace, HM-A 12840	577	288	-	2.00
Male left carapace, HM-A 12841	544	277	-	1.96
Female left carapace, HM-A 12842 (Holotype)	523	317	-	1.64

Female right carapace, HM-A 12843	476	266	-	1.78
Female right carapace, HM-A 12844	518	317	-	1.63
Male dorsal view, HM-A 12845	606	-	327	-
Male ventral view, HM-A 12846	577	-	322	-
Female dorsal view, HM-A 12847	457	-	352	-
Female ventral view, HM-A 12848	485	-	285	-

Discussion:

This species is assigned to the genus *Cytherura* because of its lateral outline; no internal features have been observed.

This species bears some similarities to *Cytherura pagana* described from the Coniacian of Nigeria by Reyment (1960), and from the Lower Coniacian of Algeria by Yves Bellion *et al.* (1973) in shape and in having a reticulate surface; *Cytherura pagana* differs in being more elongate, with a less sharply inclined postero-dorsal margin, and has weak ridges developed in the anterior half of the carapace. Moreover, *Cytherura pagana* has a long caudal process.

Occurrence:

Occurs in the Heira and Waha Formations in well E12-20; and in the Heira Formation in well E57-20.

Genus *Paijenborchellina* Kuznetsova, 1957

***Paijenborchellina benghaziensis* sp. nov.**

Plate 7; Figures 10-17

Derivation of name: After the City of Benghazi - Libya.

Diagnosis:

Species of *Paijenborchellina* with relatively long caudal process; surface ornamented with lateral riblets parallel to the dorsal and ventral margins, with a depression just below the highest point of the dorsal margin.

Holotype: Female carapace, HM-A 12851, Pl. 7, Fig.12.

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4880´.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 12849-856.

Material:

Total number of specimens twenty: seven specimens have been recorded from the Heira and Waha Formations in well E12-20, first appearance at drilling depth 4880´, last appearance at 5580´; twelve specimens were recorded from the Heira and Waha Formations in well E46-20, first appearance at drilling depth 5020´, last appearance at 6100´; one carapaces has been found in the Heira Formation in well E57-20, at drilling depth 5870´.

Description:

Carapace elongate, pear-shaped in lateral view. Sexual dimorphism distinct, females are shorter than males. Anterior margin obliquely rounded, posterior end produced into a long, downward directed caudal process. Dorsal margin arched, with prominent highest point; ventral with pronounced concavity. Left valve larger than the right, with overlap strongest anterodorsally, and along the dorsal margin. The surface of the carapace is ornamented with lateral riblets parallel to the dorsal and ventral margins and best developed in the central area. Two specimens (Plate 7, Figures 14, 16) lack the lateral riblets parallel to the dorsal and ventral margins; this may be due to the preservation. The anterior and posterior areas have fine puncti; a depression lies just below the highest point of the dorsal margin. Eye tubercle is not distinct.

In dorsal view carapace biconvex; ends narrow, maximum width at the middle in males and a little anterior to it in females. No internal details seen.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Male right carapace, HM-A 12849	742	300	-	2.47
Male left carapace, HM-A 12850	717	289	-	2.48
Female left carapace, HM-A 12851(Holotype)	577	266	-	2.16
Female right carapace, HM-A 12852	576	294	-	1.95
Female left carapace, HM-A 12853	670	309	-	2.16
Male dorsal view, HM-A 12854	637	-	300	-
Female dorsal view, HM-A 12855	566	-	266	-
Male dorsal view, HM-A 12856	536	-	244	-

Discussion:

Paijenborchellina libyca Szczechura (1980) from the Miocene of Libya bears some resemblance to this species in outline and shape, but differs in having a more depressed area close to the anterior margin, and the surface of the carapace is more pitted.

Paijenborchellina keeni from the Miocene of the Marada Formation of the Eastern Sirte Basin, Libya by Gammudi, 1990 (MSc unpublished thesis) shows some similarity to this species in outline but differs in details of ornamentation, in being slightly smaller in size.

Paijenborchellina GA B5 Grosdidier (1979) from the Cenomanian of Gabon, is somewhat similar in shape but it differs in general outline, details of ornamentation, and in the presence of a shallow depression parallel to the anterior margin.

Occurrence:
Known so far from Heira and Waha Formations in the studied wells.

Genus *Semicytherura* Wagner, 1957

Semicytherura sp. A

Plate 8; Figures 1-4

Figured specimens: HM-A 12857

Material:

One carapace from the Waha Formation in well E57-20, at drilling depth 6160´.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12857	434	217	-
Same right carapace,	434	217	-
Same dorsal view (broken after cleaning)	-	-	211

Discussion:

Only one specimen has been found, and ultrasonic cleaning removed the caudal process (Pl. 8, Fig. 3). It is provisionally placed in *Semicytherura* on the basis of the external details. This species is similar to the female of *Semicytherura* sp.A, Al-Furiah (1980) recorded from the Lower Paleocene of Saudi Arabia. The surface ornamentation is not well preserved in Al-Furiah's specimens; fine reticulation and ventral ribbing are present, but it differs from the specimen recorded here in lacking the weak longitudinal ribs in the postero-ventral area and the ornament of the anterior area.

This species bears some similarities to *Cytherura* sp. described from the Paleocene of Libya by Salahi (1966) in general outline, but it differs in the lateral surface being reticulate, has a relatively long caudal process.

Semicytherura sp. B.

Plate 8; Figures 5-8

Figured specimens: HM-A 12858 - 861

Material:

Two carapaces have been recorded from the Heira Formation in well E46-20, at drilling depth 5260′, two carapaces, and one valve were recorded from the Waha Formation in the same borehole at drilling depths 5950′, and 6040′.

Description:

Carapace elongate. Anterior margin obliquely rounded; the posterior end is bluntly pointed into a short caudal process; dorsal margin nearly straight; ventral margin convex. Greatest length lies at about mid-height, greatest height in the middle. The surface of the carapace is ornamented with fine pits. Left valve larger than right in size, overlapping the right along the dorsal, and antero-dorsal margins.

In ventral view, the ventral surface of each valve is ornamented with thin and weak ridgelets extending parallel to the ventral edge. Internal details could not be observed.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12858	526	263	-
Right carapace, HM-A 12859	526	262	-
Dorsal view, HM-A 12860	526	-	284
Ventral view, HM-A 12861	540	-	302

Discussion:

This differs from *Semicytherura* sp. A. in details of ornamentation and general outline.

Occurrence:

Occurs in the Heira and Waha Formations in well E46-20.

Family Leguminocythereididae Howe, n. fam.
Genus *Leguminocythereis* Howe, 1936
***Leguminocythereis* cf. *lokossaensis* Apostolescu, 1961**
Plate 8; Figures 9-12

Figured specimens: HM-A 12862

Material:

Three carapaces (including two broken carapaces), two of them were recorded from the Heira Formation in well E57-20, at drilling depths 5600´,and 5750´; one specimen has been recorded from the Heira Formation in well E12-20, at drilling depth 4840´.

Description:

In lateral view the carapace is roughly oval. Anterior margin is evenly, but comparatively narrowly rounded; posterior margin is tapered with extreme end bluntly rounded. The dorsal and ventral margins are convex. Greatest length passes through the centre, greatest height a little to the anterior of the centre. Left valve larger than the right, overlapping the latter mainly along the dorsal margin and more strongly along the postero-dorsal part of the carapace. The surface of the carapace has a pattern of symmetrically arranged medium thick longitudinal ridges with reticulation between them. Two short oblique ridges run from the central dorsal area, one towards the central anterior the other towards the central posterior area; three coarse longitudinal ridges run parallel to ventral margin. Eye tubercle flat and weakly developed.

In dorsal view the carapace appears egg-shaped to oval with the greatest width near the middle.

Dimensions of figured specimens in μm:

	L	H	W
Right carapace, HM-A 12862	685	357	-
Same left carapace,	700	357	-
Same ventral view,	685	-	356

Same dorsal view, 685 - 356

Discussion:

Several authors have described and illustrated specimens of *Leguminocythereis lokossaensis* and other similar species from West Africa and from Libya. Apostolescu's (1961) original illustrations, and Carbonnel's (1986) subsequent illustrations show a very characteristic outline, with a prominent postero-dorsal angle and straight to slightly convex but evenly curved dorsal margin with highest point centrally placed. The specimens described here differ in lateral outline in having the highest point well towards the anterior, and the lacking the angular postero-dorsal angle. *Leguminocythereis lokossaensis* has a pattern of longitudinal ridges similar to the specimens described here, but has well developed cross ridges giving an overall appearance of ridges with large puncti between them.

Barsotti (1963) described *Leguminocythereis lokossaensis* from the Paleocene of Libya; as pointed out by Salahi (1966), Barsotti's specimens have a different ornamentation, with more even reticulation and very poorly developed longitudinal ridges, so probably represent a new species. Salahi described two species, *Leguminocythereis lokossaensis* and *Leguminocythereis* n. sp. 2 . The illustration of *L. lokossaensis* has a very different outline from Apostolescu's original illustration. *Leguminocythereis* n.sp. 2 is more similar in outline and ornament to the illustrations of Apostolescu and Carbonnel, and may be the male dimorph with Salahi's *L. lokossaensis* being the female. *L.* n. sp. 2 differs from *L.* cf. *lokossaensis* in being larger (L:.78 cf. L:70mm), has a slightly different lateral outline, and is more obviously reticulate.

Reyment (1980) placed *Leguminocythereis lokossaensis* in the synonymy of *Mehesella biafrensis* Reyment (1960), an Nigerian Eocene species. No internal characters have been observed in the specimens of *L.* cf.

lokossaensis so no comment can be made on generic assignment. Reyment's illustration of *M. biafrensis* does not seem to be the same as Apostolescu's species, although they are similar.

Occurrence:
Occurs in the Heira Formation in wells E57-20, and E12-20.

Family Mauritsinidae Deroo, 1962
Subfamily Mauritsininae Deroo, 1962
Genus *Mauritsina* Deroo, 1962
Type species: *Cypridina hieroglyphica* BOSQUET, 1847
***Mauritsina coronata* (Esker, 1968)**
Plate 13, Figs. 1-4

1968, *Cythereis coronata* n. sp. Esker, P. 323-324, Pl. 1, Fig. 1-3; Pl. 4, Fig. 5.

1970, *Mauritsina arabica* n. sp. Bassiouni, P. 21-22, Pl. 2, Fig. 8-9

1976, *Doricythereis arabica* (Bassiouni); Grundel, P. 1300

1978, *Actinocythereis arabica* (Bassiouni); Said, P. 239-240, Pl. 25, Fig. 20-22.

1982, *Actinocythereis ? coronata* (Esker); Donze *et al.*, P. 291, Pl. 9, Figs. 7-10; Pl. 14, Figs. 8.

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.

Figured specimens: HM-A 12917-918

Material:

Only two carapaces have been found so far, one from the Waha Formation in well E12-20, at drilling depth 5450′; the other one was recorded also from the same Formation in well E57-20, at drilling depth 6040′.

Diagnosis:

Carapace subtrapezoidal in lateral view, the dorsal and ventral margins almost straight converging slightly towards the posterior, the anterior margin evenly rounded with a groove parallel to it; surface smooth with three longitudinal rows of short tubercles, prominent subcentral tubercle.

Dimensions of figured specimens in µm:

	L	H	W
Right carapace, HM-A 12917	740	444	-
Left carapace, HM-A 12918	769	430	-
Same right carapace,	769	430	-
Same dorsal view,	769	-	400

Discussion:

Donze *et al.* (1982) considered Bassiouni's species from Jordan to be conspecific with Esker's (1968) species.

Occurrence:

Known so far from the Paleocene to basal Eocene of Jordan (Bassiouni, 1970), Early to Early Late Paleocene of Egypt (Boukhary *et al.*, 1982), Middle Maastrichtian to Early Late Paleocene of Tunisia (Esker, 1968), (Donze *et al.*, 1982). In the present study it occurs in the Waha Formation (Maastrichtian) of the wells E12-20, and E57-20.

Family Trachyleberididae Sylvester-Bradley, 1948
Genus *Trachyleberis* Brady, 1898
***Trachyleberis modesta* (Apostolescu, 1961)**
Plate 8; Figures 13-16; Plate 9; Figures 1-5

1961, *Actinocythereis modesta* Apostolescu, P. 813, Pl. 13, Figs. 259 -263

1963, *Actinocythereis modesta* Apostolescu; Barsotti, P.1526,Pl. 1, Fig. 6.

1976, *Trachyleberis modesta* (Apostolescu); Ficcarelli, P. 735, Pl. 90, Figs. 11-12

1983, *Trachyleberis teiskotensis* (Apostolescu); Foster, Swain, Petters, P. 131, Pl. 9, Figs. 5, 7-16; Pl. 11, Figs. 5,6

1990, *Trachyleberis modesta* (Apostolescu); Bassiouni & Luger, P. 820, Pl. 13, Figs. 19-24; Pl. 14, Figs. 1-2.

Figured specimens: HM-A 12863-871

Material:

Two hundred and twenty seven specimens recorded from the Heira and Waha Formations in the studied wells, at different levels.

Diagnosis:

Carapace subrectangular in outline, highest point toward anterior; the surface of the carapace has large tubercles distributed around the centre of the lateral surface, and medium sized tubercles on strong broad ridges on the anterior and posterior margins; there is 6 to 7 large tubercles arranged in row parallel to the ventral margin; sexual dimorphism is very strong.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Female left carapace, HM-A 12863	600	352	-	1.70
Female right carapace, HM-A 12864	588	352	-	1.67
Female dorsal view, HM-A 12865	625	-	325	-
Female ventral view, HM-A 12866	611	-	305	-
Male left carapace, HM-A 12867	753	384	-	1.69
Male right carapace, HM-A 12868	740	370	-	2.00
Male right carapace, HM-A 12869	645	335	-	1.92
Male dorsal view, HM-A 12870	728	-	378	-
Male ventral view, HM-A 12871	714	-	357	-

Discussion:

The material recorded here it is very similar to that described and illustrated by Barsotti (1963) from the Paleocene of Libya, Foster *et al.* (1983) from the Paleocene of Nigeria, and by Bassiouni & Luger (1990) from Egypt. *Trachyleberis modesta* and *Trachyleberis teiskotensis* are similar and were placed in the same species by Reyment (1963). However, Bassiouni & Luger listed the differences between these two species and their interpretation is followed here. The differences are lateral outline of the posterior which rounded in *T. modesta* and triangular in *T. teiskotensis*, and ornamentation where *T. modesta* has rounded nodes with smooth carapace between them, while *T. teiskotensis* has spines covering a large area of the carapace, sometimes with reticulation between them. *Trachyleberis teiskotensis* figured and illustrated by Reyment (1963) differs from the Libyan material in the dorsal and ventral margins being parallel, and in surface ornamentation.

Occurrence:

The species was originally described from the Paleocene of Mali (Apostolescu, 1961); and subsequently from Libya, Mali, Dahomey-Togo, Nigeria, and from the Paleocene to Early Eocene of Egypt. In the present material it occurs in the Heira (Danian) and Waha (Maastrichtian) Formations in the studied wells.

Genus *Actinocythereis* Puri, 1953
***Actinocythereis* aff. *teiskotensis* Apostolescu, 1961**
Plate 9; Figures 6-14

Figured specimens: HM-A 12872-880

Material:

Twenty seven specimens recorded from the Heira Formation in the studied wells: well E12-20, twelve specimens, first appearance at drilling depth 4660′, last appearance 4940′; well E46-20, four specimens, first appearance at drilling depth 5530′, last appearance at 5650′; well E57-20, eleven specimens, first appearance at drilling depth 5330′.

Description:

Carapace subrectangular in lateral view. Sexual dimorphism rather marked, the females are shorter than the males. Anterior margin broadly rounded, antero-marginal rim prominent and in some specimens is ornamented with a number of pustules. Posterior margin is rounded, postero-marginal rim is distinct, 5 or 6 tubercles are present along the postero-ventral slope. The dorsal margin is straight but in some specimens appears irregular in lateral view because of over-reaching of the ornamentation. The ventral margin is slightly concave in the middle; there is a distinct postero-dorsal process. Greatest length passes through the sub central tubercle, greatest height at anterior cardinal angle. Left valve slightly larger than the right valve. The ornamentation covering the entire surface of the carapace consists of reticulation with superimposed tubercles; in a few specimens the tubercles are more prominent than the reticulation. A groove runs parallel to the anterior margin which is ornamented with subquadratic coarse reticulation in some specimens (as in Plate 9, Fig. 12). Ventral ridge is nearly straight and more developed than other ridges; it bears 6-7 tubercles. The subcentral tubercle is distinct. Eye tubercle spherical and distinct, with a depression lying behind it.

In dorsal view, the carapace has almost parallel margins; maximum width nearly central. In ventral view, the ventral margin is ornamented with small tubercles.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Female left carapace, HM-A 12872	666	346	-	1.92
Male right carapace, HM-A 12873	728	371	-	1.96
Male left carapace, HM-A 12874	833	416	-	2.00
Female left carapace, HM-A 12875	650	350	-	1.85
Female right carapace, HM-A 12876	637	350	-	1.82
Female right carapace, HM-A 12877	680	373	-	1.82
Female left carapace, HM-A 12878	653	371	-	1.76
Male dorsal view, HM-A 12879	833	-	366	-
Male ventral view, HM-A 12880	850	-	333	-

Discussion:

This species is similar to *Actinocythereis teiskotensis* described by Apostolescu (1961) from the Paleocene of Mali. *A.* aff. *teiskotensis* differs in having prominent reticulation, and lacking the prominent tubercles of *A. teskotensis*. It is also smaller than *A.teiskotensis*. Sexual dimorphism in *A. teiskotensis* is strongly pronounced, and the male has larger pustules; sexual dimorphism of the Libyan specimens is recognised by slight difference in ornamentation between the male and female, and in the larger size of the male.

This differs from *A. teiskotensis,* originally described from the Paleocene of Mali, in being reticulate rather than tuberculate. It is also smaller.

Acanthocythereis meslei paleocenica Bassiouni & Luger (1990) from the Late Paleocene of Egypt, shows some resemblance in shape and general outline, but differs in having better developed marginal spines, and has spines on the lateral surface. Moreover the postero-dorsal process is missing or weakly developed in *Acanthocythereis meslei.*

Occurrence:

Occurs in the Heira Formation in the studied wells.

Genus *Acanthocythereis* Howe, 1963
Type-species *Acanthocythereis araneosa* Howe, 1963
***Acanthocythereis bregaensis* sp. nov.**
Plate 11, Figure 13; Plate 12, Figures 1-6

Derivation of name: After Marsa El-Brega city, the location of the Sirte Oil Company.

Diagnosis:

Small species of *Acanthocythereis* in which the entire surface of the carapace has well developed reticulation, with bluntly developed tubercles near the postero-central and the postero-ventral areas.

Holotype: Carapace, HM-A 12905, Pl. 12, Fig. 1.

Type Locality: Raguba Field well E46-20, Sirte Basin.

Type Horizon: Heira Formation (Danian), depth of 5260´.

Catalogued specimens: HM-A 12904-910

Material:

Forty four specimens recorded from the Heira Formation in wells: E12-20, thirty specimens, first appearance at drilling depth 4530´, last appearance at 5220´; E46-20, seven specimens, first appearance at drilling depth 5260´, last appearance at drilling depth 5680´; E57-20, seven specimens, first appearance at drilling depth 5290´, last appearance at 5990´.

Description:

Carapace, small, subquadrate to subrectangular in lateral outline. Sexual dimorphism prominent, the presumed males are more elongate and smaller than the females. Anterior margin is broadly rounded; posterior margin bluntly pointed; a distinct marginal rim extends along the anterior and posterior margins. In some specimens the anterior margin bears traces of thick denticles. The dorsal margin is straight; ventral margin is nearly straight, both margins are subparallel, slightly tapering towards the posterior. Greatest length lies just below the mid-height of the carapace, greatest height at the anterior cardinal angle; left valve larger than the right in size. The entire surface is ornamented with well developed reticulation and bluntly developed tubercles near the postero-central and in the postero-ventral areas; relatively large reticules arranged in row A just behind the anterior marginal rim, with medium-sized rounded to subrounded reticulation over the remainder of the surface of the carapace. The postero-dorsal process is moderately developed. A distinct pore cone or tubercle is present in the central dorsal area. At the postero-ventral region the valve appears swollen with a thickened tubercles; small pore cones or tubercles are present in the antero-central area. Subcentral tubercle distinct. The eye tubercle is distinct, lying at the antero-dorsal marginal angle.

In dorsal view, the carapace has almost parallel margins which converge slightly to the anterior, with laterally compressed ends; maximum width lies at the postero-ventral region; the weakly developed postero-dorsal process can be seen. In ventral view, a few small tubercles are present at the ventral edge of each side. No internal details were observed.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Female right carapace, HM-A 12904	611	264	-	2.31
Male left carapace, HM-A 12905 (holotype)	536	294	-	1.82
Female right carapace, HM-A 12906	512	297	-	1.72
Male left carapace, HM-A 12907	453	257	-	1.76
Male right carapace, HM- A 12908	445	254	-	1.75
Female dorsal view, HM-A 12909	540	-	259	-
Male ventral view, HM-A 12910	485	-	247	-

Discussion:

Acanthocythereis spongiosa described by Al-Furaih (1980) from the Middle Paleocene of Saudi Arabia, shows similarities to *Acanthocythereis bregaensis* sp. nov. in shape and general outline but it differs in details of reticulation, in having better developed marginal spines, and in lacking the thick tubercles in the postero-ventral area.

This species shows some similarity to *Acanthocythereis heriensis* sp. nov. in general outline but differs in details of ornamentation; both species have a slightly swollen postero-ventral area.

There is a wide size range amongst the specimens studied; presumed males appear to be smaller than females.

Occurrence:

Occurs in the Heira Formation in the studied wells.

***Acanthocythereis heirensis* sp. nov.**

Plate 10; Figures 1-6

Derivation of name: After the Heira Formation in the Sirte Basin.

Diagnosis:

Subrectangular species of *Acanthocythereis* in which the entire surface has moderately to strongly developed reticulation with superimposed spines or tubercles. A distinct postero-dorsal process is present in the left valve; Subcentral tubercle distinct and bearing tubercles.

Holotype: Carapace, HM-A 12881, Pl. 10, Fig. 1.

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation, Danian, depth of 4840′.

Catalogued specimens: HM-A 12882-886.

Material:

Total number of specimens nineteen: thirteen carapaces were recorded from the Heira Formation in well E12-20, at drilling depths 4700′-4940′; four carapaces from the same Formation in well E46-20, at drilling depths 5500′, and 5590′; the other two carapaces have been found in the Heira Formation of well E57-20, at drilling depths 5490′, and 5700′.

Description:

Carapace subrectangular in lateral outline. Sexual dimorphism not recognised. Anterior margin broadly rounded; posterior margin triangular; a distinct marginal rim extends along the anterior and posterior margins there are some 8-10 small spines or denticles lying along the anterior marginal rim; the posterior marginal rim is ornamented with approximately 4-5 small spines or denticles. The dorsal margin is nearly straight; ventral margin straight; dorsal and ventral margins subparallel and tapering slightly towards the posterior. Maximum length occurs at mid-height, maximum height situated at the eye tubercle. Left valve larger than right, conspicuously overlapping it at the postero-dorsal area and less so along the anterior and ventral margins. The lateral surface is reticulate with superimposed spines or tubercles; the reticulation varies, with a large quadratic-shaped row A extending just behind and parallel to the anterior marginal rim, with medium-sized, rounded to subrounded reticulation covering the rest of the surface. The reticulation is poorly preserved in some specimens. There are many pore cones or tubercles amongst the reticulation in the postero-central area. Tubercles are frequently developed on the reticulation walls, sometimes at wall intersections but not always. The wall between rows A&B does not bear tubercles; the wall between row B&C has small tubercles; larger and more prominent tubercles are developed on the subcentral tubercle and in the central and postero-central area of the valve; prominent tubercles are seen in the middle of the dorsal margin, near the postero-dorsal angle, on the ventral margin below the subcentral tubercle, and in the postero-ventral area. Eye tubercle very distinct.

In dorsal view, the carapace has subparallel margins, with laterally compressed ends; the postero-dorsal node of the dorsal ridge, the small tubercles on the area of the dorsal ridge, and the anterior rim with their margins can all be seen clearly; maximum width passes through the subcentral tubercle. In ventral view the ventro-marginal rim of both margins is clearly parallel with a row of very small tubercles on each valve. Internal features could not be observed.

Dimensions of figured specimens in µm:

	L	H	W
Right carapace, HM-A 12881(Holotype)	606	351	-
Left carapace, HM-A 12882	536	315	-
Right carapace, HM-A 12883	618	363	-
Right carapace, HM-A 12884	594	354	-
Dorsal view, HM-A 12885	551	-	281
Ventral view, HM-A 12886	625	-	337

Discussion :

Acanthocythereis heriensis sp. nov. bears some resemblance to *Acanthocythereis taqiyeansis* Al-Sheikhly (1980) from the Lower Paleocene (Upper Danian) of the Tell-Burma section, Jordan, and the Lower Paleocene of the Bir Qdeim Section, Syria; it differs in being much smaller, the pattern of the spines or tubercles is generally similar but their density is variable in both species.

Acanthocythereis? meslei Donze *et al.* (1982) from the Middle Maastrichtian of Tunisia shows some similarities to this species in general outline but differs in details of ornamentation.

Oertliella khargensis figured and illustrated by Bassiouni & Luger (1990) from the Middle Maastrichtian of Egypt show some similarity to the present species in shape and general outline, but differs in having a row of spines aligned in a broad curve running from slightly below the middle of the carapace anteriorly to the postero-ventral margin corner, and in being larger in size.

Occurrence:
Occurs in the Heira Formation in the studied wells.

Acanthocythereis stymatuora **Al-Furaih, 1980**

Plate 11; Figures 2-12

1980, *Acanthocythereis stymatuora* Al-Furiah, P. 22, Pl. 14, Figs. 1-4.

Figured specimens: HM-A 12893-903

Material:

Sixty five specimens recorded from the Heira Formation in the studied wells.

Diagnosis:

A species of the genus *Acanthocythereis* with moderately developed postero-dorsal process in the left valve; thick anterior and posterior marginal rims; surface ornamented by strong reticulations and subrounded fossae with superimposed pustules and distinct subcentral tubercle; sexual dimorphism is prominent, the males are longer than females.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Male left carapace, HM-A 12893	800	385	-	2.07
Male right carapace, HM-A 12894	600	282	-	2.12
Male left carapace, HM-A 12895	725	370	-	1.95
Male right carapace, HM-A 12896	637	312	-	2.04
Male dorsal view, HM-A 12897	714	-	285	-
Male ventral view, HM-A 12898	693	-	280	-
Female left carapace, HM-A 12901	625	362	-	1.72
Female right carapace, HM-A 12902	594	320	-	1.85
Female right carapace, HM-A 12903	588	341	-	1.72
Female dorsal view, HM-A 12999	666	-	266	-
Female ventral view, HM-A 12900	606	-	278	-

Discussion:

The specimens studied here are identical with those figured by Al-Furaih (1980) as *Acanthocythereis stymatuora* sp. nov. from the Lower Paleocene of Saudi Arabia.

It can be easily distinguished from other species of *Acanthocythereis* by differences in the details of reticulation, by the moderately developed posterior cardinal process in the left valve, and also by the lack of spines.

Acanthocythereis alacer Al-Furaih (1980) from the Middle Paleocene of Saudi Arabia, has a distinct postero-dorsal process and reticulate surface with a few small spines at the intersection of some of the muri, and the dorsal and posterior margins bear double rows of denticles. There might be some phylogenetic relationship between *Acanthocythereis stymatuora* and *Acanthocythereis alacer.*

Occurrence:

The species was originally described from the Lower Paleocene of Saudi Arabia Al-Furaih (1980). In the present material it occurs in the Lower Paleocene of the studied wells.

Acanthocythereis? sp. A

Plate 10; Figures 7-11

Figured specimens: HM-A12887-889

Material:

Three specimens have been recorded from the Heira Formation in well E57-20, at drilling depths 5420´, 5670´, and 5910´

Description:

Carapace subrectangular in lateral outline, anterior margin broadly rounded, posterior margin narrowly rounded, antero and postero marginal rim is thick with traces of thick denticles on the postero-ventral margin. Dorsal margin is nearly straight, ventral margin slightly concave near the middle. Greatest length passes just below the centre of the subcentral tubercle, greatest height at eye tubercle. Left valve larger than right. Surface ornamentation consists of reticulation and superimposed thick tubercles;

the reticulation is rounded to subrounded except those parallel to anterior and posterior margins which are subquadratic. A large and thick tubercle lies in the central dorsal area; small and medium tubercles are associated with the reticulation walls covering most of the surface of the carapace; the ventral ridge is thick and short. The subcentral tubercle is prominent. Eye tubercles very well developed.

In dorsal view, the carapace has subparallel margins, with laterally compressed ends; maximum width at the position of the subcentral tubercle. In ventral view, the small tubercles of the ventral edges can be seen clearly.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12887	533	287	-
Right carapace, HM-A 12888	540	281	-
Right carapace, HM-A 12889	540	281	-
Same dorsal view,	540	-	242
Same ventral view,	540	-	-

Discussion:

This species is placed in the genus *Acanthocythereis* on the basis of the general external morphology, although the lack of internal details makes the generic assignment uncertain. It appears to be a new species, but as only three specimens have been found no new species has been created.

Occurrence:
Occurs in the Heira Formation in well E57-20.

***Acanthocythereis* sp. B**
Plate 10; Figures 12-14; Plate 11; Fig. 1

Figured specimens: HM-A 12890-892

Material:

Three specimens have been recorded from the Waha Formation in well E46-20, at drilling depths 6040′-6070′.

Description:

Large carapace, subrectangular in lateral outline. Anterior margin is quadrate; posterior margin narrowly rounded; the anterior margin has two rows of short denticles, the inner row of 8-9 denticles lying upon the indistinct-marginal rim; the outer row consists of 11-12 very small spines along the anterior margin. The dorsal margin is straight; ventral margin nearly straight. Maximum length passes through mid-height; greatest height at eye tubercle. Valves almost equal in size, with slight overlap by the left valve at the postero-dorsal slope. Surface ornamentation consists mainly of pore cones and small tubercles; reticulation is weak except for some moderately developed reticulation in the area along the anterior margin and in the postero-central region. The surface of the ventral region of the carapace has some very small spines. Subcentral tubercle not pronounced. The eye tubercle is spherical and very distinct.

In dorsal view the carapace has subparallel margins; with maximum width nearly central.

Dimensions of figured specimens in μm:

	L	H
Left carapace, HM-A 12890	769	415
Right carapace, HM-A 12891	800	432
Same left carapace,	800	432
Left carapace, HM-A 12892	833	450

Discussion:

Acanthocythereis sp. B is unlikely to be confused with any other species and is easily distinguished by its shape.

Acanthocythereis hystrix (Reuss) figured by Van Hinte *et al.* (1980) from the Upper Miocene of Libya shows some similarities to this species, but differs in details of ornamentation, the posterior end is more narrowly rounded, and the anterior is evenly and broadly rounded.

Acanthocythereis taqiyeansis Al-Sheikhly (1980) from the Lower Paleocene (Upper Danian) of Tell-Burma Section, Jordan shows some similarity to this species in shape, outline and in the presence of conjunctive spines on the reticulate lateral surface, but it differs in being strongly reticulate, in the presence of a prominent subcentral tubercle, and strong spines or tubercles; also the posterior end is more narrowly rounded.

Occurrence:
Occurs in the Waha Formation (Maastrichtian) in well E46-20.

Genus *Alocopocythere* Siddiqui, 1971
***Alocopocythere? bazuzensis* sp. nov.**
Plate 12; Figures 7-12

Derivation of name: After the Bazuzi field in concession 16 in Sirte Basin.

Diagnosis:

A small species of *Alocopocythere* in which the surface is ornamented by rounded reticulation, the dorsal margin is nearly straight with a prominent pore cone behind the dorsal furrow, subcentral tubercle prominent and usually with median rounded reticules. Eye tubercle is distinct, with a short rib running perpendicularly downwards from it.

Holotype: Female carapace, HM-A 12913; Pl. 12, Fig. 9.

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 5670′.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 12911-916

Material:

Total number of specimens two hundred and seven: well E12-20, eighty three specimens were recorded from the Heira and Waha Formations, at different levels; ninety three specimens were recorded from the Heira Formation in well E46-20, first appearance at drilling depth 5080′, last appearance at 5680′; and thirty one specimens have been recorded from the Heira and Waha Formations in well E57-20, at different levels.

Description:

Carapace is sub-triangular in lateral outline; dorsal and ventral margins converging at posterior; males more sub-quadrate, with sub-parallel dorsal and ventral margins. Sexual dimorphism is very distinct, males larger and more elongate than the females. Anterior margin rounded; posterior margin narrowly rounded; the marginal rim in some specimens is very weakly developed around the anterior and posterior margins, and is not clearly seen along the ventral margin. In some specimens there are some denticles along the anterior and posterior margins, those at the anterior being mostly along the antero-ventral part of the margin. Greatest length passes just above the centre of the subcentral tubercle, greatest height at eye tubercle. Left valve larger than the right, conspicuously overlapping it along the anterior margin, along the postero-dorsal margin and slightly along the ventral margin. The surface of the valve is reticulate with occasionally scattered small tubercles; the reticulation is mostly rounded and small to medium in size. In some specimens the posterior areas have smaller rounded reticulation; a row of larger reticulation runs parallel to the ventral margin and there is a tendency to develop a faint ventral ridge. Also in some specimens there are weak small ribs parallel to the anterior margin. The depressed area at the extreme posterior may appear smooth. A prominent furrow is present behind the eye tubercle, and just to the posterior of this furrow a large pore cone is present on the dorsal margin. The subcentral tubercle usually has small rounded reticulation. The eye tubercle is distinct, situated at the antero-cardinal angle of the valve, with a short rib running perpendicularly downwards from it.

In dorsal view, the dorsal margin has three prominent pore cones on each valve, gradually increasing in size towards the eye tubercle. The female carapace appears more swollen than the male. Maximum width lies at postero-central area. In ventral view, the ventro-marginal rims of both sides are subparallel and ornamented with a row of very small tubercles. Internal details are unknown.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Male left carapace, HM-A 12911	611	317	274	1.92
Male right carapace, HM-A 12912	600	317	262	1.89
Female left carapace, HM-A 12913 (Holotype)	474	288	273	1.64
Female right carapace, HM-A 12914	497	302	284	1.64
Male dorsal view, HM-A 12915	600	-	270	-
Male ventral view, HM-A 12916	551	-	270	-

Discussion:

This species is placed in *Alocopocythere* on the basis of the dorsal furrow behind the eye tubercle, the ridge running downwards from the eye tubercle, the upwardly curved postero-ventral margin, general appearance, and small size. It lacks the posterior hinge ear of the left valve, and the "ventral ridge" is not as prominent as in Siddiqui's original descriptions.

Alocopocythere abstracta Siddiqui (1971) from the Early Tertiary of West Pakistan is the closest of Siddiqui's species, but differs in lateral outline, having a prominent posterior hinge-ear in left valve, and a more rounded ventral margin; the marginal rim is also stronger than in *Alocopocythere*? *bazuzensis* sp. nov. No similar species has so far been recorded from the north Africa.

Occurrence:

Occurs in the Heira Formation in well E46-20, and in the Heira and Waha Formations in wells E12-20, and E57-20.

Genus *Buntonia* Howe, 1935

Discussion:

The species of this genus are very common in Maastrichtian and Paleocene sediments of North and West Africa. Authors such as Apostolescu and Reyment have described many species. Species tend to be separated on the basis of ornamentation i.e. presence of sulci, pitting and ribs, as well as presence of posterior spines and lateral outline. However, when large numbers of specimens are examined the ornamental diagnoses are not always distinct, and it is often difficult to assign material to species; variation within a species has been described, and it may be that polymorphism is common. Carbonnel (1985) attempted to list the relevant characters for species determination but this has proved to be difficult to apply to the Libyan material. Taking an extreme view virtually all of the material described here could be regarded as one highly variable species. However, this extreme view has not been adopted; for further comment see species descriptions.

Buntonia fortunata Apostolescu, 1961
Plate 13, Figures 9-16; Plate 14, Figures 1-10

1961, *Buntonia fortunata* Apostolescu, P. 801, Pl. 3, Figs. 61-67.

1963, *Buntonia* (*Buntonia*) *fortunata* Apostolescu; Reyment, P. 197, Pl. 17, Figs. 6, 7; Pl. 18, Fig. 1.

1983, *Buntonia* (*Buntonia*) *fortunata* Apostolescu; Foster, Swian, Petters, P. 120, Pl. 3, fig 10,; Pl. 7, Figs. 8, 9.

Figured specimens: HM-A 12923-940

Material:

Total number of specimens is one hundred and twenty carapaces; twenty two specimens (including four broken carapaces) from the Heira Formation in well E57-20, at different levels; sixty three carapaces were recorded from Heira and Waha Formations in well E12-20, at different levels; and thirty five carapaces also recorded from the two formations in well E46-20, at different levels.

Diagnosis:

A species of *Buntonia* with surface ornamentation ranging from strongly punctate to smooth, and a depression just behind the eye tubercle. Lateral outline is triangular, posterior hinge-ear frequently developed. A prominent flattened area is present behind and parallel to anterior margin. Sexual dimorphism is very strong.

Description:

The material studied shows a great degree of variation in ornamentation, while the lateral outline is more constant. It is regarded as belonging to a highly variable single species, which can be divided into three morphotypes:

Morphotype A

Plate13, Figures 9-12, 16; Plate 14, Fig.8

This has strong coarse puncti covering the entire surface of the carapace; two ventral riblets run parallel to the ventral margin. A weak ridge runs parallel to the anterior margin; in the left valve of the female carapace there is a smooth area parallel to the anterior margin; there is a tendency for the development of two ill-defined ridges in the central and posterior area of the valve. Eye tubercle is weakly developed.

Dimensionss of figured specimens in µm:

	L	H	W	L/H
Female left carapace, HM-A 12923	588	352	-	1.67
Male left carapace, HM-A 12924	544	300	-	1.83
Male right carapace, HM-A 12925	555	288	-	1.92
Male left carapace, HM-A 12926	588	282	-	2.08
Male dorsal view, HM-A 12927	520	-	220	-
Female ventral view, HM-A 12928	467	-	222	-

Morphotype B

Plate13, Figures 13-15; Plate 14, Figures 1-3, 9.

This is characterised by the presence of a depression behind the eye tubercle; the puncti are less developed and smooth areas are present in some parts of the valve.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Female right carapace, HM-A 12929	443	278	-	1.59
Female left carapace, HM-A 12930	462	284	-	1.62
Male left carapace, HM-A 12931	523	276	-	1.89
Male right carapace, HM-A 12932	520	300	-	1.73
Female right carapace, HM-A 12933	555	366	-	1.51
Female left carapace, HM-A 12934	436	281	-	1.55
Male ventral view, HM-A 12935	510	-	190	-

Morphotype C
Plate 14; Figures 4-7, 10

The surface of the carapace is mainly smooth with a few puncti in the posterior half of the carapace; in some specimens the whole surface is smooth as in (Pl. 14, Fig. 5).

Dimensions of the figured specimens in µm:

	L	H	W	L/H
Male right carapace, HM-A 12936	555	273	-	2.03
Male right carapace, HM-A 12937	555	300	-	1.85
Female right carapace, HM-A 12938	454	281	-	1.61
Male right carapace,HM-A 12939	505	284	-	1.77
Female right carapace, HM-A 12934	463	281	-	1.64

Discussion:

Morphotype A is very similar to *Buntonia fortunata* as described by Apostolescu (1961) from the "Globigerinid zone" of Sehoue, Dahomey.

The specimens illustrated by Foster *et al.* (1983), from the Late Paleocene of Nigeria differ in having a less pointed posterior end, and a less developed flat anterior area.

Buntonia sp. cf. *B. teiskotensis* (Apostolescu) is similar to morphotype C (female carapace), but differs in shape, i.e the dorsal margin is slightly higher and in the presence of anterior ridges (particularly the right valve). *Buntonia* sp. C is similar to morphotype C but differs somewhat in outline.

Protobuntonia aegyptica Bassiouni & Luger (1990) shows similarities to this species especially in the female left valve, although it is slightly larger. The principal difference lies in the presence of a posterior spine, quite prominent in some specimens, but totally lacking in *Buntonia fortunata;* Carbonnel (1986) attached some importance to this character. The male of *Protobuntonia aegyptica* has a slightly different outline. There is a tendency for greater overlap of the left valve in *Protobuntonia aegyptica.* Regarding generic assignment, *Buntonia* and *Protobuntonia* are very similar, and Reyment & Elofson (1959) regarded them as two subgenera of *Buntonia*. The principal character separating them is the posterior outline, although this has not been helpful in this study. The characters most useful have been size, where *Protobuntonia* is usually larger, and the presence of very distinct sexual dimorphism in *Buntonia* which is rarely seen in species of *Protobuntonia*. Bassiouni & Luger (1990) did not compare their new species with *Buntonia fortunata* so the relationship between these species is not clear.

Occurrence:

This has been reported from the Late Paleocene of Nigeria (Foster *et al.*, 1983), from "Globigerinid zone" of Sehoue, Dahomey (Apostolescu, 1961), and from the Paleocene of Nigeria (Reyment, 1963). In this study it occurs in Lower Paleocene and Upper Cretaceous in the studied wells.

Buntonia cf. B. ioruba Reyment, 1960
Plate 15; Figures 10-17

1963, *Soudanella* cf. *S. laciniosa triangulata* Apostolescu; Barsotti P.1525, Pl.3, Fig.20.

1980, *Buntonia (Protobuntonia) ioruba* Reyment; Reyment & Reyment, Pl.1,Fig.2.

Figured specimens: HM-A 12952-959

Material:

Total number of specimens fifty one: well E12-20, seventeen specimens (including three broken carapaces) were recorded from the Heira Formation, at drilling depths 4660′-5220′, three specimens from the Waha Formation at drilling depths 5580′-5610′; well E46-20, twenty specimens from the Heira Formation, at drilling depths 4930′ - 5650′, two specimens were recorded from the Waha Formation, at drilling depth 6040′; well E57-20, eight specimens from the Heira Formation, at drilling depth 5270′ - 5780′, one specimen has been recorded from the Waha Formation, at drilling depth 6160′.

Description:

In lateral aspect the carapace is subrectangular, anterior margin broadly and smoothly rounded, anterior marginal rim distinct in some specimens; posterior margin narrowly sharpened and slightly sub-truncated above, the dorsal margin is strong, even, and slightly convex, ventral margin slightly concave to nearly straight medially; greatest length occurs at the middle, highest at anterior third, greatest width occurs at about the posterior third of the length; sexual dimorphism is strong, the females are shorter and higher than the males; eye tubercle broad and flat; left valve slightly larger than the right in size; surface ornament consists of 11-12 well-marked longitudinal ribs, the longitudinal ribs in the central dorsal are obliquely truncated towards posterior-dorsal and anterior-dorsal, while the rest of the ribs run straight from the central posterior to the central anterior; some traces of puncti lie between the longitudinal ribs in the central-dorsal area.

Dorsally, the carapace has almost parallel margins slightly converging towards the anterior. No internal details were observed.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Male left carapace, HM-A 12952	689	372	-	1.85
Male right carapace, HM-A 12953	753	384	-	1.96
Female right carapace, HM-A 12954	755	414	-	1.82
Female left carapace, HM-A 12955	714	428	-	1.66
Female right carapace, HM-A 12956	666	386	-	1.72
Male dorsal view, HM-A 12957	742	-	300	-
Male ventral view, HM-A 12958	728	-	314	-

Female dorsal view,HM-A 12959	666	-	306	-

Discussion:

Buntonia (Protobuntonia) ioruba Reyment (1960) from the Upper Cretaceous of Nigeria is similar to this species, but the form of the posterior is different; moreover *Buntonia ioruba* has fine longitudinal riblets and intermediately located pitlets; Reyment also recognised differences in ornamentation between Maastrichtian and Paleocene specimens, the anterior of the former often being smooth, in the latter always ornamented. In this study no differences were recognised between Cretaceous and Paleocene specimens.

Reyment (1980) figured a species as *Buntonia (Protobuntonia) ioruba* from the Paleocene of Libya, which is probably conspecific with the species described here although according to Reyment's measurements (Pl.1,Fig.2), his Libyan species are much larger than either those described here, or others from Nigeria. This illustration also appear to differ from Nigerian specimens in detail of ornamentation.

Reyment (1963) suggested that *Soudanella laciniosa laciniosa* Apostolescu (1963) is referable to *B.(Protobuntonia) ioruba. Soudanella laciniosa laciniosa* was described from the Paleocene of Mali and differs from the species recorded here in having a groove parallel to the anterior margin, the anterior area bearing riblets, and the posterior margin being rounded and pointed.

Barsotti's specimens (1963) referred to *Soudanella* cf. *laciniosa triangulata* appear to be the same as the species named here as *Buntonia* cf. *ioruba*. Apostolescu's original description is of a large species (L.=0.90mm) compared with Barsotti's species (L.=0.65, H.=0.36). While *Soudanella laciniosa triangulata* shows similarities to the Libyan specimens, its lateral outline differs, especially the dorsal margin with its highest point close to the anterior and it is thicker and differs in detail. The specimens studied here are also similar to those figured by Apostolescu (1961) as *Buntonia virgulata* from the Paleocene of Mali.

Buntonia devexa Siddiqui (1971) from the Early Tertiary of West Pakistan shows some resemblance to *B.* cf. *ioruba* but differs slightly in outline and number of longitudinal ribs.

Salahi (1966) figured a species from the Paleocene of Libya as *Iorubaella* n. sp. Salahi also mentions variation in the strength of ornamentation between individuals. See also *Buntonia* sp. B.

Occurrence:

Known so far from the Upper Paleocene deposits in the EL-Fogaha zone in Sirte Basin, Libya Barsotti (1963); also known from the Paleocene of Libya by Reyment & Reyment (1980); in the present study it occurs in the Heira and Waha Formations in the studied wells.

Buntonia tatteuliensis (Apostolescu, 1961)
Plate 13, Figures. 5-8

1961, *Ambocythere? tatteuliensis* Apostolescu, P. 814, Pl. 9, Figs. 175-179; Pl. 15, Fig. 300.

1967, *Ambocythere? tatteuliensis* Apostolescu; Ficcarelli, P. 737, Pl. 90, Fig. 13-14.

1963, *Ambocythere? tatteuliensis* Apostoluscu 1961; Barsotti, P. 1526, Pl. 1, Fig.9.

1980, *Ambocythere? tatteuliensis* Apostolescu; Reyment & Reyment, Pl.1, Fig. 4.

1981, *Nucleolina tatteuliensis* (Apostolesc); Reyment, P.58, Pl. 3, Fig. 8-12.

1983, *Buntonia tatteuliensis* (Apostolescu); Foster, Swain, Petters, P.122, Pl. 5, Figs. 3-9,; Pl.6, Figs. 12, Pl. 7, figs 4,5.

1990, *Nucleolina tatteuliensis* (Apostolescu); Bassiouni & Luger, P. 793, Pl. 5, Figs. 9-11.

Figured specimens: HM-A 12919-922.

Material:

Total number of specimens is forty nine; well E12-20: Three specimens from the Heira Formation, at drilling depths 4660′, and 5140′. Well E46-20: nine specimens were recorded from the Heira Formation, at different levels. Thirty eight carapaces have been recorded from the Heira and Waha Formations in well E57-20, at different levels.

Diagnosis:

Shell subrectangular in lateral outline, central surface covered with thin sinuous longitudinal fine ribs; postero-ventral and antero-ventral areas strongly compressed; sexual dimorphism not pronounced.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12919	833	533	-
Right carapace, HM-A 12920	833	500	-
Dorsal carapace, HM-A 12921	850	-	433
ventral view, HM-A 12922	833	-	416

Discussion:

Apostolescu (1961), described this species under the provisional generic assignation of *Ambocythere*? because of the unfavourable preservation of the internal characters; he did figure marginal canals similar to those of *Ambocythere*, and suggested the possibility of an entirely new genus *Nucleolina*; however, he indicated that he had in his samples only one fairly well preserved left valve showing a hinge most closely matching that of *Buntonia* Howe (1935) as figured in Benson (1961).

Reyment (1981) and Foster *et al.* (1983), showed in their studies that there are two variants; in one the area between the fine ridges is smooth, in the other it is coarsely punctate. The material recorded here shows only the smooth variant.

Occurrence:

This species is known from the Late Paleocene of Libya, Nigeria, and Mali, and the latest Paleocene(?) or basal Eocene of Egypt (Bassiouni & Luger, 1990). In the present study it is recorded from the Lower Paleocene and Upper Cretaceous in well E57-20.

Buntonia sp. cf. B. *teiskotensis* Apostolescu, 1961
Plate 14; Figures 11-15

1963, *Buntonia pulvinata* Apostolescu, Barsotti, P.1525,Pl.3, Fig.27.

1983, *Buntonia* sp. cf. *B.teiskotensis* Apostolescu, Foster, Swain, and Petters; P.122, Pl.6, Figs. 8,10.

Figured specimens: HM-A 12941-945

Material:

Total number of specimens sixteen. Two specimens from the Heira Formation in well E57-20, at drilling depths 5330′, and 5700′; thirteen specimens have been recorded from the Heira and Waha Formations in well E46-20, at different levels; only one specimen was recorded from the Waha Formation in well E12-20, at drilling depth 5480′.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12941	487	321	-
Right carapace, HM-A 12942	476	323	-
Left carapace, HM-A 12943	485	314	-
Right carapace, HM-A 12944	444	302	-
Dorsal view, HM-A 12945	476	-	238

Discussion:

This species is characterised by an almost smooth carapace, although some faint pitting is present in the anterior region; it is triangular in shape with a prominent high point on the dorsal margin of the left valve; the left valve has a prominent depression behind and below the eye tubercle; in the right valve this is more prominent, and another depression is developed subparallel to the anterior margin.

Buntonia teiskotensis Apostolescu (1961) differs from this species in having a more swollen central area of the carapace, an evenly rounded anterior margin, unlike the obliquely rounded anterior of the present species, a more broadly rounded posterior, has a thick marginal rim, and lacks the depression behind the eye tubercle.

Buntonia sp. cf. *teiskotensis* Foster *et al.* (1983) from the Late Paleocene of Nigeria is very similar, although smaller, has a somewhat different posterior end, and is not quite as triangular in lateral outline.

Buntonia pulvinata Apostolescu (1961) from the Paleocene of Togo differs from this species in having a more pitted surface, the pitting being concentrated in the middle of the carapace, and a more triangular outline in lateral view.

Occurrence:

Known so far from the Paleocene of Libya (Barsotti, 1963), Late Paleocene of Nigeria (Foster *et al.*, 1983). In this study it occurs in Lower Paleocene and Upper Cretaceous of the studied wells.

Buntonia wadiensis sp. nov.
Plate 16; Figures 4-7

Derivation of name: After the Wadi Oil Field in concession NC-149 in Sirte Basin.

Diagnosis:

A species of *Buntonia* with a smooth lateral surface; distinct dorsal and ventral ridges, and a depression between the curved anterior end of the dorsal ridge and the eye tubercle.

Holotype: Carapace, HM-A 12963, Pl. 16, Fig. 5.

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Waha Formation (Maastrichtian), depth of 6100′.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 12964 - 966.

Material:

Total number of specimens fourteen: three specimens have been recorded from the Waha Formation in well E12-20, at drilling depths 5320′-

5340´; three specimens were recorded from the same Formation in well E46-20, at drilling depths 6010´-6040´; and eight specimens from the Heira and Waha Formations, at different levels.

Description:

Carapace pyriform in lateral outline. Sexual dimorphism not pronounced. Anterior margin broadly and evenly rounded; postero-dorsal margin is slightly concave, postero-ventral margin rounded, posterior end narrow to bluntly pointed. The dorsal margin is nearly straight but is hidden by the overlap of the dorsal ridge; ventral margin is curved. Maximum length passes through the central area, greatest height at the eye tubercle. Left valve slightly larger than the right, overlapping along the antero-dorsal area. The lateral surface of the carapace is smooth. The dorsal ridge is distinct, becoming curved towards the antero-central area; a depression is formed between the curved anterior end of the dorsal ridge, and the eye tubercle, and ridge running from the eye tubercle parallel to the anterior margin; a depression lies between this and the anterior marginal rim. Ventral ridge prominent and curved extending from the postero-ventral area joining the antero-marginal rim. In some specimens there is subcentral node, and in other specimens this node is connected with a very faint rib which ends at a very small node in the postero-central area (Pl. 16; Fig. 4), clearly seen in dorsal view. Eye tubercle flat and moderately developed.

In dorsal view, the carapace has subparallel margins, with laterally compressed ends; the dorsal ridge, and the median rib can be seen clearly. Internal details are unknown.

Dimensions of figured specimens in µm:

	L	H	W
Right carapace, HM-A 12963 (holotype)	526	322	-

Left carapace, HM-A 12964	510	300	-
Right carapace, HM-A 12966	500	290	-
Dorsal view, HM-A 12965	555	-	266

Discussion:

This species resembles *Buntonia* sp. aff. *B. attitogonensis* Apostolescu in shape and general outline, but the latter differs in having well developed ventro-lateral ribs and in the presence of a central short longitudinal rib, it is also larger in size.

Occurrence:

Known so far from the Waha Formation in wells E12-20, and E46-20; and from the Heira and Waha Formations in well E57-20.

***Buntonia* sp. A**

Plate 15; Figures 1-4

Figured specimens: HM-A 12946 - 949.

Material:

Five specimens have been recorded from the Heira Formation in well E46-20, at drilling depths 5200′, 5260′, and 5350′.

Description:

Shell pyriform in lateral outline. Sexual dimorphism has not been recognised. Well developed median short longitudinal rib; dorsal ridge becoming inclined toward the median rib; the greatest inflation occurs at about the posterior third of the shell length. Eye tubercle fairly prominent, dorsal margin straight to gently convex, ventral margin weakly convex, posterior margin narrowly to bluntly pointed, anterior margin evenly rounded, faint marginal rim, four strong ribs subparallel to posterior ventral area; valve surface smooth; valves almost equal in size; greatest length occurs at mid-height, highest in anterior third.

In ventral view, the carapace has almost parallel margins, with compressed ends; maximum width lies at about posterior third.

Dimensions of figured specimens in μm:

	L	H	W
Left carapace, HM-A 12946	600	329	-
Right carapace, HM-A 12947	588	321	-
Left carapace, HM-A 12948	576	317	-
Ventral view, HM-A 12949	523	-	215

Discussion:

The species studied here is very similar to the species described and illustrated by Foster *et al.* (1983) from the Late Paleocene of Nigeria as *Buntonia* sp. aff. *Buntonia attitogonensis* Apostolescu, 1961. It differs from the Nigerian species in having a more prominent dorsal ridge, in the presence of several pore conuli giving the appearance of small tubercles (the actual pores appear to be present in the Nigerian material without the development of pore conuli, although this feature could also be fine pitting), and in lacking the slight antero-ventral swelling. It is considered likely that these Libyan and Nigerian species are related. They both differ from *Buntonia attitogonensis* Apostolescu (1961) in lacking the thick longitudinal ridges, strong anterior marginal rim, and fine intercostal reticulation.

Occurrence:

Occurs in the Heira Formation (Danian) in well E46-20

Buntonia sp. B

Plate 15; Figures 5-9

Figured specimens: HM-A 12950-951

Material:

Two specimens have been recorded from the Waha Formation in well E12-20, at drilling depths 5450´, and 5480´.

Description:

Carapace subquadrate in lateral outline; sexual dimorphism present; anterior margin obliquely rounded; posterior quadrate. The dorsal margin nearly straight; ventral margin straight to slightly curved, both margins slightly convergent towards posterior. Greatest length passes just below the mid-height, greatest height lies at anterior cardinal angle. Left valve larger than right, the left overlaps the right in the regions of the antero-dorsal, dorsal, postero-dorsal, and the ventral margins. Surface ornamentation consists of 12-13 longitudinal ribs restricted in the posterior half of the carapace with small puncti spread over the lateral surface of the valve. The anterior half of the carapace is relatively smooth; a smooth depression lying parallel to anterior margin and below the eye position. There are numerous normal pore canal openings on the entire surface of the carapace. Eye tubercle flat and very weak.

In dorsal view, the carapace has parallel sides which slightly converge towards the anterior, with both ends laterally compressed; maximum width lying nearly in the posterior third of the carapace. Internal details are unknown.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Male left carapace, HM-A 12950	769	415	-	1.85
Male same dorsal view,	769	-	307	-
Female right carapace, HM-A 12951	714	428	-	1.66
Female same ventral view,	714	-	314	-

Discussion:

This is very similar to *Buntonia* cf. *ioruba,* but differs in lateral outline and details of ornamentation. The posterior end is more truncated, the dorsal margin is less triangular with a less prominent highest point, and has an obliquely curved antero-dorsal margin. The ornamentation consists of 12-13 longitudinal ridges present in the central and posterior area; the anterior area is almost smooth with "ghost" ridges present and some puncti. The variation in ornament between this species and *Buntonia cf. ioruba* could be regarded as intraspecific, and Reyment (1960) mentions the presence of a smooth anterior region in some specimens of *Buntonia ioruba*. However, the lateral outline is different and suggests that this is a separate species.

Iorubaella n.sp.1 Salahi (1966) from the Paleocene of Libya resembles the present species in shape but differs slightly in general outline and being slightly larger in size.

Occurrence:

This species is known so far from the Waha Formation in well E12-20.

Buntonia sp. C

Plate 16; Figures 1-3

Figured specimens: HM-A 12960-962

Material:

Total number of specimens: twenty six. Two specimens have been recorded from the Waha Formation in well E57-20, at drilling depths 6130′, and 6187′; two specimens from Heira and Waha Formations in well E12-20, at drilling depths 5140′, and 5480′; twenty two carapaces from the two Formations in well E46-20, at different levels.

Description:

Carapace elongate, elongate triangular in lateral view. Anterior margin obliquely rounded; with faint antero-marginal rim; posterior margin bluntly to narrowly rounded in some specimens, and slightly truncated above; postero-ventral slope gently curved. Dorsal and ventral margins taper towards posterior; dorsal margin even and convex, highest point more centrally placed than in many species; ventral margin nearly straight to slightly concave in middle. Left valve larger than right, strongly overreaching in centro-dorsal and antero-dorsal areas, and near the central-ventral area. Greatest length passes just below the mid point. Surface of the carapace is mostly smooth with some weak pitting, a weak ventral ridge runs parallel to the ventral margin, extending from the postero-ventral area touching ventral margin centrally and running towards centre of anterior area. There is a strong depression in antero-dorsal area just behind the eye tubercle. Eye tubercle weakly developed. In dorsal view the maximum width occurs centrally.

Dimensions of figured specimens in µm:

	L	H
Left carapace, HM-A 12960	625	312
Right carapace, HM-A 12961	588	305
Left carapace, HM-A 12962	600	317

Discussion:

Buntonia cretacea Grekoff (1951) from the Senonian of Cameroon, Ivory Coast, and Senegal is very similar to the species recorded here, both in shape and ornamentation. It differs in being slightly higher compared to the length, by the presence of posterior dentcles, by the presence of a faint ridge parallel to the whole anterior margin, and a dorsal margin which is nearly straight.

Reyment (1960) described and figured *Buntonia cretacea* Grekoff from the Upper Cretaceous and Lower Tertiary of Nigeria, but this appears to differ from the illustration of Grekoff (1951), Apostolescu (1961), and Foster *et al.* (1983). The species described by Foster *et al.* (1983) as *Buntonia*? sp. aff. *B. cretacea* from the Late Paleocene of Nigeria shows similarities to this species, but the Nigerian species lacks the depression behind the eye tubercle, and has a distinct ridge behind and parallel to the anterior margin.

This species has a similar ornament to *Buntonia* sp. cf. *B. teiskotensis*, but differs in shape; this could perhaps be the male dimorph of *B.* cf. *B. teiskotensis.*

Occurrence:

This species occurs in the Waha Formation in well E57-20, and in Heira and Waha Formations in wells E12-20, and E46-20.

Genus *Cythereis* Jones, 1849

***Cythereis teiskotensis* (Apostolescu, 1961)**

Plate 16, Figures 8-12; Plate 17, Figures 1-4

1961, *Bradleya teiskotensis,* Apostolescu, P. 819, Pl. 12, Figs. 241-245.

1963, *Bradleya teiskotensis,* Apostolescu; Barsotti, P.1527,Pl. 2,Fig. 19.

1963, *Cythereis teiskotensis,* (Apostolescu); Reyment, P. 161, Pl. II,Fig. 3; Pl. Iv, Figs. 1,a-c; Pl. xv, Figs. 1,2.

1980, *Cythereis teiskotensis* (Apostolescu); Reyment & Reyment, Pl. 1, Fig. 7.

Figured specimens: HM-A 12967-975

Material:

Two hundred and forty five specimens have been recorded from the Heira Formation in the studied wells, at different levels.

Diagnosis:

Carapace subrectangular in lateral outline with broadly and evenly rounded anterior margin, the posterior margin is obliquely truncated; eye tubercle distinct, two strong nodes present along dorsal margin; prominent subcentral tubercle, short postero-median ridge composed of 4 tubercles; ventral ridge expanded to occupy large part of postero-ventral area, where it shows a complex of nodes or reticulation. The surface may be smooth or reticulate.

Dimensions of figured specimens in μm:

	L	H	W
Left carapace, HM-A 12967	775	465	-
Left carapace, HM-A 12968	714	428	-
Right carapace, HM-A 12969	800	461	-
Dorsal view, HM-A 12970	800	-	461
Ventral view, HM-A 12971	800	-	466
Right carapace, HM-A 12722	680	386	-
Right carapace, HM-A 12973	816	500	-
Juvenile right carapace, HM-A 12974	588	329	-
Dorsal view, HM-A 12975	833	-	500

Discussion:

Apostolescu's (1961) illustrations indicate considerable variation in the strength of the dorsal nodes and of the subcentral tubercle and median ridge. Some specimens appear smaller, others appear to have reticulation developed.

The specimens illustrated by Reyment (1963) from the Paleocene of Nigeria, do not show the characteristic strong dorsal nodes; they are somewhat similar to the specimens illustrated by Apostolescu in Pl.12; Fig. 245, and in this respect they are similar to the species referred to here as *Cythereis* cf. *teiskotensis*.

Barsotti (1963) and Reyment & Reyment (1980) have illustrated this species from the Late Paleocene of Libya. Some specimens have well developed reticulation over most of the surface of the valve. In others it is restricted to the central and ventral areas and associated with the ventral ridge; these also show weak, or "ghost" reticulation in the anterior area. Finally, some specimens are non-reticulate. This could be regarded as an example of polymorphism, with morphs. Presumed larval stages show coarse puncti in the central area, with reticulation below the ventral ridge. (Pl. 17,Fig. 3).

Occurrence:

Known so far from the Paleocene of Mali Apostolescu (1961), Upper Paleocene in the El-Fogaha zone in Sirte basin Barsotti (1963), Paleocene of Nigeria Reyment (1963); in this study it occurs in the Heira Formation in the studied wells.

***Cythereis* cf. *teiskotensis* (Apostolescu, 1961)**
Plate 17; Figures 5-8, 12-13

1966, *Cythereis teiskotensis* (Apostolescu); Salahi, P. 24, Pl. 4, Fig. 24.

Figured specimens: HM-A 12976-981

Material:

Twenty seven specimens have been recorded from the Heira Formation in the studied wells, at different levels.

Description:

Large carapace, with subrectangular outline. Sexual dimorphism is not pronounced; anterior margin evenly rounded, some specimens with fine denticles along the anterior margin, the posterior margin is obliquely truncated, dorsal and ventral margins almost straight; valves almost equal in size. Greatest height in the anterior third, greatest length at mid height; there is a dorsal ridge, subcentral tubercle, curved postero-median ridge and ventral ridge ; eye tubercle is distinct; surface of the carapace is smooth (see discussion below); some 20 simple pore canals are spread over the surface of the carapace.

In dorsal view, the carapace has subparallel margins; projection of subcentral tubercle, and the postero-median ridge can all be seen clearly; maximum width at about posterior third. In ventral view, a row of small denticles can be seen along the ventral edges of the anterior and posterior area. No internal features observed.

Dimensions of figured specimens in µm:

	L	H	W
Right carapace, HM-A 12976	757	428	-
Left carapace, HM-A 12977	728	414	-
Right carapace, HM-A 12978	728	428	-
Left carapace, HM-A 12979	714	400	-
Dorsal view, HM-A 12980	769	-	415
Ventral view, HM-A 12981	784	-	461

Discussion:

One specimen (Pl. 17, Fig. 7) has what could be regarded as the two dorsal nodes joined by a prominent dorsal ridge; in other specimens (Pl. 17, Figs. 5-6) there appears to be only a dorsal ridge. The postero-median ridge is prominent and curved, sometimes with suggestion of the four tubercles characteristic of *Cythereis teiskotensis*. The ventral ridge has similarities to that of *Cythereis teiskotensis*. *Cytheris* cf. *teiskotensis* also has small denticles along the anterior margin.

It is not clear how to interpret this variation, but the absence of the dorsal nodes is used to place these species in a separate taxon from *Cythereis teiskotensis*.

Bismuth *et al.* (1981b) illustrated forms as *Cythereis mahjoubi* Donze & Saint-Marc from the Lower Turonian of Djebel Semmama of Tunisia which are very closely to this species in general outline and shape, in having a prominent subcentral tubercle, short dorsal ridge, and in the type of surface ornamentation. However, *Cythereis mahjoubi* differs in being smaller in size, having a more elongate posterior margin, and having more straight ventral ridge.

Occurrences:

Known so far from the Paleocene of Libya (Salahi, 1966); in this study it occurs in the Heira Formation in the studied wells.

Genus *Cristaeleberis* Bassiouni, 1970
***Cristaeleberis fornicata* Bassiouni, 1970**
Plate 17; Figures 9-11

1970, *Cristaeleberis fornicata* Bassiouni, P.29, Pl. 3, figs 9-10.

1990, *Cristaeleberis fornicata* (Bassiouni); Bassiouni & Luger, P. 825, Pl. 16, Figs. 4-6.

Figured specimen: HM-A 12982

Material:

Only one carapace from the Waha Formation of well E46-20, at drilling depth 6040′.

Description:

Carapace subrectangular in lateral outline. Anterior broadly rounded, antero-marginal rim thick and ornamented with a row of 8-9 spines or pustules; posterior margin rounded, postero-marginal rim thick and also ornamented with 5-6 small spines or pustules. The dorsal and ventral margins are subparallel; there is a distinct postero-dorsal process. Greatest length is at mid-height; greatest height at the antero-cardinal angle. Valves almost equal in size. The surface of the carapace is ornamented with very weakly developed and irregular reticulation. Small spines or pustules are spread over the entire surface of the carapace; these are present in the dorsal area, 6-7 prominent spines at the postero-central area, approximately 5 or 6 small spines along the ventral margin, and 5-6 small pustules or spines in the antero-central area. A groove extends along the anterior margin. A very conspicuous depressed area is present in the dorso-central area, extending to below the eye tubercle. Subcentral tubercle is present and bears 4 small tubercles. Eye tubercle distinct.

In dorsal view, the carapace has subparallel sides with laterally compressed ends; maximum width in the posterior third of the carapace.

Dimensions of figured specimen in µm:

	L	H
Right carapace, HM-A 12982	714	400
Same left carapace,	714	400
Same dorsal view,	714	-

Discussion:

This is identical to *Cristaeleberis fornicata* Bassiouni figured and illustrated by Bassiouni & Luger (1990) from the Maastrichtian of the Dakhla Formation in Egypt, except for some slight variation in the surface ornamentation which might be attributed to geographical variation.

Donze *et al.* (1982) described and illustrated *Cristaeleberis thomasi* Donze & Said from the Middle Cretaceous of El-Kef, Tunisia which is similar to this species in having a subrectangular outline in lateral view, maximum height lying at the antero-cardinal angle, and having a similar size, but it differs in details of surface ornamentation, and in dorsal and ventral views.

Occurrence:

This species is known from the Maastrichtian of Jordan and Egypt Baasiouni (1970), El-Sweify (1984), Maastrichtian of Dakhla Formation in Egypt Bassiouni & Luger (1990). In the present material it is restricted to the Maastrichtian of the Waha Formation.

Genus *Echinocythereis* Puri, 1954

***Echinocythereis lehibensis* sp. nov.**

Plate 18; Figures 1-12

Derivation of name: After the Lehib Oil Field in concession six in Sirte Basin.

Diagnosis :

Subrectangular species of *Echinocythereis* in which the entire surface has moderately developed reticulation with superimposed spines or tubercles. A weakly developed postero-dorsal process is more clear in the left valve.

Holotype: Carapace, HM-A 12983; Pl. 18, Fig. 1.

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 5330′.

Catalogued specimens: HM-A 12984-994.

Material:

Total number of specimens thirty five: All were recorded from the Heira Formation; well E12-20, sixteen specimens, at drilling depth 4530′-5140′; well E46-20, four specimens, at drilling depth 5530′; well E57-20, fifteen specimens, at drilling depths 5290′ - 5910′.

Description:

Carapace subrectangular in lateral view. Sexual dimorphism rather marked, the presumed males are longer and higher than the females. Anterior margin is broadly and evenly rounded; a marginal rim runs around the anterior, ventral, and posterior margins; it is always well developed at the anterior, but is variable in strength along the ventral and posterior margins; the anterior margin is ornamented with three rows of spines or denticles; the outer row consisting of 14-17 short spines or denticles, the inner row being less heavily spinose, consisting of 10-12 medium spines or denticles on the antero-marginal rim. The posterior margin is narrowly rounded to bluntly pointed; the postero-marginal rim has 5-6 medium-short spines or denticles, strongest at the ventral part; many denticles are present along the ventral and dorsal margins. The dorsal margin is straight and irregular due to overlapping of the ornamentation; the dorsal marginal area has several tubercles which can be recognised in all morphotypes; the two most prominent of these are situated in the centro-dorsal area and near the posterior; the ventral margin is straight, both margins are subparallel. Greatest length lies nearly at the mid-height, greatest height at the antero-cardinal angle. Left valve larger than the right, overlapping along the ventral margin and at the postero-dorsal. The eye tubercle is prominent, with a ridge running from it to join the posterior walls of the second row (B) of reticulation. The entire surface is ornamented with medium developed reticulation, relatively large subquadratic reticules arranged in row A lying just behind the anterior marginal rim; medium rounded to subrounded reticulation covers the remainder of the surface of the carapace. The reticulation is very poorly preserved in some specimens. Small spines or small tubercles are associated with the reticulation walls. 4-5 prominent but small nodes or tubercles are present in the anterior area. A large tubercle lies at the central-dorsal area. More than 20 spines or tubercles are present in the postero-central and postero-dorsal areas. The tubercles vary in degree of prominence and development between the specimens. A small tubercle lies on the ventro-lateral area. The subcentral tubercle consists of some 7 weak tubercles arranged in a consistent pattern present in all morphotypes.

In dorsal view the carapace has subparallel margins, with compressed ends, the denticles or spines along the dorsal margin are nearly parallel to each other in the two valves. Maximum width occurs at 3/4 length to posterior.

The ornamentation shows considerable variation, ranging from reticulate specimens to tuberclate. The range of variation may be continuous, but three characteristic types can be recognised, referred to here as Morphotypes A, B, and C:

Morphotype A
Plate18; Figures 1-7

In the tuberculate form, reticulation is clearly present, but variable sized tubercles are developed along the reticulation muri, giving an overall impression of a tuberculate surface, especially in poorly preserved specimens. Row A reticulations are large and subquadratic, elsewhere the reticulae are smaller and rounded to subrounded. The tubercles along the anterior marginal rim are very prominent.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Male left carapace, HM-A 12983 (holotype)	689	405	-	1.72
Male right carapace, HM-A 12984	680	386	-	1.76
Female left carapace, HM-A 12985	588	364	-	1.61
Female right carapace, HM-A 12986	571	354	-	1.61
Female right carapace, HM- A 12987	560	331	-	1.69
Female dorsal view, HM- A 12988	618	-	303	-
Male ventral view, HM- A 12989	650	-	325	-

Morphotype B
Plate18; Figure 8

This appears to be more reticulate than morphotype A, the tubercles on the anterior marginal rim are not as pronounced, and the ventro-central area is tending to become smooth.

Dimensions of figured specimen in µm:

	L	H	W
Female right carapace, HM-A 12990	577	366	-

Morphotype C
Plate 18, Figures 9-12

This is strongly reticulate, the anterior marginal rim bears small fairly inconspicuous denticles. The pattern of reticulation in the posterior half of the valve can be matched with that of morphotype B. Small tubercles are developed on the reticulation muri, and more prominent tubercles are present on the subcentral tubercle.

Dimensions of figured specimens in µm:

	L	H	W	L/W
Female right carapace, HM-A 12991	600	376	-	1.59
Female left carapace, HM-A 12992	577	355	-	1.62
Female dorsal view, HM-A 12993	623	-	317	-
Female ventral view, HM-A 12994	588	-	305	-

Discussion:

This type of infraspecific variation has been described in several papers by Reyment (1988). *Echinocythereis lehibensis* sp. nov. is similar to several species in outline and ornament, but differs in detail of outline and ornament such as the ridge running from the eye tubercle, the pattern of tubercles on the subcentral tubercle, and the obliquely-running reticulation muri in the posterior half of Morphotypes B and C.

Echinocythereis aragonensis posterior Oertli described and illustrated by Oertli (1960) (Pl.3; Fig.18) from the Eocene of Spain, shows some resemblance to the present species in shape, but differs in having a concave postero-dorsal margin, and in being larger in size.

Occurrence:

Known so far from the Lower Paleocene (Danian) of the Heira Formation in the studied wells.

Echinocythereis? **sp. A**

Plate 19; Figures 1-5

Figured specimens: HM-A 12995 - 996

Material:

Two specimens have been recorded from the Waha Formation in well E46-20, at drilling depth 6040′.

Description:

Carapace subquadrate with highest point at prominent eye tubercle. Anterior margin broadly rounded and ornamented with very small denticles; posterior margin tapered in some specimens, others more quadrate. Dorsal and ventral margins almost straight. Greatest length lies just below centre. Surface ornament consists of very weakly defined reticulation suroumnted by small tubercles; traces of a shallow groove run parallel to the anterior margin, ventral ridge is nearly straight. The subcentral tubercle is very weakly developed. Eye tubercle spherical and very distinct.

In dorsal view, the carapace is suboval and flattened, maximum width nearly central. In ventral view, the ventral ridge can be clearly observed. Internal features are unknown.

Dimensions of figured specimens in µm:

	L	H	W
Right carapace, HM-A 12995	645	387	-
Same left carapace,	645	387	-
Same dorsal view,	645	-	361
Same ventral view,	645	-	361
Left carapace, HM-A 12996	637	375	-

Discussion:

This species is similar to *Echinocythereis*? sp.2 Foster *et al.* (1983) recorded from the Paleocene of Nigeria, differing in the following respects:

the lack of a distinct ventral ridge, the dorsal margin is moderately convex, the lack of a shallow groove in the anterior region.

The species described by Reyment (1981) as *Phalcocythere vesiculosa* (Apostolescu), from the Paleocene of Northwestern Nigeria, shows some affinity to this species (particularly Reyment's Fig. 3 the male dimorph form) but it differs in lacking the weakly defined reticulation and having more prominent tubercles.

This is placed in *Echinocythereis* due to its general external appearance, but the lack of internal details leaves its generic assignment in doubt.

Occurrence:

Occurs in The Waha Formation (Maastrichtian) in well E46-20.

Genus *Hornibrookella* Moos, 1965

Type species : *Cythere anna* Lienenklaus, 1894

***Hornibrookella episcelis* Al-Furaih, 1977**

Plate 20; Figures 4-9

1977, *Hornibrookella episcelis* Al-Furaih P. 492; Pl. 56; Figs. 1-4.

Figured specimens: HM-A 13007 - 011.

Material:

Three carapaces from the Heira Formation in well E57-20, at drilling depths 5600′, and 5870′; three carapaces from the Waha Formation in well E12-20, at drilling depth 5290′.

Diagnosis:

A species of *Hornibrookella* with caudal process; anterior margin broadly rounded; subcentral tubercle moderately distinct; surface reticulate with a tendency to develop weak longitudinal ribs especially in the left valve, in the dorsal and antero-dorsal regions.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Female left carapace, HM-A 13007	706	413	-	1.70
Female right carapace, HM-A 13008	680	413	-	1.64
Male left carapace, HM-A 13009	731	400	-	1.82
Same male right carapace,	731	400	-	1.82
Female dorsal view, HM-A 13010	694	-	386	-
Female ventral view, HM-A 13011	714	-	385	-

Discussion:

The present specimens are almost identical with those described by Al-Furaih (1977) from the Uppermost Cretaceous and Lower Paleocene of Saudi Arabia, leaving no doubt about them belonging to the same species. Slight differences are present; the Libyan specimens are smaller (L: 680-706 cf. 780-805 μm), and the reticulation wall between rows A and B is more clearly defined in Al-Furaih's specimens.

Occurrence:

Known so far from the uppermost Cretaceous and Lower Paleocene of Saudi Arabia Al-Furaih (1977). In the present material it occurs in the Heira Formation (Danian) in well E57-20, and in the Waha Formation (Maastrichtian) in the well E12-20.

***Hornibrookella* cf. *quinquecellulosa* Al-Furaih, 1977**
Plate, 19; Figures 6-13

?1977, *Hornibrookella quinquecellulosa* Al-Furaih; pp.498-500, Pl.58, Figs.1-4; text-Fig.9

Figured specimens: HM-A 12997-13005.

Material:

Total number of specimens sixty three: nine specimens were recorded from the Heira Formation, in well E46-20, at different levels;

eighteen specimens from the Heira and Waha formations in well E12-20; and thirty six specimens have been recorded from both formations, in well E57-20.

Description:

Female carapace subquadrate in lateral outline. Sexual dimorphism rather marked, the females are shorter and higher than the males; anterior margin broadly curved, somewhat extended below, posterior margin rounded, truncated to slightly concave in dorsal half, distinct anterior and posterior marginal rims, dorsal margin nearly straight to slightly convex, ventral margin moderately convex, due to over-reach of ventral ridge. Greatest convexity somewhat posterior of middle, greatest length occurs at about mid-height, greatest height at the middle; valves almost equal in size. Strongly developed ventral ridge runs from postero-ventral to antero-ventral, subcentral tubercle present but weak, surface of valves is strongly reticulate; in the dorsal, anterior, and posterior areas they appear concentrically arranged; anteriorly distinct, although not thick, ridges runing from the eye tubercle parallel to the anterior margin and joining the ventral ridge. A weak dorsal ridge runs obliquely towards the anterior swinging around parallel to the anterior ridges, one or two other ridges formed by mural thickening are present in some species parallel to the dorsal ridge. The subcentral tubercle has very small reticula or pits. The strong ventral ridge has a row of large reticula along its dorsal side, and projects beyond the ventral margin, especially at the posterior.

Dorsally, the carapace has almost parallel margins, with laterally compressed ends; maximum width central; the reticulation on the area between the dorsal ridges, can be seen clearly. In ventral view the ventro-marginal rim of both sides is moderately developed; a distinct depression present at the anterior third of the ventral margin. Internal features are unknown.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Male left carapace, HM-A 12997	714	400	-	1.78
Male right carapace, HM-A 12998	753	430	-	1.75
Male left carapace, HM-A 12999	753	415	-	1.81
Female right carapace, HM-A 13000	666	426	-	1.56
Female left carapace, HM-A 13001	636	415	-	1.53
Female left carapace, HM-A 13002	662	428	-	1.54
Female dorsal view, HM-A 13003	675	-	425	-
Female ventral view, HM-A 13004	662	-	566	-
Male dorsal view, HM-A 13005	784	-	415	-

Discussion:

Hornibrookella quinquecellulosa Al-Furaih (1977) recorded from the Upper Cretaceous and Lower Tertiary of Saudi Arabia differs from this species in being slightly larger and the posterior having a more pronounced caudal process, the dorsal margin is more convex due to the strongly projecting curved dorsal ridge and there are some minor difference in reticulation pattern. *Hornibrookella cyclifossata* Al-Furaih (1980) from the Lower Paleocene of Saudi Arabia differs in lateral outline with very straight dorsal margin, anterior margin very obliquely rounded towards the venter, and has a more pronounced caudal process; the male of this species shows more similarity in lateral outline to *Hornibrookella* cf. *quinquecellulosa* than does the female.

Two species described by Reyment (1981) as *Alocopocythere*? *teiskotensis* (Apostolescu), and *Alocopocythere*? aff. *teiskotensis* (Apostolescu) from the Paleocene of northwestern Nigeria show some similarity to this species, but differ in the less developed ventral ridge, and in their quite different shape at the posterior (i.e the posterior end of *A*? aff.

teiskotensis has a more pronounced caudal process); *A.? teiskotensis* also has posterior marginal spines, a feature not seen in *Hornibrookella* cf. *quinquecellulosa*.

Occurrence:

Occurs in the Heira Formation in well E46-20, and in the Heira and Waha Formations in wells E12-20, and E57-20.

Hornibrookella sp. A

Plate 20, Figures 1-3

Figured specimens: HM-A 13006

Material:

Only one carapace has been found in the Heira Formation in the well E46-20, at drilling depth 5620′.

Description:

Carapace subrectangular in lateral outline. Anterior margin broadly and evenly rounded, antero-marginal rim thick and distinct; posterior with a pronounced caudal process, and compressed in dorsal view; dorsal and ventral margins almost straight and tapering towards posterior, postero-dorsal slope straight to very slightly concave, postero-ventral margin almost straight, and posterior cardinal angle protruding. Greatest length just below central, greatest height at anterior third. Valves nearly equal in size. There is a distinct curved ventral ridge. Surface ornamentation consists of very coarse subquadrate reticulation at the anterior which is parallel to the anterior margin, and smaller reticulae somewhat concentrically arranged around the subcentral tubercle, subcentral tubercle swelling; the area around the subcentral tubercle is almost smooth; moderately developed postero-dorsal process. Eye tubercle flat and prominent.

In dorsal view, the carapace has almost parallel margins, with laterally compressed ends; maximum width is situated in front of the middle; postero-dorsal node of the dorsal ridge, the reticulation on the area between the dorsal ridge in posterior half, anterior rim can all be seen clearly. Internal features are unknown.

Dimensions of figured specimen in µm:

	L	H	W
Left carapace, HM-A 13006	625	375	-
Same right carapace,	625	375	-
Same dorsal carapace,	625	-	319

Discussion:

This species shows some resemblance to *Hornibrookella cuspidata* Al-Furaih (1977) from the Upper Paleocene of Saudi Arabia particularly the male dimorph (Pl. 53, Fig. 4a) but differs in lateral outline; *Hornibrookella* sp. A. tapers more towards the posterior but has a bluntly rounded posterior end unlike the pointed posterior of *H. cuspidata*. *H. cuspidata* also has a prominently curved dorsal ridge and lacks the smooth central area of *Hornibrookella*. sp. A.

Al-Furaih reported that *H. cuspidata* bears some resemblance to *H. arcana* (Lubimova and Guha) (see Siddiqui, 1971) from the Eocene of Kutch, India. Although the specimens studied here shows some similarity in outline to *H. cuspidata,* they are not very similar to *H. arcana.*

Hornibrookella episcelis Al-Furaih (1977) from Saudi Arabia is somewhat similar to this species in general outline but differs in having a more prominent caudal process, the postero-dorsal zone is more concave, and it differs in details of ornamentation.

Hermanites cf. *H. paijenborchianus* (Keij) Cronin and Khalifa (1979) (personal communication with Professor Kalifa) from the Middle and Late Eocene of Egypt, closely approaches the present form in outline but is smaller, has a less reticulate surface, and a more concave postero-dorsal slope and the ventral ridge is almost straight.

Occurrence:

Known so far from the Lower Paleocene (Danian) of the Heira Formation in well E46-20.

Genus *Hermanites* Puri, 1955

***Hermanites wahaensis* sp. nov.**

Plate 20, Figures 10-14; Plate 21, figure 16.

Derivation of name: After the Waha Formation in the Sirte Basin.

Diagnosis:

A species of *Hermanites* with concave postero-dorsal margin; distinct postero-dorsal ala; walls of reticulation strengthened to give impression of longitudinal and oblique ridges in dorsal half of carapace.

Holotype: Male carapace, HM-A 13012, Pl. 20, Fig. 10.

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Waha Formation (Maastrichtian), depth of 5480´.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: 13013 - 014.

Material:

Three specimens recorded from the Waha Formation in well E12-20, at drilling depths 5290´, and 5480´; Three specimens from the Heira Formation in well E57-20, at drilling depths 5450´, 5530´, and 5600´.

Description:

Carapace subrectangular in outline. Sexual dimorphism present, the presumed males are more elongate, than the females. Anterior margin broadly rounded in the female; antero-marginal rim thick; postero-dorsal margin is concave, postero-ventral margin is slightly curved, posterior end is pointed to narrowly rounded. The dorsal and ventral margins are nearly straight and slightly tapering towards the posterior. Greatest height at anterior cardinal angle; greatest length passes below the subcentral tubercle. Left valve larger than the right, overlaps at the anterior cardinal angle and along the postero-dorsal slope. Surface ornamentation consists mainly of strongly developed and prominent reticulation covering the whole surface including the postero-dorsal and postero-ventral ala of the dorsal and ventral ridges; the reticulation varies with moderately large rectangular shape in row (A) arranged parallel to the anterior marginal rim; followed by row (B) of smaller quadrate reticules, reticulation becomes smaller towards the subcentral tubercle. In male specimens weak reticulation is present on the area between the dorsal part and the subcentral tubercle. The longitudinal reticulation walls in the dorsal half of the carapace are strengthened to give the impression of longitudinal ridges; three ridges are seen to the anterior of the subcentral tubercle, and also running obliquely from the postero-dorsal area towards the anterior. The dorsal ridge is straight in the posterior half, commencing from the corner of the postero-dorsal area, and then curves towards the central-anterior area; the ventral ridge is distinct and slightly curved upwards, terminating with a weakly developed ala. Subcentral tubercle prominent. Eye tubercle rounded and distinct.

In dorsal view, the carapace has subparallel margins, with laterally compressed ends; maximum width at the posterior third through the weak developed ventral node; anterior rim, the dorsal ridge can all be seen clearly. No internal features were observed. In ventral view, the small tubercles along the anterior, the prominent ventral ridge, and the reticulation can be seen clearly.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Male left carapace, HM-A 13012 (holotype)	650	312	-	2.08
Same male right carapace,	650	312	-	2.08
Female left carapace, HM-A 13013	611	352	-	1.73
Same female right carapace,	611	352	-	1.73
Female dorsal view, HM-A 13014	611	-	317	-
Same Female ventral view,	611	-	317	-

Discussion:

Hermanites bireticulata described by Al-Furaih (1980) from the Lower Paleocene of Saudi Arabia closely resembles this species in shape and general outline, but differs in details of surface ornamentation and reticulation; the weak ala at the posterior termination of the ventral ridge is weaker or absent, the reticulation is more evenly developed without any impression of longitudinal ridges. *H. bireticulata* is also larger (L:800 cf. L: 650 µm).

Hermanites n. sp. 2 Salahi (1966) from the Oligocene of Libya differs in being larger (L: 860 cf. L: 650 µm), in being more evenly reticulate especially in the posterior half of the carapace, and in slight differences in lateral outline at the posterior.

Hermanites tranquillis Al-Furaih (1980) from the Upper Cretaceous of Saudi Arabia shows some similarities in ornamentation but differs markedly in dorsal outline; the dorsal ridge is highly arched, the anterior half running to just above the subcentral tubercle, the posterior half forming the dorsal margin and steeply inclined towards the posterior; the subcentral tubercle is less prominent.

Bassiouni *et al.* (1984) illustrated forms as *Limburgina moosi* Bassiouni from the Middle Eocene of Fayoum, Egypt, which are similar to *Hermanites wahansis* sp. nov. but differs in having a straight ventral ridge, weak dorsal ala, and in lacking the three ridges which are running obliquely from the postero-dorsal area towards the anterior.

Occurrence:

Known so far from the Waha Formation (Maastrichtian) in the well E12-20; and from the Heira Formation (Danian) in well E57-20.

Genus *Oertliella* Pokorny, 1964
Type species : *Cythere reticulata* Kafka, 1886
***Oertliella petraensis* Al-Sheikhly, 1980**
Plate 21; Figures 1-5

1980, *Oertliella petraensis* Al-Sheikhly; P. 113; Pl. 18, Pl. 19, Figs. 1,2,4.

Figured specimens: HM-A 13015-018

Material:

Total number of specimens eleven, all recorded from the Heira Formation: four specimens from well E12-20, at drilling depths 4880′, and 4940; three specimens from well E46-20, first appearance at drilling depth 5170, last appearance at drilling depth 5530; and four specimens from well E57-20, first appearance at drilling depth 5290, last appearance at drilling depth 5560.

Diagnosis:

A small species of *Oertliella* with well developed postero-dorsal process; subcentral tubercle well marked, with a bifurcating spine or tubercle and other spines. Ventral ridge strong, nearly straight, in some specimens expanding posteriorly into ala-like extension.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Male left carapace, HM-A 13015	618	363	-	1.70
Male right carapace, HM-A 13016	666	373	-	1.78
Female left carapace, HM-A 13017	555	322	-	1.72

Female carapace dorsal view, HM-A 13018	576	-	247	-
Same female ventral view,	576	-	247	-

Discussion:

This species was first described from the Lower Paleocene (M-U Danian) of the Tell-Burma section, Jordan (Al-Sheikhly, 1980). *Oertliella delicata* Bassiouni & Luger (1990) from the Middle to Late Paleocene of Egypt shows some affinity to the present species, but it differs somewhat in the postero-dorsal process.

Occurrence:

The species was originally described from the Lower Paleocene (U-M Danian) of the Tell-Burma section, Jordan Al-Sheikhly (1980). In the present material it occurs in the Heira Formation (Danian) in the studied wells.

Genus?*Protobuntonia* Grekoff, 1954
Type species : *Protobuntonia numidica* Grekoff, 1954
***Protobuntonia nakkadii* Bassiouni, 1970**
Plate 21; Figures 6-9

1970, *Protobuntonia nakkadii* Bassiouni; P.23-24, Pl. 2; Figs.1-3

1978, *Protobuntonia numidica* Grekoff, Said; P.226,Pl.25, Fig. 9

1982, *Protobuntonia nakkadii* Bassiouni; Donze, Colin, Damotte, Oertli, Peypouquet, and Said; P. 295, Pl. 12, Fig. 1,Pl. 14, Fig.6.

1990, *Protobuntonia nakkadii* Bassiouni; Bassiouni & Luger; P. 845, Pl. 23, Figs. 23-24.

Figured specimens: HM-A 13019-020

Material:

Two carapaces have been found in the Waha Formation in well E46-20, at drilling depths 5980´ - 6010´.

Description:

A species of *Protobuntonia* in which the posterior and anterior areas are smooth. Anterior margin compressed, smooth, and evenly rounded; posterior truncated and acuminated dorsal margin evenly straight with pronounced postero-cardinal angle. Surface of the carapace is smooth to finely punctate; 1-2 weak ribs parallel to the ventral margin (clear in the left valve) with fine puncti between them; faint rib parallel to the anterior margin. Eye tubercle flat and not well pronounced.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 13019	833	483	-
Same right carapace,	833	483	-
Same dorsal view,	833	-	347
Ventral view, HM-A 13020	784	-	353

Discussion:

This species corresponds well with those of the Late Maastrichtian-Danian of the El-Kef section in Tunisia Donze *et. al.* (1982), but there are some differences between these, and the type specimens described by Bassiouni (1970) from the Middle Paleocene of Jordan.

The main differences between the Maastrichtian specimens from Libya, and Danian specimens from Tunisia on the one hand and the Jordanian Middle Paleocene specimens on the other are that the latter are longer with a less triangular outline, less pointed posterior end, and a less pitted carapace.

Protobuntonia numidica Grekoff (1954) shows some similarity to *P. nakkadii* but differs somewhat in ornamentation, and the posterior is slightly less acuminated than in *P. nakkadii*.

Occurrence:

The species was originally described from the Middle Paleocene of Jordan Bassiouni (1970), from the Late Maastrichtian to Late Paleocene of Tunisia Donze *et. al.* (1982); and from the Middle Maastrichtian and Middle Paleocene of Egypt Bassiouni & Luger (1990). In the present material it occurs in the Waha Formation (Maastrichtian) in well E46-20.

Protobuntonia sp. A
Plate 21; Figures 10-13

Figured specimens: HM-A 13021- 022
Material:

Four specimens have been recorded from the Heira Formation in well E57-20, at drilling depths 5450′, 5530′, and 5640′.

Description:

Carapace elongate subtriangular in lateral outline. Anterior margin is broadly and evenly rounded; the postero-dorsal margin straight, postero-ventral margin curved, posterior extremity bluntly pointed. The dorsal margin is nearly straight; ventral margin slightly curved, dorsal and ventral margins converge towards the posterior. Greatest length lies below the centre of the carapace; greatest height at the antero-dorsal angle. Left valve larger than the right, with overlap strongest centro-ventrally; a small tubercle is present on the lateral surface at the posterior. The carapace is slightly swollen towards the ventral margin, with a broad flattened area at the posterior. The surface is punctate, with finer puncti on the anterior and posterior flattened areas. Longitudinal riblets are present parallel to the ventral margin and also in the central area of the carapace. Two weakly developed ribs run parallel to the anterior margin with very small puncti between them. Eye tubercle flat and weakly developed.

In dorsal view, the carapace has subparallel margins; maximum width nearly at the middle. No internal details were observed.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 13021	703	386	-
Same ventral view,	703	-	289
Right carapace, HM-A 13022	703	372	-
Same dorsal view,	703	-	295

Discussion:

Protobuntonia semmamaensis Bismuth and Le Féyre (Bismuth *et al.*, 1981a) was described from the Middle Cenomanian of Djebel Semmama, Tunisia and *Protobuntonia* sp. A may be descended from the older *Protobuntonia semmamaensis,* because it is similar to this species, but lacks the weak longitudinal riblets in the central part of the lateral surface.

Protobuntonia numidica Grekoff (1954) illustrated and figured by Bassiouni (1970) from the Maastrichtian of Jordan, and by Reyment & Elofson (1959) from the Senonian of Tunisia, shows some similarity to this species in shape but it differs slightly in general outline and in details of ornamentation, as well as being larger.

Occurrence:
Known so far from the Heira Formation (Danian) in the well E57-20.

Protobuntonia sp. B
Plate 21, Figures 14-15; Plate 22, Figures 1-2

Figured specimens: HM-A 13023 - 024

Material:

Three specimens from the Waha Formation in well E12-20, at drilling depths 5450′, and 5480′.

Description:

Carapace triangular in lateral outline. Anterior margin even and broadly rounded; posterior end pointed. The dorsal and ventral margins

straight, both converge towards the acutely pointed posterior end. Greatest length passes through the centre, greatest height occurs at eye tubercle. Left valve slightly larger than the right, with slight overlap at postero-dorsal margin and along the anterior margin. The lateral surface of the carapace is smooth with a very fine punctation. A shallow short sulcus is parallel to the postero-dorsal margin, with another just behind the feeble eye tubercle.
In dorsal view the carapace is oval with compressed anterior and posterior ends.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 12023	588	364	-
Same dorsal view,	588	-	251
Right carapace, HM-A 12024	566	355	-
Same ventral view,	566	-	244

Discussion:

This species shows some similarities to *Buntonia* (*Protobuntonia*) n.sp.1 Salahi (1966) from the Paleocene of Libya, but differs in having two prominent spines on each valve at the posterior end, in having a more prominent punctation, and in the presence of a weakly developed sulcus around the anterior margin.

Grosdidier (1973) illustrated forms which he called *Protobuntonia* IRH 28 from the Maastrichtian and Coniacian of the Coastal Fars Province in Iran, which differs in outline, i.e the dorsal margin is highly arched in the middle and slightly concave in the posterior third, and the anterior is obliquely rounded.

Brachycythere gr. anagulata Grekoff (Pl. 3, Figs. 5,6) figured by Joseph *et al.* (1987) from the Upper Maastrichtian of the northern Hamada Al-Hamra, Libya, is similar to this species in shape and general outline, but differs slightly in the presence of venter swelling clearly seen in the right valve.

Occurrence:
Occurs in the Waha Formation (Maastrichtian) in the well E12-20.

Genus *Paragrenocythere* **Al-Furaih, 1975**
Type-species : *Paragrenocythere biclavata* **Al-Furaih, 1975**
Paragrenocythere gravis **Al-Furaih, 1980**
Plate 22; Figures 3-8

1980, *Paragrenocythere gravis* Al-Furaih, P.50, Pl.42,Figs. 1-4

1988, *Paragrenocythere gravis* Al-Furaih; Athersuch; Pl.3, Fig. 16.

Figured specimens: HM-A 13025 - 030

Material:

Total number of specimens: one hundred and seventy eight specimens, all have been recorded from the Waha and Heira Formations, at different levels; well E12-20: one hundred and nine specimens; well E46-20: twelve specimens; and well E57-20: fifty seven specimens.

Diagnosis:

A species of the genus *Paragrenocythere* with massive posterodorsal clavi and very strong nearly straight ventral ridge.

Dimensionss of figured specimens in μm:

	L	H	W	L/H
Male right carapace, HM-A 13025	833	483	-	1.72
Male left carapace, HM-A 13026	800	461	-	1.73
Male left carapace, HM-A 13027	833	500	-	1.66
Female right carapace, HM-A 13028	700	428	-	1.63
Male dorsal view, HM-A 13029	815	-	492	-
Male ventral view, HM-A 13030	833	-	500	-

Discussion:

The specimens studied here show some variation in the development of the postero-dorsal clavi, and the strength of the alar-like extension of the ventral ridge, but this is not considered sufficient to separate the material into separate species. Al-Furaih described two very similar species, both from the uppermost Maastrichtian and Lower Paleocene of Saudi Arabia *Paragrenocythere biclavata* and *Paragrenocythere gravis*. *P. biclavata* was described as having "well developed" clavi; *P. gravis* as "massive"; the ventral ridge in *P. biclavata* curves upwards at the anterior, while that of *P. gravis* is straight, and the alar-like extension of the ventral ridge is more prominent in *P. biclavata*. There is also a clear size difference; according to Al-Furaih, female *P. biclavata* mostly range between 805-878 µm., with one exceptionally large paratype at 976 µm.; *P. gravis* females are smaller, 659-707 µm. The specimens from Libya are very similar to these species; they have the prominent straight ventral ridge typical of *P. gravis*, but some specimens have the prominent alar-like extension of *P. biclavata*.

The Libyan material and both Saudi Arabia species shows 3-4 riblets running obliquely from a dorsal position to a antero-central position around the subcentral tubercle. It is not clear whether there are two species or one variable species; however, taking the straight ventral ridge as the one clear character within the specimens, the Libyan species are placed in *P. gravis*. If *P. biclavata* and *P. gravis* are eventually shown to be the same species, *P. biclavata* takes precedence as the senior synonym.

Bassiouni & Luger (1990) described and illustrated a species they referred to *Phalcocythere cultrata* Apostolescu 1961. Their illustrations (Pl. 9, Figs. 13-20) certainly seem to be the same as *Phalcocythere cultrata* illustrated by Reyment (1981). *Paragrenocythere gravis* studied here shows similarities to this species, but differs slightly in lateral outline and in having a lineation to the reticulation in the anterior and antero-dorsal areas. Most specimens from Libya possess two dorsal clavi (Pl. 22, Figs. 5-6) while *Phalcocythere cultrata* has three; however, a third weaker clavus is sometime present in Libyan material (Pl.22, Fig. 3). The specimens illustrated as (Pl. 22, Fig. 3), also has an unornamented ventro-dorsal area similar to (Pl. 9, Fig, 14) of Bassiouni & Luger. While there is difficulty in identifying this species, the Libyan material is considered to belong to a different species from the Egyptian material. Regarding generic assignment, it is interesting to note that Al-Furaih (1980) in his discussion of *Paragrenocythere* considered *Bradleya cultrata* Apostolescu (1961) to belong to his new genus.

Occurrence:

The species was originally described from the uppermost Maastrichtian and Lower Paleocene of Saudi Arabia Al-Furaih (1980); from the Campanian to Maastrichtian of Oman. In the present material it occurs in the Waha (Maastrichtian) and Heira (Danian) Formations in the studied wells.

***Paragrenocythere neoponticulata* sp. nov.**
Plate 22, Figures 9-14

Derivation of name: Referred to similarity of *Paragrenocythereis ponticulata* Al-Furaih 1980.

Diagnosis:

A species of *Paragrenocythere* with a weak dorsal ridge; ventral ridge well-developed and ponticulate.

Holotype: Female carapace, HM-A 13033; Pl. 22, Fig. 11

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4660′.

Stratigraphic Range: Maastrichtian-Danian

Catalogued Specimens: HM-A 13031 - 036

Material:

Total number of specimens: Thirty eight; thirteen specimens were recorded from the Heira Formation in well E12-20, first appearance at drilling depth 4660′, and last appearance at drilling depth 5100′; three specimens from the Heira Formation in well E46-20, at drilling depth 5530′; and eighteen specimens have been recorded from the Heira formation, at different levels and two specimens from the Waha Formation, at drilling depth 6040′-6070′, in well E57-20

Description:

Carapace subquadrate in lateral outline. Sexual dimorphism present, the presumed males are more elongate than the females. Anterior margin broadly rounded; anterior marginal rim thick; postero-dorsal margin is concave; postero-ventral margin curved. The dorsal margin is weak and irregular due to ornamentation, the ventral margin is slightly curved in the females, and nearly straight in males, both margins slightly tapering towards the posterior. Greatest height at eye tubercle, greatest length nearly through the subcentral tubercle, valves almost equal in size, except the left valve which slightly overlaps the right at the postero-dorsal margin. Surface ornamentation consists mainly of medium to coarse reticulation which covers the whole surface, the reticulation varies with large rectangular shape arranged parallel to the anterior and posterior marginal rims, followed by medium quadrate to subquadrate reticulation covering the entire surface of the carapace. There are weak postero-dorsal clavus clearly seen in male specimens. the dorsal ridge is weak and ponticulate, and slightly curved up wards, terminating with a weakly developed ala, subcentral tubercle present. Eye tubercle present.

In dorsal view, the carapace has subparallel margins, with laterally compressed ends; maximum width lies at about posterior third; the three reticules present in the area between the dorsal ridge can be seen clearly. Internal details are unknown.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Female right carapace, HM-A 13031	704	422	-	1.66
Female left carapace, HM-A 13032	714	457	-	1.56
Female right carapace, HM-A 13033 (Holotype)	714	428	-	1.66
Male right carapace, HM-A 13034	769	384	-	2.00
Male left carapace, HM-A 13035	769	353	-	2.17
Female dorsal view, HM-A 13036	714	-	400	-

Discussion:

This can be easily distinguished from other species of *Paragrenocythere* by its much weaker dorsal ridge and its ponticulate ventral ridge.

The material recorded here is similar to that illustrated by Al- Furiah (1980) from the Paleocene of Saudi Arabia, but differs in having a slightly more irregular dorsal margin.

Occurrence:

It occurs in the Heira Formation (Danian) in the studied wells and in the Waha Formation (Maastrichtian) in well E57-20.

Genus *Phalcocythere* Siddiqui, 1970

***Phalcocythere jebelensis* sp. nov.**

Plate 23; Figures 7-13

Derivation of name: After the Jebel Oil Field in concession six.

Diagnosis:

A species of *Phalcocythere* with postero-dorsal process; surface reticulate, subcentral tubercle prominent and surrounded by four reticules; ventral ridge moderately elevated. Eye tubercle distinct.

Holotype: Female carapace, HM-A 13043, Pl. 23, Fig. 7.

Type Locality: Raguba Field Well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4840′.

Catalogued specimens: HM-A 13044 - 049

Material:

Fifty three specimens were recorded from the Heira Formation in the studied wells: well E12-20, twenty seven specimens, first appearance at drilling depth 4530′, last appearance at drilling depth 5220′; well E46-20, fourteen carapaces, first appearance, at drilling depth 4930′, last appearance at drilling depth 5530′; well E57-20, twelve carapaces, first appearance at 5290′, last appearance at 5910.

Description:

Carapace subrectangular to subquadrate in lateral outline. Sexual dimorphism pronounced, with more elongate males; anterior and posterior marginal rims are distinct, anterior margin broadly rounded. An antero-marginal rim is present, clearly beginning at the eye tubercle and ending at the corner of of the antero-ventral area; in some specimens with very short small denticles; posterior margin narrowly rounded, and slightly truncated above; dorsal and ventral margins more or less parallel, dorsal margin almost straight; ventral margin slightly concave in anterior third; greatest length occurs at mid height, greatest height at anterior third. Surface ornamentation consists of reticulation with a few superimposed tubercles, the reticulation in the anterior area is coarser than elsewhere; postero-dorsal process well-marked, subcentral tubercle well-developed, solid with two dorsal, and two ventral reticules; ventral ridge well-developed, starting from the posterior quarter, with very distinct alar expansion (which is broken in most of the specimens), and running to the antero-ventral area; dorsal ridge runs from posterior caudal process to just above subcentral tubercle, is straight in its posterior half, slightly curved at anterior. Valves almost equal in size, right valve slightly over-reaches the left along the anterior margin. Eye tubercle rounded and distinct. An eye rib runs towards the subcentral tubercle.

In dorsal view, the female carapace has subparallel margins which slightly converge towards the anterior and has laterally compressed ends; maximum width passes through the subcentral tubercle. In ventral view, the ventral ridge with its posterior node clearly visible. Internal details are unknown.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Female left carapace, HM-A 13043 (holotype)	658	374	-	1.75
Male left carapace, HM-A 13044	680	333	-	2.04
Female right carapace, HM-A 13045	653	372	-	1.96
Female right carapace, HM-A 13046	666	400	-	1.66
Female right carapace, HM-A 13047	634	388	-	1.63
Female dorsal view, HM-A 13048	666	-	280	-
Male ventral view, HM-A 13049	696	-	285	-

Discussion:

This species has been referred to *Phalcocythere* on the basis of the general outline and ornamentation.

Phalcocythere (Phalcocythere) bullita Al-Furaih (1980) from the Paleocene of Saudi Arabia shows some affinity to the present species, but the reticulation and form of subcentral tubercle differs, also *Phalcocythere*

(*Phalcocythere*) *bullita* has a high elevated ventral ridge and is slightly smaller in size.

The species recorded here is also similar to *Phalcocythere (Phalcocythere) tranquillis* Al-Furaih (1980) from Saudi Arabia in outline but it differs in details of ornamentation, especially around the eye tubercle, and the present species has a more solid subcentral tubercle, and more prominent caudal process.

None of the eight species from the Early Tertiary of West Pakistan figured by Siddiqui (1971) are closely comparable with this species.

Acanthocythereis sp. MB 530 n. sp. Yves Bellion *et al.* (1973) from Lower Campanian to Maastrichtian of Algeria, resembles this species, differing in the shape of the posterior end and in the detail of the surface ornamentation.

Occurrence:
Known so far from the Heira Formation (Danian) in the studied wells.

Phalcocythere ralahensis sp. nov.
Plate 23; Figures 1-6

Derivation of name: After the Ralah Oil Field in concession six in Sirte Basin.

Diagnosis:

A species of *Phalcocythere* with reticulate surface, moderately developed ventral ridge; posterior with subquadratic shape.

Holotype: Carapace, HM-A 13037, Pl. 23, Fig. 1.

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4660′.
Catalogued specimens: HM-A 13038 - 042

Material:

Sixteen carapaces were recorded from the Heira Formation in the studied wells: Well E12-20, four carapaces, at drilling depths 4660′ - 4700′; well E46-20, first appearance at drilling depth 4900′, last appearance at drilling depth 5620′; well E57-20, first appearance, at drilling depth 5290′, last appearance at drilling depth 5750.

Description:

Carapace subrectangular to subquadrate in lateral view. Anterior and posterior margins distinct, anterior broadly and evenly rounded, posterior extremity quadrate to bluntly rounded. Dorsal and ventral margins are nearly sub-parallel; dorsal margin almost straight, ventral margin straight to slightly convex, greatest length occurs at about mid-height, greatest height at anterior third. Valves almost equal in size. Surface ornament consists of medium to coarse reticulations, the anterior area has coarser reticulation than that over the surface of the carapace; moderately developed ventral ridge, faint dorsal ridge; weak defined postero-dorsal process; subcentral tubercle distinct. Eye tubercle prominent.

In dorsal view, the two sides converge slightly towards the anterior, with both ends laterally compressed; maximum width nearly posterior third; the postero-dorsal process of the dorsal ridge, and the dorsal ridge are clearly observed. In ventral view, the depression at the area along the ventral margin, and the reticulation of the ventral surface and the ventral ridge can all be seen. No internal details were observed.

Dimensions of figured specimens in μm:

	L	H	W
Left carapace, HM-A 13037 (holotype)	476	295	-
Right carapace, HM-A 13038	485	295	-
Left carapace, HM-A 13039	520	320	-
Right carapace, HM-A 13040	525	329	-
Dorsal view, HM-A 13041	500	-	270

Ventral view, HM A 13042 485 - 276

Discussion:

This species is very similar to *Phalcocythere rete* Siddiqui (1971) from the Early Tertiary of West Pakistan, in ornament and general outline, particularly the female dimorph form (Pl. 31, Fig. 10); but *Phalcocythere rete* differs in having more truncated posterior margin and lacks the faint postero-dorsal process.

Phalcocythere dissenta Siddiqui (1971) from the Early Tertiary of Pakistan also shows some similarity to this species, but differs slightly in shape and in being larger in size.

Occurrence:

Known so far from the Heira Formation (Danian) in the studied wells.

***Phalcocythere* cf. *P.* (*Phalcocythere*) *tranquillis* Al-Furaih, 1980**
Plate 23; Figure 14

Figured specimen: HM-A 13050

Material:

Seventeen specimens were recorded from the Heira Formation in well E12-20, first appearance at drilling depth 4660′, and last appearance at drilling depth 5100′; three specimens from the Heira Formation in well E57-20, at drilling depths 5420′, 5530′, and 5910′.

Description:

Carapace subrectangular in lateral outline. Anterior margin evenly rounded, posterior margin truncated, distinct anterior and posterior marginal rims; dorsal margin nearly straight. Distinct postero-dorsal process. Ventral margin straight to slightly convex in the middle of the carapace. Greatest length just below the subcentral tubercle, greatest height at anterior third, greatest width passes through the subcentral tubercle, valves almost equal in size. The whole surface of the carapace is strongly reticulate with a small papillae sometimes developed at mural junctions; the reticulation in the centre of the carapace is smaller than at the anterior and posterior. Dorsal ridge starts from above subcentral tubercle, curving upwards, and then becoming straight, nearly over-reaching the dorsal margin at the postero-dorsal area, a centro-dorsal process lies in the middle of the dorsal ridge. The ventral ridge is prominent and slightly curved. Some pore canals can be seen. Subcentral tubercle is well developed and ornamented with 6 small reticules. Eye tubercle rounded and prominent.

Dimension of figured specimen in µm:

	L	H
Right carapace, HM-A 13050	625	325

Discussion:

This is very similar to *Phalcocythere tranquillis* Al-Furaih (1980) from the Lower Paleocene of Saudi Arabia but differs in lacking the very prominent extended eye tubercle of the former, and has a stronger ventral ridge.

Occurrence:
This species occurs in the Heira Formation (Danian) in wells E12-20, and E57-20.

Genus *Paracosta* Siddiqui, 1971

Discussion:

A large number of costine genera and species have been described from west Africa, north Africa, and the Middle East showing similar morphological features. *Paracosta* was described from the Early Tertairy of Pakistan by Siddiqui (1971), and diagnosed as having four longitudinal ridges rather than the three of *Costa*. Benson (1977) described *Paleocosta* from Tunisia which shows many similarities to *Paracosta,* essentially differing in having coarser intercostal reticulation. *Reymenticosta* Bassiouni & Luger (1990) differs in lateral outline, but otherwise is similar to *Paracosta.* *Afranticythereis* Carbonnel & Johnson (1989) from west Africa is also very similar, but is said to lack the fourth longitudinal ridge. *Reticulina* Bassiouni (1969c) also shows many ornamental details in common with *Paracosta,* but has very weak longitudinal ridges. Other genera which have been used for species belonging to this grouping are *Anticythereis* and *Veenia.* The ornament is widely used in both species and generic determination, but can be seen to be quite variable even within certain species. It is not at all clear how these species should be grouped and which generic names would then take precedence, so in this study they are all placed into *Paracosta*; for further comment see species description.

Paracosta aff. _ansaryi_ (Bassiouni, 1969)
Plate 25; Figures 5-7; Plate 28, Figures 1-2

Figured specimens: HM-A 13070 - 072

Material:

Two carapaces, and one valve have been recorded from the Heira Formation at drilling depth 5650′, and from Waha Formation at drilling depth 5680′in well E46-20

Description:

Moderately large carapace, nearly triangular in lateral view. Anterior margin rounded, in some specimens with 19-20 short small denticles; antero-marginal rim is present and in some specimens is ornamented with 6-7 very short small denticles. Posterior bluntly pointed, in some specimens with 5-6 small denticles. Dorsal and ventral margins convex and converge towards the posterior. Greatest length passes through the middle, greatest height lies at the anterior cardinal angle. Left valve slightly larger than the right. Surface ornamentation consists of weakly developed coarse reticulation. There are three major longitudinal ridges with a tendency for a fourth small and short ridge between the ventral margin and ventral ridge. A very prominent ridge running parallel to the antero-marginal rim joins the ventral ridge ending at the postero-ventral area. A ring-groove is present in the middle of the upper median ridge. Eye tubercle is present .

Dimensions of figured specimens in µm:

	L	H
Right carapace, HM-A 13070	700	442
Right valve, HM-A 13071	728	400
Left carapace, HM-A 13072	714	441

Discussion:

This species is very similar to *Paracosta* (*Paleocosta*) *ansaryi* (Bassiouni) figured and illustrated by Al-Sheikhly (1980) from the Uppermost Middle Eocene and the lowermost Upper Eocene of Jordan and Syria, in shape and general outline. The main difference between the two is in the prominent upper median ridge, which in *Paracosta* (*Paleocosta*) *ansaryi* continuos strongly to the anterior of the ring-groove giving the appearance of a single ridge running from near the posterior to the antero-ventral corner; in the Libyan material the upper median ridge is not continue anterior of the ring-groove. *Paracosta* (*Paleocosta*) *ansaryi* also has a prominent oval reticulation lying on the upper median ridge near its posterior.

Occurrence:
Known so far from the Heira formation (Danian) in well E46-20.

Paracosta **cf.** ***arabica*** **(Bassiouni), 1960a**

Plate 25; Figures 1-4

Figured specimens: HM-A 13066 - 069

Material:

Five carapaces have been found in the Waha and Heira Formations in well E46-20, at drilling depths 4930′, 4990′, 5050′, and 6070′.

Description:

Carapaces subrectangular in lateral outline; sexual dimorphism is not pronounced; anterior margin slightly obliquely rounded; posterior narrowly rounded; the marginal rim is best developed around the anterior and ventral margins, and is not clearly seen along the posterior margin. In some specimens, there are some denticles along the anterior margin. Dorsal and ventral margins subparallel; dorsal margin curved and short, mostly hidden by dorsal ridge; ventral margin slightly curved, and slightly converging with dorsal margin towards the posterior. Maximum length occurs nearly at the middle; maximum height at eye tubercle. Left valve slightly larger than right, conspicuously overlapping it along antero-dorsal and postero-dorsal margins. The surface of the valves is reticulate, the reticulation is mostly semi-rounded and medium-large in size; row (A), parallel to the anterior margin and has medium quadrate reticulation; the depressed posterior area also have medium quadrate to subquadrate reticulation. The median ridge runs from the anterior margin around both sides, and each row of the vertically standing reticulation lying between the dorsal and the two median ridges, is divided into four rows of smaller reticulations, sharply developed longitudinal ridges, and an ill-defined rib parallel to the anterior part of the upper median ridge. Eye tubercle present.

Dimensions of figured specimens in μm:

	L	H
Left carapace, HM- A 13066	653	373
Right carapace, HM-A 13067	666	386
Left carapace, HM-A 13068	582	331
Right carapace, HM-A 13069	576	317

Discussion:

This species shows similarities to *Paracosta arabica* (Bassiouni, 1969a), *Paracosta praecrassireticulata* (Bassiouni, 1969a), and *Paleocosta libyaensis* Benson (1977); it differs from *Paracosta arabica* in having a prominent antero-marginal rim, and in the finer details of the anterior reticulations; from *Paracosta praecrassireticulata* in lacking the ridgelet running from the subcentral area towards the antero-ventral area and ridglet between the median and ventral longitudinal ridges; from *Paleocosta libyaensis* in lacking the ridgelet between the median and ventral ridges, in the shape of the reticulation meshes between the longitudinal ridges, and in details of the anterior and posterior reticulations. However, as there appears to be considerable intraspecific variation within these species, the definition of the species is not clear and it is possible that a good deal of synonymy is required.

Occurrence:

Occurs in the Waha (Maastrichtian) and Heira (Danian) Formations in the well E46-20.

Paracosta bensoni **(Damotte & Donze,1982)**
Plate 26, Figures 10-13; Plate 27, Figures 1-14, Plate 29, Figures 1-4

1963, *Anticythereis bopaensis* Apostolescu; Barsotti, P.1526; Pl. 2, Figs.13-14.

1966, *Isobuntonia* aff. *harpa* Apostolescu; Salahi, P. 11-12, Pl.5, Fig.13

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.

Figured specimens: HM-A 13089 - 107

Material:

Total number of specimens eight hundred and forty two. Well E12-20: seventy eight specimens from the Waha Formation recorded at all depths except at 5360′; one hundred and seventy nine specimens recorded from the Heira Formation at all depths. Well E46-20: fifty eight specimens from the Waha Formation recorded at all depths; three hundred and sixty three specimens recorded from the Heira Formation at all depths except at 5560′. Well E57-20: twenty seven specimens from the Waha Formation recorded at all depths; one hundred and thirty seven specimens from the Heira Formation recorded at all depths.

Description:

Carapace subrectangular or wedge shaped in lateral outline. Sexual dimorphism is pronounced, the females are shorter and higher than the males. There is variation in lateral outline, some species being more triangular than others. Anterior margin evenly rounded; some specimens have small anterior denticles although these are mostly poorly developed in the material studied; the anterior marginal rim is usually well defined commencing from the eye tubercle and running close to the anterior margin, forming a ridge close to the ventral margin and ending in the postero-ventral zone. Posterior margin is narrowly rounded, occasionally bluntly pointed; the dorsal margin has fairly prominent anterior and posterior hinge-ear in the right valve, less distinct in the left valve; dorsal and ventral margins convex and converge towards the posterior. Dorsal ridge prominent, extending from the postero-dorsal area, becoming highly arched centrally, and then strongly curved downwards to join the median ridge in the antero-central area. Ventral ridge is distinct, either nearly straight or runs slightly obliquely from the antero-ventral to the postero-ventral areas. Greatest length passes through the middle, greatest height lies at the anterior cardinal angle, maximum width occurs just behind the centre of carapace. Left valve over-reaches the right valve at the anterior and posterior cardinal angles. Surface ornamentation consists of reticulation, the reticula vary in shape and size, but most of the coarser reticulation lies in the central area of the carapace. There are three major longitudinal ridges with a tendency for a fourth ridge between the median and ventral ridges. There are three strong depressions on the surface of the valve, the first in the central just to the posterior of the position of the adductor muscle attachment area and referred to hereafter as the central depression; the second lies between the eye tubercle and the downturned dorsal ridge, hereafter referred to as the antero-dorsal depression; and the third lies behind the downturned anterior part of the dorsal ridge and is referred to as the dorsal depression. Eye tubercle is distinct, in some specimens ornamented with three pores.

In dorsal and ventral view, the carapace has almost parallel margins, with laterally compressed ends.

Morphotype A

Plate 26, Figures 10-13; Plate 27, Figures 1-7; Plate 29; Figures 1-4

This is very similar to the specimens described by Donze *et al.* (1982) as *Paleocosta bensoni* from the Thanetian of the El-Kef section in Tunisia, particularly the female dimorph, but the present species differs in the posterior being slightly curved upward and in the presence of strong central, antero-dorsal, and dorsal depressions; the Tunisian species appears to having less prominent longitudinal ridges and has more subdivided smaller reticulations between the ridges as in Pl. 4, Fig. 6 of Donze *et al.*, (1982); the anterior margin is obliquely rounded, especially in the male dimorph form (Pl. 4, Fig. 7), and also it is larger in size.

This morphotype is characterised by strong and high longitudinal ridges, particularly the dorsal ridge. The postero-ventral margin in lateral view is curved upward in the female but is less curved in the male. Anterior marginal rim is distinct. Eye tubercle distinct and ornamented with three pores. Benson (1977) illustrated *Paleocosta*? sp. from the Middle Paleocene of Tunisia which is similar to this morphotype, but lacks the smooth strong central, antero-dorsal, and dorsal depressions, has well developed posterior and anterior marginal denticles, and the shape of the reticulation differs.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Female right carapace, HM-A 13089	594	354	-	1.67
Female left carapace, HM-A 13090	588	352	-	1.67
Male dorsal view, HM-A 13091	650	-	300	-
Female dorsal view, HM-A 13092	588	-	282	-
Male left carapace, HM-A 13093	650	337	-	1.92
Male right carapace, HM-A 13094	637	337	-	1.89
Female left carapace, HM-A 13095	576	364	-	1.58
Female right carapace, HM-A 13096	611	376	-	1.62
Female left carapace, HM-A 13097	588	346	-	1.69
Female dorsal view, HM-A 13098	600	-	305	-
Female ventral view, HM-A 13099	602	-	313	-

Morphotype B
Plate 27, Figures 8-14

This differs from morphotype A in having slightly less prominent longitudinal ridges, in being slightly larger, the antero-dorsal depression is always prominently reticulate, and the central depression is slightly smaller in size.

Isobuntonia aff. *Isobuntonia harpa* Apostolescu (1961) figured by Salahi (1966) from the Paleocene of Libya resembles this morphotype. *Isobuntonia harpa* was originally described from the Eocene of Togo by Apostolescu (1961) and differs in having very thick well developed longitudinal ridges.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Male left carapace, HM-A 13100	714	371	-	1.92
Male right carapace, HM-A 13101	753	384	-	1.96
Male right carapace, HM-A 13102	653	333	-	1.96
Female right carapace, HM-A 13103	612	362	-	1.69
Female right carapace, HM-A 13104	625	362	-	1.72
Female left carapace, HM-A 13105	594	354	-	1.67
Female dorsal view, HM-A 13106	625	-	312	-
Male right valve, inside view, HM-A 13107	725	355	-	2.00

Discussion:

Reymenticosta bensoni described and figured by Bassiouni & Luger (1990) from the Paleocene of Egypt is very similar to the material described here, but differs slightly in the posterior outline, in being larger in size, and the reticulation is less subdivided between the longitudinal ridges. It is not clear whether the Egyptian species has the three pores which are present on the eye tubercle of the Libyan and Tunisian material.

Reymenticosta parabensoni described and figured by Bassiouni & Luger (1990) from the Late Paleocene to basal Eocene of Egypt shows some resemblance to the present species in shape and general outline, but it differs in having more prominent longitudinal ridges, two clear sets of coarse reticulation between the longitudinal ridges, in being larger in size; some specimens (as in Pl. 21, Fig. 13 of Bassiouni & Luger) show slight differences in lateral outline, i.e the ventral margin is concave near the central-ventral area, and the longitudinal ridges are more prominent in dorsal view than in the present species.

Occurrence:

The species was originally described from the Thanetian of the El-Kef section in Tunisia by Donze *et. al.* (1982); from the Paleocene of Libya by

Barsotti (1963), and Salahi (1966). In the present material it was found in the Waha (Maastrichtian) and Heira (Danian) Formations in the studied wells.

Paracosta keeni sp. nov.

Plate 25, Figures 8-14; Plate 26, Figures 1-9

Derivation of name: In honour of Dr. M. C. Keen.

Diagnosis:

A species of the genus *Paracosta* with weakly developed longitudinal ridges. The entire surface of the valve is ornamented with a nearly uniform medium-sized reticulation. Eye tubercle distinct, in some specimens with three pores particularly in the left valve. Central, dorsal, and antero-dorsal depressions are present.

Holotype: Male carapace, HM-A 13080, Pl. 26, Fig. 1.

Type Locality: Raguba Field Well E57-20, Sirte Basin, Libya.

Type Horizone: Waha Formation (Maastrichtian), depth of 4880′.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 13073 - 088

Material:

Total number of specimens one thousand two hundred and forty eight: Well E12-20: Two hundred and fifty five specimens were recorded from the Heira Formation at all depths; ninety seven specimens were recorded from the Waha Formation at all depths. Well E46-20: Four hundred and fifty seven specimens from the Heira Formation at all depths; fifty specimens from the Waha Formation recorded at all depths. Well E57-20: three hundred fifty five specimens from the Heira Formation recorded at all depths; thirty four specimens from the Waha Formation recorded at all depths.

Description:

Carapace subrectangular in lateral outline. Sexual dimorphism is pronounced, the females are shorter and higher than the males, anterior margin broadly rounded. Some specimens have small denticles; anterior marginal rim weakly developed in most of the specimens. Posterior margin broadly rounded. Dorsal and ventral margins straight to slightly convex and tapering towards the posterior. The dorsal ridge is gently curved downwards in centro-dorsally. Greatest length in the middle, greatest height at anterior third. Left valve slightly larger than the right. The entire surface of the carapace is ornamented with a nearly uniform medium-sized reticulation. There are central, centro-dorsal, and antero-dorsal depressions, all strongly reticulate. The upper median ridge is weak and low, extending from postero-central area; the ventral ridge is present but is not strongly developed. Eye tubercle is distinct, and ornamented with three pores particularly the left valve.

In dorsal view the maximum width is posterior third, and the upper median ridge can be seen clearly; the carapace has parallel sides with compressed ends.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Female left carapace, HM-A 13073	675	400	-	1.68
Female right carapace, HM-A 13074	717	427	-	1.67
Juvenils right carapace, HM-A 13075	566	311	-	1.81
Male dorsal view, HM-A 13076	714	-	328	-
Male ventral view, HM-A 13077	714	-	314	-
Female dorsal view, HM-A 13078	689	-	358	-
Female ventral view, HM-A 13079	625	-	350	-
Male left carapace, HM-A 13080 (holotype)	850	416	-	2.04

Male right carapace, HM-A 13081	769	384	-	2.00
Male left carapace, HM-A 13082	769	400	-	1.92
Female right carapace, HM-A 13083	700	414	-	1.69
Female right carapace, HM-A 13084	675	413	-	1.63
Female right carapace, HM-A 13085	742	414	-	1.79
Female left carapace, HM-A 13086	685	414	-	1.65
Female left carapace, HM-A 13087	670	387	-	1.73
Female dorsal view, HM-A 13088	641	-	346	-

Discussion:

This species shows some similarity to the species recorded here as *Paracosta bensoni,* but differs in having a less developed upper median ridge, the central, dorsal, and antero-dorsal depressions are strongly reticulate; the posterior margin is broadly rounded; and it is larger in size.

Juveniles differ from the adult in having less developed ornamentation, and less distinct central, central dorsal, and antero-dorsal depressions; however, the main features seen in the adult such as the eye tubercle and the reticulation are clearly developed.

Apostolescu (1961) illustrated specimens from the Paleocene of Togo as *Anticythereis bopaensis* which are very similar to this species, but differ especially in lateral outline with a much more convexly rounded dorsal margin behind the centro-dorsal area and a narrow rounded posterior; the longitudinal ridges are more prominent although one figure (Apostolescu, 1961) (Pl.10 ,Fig. 201) seems to be similar to *Paracosta keeni* sp. nov. Apostolescu's specimens are also smaller.

Reyment illustrated specimens from the Paleocene of Libya which he identified as *Anticythereis bopaensis* Apostolescu. This is undoubtedly the same as *Paracosta keeni* sp. nov. There is some confusion in the literature concerning Apostolescu's species.

Reyment & Reyment (1980) recognised variation in his Libyan material recognising typical *A. bopaensis* (Pl. 1, Fig. 5) and another form (Pl.

1, Fig. 6) as synonymous with *A. exigua* (Apostolescu), the latter specimen lacking longitudinal ridges and having even reticulation.

Carbonnel (1986) has figured *Anticythereis bopaensis* from the Senegal which seems very similar to Apostolescu's original illustration, but is unlike the figures given for this species by Foster *et. al.* (1981); the latter placing it in the genus *Leguminocythereis* (Foster *et al.* Pl.5, Fig.1-2). Carbonnel excludes Foster *et. al.* and Reyment from his synonymy list for this species. If Carbonnel's illustration are taken as being typical for *Anticythereis bopaensis*, it is clear that it shows many similarities to the species recorded here as *Paracosta keeni* sp. nov.

Carbonnel (1988) illustrated forms as *Anticythereis* aff. *bopaensis* Apostolescu, 1961 from the Paleocene of Senegal and Guinea-Bissau which are similar to the present species.

Occurrence:

Occurs in the Waha (Maastrichtian) and Heira (Danian) Formations in the studied wells.

Paracosta pervinquieri **(Donze & Said, 1982)**
Plate 30; Figures 1-5

1982, *Paleocosta pervinquieri* Donze,C., O., P., and Said; P.284, Pl. 3, Figs. 4-10

1990, *Paracosta pervinquieri* (Donze & Said); Bassiouni & Luger, P. 834, Pl. 20, Figs. 7-10, 12 .

Figured specimens: HM-A 13108 - 112

Material:

Well E12-20: Three carapaces were recorded from the Heira Formation, at drilling depths 4660′, and 4840′; and two carapaces from the Waha Formation at drilling depths 5480′, and 5580′.

Diagnosis:

A species of *Paracosta* with well developed longitudinal ridges and subrounded reticules covering the surface between them and the posterior portion of the carapace. The upper median ridge runs from the posterior to the well defined ring groove, where it splits into two prominent parallel branches which run to the anterior marginal rim and have a row of rounded reticules between them. Anterior margin evenly rounded, antero-marginal rim distinct, commencing from the eye tubercle and joining the ventral ridge, the latter ending in the postero-ventral zone. Dorsal ridge commences in postero-dorsal area and is inclined towards the antero-central area.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 13108	757	357	-
Right carapace, HM-A 13109	714	377	-
Right carapace, HM-A 13110	714	357	-
Dorsal view, HM-A 13111	757	-	357
Ventral view, HM-A 13112	769	-	369

Discussion:

This can be easily distinguished from other species of the genus by its prominent upper median ridge which splits into two branches in the antero-central area. Within the species *Paracosta pervinquieri* there are some very slight differences which could be attributed to the geographical and stratigraphical distribution. The dorsal ridge in the specimens from Tunisia is slightly convex and not as nearly straight as in the material from Libya.

Occurrence:

The present species was originally described from the Late Maastrichtian to Early Paleocene from Tunisia Donze *et. al.* (1982), from the

Middle Maastrichtian of the Dakhla Formation, Egypt Bassiouni & Luger (1990). In the present material it occurs in the Waha (Masstrichtian), and Heira (Danian) Formations in well E12-20; and in the Waha Formation in well E57-20.

Paracosta warriensis (Reyment, 1960)
Plate 24; Figures 1-13, Plate 28, Figures 3-4

1960, *Veenia warriensis* Reyment, P.180, Pl.12, Figs. 2, a-c, 3;

Pl.18, Figs.1,a-b

1963, *Veenia (Veenia) warriensis* Reyment; Reyment P. 186, Pl. 5, Figs.3,a-c.

1966, *Costa dahomeyi* (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* (Apostolecu); Carbonnel & Johnson, P. 420, Pl. 3, Figs. 4-6

Figured specimens: HM-A 13051 - 065.

Material:

Well E12-20: forty specimens have been recorded from the Heira Formation, first appearance at drilling depth 4530′, last appearance at 5260′; six specimens were recorded from the Waha Formation, first appearance at drilling depth 5480′, last appearance at drilling depth 5580′. Well E46-20: fourteen specimens were recorded from the Heira Formation at drilling depth 5050′, last appearance at 5530′, three specimens from the Waha Formation at drilling depth 6121′. Well E57-20: nineteen specimens from the Heira Formation, from 5290′ - 5950′; six specimens from the Waha Formation, at drilling depth 6130′ - 6187′.

Diagnosis:

A species of *Paracosta* with vertically standing rectangular reticulation (i.e. long axis of rectangle is perpendicular to the ridges) lying between the posterior parts of the dorsal and the two median longitudinal ridges, (mainly undivided reticulation between ridges) and with a rib running parallel to the anterior part of the upper median ridge. Antero-marginal rim distinct starting from the spherical eye tubercle, running along the marginal rim; the anterior margin is broadly and evenly rounded; the posterior margin more narrowly curved. In lateral view the prominent longitudinal ridges can be seen; the dorsal ridge is curved, the median ridge bifurcated in the sub-central area, with two weaker parallel ridges running towards the anterior-ventral area with reticulation between them, the ventral ridge is very prominent; the ventral-most fourth ridge joins the ventral ridge towards the posterior. The reticulation between the three major longitudinal ridges is coarse and shows consistent pattern. The anterior and posterior areas have smaller scale reticulations but varies between specimens through the merging of some of the meshes. Eye tubercle is distinct.

Dimensions of figured specimens in μm:

	L	H	W	L/H
Male right carapace, HM-A 13051	769	400	-	1.92
Male left carapace, HM-A 13052	768	400	-	1.92
Male left carapace, HM-A 13053	784	415	-	1.88
Male right carapace, HM-A 13054	757	371	-	2.04
Female left carapace, HM-A 13055	703	400	-	1.75
Female right carapace, HM-A 13060	680	400	-	1.70
Female left carapace, HM-A 13061	671	410	-	1.63
Female right carapace, HM-A 13062	666	386	-	1.72
Female left carapace, HM-A 13063	653	413	-	1.58
Female right carapace, HM-A 13064	680	426	-	1.59
Female left carapace, HM-A 13065	662	402	-	1.57
Male dorsal view, HM-A 13056	800	-	386	-

Male ventral view, HM-A 13057	714	-	357	-
Female ventral view, HM-A 13058	666	-	375	-
Female dorsal view, HM-A 13059	703	-	358	-

Discussion:

The specimens studied here are similar to those figured by Salahi (1966) as the female of *Costa dahomeyi*. These are quite distinct from *Costa dahomeyi*, differing in lateral outline, longitudinal ridges, and different width of reticulations.

Some differences in the degree of development of the longitudinal ridges and the reticulation can be recognised within the sample studied here; Maastrictian specimens have sharp longitudinal ridges with moderately developed coarse reticulation between them, and a moderately developed anterior marginal rim; whereas the specimens from the Lower Paleocene found in the same borehole, have thicker more bluntly developed longitudinal ridges, with well developed coarse reticulation, and a thick antero-marginal rim.

Reyment has figured this species in three separate publications, and these indicate a large degree of variation within the species; in the original paper, the Maastrichtian species from Nigeria show very strong ribbing and reticulation.

Reyment's (1963) illustration from the Paleocene of Nigeria show's a pattern of longitudinal ridges and coarse reticulation which matches the Libyan species very well; the anterior reticulation differs from that of Reyment's (1960) Maastrichtian species and also from the Libyan species; in particularly the Libyan species have a pair of parallel ribs running from the subcentral area towards the anterior-ventral area, these ribs being more prominent in some specimens than others.

Reyment's (1981) SEM figure of a Nigerian Paleocene specimen shows almost even but coarse reticulations over the valve without any prominent longitudinal ridges at all; this latter character is stated to be variable, with some species having a dorsal and two lateral ribs but in other species the two lateral ribs may be absorbed in to the reticulation ornament.

Reyment & Reyment (1980) figured a species from Libya which almost agrees with the material being described here, but differs in lacking the finer reticulation; this may be a preservational feature however.

Genus *Phyrocythere* Al-Furaih, 1980
Type-species : *Phyrocythere dextrodigitata* Al-Furaih, 1980
***Phyrocythere attahaddensis* sp. nov.**
Plate 30; Figures, 6-9

Derivation of name: After the Attahaddy Gas Field in concession six in Sirte Basin.

Diagnosis:

A species of *Phyrocythere* in which the subcentral tubercle is well-developed and divided into three nodes, surface strongly reticulate with three rows of irregular large tubercles arranged horizontally in the postero-central area. Eye tubercle distinct.

Holotype: Carapace, HM-A 13113, Pl. 28, Fig. 6.

Type Locality: Raguba Field well E12-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 4880´.

Catalogued specimens: HM-A 13114 - 116

Material:

Total number of specimens ten: All have been recorded from the Heira Formation in: Well E12-20, six carapaces, at drilling depths 4780´, 4880´, and 4940´.; well E46-20, two carapaces, at drilling depths 5080´, and 5620´; well E57-20, two carapaces, at drilling depths 5330´, and 5530.

Description:

Carapace subrectangular in lateral view; anterior margin broadly and bluntly rounded, marginal rim thick, extending from the eye tubercle around the anterior; the posterior narrowly rounded, posterior marginal rim ornamented with a few tubercles, dorsal margin irregular due to ornamentation, ventral margin concave medially, and ornamented with row of small tubercles; greatest length in the middle, greatest height at the anterior third. Left valve larger than the right. Eye tubercle distinct. A ridge passes from the eye tubercle to the anterior area; subcentral tubercle is distinct, consisting of three large tubercles, and surrounded by ghost reticulation; surface ornamentation is a combination of reticulation and tubercles; the reticula are concentrated in the anterior, posterior, dorso-central, and centro-dorsal areas. In the postero-lateral area there are three subhorizontal rows of tubercles, each row consisting of three various sized tubercles, two large tubercles are present in the centro-ventral area and three small tubercles (or pore cones) lie between the muri in the antero-ventral area.

In dorsal view, the carapace has subparallel margins, with laterally compressed ends; the pore cone at the centre of the dorsal margin on both sides of the valve, and the subcentral tubercle are distinctly observed; maximum width lies in the anterior third of the carapace on the subcentral tubercle. No internal details were observed.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 13113 (holotype)	625	325	-
Right carapace, HM-A 13114	658	361	-
Dorsal view, HM-A 13115	653	-	253
Ventral view, HM-A 13116	650	-	250

Discussion:

Phyrocythere attahaddensis sp. nov. is unlikely to be confused with any other species of the genus and is easily recognised by the presence of the three rows of irregular tubercles arranged in the postero-central and the form of the subcentral tubercle. It is possible that all the specimens recorded here are males.

The specimens of *Phyrocythere acropolis* illustrated by Al-Furaih (1980, Pl. 57, Fig. 2) from the Lower Paleocene of Saudi Arabia are somewhat similar to the present species and the species is possibly conspecific. Al-Furaih mentioned that such specimens were regarded as males although their ornamentation differs from the females of the species. *P. acropolis* is less reticulate and has a subcentral tubercle divided into four nodes. The anterior margin is also ornamented with row of denticles.

Phyrocythere pustulosa Al-Furaih (1980) from Saudi Arabia shows some similarity in outline but differs in detail of ornamentation.

Occurrence:
Known so far from the Heira Formation (Danian) in the studied wells.

Genus *Quadracythere* Hornibrook, 1952

***Quadracythere* cf. *lagaghiroboensis* (Apostolescu, 1961)**

Plate 30, Figures 10-12; Plate 31, Figures 5

Figured specimens: HM-A 13117

Material:

Only one specimen has been found in the Heira Formation in well E57-20, at drilling depth 5600´.

Description:

Carapace subquadrate in lateral outline; anterior margin broadly rounded; antero-marginal rim thick; postero-dorsal margin concave, postero-ventral margin curved. Dorsal and ventral margin subparallel;

dorsal margin slightly curved and short, mostly hidden by dorsal ridge; ventral margin straight to slightly convex at antero-ventral area. Greatest length passes just below the subcentral tubercle; greatest height at eye tubercle. Left valve slightly larger than right, overlapping it along the antero-dorsal, and postero-dorsal margins. The lateral surface of the carapace is strongly ornamented by coarse, subquadrate macroreticulation especially developed in the area parallel to the dorsal ridge, and anterior margin; the dorsal ridge appears discontinuous, anterior part commences below and behind the eye tubercle; the ventral ridge nearly straight and short; subcentral tubercle nearly smooth and distinct. Eye tubercle is distinct.

In dorsal view, the carapace has almost parallel margins, with laterally compressed ends; maximum width lies at subcentral tubercle.

Dimensions of figured specimen in µm:

	L	H	W
Left carapace, HM-A 13117	680	346	-
Same right carapace,	680	346	-
Same dorsal view,	680	-	280
Same ventral view,	680	-	280

Discussion:

Quadracythere lagaghiroboensis figured and described by Apostolescu (1961, Pl.11; Figs. 224-226) from the Paleocene of Cote-d' voire; Reyment, (1963, Pl.3; figs2a-c; Pl.14, Figs.1-2) from the Paleocene of Nigeria; Diop *et al.* (1982, Pl.2; Fig.6) from the Paleocene of Senegal, and Foster *et al.* (1983, Pl.12; Figs. 5,6,8,9) from the Late Paleocene of Nigeria. Comparison of their illustrations shows considerable variation in details of ornamentation. In particular Reyment and Foster *et al.* figure specimens where the reticulation muri, especially in the posterior half, have a tendency to form weak longitudinal ridges; a feebly pronounced ridge can be seen running from the subcentral tubercle to the postero-dorsal node. These ridges are not seen in the illustrations of Apostolescu or Diop *et al.* The subcentral tubercle also varies, from being covered with small reticulation in Apostolescu and Reyment to being a prominent, almost smooth, knob in Foster *et al.* and Diop *et al.* The specimens described here most closely resemble those of Diop *et al.* in general outline, in having a prominent knob-like subcentral tubercle, and in the dorsal ridge which is arched with a row of large reticulations below it; the dorsal ridge joins a vertical posterior ridge at an ill-deffined postero-dorsal node, giving a very characteristic feature clearly seen in Diop *et al's* illustration.

Reyment (1966), Reyment (1981) have listed *Quadracythere lagaghiroboensis* (as *Hornibrookella lagaghiroboensis* in 1980) from the Sirte Basin, but without illustration. Reyment recorded the smaller size of the Libyan specimens compared with those from West Africa. It is not clear whether their species is the same as that described here, but it is likely to be so.

Occurrence:
It occurs in the Heira Formation (Danian) in well E57-20.

Genus *Schizoptocythere* Siddiqui & Al-Furaih, 1981
***Schizoptocythere arshadensis* sp. nov.**
Plate 31; Figures 6-9

Derivation of name: After the Arshad Oil Field in concession six in Sirte Basin.

Diagnosis:

A species of the genus *Schizoptocythere* with weakly developed ventro-central swelling, an almost smooth surface, dorsal and ventral margins taper towards the posterior.

Holotype: Carapace, HM-A 13120, Pl. 31, Fig. 6

Type Locality: Raguba Field well E46-20, Sirte Basin, Libya.

Type Horizon: Waha Formation (Maastrichtian), depth of 6040′

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 13121 - 123

Material:

Total number of specimens nineteen: Well E12-20: six carapaces have been recorded from the Heira Formation at drilling depths 4840′, and 4900′; well E46-20: two carapaces from the Heira Formation, at drilling depths 5050′-5080′; and eight carapaces have been found in the Waha Formation, at drilling depths 6040′-6121′; well E57-20: three carapaces from the Heira Formation at drilling depths 5290′and 5490′.

Description:

Carapace subtriangular in lateral view. Anterior margin broadly and evenly rounded, posterior margin narrowly rounded to bluntly pointed, both margins are ornamented with small denticles. Dorsal and ventral margins straight, converging towards the posterior. Greatest length nearly at the mid-height, greatest height at antero-cardinal angle. Valves almost equal in size. The lateral surface is mainly smooth with traces of very weakly developed tubercles. A weakly developed swelling is present in the ventro-central area. Small spines or denticles are present along the ventral margin, although these are indistinct in some specimens. Eye tubercle present, but appears to be broken in most specimens.

In dorsal view, the carapace has parallel margins with compressed ends; greatest width occurs near the centre.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 13120 (holotype)	588	341	-
Right carapace, HM-A 13121	555	277	-
Ventral view, HM-A 13122	555	-	210
Dorsal view, HM-A 13123	536	-	210

Discussion:

This species is placed in the genus *Schizoptocythere* on the basis of the shape of the carapace. *Schizoptocythere* sp. A resembles *Schizoptocythere arshadensis* sp. nov. in having a compressed carapace, rimmed and denticulate anterior and posterior margins, mainly smooth surface and having a ventro-central swelling; *Schizoptocythere* sp. A differs in having a distinct eye tubercle, better developed postero-dorsal tubercle, and in lateral outline.

None of the nine species from the Early Tertiary of Saudi Arabia, Pakistan, and India figured and illustrated by Siddiqui & Al-Furaih (1981) are closely comparable with this species.

Occurrence:

The species occurs in the Heira Formation (Danian) in wells E12-20, and E57-20; and in the Heira and Waha (Maastrichtian) Formations in well E46-20.

Schizoptocythere **sp. A**
Plate 31, Figures 1-4

Figured specimens: HM-A 13118 - 119

Material:

Two specimens have been recorded from the Heira Formation in well E46-20, at drilling depths 5320´, and 5350´.

Description:

Carapace subrectangular in lateral outline. Shell surface nearly smooth with some pitting arranged randomly over the surface of the carapace, being clearer in the right valve. There is a prominent swelling on each valve in the ventro-central area; left valve has a postero-dorsal process. There are 1-2 tubercles in the postero-dorsal area. A distinct groove runs parallel to the anterior margin. Eye tubercle distinct, and has a depression behind it.

Dimensions of figured specimens in μm:

	L	H	W
Left carapace, HM-A 13118	510	290	-
Left carapace, HM-A 13119	526	290	-
Right carapace, same, A 13118	510	290	-
Same dorsal view,	510	-	193

Discussion:

None of the nine species of the genus *Schizoptocythere* described by Siddiqui & Al-Furaih (1981) from the Early Tertiary of Western Asia closely resembles this species. The most similar is *Schizoptocythrere* sp. aff. *S. howei* Khosla (1972), but this differs in having a ventro-lateral node, the postero-dorsal slope is more concave than in the present species, it lacks the depression behind the eye tubercle, and is larger in size. *Schizoptocythere lissos* described by Siddiqui & Al-Furaih (1981) from the Early Tertiary of Western Asia also shows some similarity to this species, but differs in having an oblique anterior margin, the posterior margin is more narrowly rounded, and it is larger.

Sohn (1970) figured a species from the Early Tertiary of Pakistan as *Exophthalmocythere? ventronodosa*. This differs from the present species in having distinct denticles or spines along the anterior, and ventral margins and the postero-ventral slope; it also lacks the groove parallel to the anterior margin, and the posterior is narrowly rounded.

Schizoptocythere howei Khosla (1972) from the Eocene beds of Rajasthan, India, is similar in outline but has long thick spines around the anterior, ventral and posterior margins; and the left valve has a strong postero-dorsal process ending with thick spine.

Occurrence:
Known so far from the Heira (Danian) Formation in well E46-20.

Genus *Uroleberis* Triebel, 1958
***Uroleberis megilensis* sp. nov.**
Plate 32; Figures 10-13

Derivation of name: After the Megil Oil Field in concession six in Sirte Basin.

Diagnosis:

A species of *Uroleberis* with triangular lateral outline and lacking a caudal process; surface punctate, puncti varying in size; three longitudinal ventral riblets parallel to the ventral margin.

Holotype: Carapace, HM-A 13135, Pl. 32, Fig. 10

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 5790′.

Catalogued specimens: HM-A 13136 - 138

Material:

Total number of specimens ten. One carapace has been found in the Heira Formation in well E12-20, at drilling depth 4780′. Well E57-20: Nine specimens have been recorded from the Heira Formation, first appearance at drilling depth 5270′, last appearance, at 5990′.

Description:

The shape is triangular in outline. Sexual dimorphism has not been recognised. Anterior margin evenly and narrowly rounded; posterior margin broadly rounded without a caudal process; dorsal margin arched; ventral margin weakly convex. Valves strongly inflated in the postero-ventral region; greatest length lies just below the mid-point, greatest height occurs slightly behind the mid-point towards posterior, greatest width slightly posterior to mid-point. Left valve larger than the right; over-reaches the right valve at antero-ventral corner. Surface of the shell punctate; puncti are rounded and vary in size, the larger one's arranged more or less concentrically in and around the centre part of the carapace while the smaller occur randomly over the rest of the carapace. There are three longitudinal ventral riblets parallel to the ventral margin with small puncti between them. Eye tubercle is weak but clearly seen. In dorsal view it is strongly inflated towards the posterior.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 13135 (holotype)	510	365	-
Right carapace, HM-A 13136	500	370	-
Right carapace, HM-A 13137	490	360	-
Dorsal view, HM-A 13138	510	-	380

Discussion:

Xestoleberis n. sp. Salahi (1966), from the Paleocene Beshima Formation of Libya is similar, but differs in having a depression in the central area of the ventral margin; it is also larger than the present species (600 µm. cf. 500 µm.).

Uroleberis armeniaca Neale & Singh (1985) from the Middle Eocene of Assam shows some similarity in general outline but differs in having a pronounced caudal process, the anterior end is more narrowly rounded, and the surface has larger puncti than the present species. In general appearance it is similar to the species figured by Reyment (1981) as *Uroleberis* aff. *glabella* from the Paleocene of northwestern Nigeria, but the latter differs in having a well developed caudal process and different ornamentation.

Al-Furaih (1984) illustrated specimens of *Foveoleberis ovata* from the Maastrichtian of Saudi Arabia which are very similar to this species, particularly the right side of the carapace, but differ especially in dorsal outline and being smaller in size.

Occurrence:
Occurs in the Heira Formation (Danian) in wells E12-20, and E57-20.

Uroleberis sirtensis sp. nov.
Plate 32, Figures 1-5; Plate 33, Figures 1-2

Derivation of name: After the Sirte Basin in Libya.

Diagnosis:

A species of *Uroleberis* in which surface is strongly ornamented with coarse reticulation and has four thick prominent longitudinal ventral ribs, running parallel to ventral margin.

Holotype: Male carapace, HM-A 13124, Pl. 32, Fig. 1.

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 5870´.

Catalogued specimens: HM-A 13125 - 130

Material:

Seven specimens have been recorded from the Heira Formation. Well E12-20, two carapaces, at drilling depths 4660´,and 4700´; well E57-20: five specimens, at drilling depths 5750´, 5870´, and 5910´.

Description:

Shape ovate in lateral view. Sexual dimorphism present, the male being larger and more elongate than the female. Dorsal margin strongly convex and evenly curved, ventral margin moderately convex; greatest length occurs at mid-point, greatest height passes through mid-length, greatest width slightly posterior of mid-point. Left valve slightly larger than right; surface reticulate or very coarsely punctate; four thick longitudinal ribs are present parallel to the ventral margin, with large puncti between them. Eye tubercle not distinct.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Male left carapace, HM-A 13124 (holotype)	536	368	-	1.45
Female left carapace, HM-A 13125	416	293	-	1.41
Female right carapace, HM-A 13126	426	302	-	1.41
Male dorsal view, HM-A 13127	588	-	423	-
Male ventral view, HM-A 13128	600	-	435	-
Female dorsal view, HM-A 13129	536	-	368	-
Female ventral view, HM-A 13130	500	-	380	-

Discussion:

This species is similar to *Uroleberis teiskotensis* described by Apostolescu (1961) from the Paleocene of Mali, and by Barsotti (1963) from the Paleocene of Libya. *Uroleberis sirtensis* differs in the presence of the longitudinal ribs running parallel to the ventral margin, in having coarser reticulation, and a more convex dorsal margin.

Uroleberis oculata by Al-Furaih (1980) from the Paleocene of Saudi Arabia is very similar but differs from this species in the presence of a well-marked eye spot, and a more acutely rounded anterior margin.

Xestoleberis n. sp. 3 Salahi (1966) from the Paleocene of Libya (Surfa Formation), shows some affinity to *Uroleberis sirtensis* sp. nov. but it differs in lateral outline.

Occurrence:

Occurs in the Heira Formation (Danian) in wells E12-20, and E57-20

***Uroleberis sahlensis* sp. nov.**

Plate 32; Figures 6 - 9

Derivation of name: After the Sahl Gas Field in concession six in Sirte Basin.

Diagnosis:

A small species of the genus *Uroleberis* with high rounded dorsal margin; surface punctate with 3-4 prominent longitudinal ventral ribs.

Holotype: HM-A 13131, Pl. 32, Fig. 6

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 5270′.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 13132 - 134

Material:

Total number of specimens seventeen: Well E12-20; three carapaces from the Heira Formation, at drilling depths 4660′, and 4780′; two specimens from the Waha Formation, at drilling depths 5340′, and 5580′. Well E57-20: Eleven carapaces have been recorded from the Heira Formation, first appearance, at drilling depth 5270′, last appearance, at 5950′; one carapace, from the Waha Formation, at drilling depth 6160′.

Description:

In lateral view the dorsal margin is strongly and almost evenly curved with slight acuminate posterior; greatest height at mid-point, greatest length occurs slightly below mid point, eye tubercle is not clear;

valves almost equal in size; ornament varies from smooth to finely punctate to coarsely punctate; 3-4 prominent longitudinal ribs parallel to the ventral margin.

Dimensions of figured specimens in µm:

	L	H	W
Left carapace, HM-A 13131 (holotype)	555	422	-
Left carapace, HM-A 13132	526	421	-
Dorsal view, HM-A 13133	566	-	344
Ventral view, HM-A 13134	543	-	391

Discussion:

This is similar to several species described by Al-Furaih (1980) from the Lower and Middle Paleocene of Saudi Arabia and by Apostolescu (1961) from West Africa and Mali, but differs from all of these in lateral outline with it's very high dorsal margin.

Occurrence:

This species occurs in the Waha and Heira formations in wells E12-20, and E57-20.

Family Xestoleberididae Sars, 1928

Genus *Xestoleberis* Sars, 1866

***Xestoleberis tripoliensis* sp. nov.**

Plate 33; Figures 3-8

Derivation of name: After capital of Libya.

Diagnosis:

Posterior margin almost symmetrically rounded in female, postero-dorsal angle is angular in male.

Holotype: Female carapace, HM-A 13139, Pl. 33, Fig. 3

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 5910´.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 13140 - 144

Material:

Total number of specimens seventeen (including two broken carapaces): Well E12-20: two specimens from the Heira Formation, at drilling depths 4780´, and 4840´; three specimens from the Waha Formation at drilling depths 5480´, and 5610´. Well E46-20: six specimens from the Heira Formation, first appearance at drilling depth 5110´, last appearance at 5530´. Well E57-20: Six specimens have been recorded from the Heira Formation, first appearance at drilling depth 5450´, last appearance at 5950´.

Description:

Carapace subovate in lateral outline. Sexual dimorphism pronounced, males more elongate than females. Anterior margin obliquely rounded and less high than the posterior margin; posterior margin broadly rounded, dorsal margin convex; ventral margin nearly straight to slightly concave towards anterior end. Greatest height slightly to posterior of centre; greatest length passes through the mid-point. The surface of the carapace is smooth. Internal features not seen.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Female left carapace, HM-A 13139 (holotype)	566	400	-	1.41
Female right carapace, HM-A 13140	588	400	-	1.47
Male right carapace, HM-A 13141	526	347	-	1.51
Male left carapace, HM-A 13142	510	340	-	1.50
Female dorsal view, HM-A 113143	588	-	431	-
Female ventral view, HM-A 13144	588	-	411	-

Discussion:

This is similar to the holotype of *Xestoleberis kiseibaensis* figured by Bassiouni & Luger (1990, Pl. 25, Fig. 8) although it is larger (588 cf. 430 µm). This figure is described as a right valve of a carapace, which would be unusual for *Xestoleberis*; it is interpreted here as the left valve, with an anterior margin less high than the posterior. Bassiouni & Luger could not observe any internal characters. So they presumably established orientation on external features only. If the left valve is accepted as being the larger, then the orientation must be as interpreted here.

Occurrence:

Occurs in the Heira Formation (Danian) and Waha Formation (Maastrichtian) in well E12-20, and in the Heira Formation in wells E46-20, and E57-20.

Xestoleberis? *summoudensis* sp. nov
Plate 33; Figures 9-14

Derivation of name: After the Summoud Gas Field in the Sirte Basin.

Diagnosis:

A *Xestoleberis* species in which the surface of the carapace is smooth; the ventral margin nearly straight, dorsal margin curved.

Holotype: Male carapace, HM-A 13145, Pl.33, Fig.9

Type Locality: Raguba Field well E57-20, Sirte Basin, Libya.

Type Horizon: Heira Formation (Danian), depth of 5450′.

Stratigraphic Range: Maastrichtian - Danian.

Catalogued specimens: HM-A 13146 - 150

Material:

Total number of specimens eighteen: Well E12-20: Five specimens recorded from the Heira Formation, first appearance at drilling depth 4660′, last appearance at 4900′; two specimens from the Waha Formation, at drilling depths 5320′, and 5610′. Well E46-20: Three carapaces from the Heira Formation, at drilling depths 5020′, and 5530′.. Well E57-20: eight specimens from the Heira Formation, first appearance at 5290′, last appearance at 5990′.

Description:

Carapace, small, subquadrate in lateral view. Presumed sexual dimorphism present with more elongate males. Anterior margin obliquely rounded. Dorsal margin convex with a slight hinge-ear especially in the female left valve, the dorsal margin of the male is more symmetrical than the female ventral margin nearly straight in the right valve, concave in left. Greatest length occurs just below the mid-height, greatest height central. Left valve larger than right, overlapping at anterior dorsal area and along the anterior margin. The lateral surface is smooth.

Dimensions of figured specimens in µm:

	L	H	W	L/H
Male left carapace, HM-A 13145 (holotype)	453	266	-	1.70
Male right carapace, HM-A 13146	443	260	-	1.70
Male right carapace, HM-A 13147	444	266	-	1.66
Female left carapace, HM-A 13148	566	366	-	1.54
Male dorsal view, HM-A 13149	425	-	258	-
Male ventral view, HM-A 13150	425	-	255	-

Discussion:

The total lack of internal details makes generic assignment difficult; it is placed in to *Xestoleberis* on the basis of general lateral outline and small size.

Occurrence:

Occurs in the Heira Formation (Danian), and Waha Formation (Maastrichtian) in well E12-20; and in the Heira Formation in wells E46-20, and E57-20.

CHAPTER SIX

BIOSTRATIGRAPHY

The sections studied in the wells span the Maastrichtian-Paleocene. In most parts of the world the Cretaceous - Tertiary boundary is represented by an unconformity, with much of the Maastrichtian and Paleocene being absent. As will be shown below, this hiatus is present in most sections in north Africa and the Middle East. However, the type section for the Cretaceous-Tertiary boundary has been chosen in Tunisia at El-Kef where the succession is complete. The ostracods of El-Kef have been studied by Donze *et al.* (1982). There have been no micropalaeontological studies of the Waha or Heira formations in the studied area; this study suggests the former is Maastrichtian in age, and the latter Danian.

Seventy three species and two subspecies have been identified in this study; seventeen of these have been described from localities in west Africa, north Africa and the Middle East (Table 6-1). Twenty five species are proposed as new; the remainder are left in open nomenclature, although some of them are very similar to described species. Those species which have already been described are important for age determination and correlation with adjacent areas.

The samples used in this study are ditch cuttings representing between 30-40, or 60 feet of well drilling; occasionally, due to the absence of the samples, different intervals were examined. This means that it is impossible to determine the true distribution of microfossils in the wells. Contamination of material may be caused by drilling operations as well as caving of the wells. The presence of certain species (see below) indicates that the Heira Formation studied here is of Early Paleocene age, probably Early Danian, even although many of the common species found are typical of the Late Paleocene in other localities. This suggests that much of the fauna described here is present due to contamination.

The seventeen species listed in Table 6-1 are important for stratigraphical age determination, and can be used as stratigraphical markers

Species name \ Age	Maastrichtian			Paleocene			Eocene	Libya Present study
	Early	Middle	Late	Early	Middle	Late	Early	
Cristaeleberis fornicata Bassiouni	J	J:E	J					W. FM.
Paragrenocythere gravis Al-Furaih	O		?S?	S				W.&H.FMS.
Mauritsina coronata (Esker)		T	T	T:E:J	T:E:J	E:J	J	W. FM.
Paracosta pervinquri (Donze & Said)		E	T	T				W.&H.FMS.
Protobuntonia nakkadii Bassiouni		E	T:J	T:J	E:T:J	T		W. FM.
Hornibrookella episcelis Al-Furaih			?S?	S				W.&H.FMS
Paracosta warriensis (Reyment)			?N?	N	N	N		W.&H.FMS.
Acanthocythere stymatora Al-Furaih				S				H.FM.
Oertliella petraensis Al-Sheikhly				J				H.FM.
Buntonia (Buntonia) fortunata Apostolescu				D		´N:?I?		W.&H.FMS.
Cytherella bassiouni sp nov.					E	E		W.&H>FMS
Cythereis teiskotensis (Apostolescu)						?´N?:L:Su M		H.FM.
Bairdopillata magna (Alexander)						L		H.FM.
Isohabrocythere teiskotensis Apostolescu						E:N:D:M:L:	E	H.FM.
Trachyleberis modesta (Apostolescu)						N:I:M:E:L	E?	W.&H.FMS
Buntonia tatteuliensis (Apostolescu)						E?:M:L:N:	E	H.FM.
Paracosta bensoni (Damotte & Donze)						E:T:L	E?	W.&H.FMS.

´N............... NW Nigeria
N............... SW Nigeria
E............... Egypt
D............... Dahomey-Togo
M.............. Mali
W...............Waha Formation
H................Heira Formation
L.................Libya
I..................Ivory Coast
T.................Tunisia
J..................Jordan
S.................Saudi Arabia
O................Oman
?...?............not specific stage

Table 6-1 Paleogeographic distribution of previously described ostracod species.

for the Maastrichtian-Paleocene. However, when considering the stratigraphical distributions it should be remembered that some of the species have different ranges in different localities due to (1) lack of study of all ages in all localities, (2) the presence of unconformities, and (3) facies difference. The total ranges of the species are believed to be more or less correct (see below). The ostracod distribution charts in the studied wells are shown in Tables (6-2, 6-3, 6-4) They show that only a few species have first down hole appearance in the sections studied; in general the species recorded here are part of a widespread southern Mediterranean, western Africa, Middle East fauna; and most of the remainder are closely related to widespread species. The fauna is markedly different from that described from Iraq by Al-Sheikhly (1980) and Al-Bashir (1986), where there are no species found in common between the two countries. The Libyan faunas also differ from those of Europe.

The stratigraphic ranges of the ostracods are based on published records from localities in Oman, Saudi Arabia, Jordan, Egypt, Mali, Libya, Tunisia, Nigeria, Ivory Coast, Dahomey-Togo, and Cameroon (Fig. 1-2). Detailed distribution are given for each species under the Systematic description (Chapter 5).

Maastrichtian

Nine species make their first down hole appearance in the Waha Formation, of which only four are previously described. The first of these is *Cristaeleberis fornicata* (Bassiouni) which is the most important species occurring in the Waha Formation because it is only known from the Maastrichtian. This species was originally described from the whole of the Maastrichtian of Jordan (Bassiouni, 1970); in Egypt it is restricted to Maastrichtian (Bassiouni & Luger, 1990); in the present study it is recorded from the Waha Formation. This confirms a Maastrichtian age for the Waha

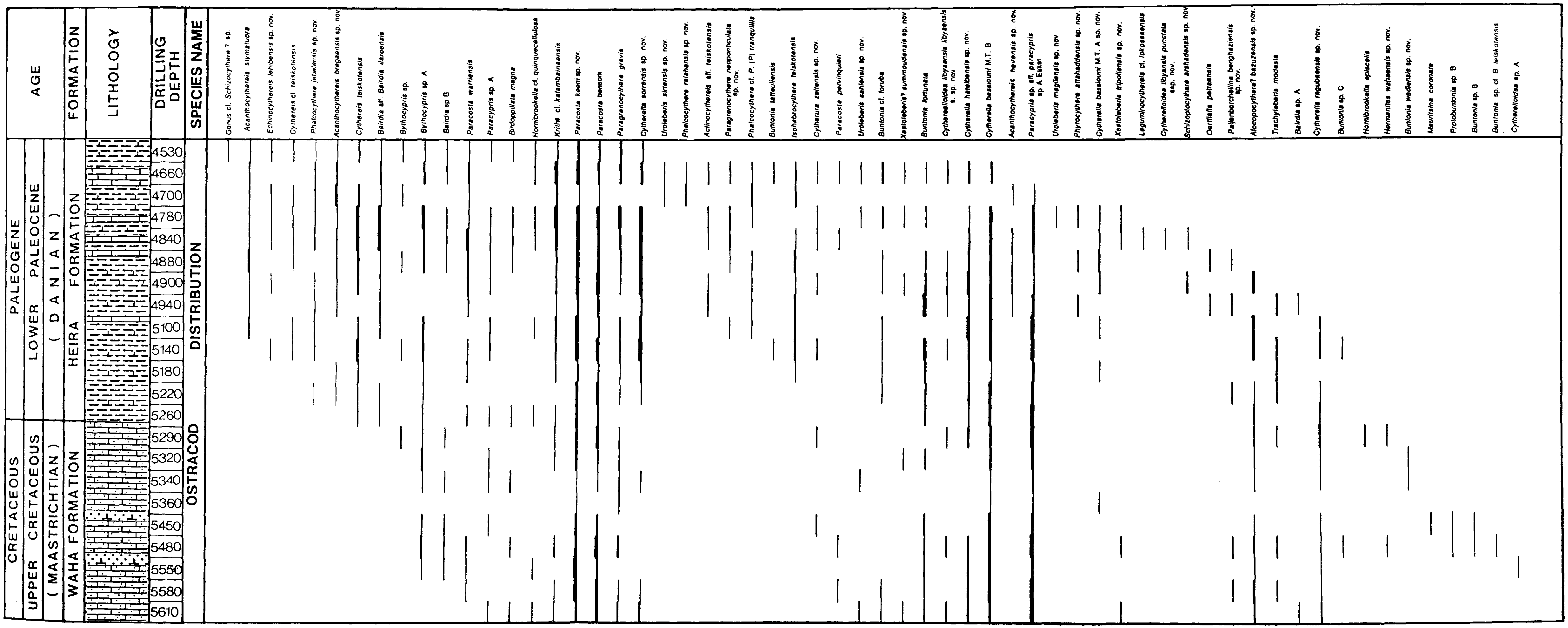

Table 6-2 Ostracod distribution in well E12-20.

Key to Ostracod distribution

1-4 valves
4-8 valves
8-16 valves
16-32 valves
>32 valves

Note: one carapace considered as two valves

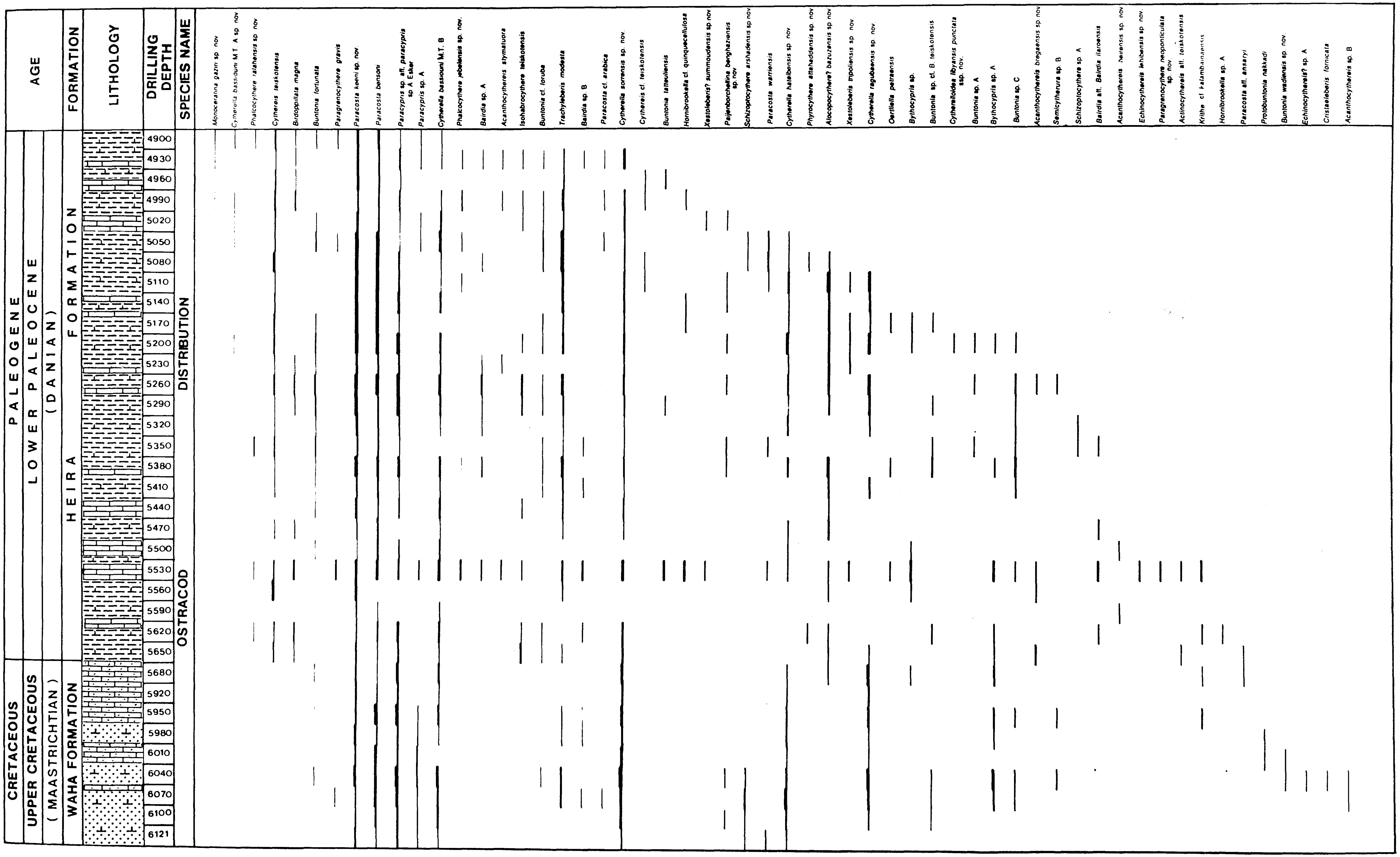

Table 6-3 Ostracod distribution in well E46-20.

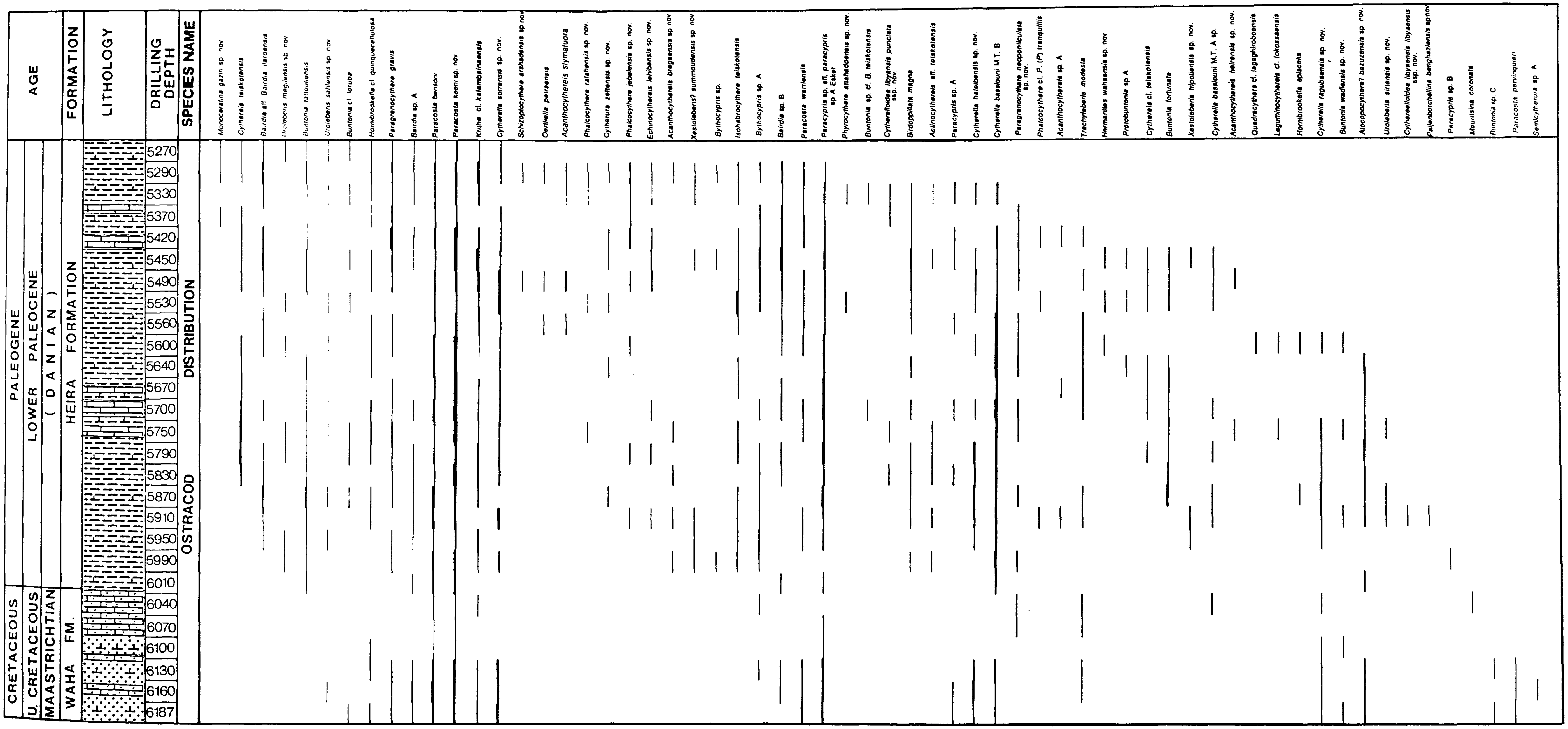

Table 6-4 Ostracod distribution in well E57-20.

Formation and shows a relationship between the Maastrichtian of Jordan, Egypt, and Libya.

The relationship between Tunisia, Egypt, and Libya is further demonstrated by the presence of *Protobuntonia nakkadii* Bassiouni which is known from the Middle Maastrichtian and Middle Paleocene (*angulata* Zone) of Egypt, the Late Maastrichtian and the whole of the Paleocene of Tunisia, and in the Maastrichtian of Libya. *Paracosta pervinquieri* (Donze & Said) is known from the latest Maastrichtian to the Early Danian of Tunisia (Donze *et. al.*, 1982), and from the Middle Maastrichtian of Egypt, as well as from the Maastrichtian and Lower Paleocene of Libya.

Mauritisina coronata (Esker) is recorded from the Paleocene to basal Eocene of Jordan (Bassiouni, 1970), Early to Early Late Paleocene of Egypt (Boukhary *et. al.*, 1982), and Middle Maastrichtian to Early Late Paleocene of Tunisia; in the present study it is known from the Waha Formation (Maastrichtian). *Acanthocythereis* sp B, *Echinocythereis* ? sp A, *Cytherelloidea* sp A, *Buntonia* sp B, *Protobuntonia* sp B, and *Semicytherura* sp A, were only found in the Waha Formation, but most of these occur in low abundance and are also badly preserved.

Most of the common Maastrichtian species are reported from north Africa and the Middle East rather than from west Africa, although there are some species which are common in the Maastrichtian-Danian and show some relationship with some species studied here; e.g. *Paracosta warriensis* (Reyment) is known from the Upper Maastrichtian to the Upper Paleocene of Nigeria as well as of Libya.

PALEOCENE

Only the highest occurrence of a species in a well can be considered with confidence as all lower records may be due to contamination. *Paracosta pervinquieri* it is the most important species recorded here. It ranges from the latest Maastrichtian (*mayaroensis* zone) to the Early Danian (*engubina* zone) of Tunisia (Donze *et al.* 1982). In Egypt it is recorded from the Middle Maastrichtian. In the present study it is recorded from the Waha and Heira Formations. The occurrence of this species in the Early Danian of El-Kef in Tunisia suggests that the Heira Formation is more likely to be Early Danian in age.

As is clear from Table 6-1 the Paleocene ostracod species can be used as stratigraphic markers for the investigated time span. *Isohabrocythere teiskotensis* Apostolescu is the only species located in the present study which appears at the same horizon in the three studied wells. It has been reported from the Late Paleocene of NW Nigeria, Dahomey - Togo, Mali, Libya, and from the Late Paleocene to the base of the Eocene of Egypt; in the present study it occurs in the Heira Formation (Paleocene).

A relationship to Saudi Arabia is demonstrated by the presence of two common species from the uppermost Maastrichtian to Lower Paleocene. These are *Paragrenocythere gravis* Al-Furaih and *Hornibrookella episcelis* Al-Furaih *Paragrenocythere gravis* is also recorded from the Campanian to Maastrichtian of Oman (Athersuch, 1988). *Acanthocythereis stymatuora* Al-Furaih is restricted to the Lower Paleocene of Saudi Arabia, and also of Libya. The presence of these species in Libya suggests that the Saudi Arabian Fauna is widespread in some areas of northern Africa. Moreover, there are some similarities at the generic level between the Saudi Arabia fauna and west Africa.

The lack of species common to Saudi Arabia and other Middle Eastern countries may be due to the absence of the whole or of part of the Lower Paleocene in those countries. Many authors have recognized two faunal breaks in the Paleocene of the Middle East using planktonic foraminiferal zones. These breaks were recorded from Egypt by El-Naggar (1966) at the Cretaceous-Paleocene boundary. In the Tell-Burma section, Jordan (Futyan, M.S 1968), this break also occurs at the Cretaceous-Paleocene boundary but was slightly shorter in duration than the Egyptian break. In Iraq the entire Lower Paleocene and the lowest part of the Middle Paleocene is absent. The second faunal break is well recognized in the Middle to Upper Paleocene of southern Jordan by Futyan (M.S. 1968); and most of the Lower and Middle Paleocene of Egypt is absent (Bassiouni & Luger, 1990). This may account for the lack of species in common between Saudi Arabia and Egypt.

Although there is a complete succession through the Maastrichtian-Danian boundary in the El-Kef section in Tunisia, no common species have so far been found in common between Saudi Arabia and Tunisia. That may be due to the type of depositional environment, i.e. Al-Furaih (1980) suggested that the Upper Cretaceous and Lower Tertiary ostracods of the Aruma and Umm er Radhuma Formations were deposited in a shallow water environment, while the depositional environment of the El-Kef section of Tunisia, according to Donze *et al.* (1982), is middle slope (Maastrichtian) to upper slope or outer shelf (Late Paleocene and Early Eocene).

The presence of *Paracosta bensoni* (Damotte & Donze) in the Waha Formation may be due to well contamination. This species was found by Donze *et. al.* (1982) in the Thanetian of the El-Kef section in Tunisia and by Barsotti (1963), and Salahi (1966) in the Late Paleocene of Libya. Bassiouni & Luger (1990) figured *Paracosta bensoni* as a new genus, *Reymenticosta bensoni*, from the Late Paleocene of Egypt.

Cythereis teiskotensis is a characteristic Paleocene species. It is recorded from the Late Paleocene of Mali (Apostolescu, 1961), Late Paleocene of NW Nigeria (Reyment, 1963), and the Late Paleocene of Libya (Barsotti, 1963); in this study it occurs just at the base of the Heira Formation in wells E12-20, and E46-20, and in the lower part of the same formation in well E57-20. The relationship to west Africa is demonstrated by the presence of

Buntonia tatteuliensis (Apostolescu), which is recorded from the Late Paleocene of NW Nigeria, Mali, and Libya. In Egypt it is known from the Late Paleocene to the base? of Eocene (Bassiouni & Luger, 1990).

Bairdopillata magna (Alexander) is recorded from the Late Paleocene of Libya (Barsotti, 1963); in this study it is recorded from the Heira Formation (Paleocene) in the Raguba Field. *Oertliella petraensis* is known from the Danian of Jordan (Al-Sheikhly, 1980), in this study it is recorded from the Heira Formation (Paleocene).

CHAPTER SEVEN

PALAEOECOLOGY

The interpretation of the material recorded from the three wells in this study is difficult because of contamination, so it is not possible to study details of palaeoecology although it is possible to consider some general points. If the whole fauna is considered (Fig. 7-1) it is very clear that the dominant members are species of the genera *Paracosta, Cytherella,* and *Paracypris*. Within *Paracosta* two species, *Paracosta bensoni* (Damotte and Donze), and *Paracosta keeni* sp nov. form 90% of the total. *Paracosta bensoni* is only recorded from the Late Paleocene and Early Eocene elsewhere, suggesting that much of the material examined is contaminated from higher levels in the wells. Bassiouni & Luger (1990) placed this species in their shallowest biofacies, the Afro-Tethyan Type, indicative of inner - middle shelf depths; Donze *et al.* (1982) recorded it from their outer shelf assemblage, but they did not study shallower water facies. *Cytherella bassiouni* sp nov. is the commonest species of *Cytherella* and has been recorded as *Cytherella piacabucuensis* by Bassiouni & Luger (1990) and placed in their South Tethyan Type, interpreted as outer shelf. None of the *Paracypris* species can be placed into described taxa, but in general, similar species have been interpreted as mid to outer shelf to bathyal. *Bairdia iloraensis* (present here as *B.* aff. *iloraensis*, and representing the most abundant *Bairdia* species) is part of Bassiouni & Luger's shallow water Afro-Tethyan Type. *Krithe kalambainaensis* is the only *Krithe* species present, recorded here as *K.* cf. *kalambainaensis*; Bassiouni & Luger placed this in their Afro-Tethyan Type, indicating inner - middle shelf depths. It is interesting to note that the deep water (outer shelf - bathyal) species of *Krithe*, which are common in the Maastrichtian - Paleocene sediments in Tunisia (Esker, 1968; Donze *et al.*, 1982), are absent from these Libyan wells. Overall, this evidence suggests a shelf area, probably mid- shelf. In terms of water depth this would be infralittoral, probably deeper infralittoral.

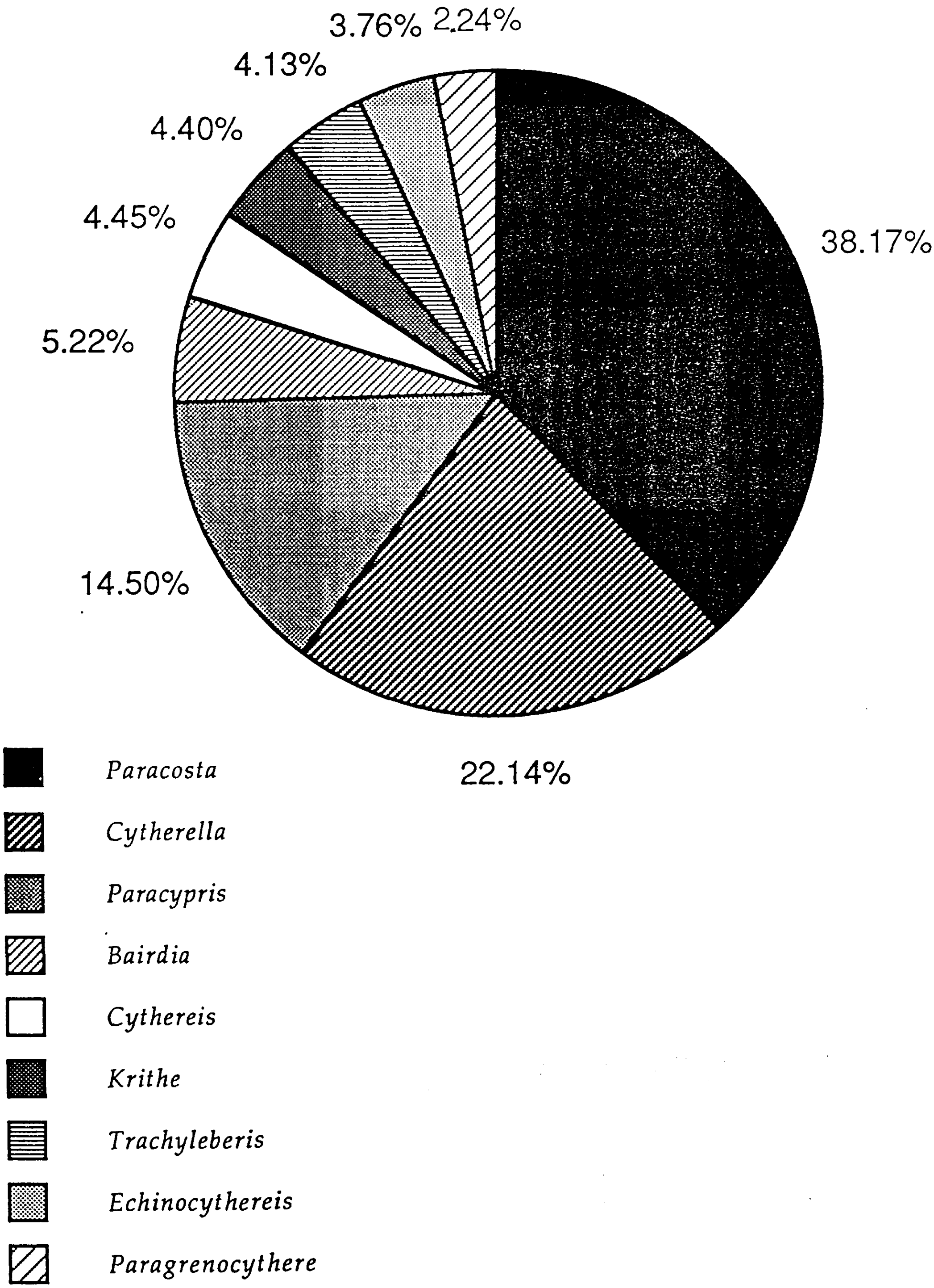

Fig. 7-1 Percentage composition of important ostracod taxa in the samples studied.

The original environmental terms of authors are retained in the following section, i.e. inner, mid, and outer shelf, bathyal etc.

Bassiouni & Luger (1990) have described ostracod faunas from Egypt, where they have defined four main biofacies, basing their interpretation on the accompanying foraminiferal faunas:

1: South Tethyan Type (Early to Early Late Paleocene)

The sediment is dominantly calcareous clay and more rarely calcareous marl, and is taken to indicate outer shelf environments. Most of the species occurring here are known from other localities in the Mediterranean southern Tethys. The species found in common with the Libyan material are *Mauritisina coronata* (Esker) recorded here from the Waha Formation, and *Cytherella piacabucuensis* (as *Cytherella bassiouni* sp. nov. in this study) found in the Waha and Heira Formations. *Bairdia* aff. *Bairdia ilaroensis* Reyment & Reyment is recorded from the Heira Formation. However many of the widely distributed species of this biofacies are absent from the Libyan material.

2: Esna Type (Late Late Paleocene to basal Eocene)

This takes its name from the Esna Formation of Egypt, and indicates outer to middle shelf. The lithology is exclusively calcareous claystone. Most of the species are unknown from other localities, with the exception of *Cytherella bassiouni* sp. nov.

3: Garra Type (Late Late Paleocene)

This is named after the Garra Formation of Egypt and is composed of calcareous marls, indicating middle shelf environments. Most of the species occurring here are local; *Trachyleberis modesta* (Apostolescu), *Isohabrocythere teiskotensis* Apostolescu, and *Cytherella bassiouni* sp. nov. are found in common with Libya.

4: Afro-Tethyan Type (Late Paleocene to Early Eocene)

The species occuring in this biofacies are mostly well known from other localities in northern and west Africa. The lithology in Egypt is calcareous marl, and indicates the shallowest of the four biofacies. Species found in common with Libya are *Trachyleberis modesta* (Apostolescu), *Cytherella bassiouni* sp. nov., *Buntonia tatteuliensis* (Apostolescu) and *Paracosta bensoni* (Damotte & Donze) found in the Waha and Heira Formations, and *Isohabrocythere teiskotensis* Apostolescu, found in the Heira Formation. Related species found in this study are *Leguminocythereis* cf. *lokossaensis* Apostolescu, *Bairdia* aff. *Bairdia ilaroensis* Reyment & Reyment, and *Paracypris* sp. B.

Several widespread species were recognized by Bassiouni & Luger (1990) from Egypt with inner and inner - mid shelf depth ranges: *Isohabrocythere teiskotensis* Apostolescu, *Buntonia tatteulensis* (Apostolescu), *Cristaeleberis fornicata* Bassiouni, *Paracypris? nigeriensis* (Reyment), *Krithe kalambainaensis* (Reyment), *Oertliella vesiculosa* (Apostolescu), *Mauritsina teiskotensis* (Apostolescu), *Phalcocythere cultrata* (Apostolescu), and *Paracosta bensoni* (Damotte & Donze). *Acanthocythereis stymatuora* Al-Furaih, *Paragrenocythere gravis* Al-Furaih and *Hornibrookella episcelis* Al-Furaih are found in Saudi Arabia in shallow marine environment.

Donze *et al.* (1982) studied the ostracod fauna in the El-Kef section in Tunisia and recognized the depositional environment as upper bathyal in the Late Cretaceous, shallowing to the outer shelf in the latest Cretaceous, deepening to upper bathyal in the Paleocene, with shallowing again in the

Late Paleocene and Early Eocene to outer shelf conditions. The upper bathyal environment was characterised by smooth genera such as *Cytherella, Krithe, Bairdia, Macrocypris* and *Argilloecia*. Additional species belonging to the superfamily Cythereacea have well developed ocular structures and were interpreted as suggesting water depths of 400-500m. Analysis of the genera *Krithe* and *Parakrithe* in the El-Kef section suggest a strong oxygen minimum zone at the top of the Maastrichtian. Maastrichtian species which are regarded as upper bathyal are *Cristaeleberis thomasi* Donze & Said, *Acanthocythereis? meslei* Donze & Oertli, *Megammatocythere praecursor* Colin & Oertli, *Aphrikanocythere phumatoides* Damotte & Oertli, and *Kefella maresi* Donze & Said. The Paleocene species range from upper bathyal to outer shelf, and include *Paracosta pervinquieri* (Donze & Said) found in this study from the Waha and Heira Formations, and *Protobuntonia nakkadii* Bassiouni recorded here from the Waha Formation. Outer shelf species were recorded by Donze *et al.* (1982) from the Thanetian of the El-Kef section are *Megommatocythere hariaensis* Colin & Oertli, *Paracosta kefensis* (Benson), *Paracosta bensoni* (Damotte & Donze), *Paracosta* cf. *mokattamensis* (Bassiouni), and *Soudanella laciniosa triangulata* Apostolescu.

In summary, taking the fauna as a whole, the evidence is strongly suggestive of shallower water than in Tunisia, probably infralittoral in depth. The presence of some deeper water species, e.g. the common *Cytherella piacabucuensis* and the rare *Paracosta pervinquieri* indicate deeper, outer shelf conditions. It is likely that the environment fluctuated between these two, although it was dominantly infralittoral. The Heira Formation in the three wells studied here is a predominantly shale sequence, with some prominent limestone members in the upper half (Fig. 4-4). Within the shales there is evidence of thin limestone beds. The shales are usually interpreted as "deeper" water, the limestones as "shallower", suggesting fluctuating sea levels. The two faunal elements may be a reflection of this. Very few taxa are restricted to the Waha Formation, and most of the ostracods from Waha levels are probably contaminants, so it is not possible to give separate palaeclogical conclusions for this Formation.

CHAPTER EIGHT

PALAEOBIOGEOGRAPHY

North Africa formed the southern shore of western Tethys during the Late Cretaceous and Paleogene, and many ostracod species have been reported to range along this southern margin and define a south Tethyan Province. This fauna has much in common with areas further to the east and also with west Africa via "Trans-Saharan Seaway". However, this picture is dependent upon accurate species determination, and as seen in the systematic section there is not always agreement in this area. Accurate age determinations are obviously important when comparing faunas from widely separated regions, and the presence of several widely developed unconformities has to be taken in to account when discussing species distributions, i.e. absence may be as much to do with sedimentary hiatus as with original distribution. A brief review of the Late Cretaceous - Paleocene faunas from this region will be given before the general discussion.

Libya

Three studies have been published on the Paleocene ostracods of Libya. The first data were presented by Barsotti (1963), who studied the Paleocene ostracods of the El-Fogaha region to the west of the Jabel El-Haroudj on Fig. 4-2 (approx. coord. 27 49'N, 16 35'E) and well A1-85, located in the El Haleigh zone (coord. 27 52' 00"N, 18 06' 46"E). He described 23 species and reported that 20 of these commonly occur in the west African basins of Senegal, Ivory coast, Dahome-Togo and the Sudan District of Mali. He divided the El-Fogaha series into two intervals: the lower interval consists of marly-clays with interbedded marly limestones and bioclastic limestones; the upper interval is more carbonitic with bioclastic limestones, marly limestones, sometimes dolomitic and gypsiferous, marls and intercalations of clay. Abundant microfossils occur only in the lower interval. This is in agreement with the vertical distribution of the microfauna (foraminifera) in the columnar section given by Haynes (1962).

In the A1-85 well the microfaunas studied were in a marly calcareous interval.

Barsotti recorded an association of *Dahomeya alata,* and *Leguminocythereis lokossaensis* at the top of the Paleocene interval in the A1-85 well which matches the occurrence of these species in the coastal basins of Dahomey-Togo and Ivory Coast (upper part of the Paleocene and Lower Eocene) (after Apostolescu, 1961).

The following species are formed in common between the faunas studied by Barsotti and the faunas described here from the Raguba Field: *Bairdoppilata magna, Isohabrocythere teiskotensis, Actinocythereis teiskotensis, Buntonian tatteuliensis, Paracosta bensoni, Leguminocythereis lokossaensis?, Cythereis teiskotensis,* and *Buntonia virgulata.*

The second publication is that of Salahi (1966) who illustrated and described the fauna from Well C3-6 (coord. 28 51' 57"N , 19 50' 54"E) in the Esso Zelten in the Sirte Basin. He recorded 60 species from the Upper Cretaceous, Paleocene, Eocene and Oligocene. These included 45 new species although these were not formally named.

The Maastrichtian is 200 ft. thick, and the top 60 ft. was described as being potentially rich in ostracods, with the two most common species being *Buntonia (Protobuntonia)* cf. *B. (P.) numidica* and *Leguminocythereis exigua.*

The Paleocene is 1000 ft. thick, and is characterized by an extremely rich ostracod fauna, both in terms of numbers of individuals and of species. The following species are typical of this horizon: *Buntonia (Buntonia) bopaensis, Buntonia (Buntonia) virgulata, Buntonia (Buntonia)* n.sp.2, *Buntonia (protobuntonia)* n.sp.1, *Costa dahomeyi, Acanthocythereis?* n.sp. 2, *Cythereis teiskotensis, Quadracythere?* n.sp.1, *Xestoleberis* n. sp.3 and *Bradleya* aff. *B. cultrata.*

The third publication is that of Reyment & Reyment (1980) who recorded 10 species from the Paleocene of Well A5-32 drilled by the Al Waha Oil Company in the Sirte Basin. These species are: *Isohabrocythere teiskotensis* Apostolescu, *Buntonia (Protobuntonia) ioruba* Reyment, *Leguminocythereis lagaghirobonsis* Apostolescu, *Buntonia tatteulensis* (Apostolescu), *Anticythereis bopaensis* Apostolescu, *Cythereis teiskotensis* (Apostolescu), *Paracosta warriensis* Reyment, *Trachyleberis teiskotensis* (Apostolescu), and *Bradleya? praecrassa* (Apostolescu). Most of these species are recorded in the present study.

Tunisia

A relationship with Tunisia is seen by the occurrence of several common Maastrichtian and Paleocene species reported by Esker (1968), Said (1978), and Donze *et al.* (1982). Two common species found by Esker (1968) from the Danian part of the Zebbeus Formation near the El-Kef section, are *Cythereis coronata,* and *Costa? warriensis,* where the former has been reported here from the Maastrichtian and the latter is found in the Maastrichtian and Paleocene. Esker also illustrated *Paracypris* sp A which is similar to the species recorded in this study as *Paracypris* sp aff. *Paracypris* sp A Esker.

Esker believed his faunas were more closely related to northern European Late Maastrichtian faunas than to those previously described from Africa and suggested that there may have been a marine connection between the North Sea Basin and Tethys during the Danian.

Donze *et al.* (1982) studied the ostracod faunas from the Late Campanian to Ypresian in the El-Kef section in north western Tunisia. They recognized that several species range through the Cretaceous-Tertiary boundary, and the Danian is characterized by the explosion of the genus *Paleocosta,* which in this study is referred to *Paracosta,* whose first representative appears at the top of the Maastrichtian. They suggested that the sedimentary environment of the El-Kef section was gradually shallowing, attributed to the middle slope (Maastrichtian) to upper slope or outer shelf (Late Paleocene and Early Eocene).

The species common to Donze *et al.* (1982) and Libya are *Paracosta bensoni* (Damotte & Donze), *Mauritsina coronata* (Esker), *Protobuntonia nakkadii* Bassiouni, and *Paracosta pervinquieri* (Donze & Said). As is clear from Table 8-1, a large number of ostracod species are common to Egypt and Tunisia, and many of these have not been reported so far from Libya. Part of the explanation for there absences in Libya is to be found in facies differences (chapter 7), and part is due to the detailed work by Donze *et al.* (1982) in Tunisia and Bassiouni & Luger (1990) in Egypt with no corresponding work for Libya. Most of these species are from the Paleocene and Early Eocene; *Paracosta pervinquieri* and *Protobuntonia nakkadii* are from the Late Maastrichtian - Paleocene.

There are great similarities between the assemblages of Tunisia and Libya in generic composition across the Maastrichtian-Danian boundary, expressed by the common occurrence of *Cytherella* spp., *Bairdia* spp., *Krithe* spp., *Xestoleberis* spp., *Acanthocythereis* spp., *Actinocythereis* spp., *Paracosta* spp., and *Bythocypris* spp.

Egypt

The ostracod faunas of Egypt described and illustrated by Bassiouni & Luger (1990) from the Maastrichtian to Early Eocene of Egypt show great similarities to those present in this study. Bassiouni and Luger suggests four types of ostracod association represented different environments (for details see Bassiouni & Luger 1990 p. 852 and previous section). The previously described species found in common with Egypt in the Maastrichtian are *Paracosta pervinquieri* (Donze & Said), and *Cristaeleberis fornicata*

Bassiouni, in the present study the former is present in the Maastrichtian and Paleocene, the latter only in the Maastrichtian.

Paleocene species in common between the two countries are *Buntonia tatteuliensis, Isohabrocythere teiskotensis* both recorded from the Late Paleocene of Egypt, *Paracosta warriensis* (Upper Paleocene), *Trachyleberis modesta* (Paleocene to basal Eocene), *Paracosta bensoni* (Paleocene), *Cytherella bassiouni* sp nov. (Middle Paleocene to Early Eocene) *Mauritisina coronata* (Early to Late Paleocene), *Protobuntonia nakkadi* (Middle Maastrichtian to Middle Paleocene). Several species from western Africa were found in common with Egypt (Table 8-1).

Jordan

Among the ostracod species reported from Jordan by Bassiouni (1970), three species are found in common with Libya. These are *Mauritsina coronata* (Esker) (Early Paleocene to Early Eocene of Jordan, in the present study it is found in the Maastrichtian) *Protobuntonia nakkadii* Bassiouni (Late Maastrichtian to Middle Paleocene of Jordan, in the present study it is found in the Maastrichtian) and *Cristaeleberis fornicata* has been found in the Maastrichtian in Jordan and Libya. These species are mostly known from other localities in the Mediterranean southern Tethys. *Oertliella petraensis* is the only species found so far from the Danian of Jordan (Al-Sheikhly, 1980), and found in the Heira Formation (Paleocene) in the studied area.

As is clear from Table 8-1, four ostracod species are found in common between Jordan, Tunisia, and Egypt in the Paleocene, these are *Megommatocythere denticulata* (Esker), *Mauritsina jordanica nodoreticulata* Bassiouni, *Reticulina proteros* Bassiouni, and *Soudanella lacinosa triangulata* Apostolescu. There are also some species in common between Jordan and Syria, and some western African localities.

Age / Species name	Maastrichtian Early	Maastrichtian Middle	Maastrichtian Late	Paleocene Early	Paleocene Middle	Paleocene Late	Eocene Early
Megommatocythere denticulata (Esker)	T	T	T	T	T:E	E	
Bairdia ilaroensis Reyment & Reyment	?G?	E			E	'N:E	E
Hornibrookella quinquecellulosa AL-Furaih		?S?		S			
Paragrenocythere ponticulata AL-Furaih		?S?		S			
Leguminocythereis exigua (Apostolescu)		?L?				I	
Buntonia sehouensis Apostolescu		E	D	D		I:M	E
Buntonia (Protobuntonia) ioruba Reyment			N	N	N	N:L	
Paracypris sp A Esker				T			
Krithe echolsae Esker				E	T	T	
Hazelina bulaqensis Bassiouni & Luger				E	T	T	
Mauritsina jordanica nodoreticulata Bassiouni				E		T:J	
Oertliella vesiculosa (Apostolescu)				Se		E:L:M	
Leguminocythereis lagaghiroboensis Apostolescu				E	E	E:L:I	
Cytheropteron lekefense Esker				T	E	E	
Soudanella laciniosa triangulata Apostolescu				Se		T:J	T:J
Paracypris jonesi Bonnema				L	L:E	L:E	E?
Buntonia virgulata Apostolescu				M		L	Se
Paracosta (P) praecrtassireticulata (Bassiouni)				Se:?T?	Sy:Ir		?Sy:Ir? J : P
Reticulina proteros Bassiouni				T:J	E:T:J	E:T:J	T:J
Reticulina lamellata Bassiouni & Luger				T	T:E	T:E	T
Phalcocythere cultrata (Apostolescu)				L	?E?	I:'N:M	E?
Phalcocythere (P) tranquillis Al-Furaih					S		
Quadracythere lagaghiroboensis (Apostolescu)					?I:N:L?		
Paracosta kefensis (Benson)					T	T:E	
Paracosta (Paleocosta) arabica (Bassiouni)					?J:Sy:L:Ir		?Sy:Ir:L?
Bythocypris? gohrbandti Esker					T	T:E	E
Parakrithe kalambainaensis (Reyment)						'N:E	
Actinocythereis teiskotensis Apostolescu						M	
Leguminocythereis frescoeensis Apostolescu						I:L	
Leguminocythereis lokossaensis Apostolescu						I:L	D:E
Buntonia tichittensis Apostolescu						N:N:M:L:E	E
Dahomeya alata alata Apostolescu						I:'N:L:E	Se
Paracosta (Paleocosta) ansaryi (Bassiouni)							J:Sy

'N............NW Nigeria
N............SW Nigeria
Se............Senegal
M............Mali
I................Ivory Coast
D..............Dahomey - Togo
G..............Ghana

L...........Libya
T...........Tunisia
E...........Egypt
S...........Saudi Arabia
J............Jordan
Sy..........Syria
Ir...........Iraq
P............Pakistan

Table 8-1 Paleogeographic distribution of some important west and north African and Middle Eastern ostracod species in the Maastrichtian to Early Eocene.

Iraq

Among the ostracod species reported from Iraq by Al-Sheikhly (1980), and Bashir (1986) none are yet known from the Maastrichtian and Paleocene of Libya and the west African localities. However, that may be due to the absence of the uppermost part of the Upper Maastrichtian (Globotruncana esnenensis Zone), and parts of, or the whole of the Lower Paleocene, as seen in the biostratigraphical work carried out by Futyan (1968), Kassab (1976b) and Yassini (1979) on the Middle East.

Saudi Arabia

Among the ostracod species described from Saudi Arabia by Al-Furaih (1980), a relationship with Libya is demonstrated by the presence of two common species, *Paragrenocythere gravis,* and *Hornibrookella episcelis,* from the Uppermost Maastrichtian to Lower Paleocene. *Paragrenocythere gravis* is also recorded from the Campanian to Maastrichtian of Oman (Athersuch). *Acanthocythereis stymatuora* is the only species linking the Lower Paleocene of Saudi Arabia and Libya, but there are great similarities in the generic composition of Maastrichtian and Paleocene faunas, with the common occurrence of *Acanthocythereis* spp., *Alcopocythere* spp., *Buntonia* spp., *Hermanites* spp., *Hornibrookella* spp., *Nucleolina* spp., *Paragrenocythere* spp., *Phyrocythere* spp., *Semicythurura* spp., and *Uroleberis* spp.

Phalcocythere (*P*) *tranquillis* Al-Furaih recorded from the Lower Paleocene of El-Alat is similar to the species recorded here as *Phalcocythere* cf. *Phalcocythere* (*P*) *tranquillis* from the Paleocene. *Hornibrookella quinquecellulosa* Al-Furaih from the Lower Paleocene of El-Alat and from the Upper Cretaceous of Abqaiq in Saudi Arabia is similar to the species recorded here as *Hornibrookella* cf. *quinquecellulosa* Al-Furaih from the Maastrichtian and Paleocene of the studied section. These two species suggest a relationship between Libya and Saudi Arabia in the Upper Cretaceous and Lower Paleocene. Most of the ostracod species reported from Saudi Arabia by Al-Furiah (1980) are not yet known from Egypt, but this may be due to the absence of lowest Paleocene strata in Egypt.

NW Nigeria

The faunas of north western Nigeria were studied by Reyment (1981) and Foster *et al.* (1983). Reyment (1981) gave important data on the ostracod faunas of the Kalambaina Formation, in the southernmost extension of the Iullemeden Basin in NW Nigeria. The age of this formation is Late Paleocene, and it consists of clayey limestone, shale and marl. Generally it was deposited in a shallow marine environment. The ostracods in common with Libya are *Isohabrocythere teiskotensis* Apostolescu, *Buntonia tatteulensis* (Apostolescu), and *Paracosta (Paracosta) warriensis* (Reyment).

The same formation in NW Nigeria, and the Ewekoro limestone and Imo shale formations of southern Nigeria, were studied by Foster *et al.* (1983). They found that the ostracod faunas from the Kalambaina Formation are of a more Tethyan Type than those of southern Nigeria, although several species were found in common between the two regions. Among the ostracod species found in common with Libya are *Buntonia (Buntonia) fortunata* Apostolescu, *Isohabrocythere teiskotensis* Apostolescu, *Buntonia tatteullensis* (Apostolescu), *Buntonia* cf. *B. teiskotensis* (Apostolescu), and *Trachyleberis modesta* (Apostolescu).

SW Nigeria

The Upper Cretaceous and Lower Paleocene ostracod faunas from southern Nigeria are well documented by Reyment (1960, 1963, and 1966). Species in common with Libya are *Paracosta (Paracosta) warriensis,* known from the Upper Maastrichtian to Upper Paleocene of Nigeria, and in Libya recorded from Maastrichtian to Paleocene; *Cythereis teiskotensis* is restricted to Paleocene in both countries; *Buntonia* (*Buntonia*) *fortunata* is known from the Paleocene of Nigeria, and in this study is recorded from the Maastrichtian and Paleocene. Species found with affinities to the Nigerian species, are *Bairdia* aff. *ilaroensis* Reyment & Reyment, *Quadracythere* cf. *lagahiroboensis* (Apostolescu), and *Protobuntonia* cf. *ioruba* (Reyment).

Bassiouni & Luger (1990) recognised several species from the Middle Paleocene of SW Nigeria in their Egyptian faunas. These are *Bairdia ilaroensis* found in the Maastrichtian and Paleocene, *Paracypris nigeriensis* from Late Paleocene to Early Eocene, and *Brachycythere oguni* from the Maastrichtian of Egypt. Species such as *Soudanella laciniosa triangulata, Leguminocythereis lagaghiroboensis* and *Dahomeya alata anteroglabrata* are known from the Early Paleocene of Nigeria and the Late Paleocene of Egypt.

Western Africa (Mali, Ivory Coast, Dahomey-Togo)

The species in common between Libya and Mali in the Paleocene are *Buntonia tatteuliensis, Isohabrocythere teiskotensis,* and *Cythereis teiskotensis* all known from the Late Paleocene of Mali, and *Trachyleberis modesta* found in the Late Paleocene of Mali is recorded from the Maastrichtian and Paleocene of Libya.

Two species were recorded from the Early Paleocene of Mali and from the Maastrichtian and Middle Paleocene of Egypt (Bassiouni & Luger 1990). These species are *Brachycythere* cf. *oguni* and *Mauritsina teiskotensis teiskotensis*. Three species from Dahomey-Togo were found in common with Libya, these are *Buntonia fortunata* (of Early Paleocene of Sehone, Dahomey), *Paracosta* (*Paracosta*) *warriensis* reported from the Upper Paleocene, and *Isohabrocythere teiskotensis* from the Late Paleocene.

Among the Paleocene ostracods from the Ivory Coast found in Libya are *Buntonia* (*Buntonia*) *fortunata* and *Trachyleberis modesta* recorded from the Late Paleocene. According to Bassiouni & Luger (1990), there are great similarities between the ostracod faunas of Egypt and Ivory Coast.

Discussion

The distribution of the ostracod faunas of the area stretching from west Africa to north Africa and the Middle East has led many authors to suggest a migration route through the epicontinental "Trans-Saharan Seaway" during the Late Cretaceous and Early Tertiary. The evidence for an epicontinental seaway connecting Nigeria and Libya through the Sahara has been given by Barsotti (1963) and Reyment (1966, 1980). Barsotti suggested that the Paleocene ostracod fauna of the Sirte Basin had migrated from the southwest, i.e. Nigeria.

This connection has been confirmed by Fürst (1968, from Desio, 1970), where a palaeogeographic map showing the distribution of the marine Upper Cretaceous and Paleocene formations in central and northern Africa is presented. He indicated only one long narrow seaway in the Paleocene uniting the basin of the upper Niger with Tethys.

Reyment (1966), reported that many of the Nigerian ostracod species are present in the Paleocene of Libya, and chose seven west African Paleocene - Lower Eocene ostracod species for which he considered the data sufficient to postulate migratory directions. He concluded that the Ivory Coast and Nigeria were two centres of dispersal with movement between them in both directions and with migration from these areas towards north Africa via the "Trans-Saharan Seaway" and around the coast of west Africa to Senegal. Generally, Reyment based his conclusion on the great similarities between ostracod, ammonite, and molluscan faunas of west and north Africa during the Late Campanian to Paleocene. Reyment & Reyment (1980) studied some species from the Late Paleocene of the Sirte Basin in Libya, and found the vast majority of the species identical with forms known from the Paleocene of west Africa. He suggested that most of the species in common arrived in the Sirte Basin through the epicontinental "Trans-Saharan Seaway", (for details see Reyment & Reyment, 1980).

Bassiouni & Luger (1990) suggested that there was a shallow marine transcontinental connection between southern Tethys and the Guinean province through Mali and NW Nigeria during the transgression of the Late Paleocene (Reyment and Reyment, 1980). The direction of migration of the epineritic species was believed to be both southward and northward. They also suggested that migration around western Africa was unidirectional, probably related to the direction of sea currents.

The species studied here and found in common with west Africa gives further evidence for the "Trans-Saharan Seaway" (Barsotti, 1963; Reyment, 1963, 1966; and Reyment & Reyment 1980; Berggren, 1974; and Bassiouni & Luger, 1990).

The species found in common between Middle Eastern countries and the Sirte Basin, are *Acanthocythereis stymatuora* Al-Furaih recorded from the Lower Paleocene of Saudi Arabia, *Paragrenocythere gravis* Al-Furaih, and *Hornibrookella episcelis* (Al-Furaih) recorded from the Upper Cretaceous and Lower Paleocene of Saudi Arabia. These probably suggest a migratory route between the two areas. Species such as *Oertlilla petraensis* Al-Sheikhly, *Protobuntonia nakkadii* Bassiouni, *Cristaeleberis fornicata* Bassiouni And *Mauritsina coronata* (Esker) are recorded from Jordan and also probably there was a marine connection between the two areas. Al-Sheikhly (1980, unpublished thesis) mentioned that *Paracosta (Paracosta) arabica* (Bassiouni), known from the Paleocene of Jordan, Paleocene to Middle Eocene of Syria, and northern Iraq, and from the Paleocene to Middle Eocene of Libya has migrated westward from Iraq to Libya.

CHAPTER NINE

CONCLUSION

Twenty five new ostracod species have been recorded in this study from the Waha and Heira Formations in three wells from the central part of the Sirte Basin.

The Heira Formation is considered to have been deposited in a shelf area, probably mid-shelf (infralittoral zone).

In general the previously described species present in this study are part of a widespread southern Mediterranean, western Africa, and Middle Eastern fauna, supporting the palaeobiogeographic distribution pattern described by Barasotti (1963), Reyment (1963, 1966); and Reyment & Reyment (1980), and Berggren (1974) on possible migration routes within Africa and adjacent epicontinental seas.

Part of the ostracod fauna described from Saudi Arabia by Al-Furaih (1980) is widespread in the Sirte Basin. There are also similarities at the generic level with the Saudi Arabian and west African faunas, suggesting migration over a larger region than previously described.

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PLATES

Plate 1

Cytherella ragubaensis sp. nov.

Fig. 1- Left Carapace, HM-A 12751 (Holotype), X 80

Fig. 2- Left Carapace, HM-A 12752, X 80

Fig. 3- Right Carapace, HM-A 12753, X 70

Fig. 4- Left Carapace, HM-A 12754, X 80

Fig. 5- Ventral view, HM-A 12755, X 78

Fig.14- Stereoscopic paired photographs right valve inside view, HM-A12756, X 80

Cytherella hateibensis sp. nov.

Fig. 6- Left carapace, HM-A 12757, X 67.5

Fig. 7- Right carapace, HM-A 12758, X 75

Fig. 8- Right carapace, HM-A 12759, X 67.5

Fig. 15- Ventral carapace, HM-A 12760, X 65

Cytherella bassiouni sp. nov.

Morphotype A

Fig. 9- Left carapace, HM-A 12761, X 80

Fig. 11- Left carapace, HM-A 12762, X 90

Fig. 12- Right carapace, HM-A 12763, X 75

Fig. 13- Left carapace, HM-A 12764, X 75

Fig. 16- Dorsal view, HM-A 12765, X 75

Morphotype B

Fig. 10- Left carapace, HM-A 12766 (Holotype), X 70

Fig.17- Ventral View, HM-A 12767, X 70

PLATE 1

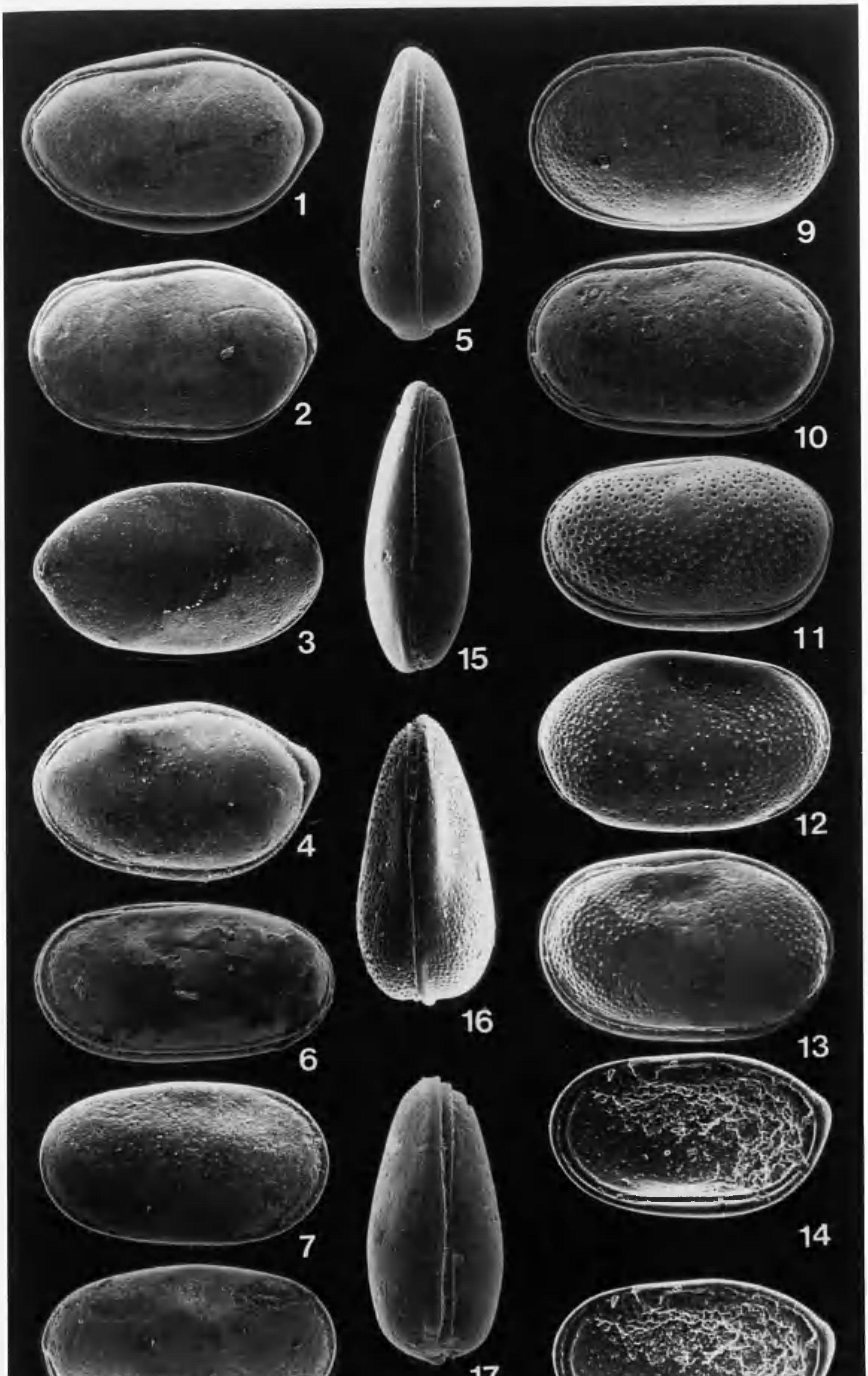

Plate 2

Cytherella sorrensis **sp. nov.**

Fig. 1- Male right carapace, HM-A 12768, X 75

Fig. 2- Male left carapace, HM-A 12769, (Holotype), X 75

Fig. 3- Female right carapace, HM-A 12770, X 100

Fig. 4- Female left carapace, HM-A 12771, X 102.5

Fig. 5- Female dorsal view, HM-A 12772, X 100

Fig. 6- Female ventral view, HM-A 12773, X 100

Fig. 7- Male dorsal view, HM-A 12774, X 80

Fig. 8- Male ventral view, HM-A 12775, X 80

Cytherelloidea libyaensis **sp. nov.**

Cytherelloidea libyaensis libyaensis **subsp. nov.**

Fig. 9- Left carapace, (Holotype), HM-A 12776, X 95

Fig. 10- Right carapace, HM-A 12777, X 82

Fig. 11- Left carapace, HM-A 12778, X 80

Fig. 16- Dorsal view, HM-A 12779, X 95

Cytherelloidea libyaensis punctata **subsp. nov.**

Fig. 12- Stereoscopic paired photographs left carapace, HM-A 12780 (Holotype), X 97.5

Fig. 13- Right carapace, HM-A 12781, X 92.5

Fig. 14- Dorsal view, HM-A 12782, X 95

Fig. 15- ventral view, HM-A 12783, X 95

PLATE 2

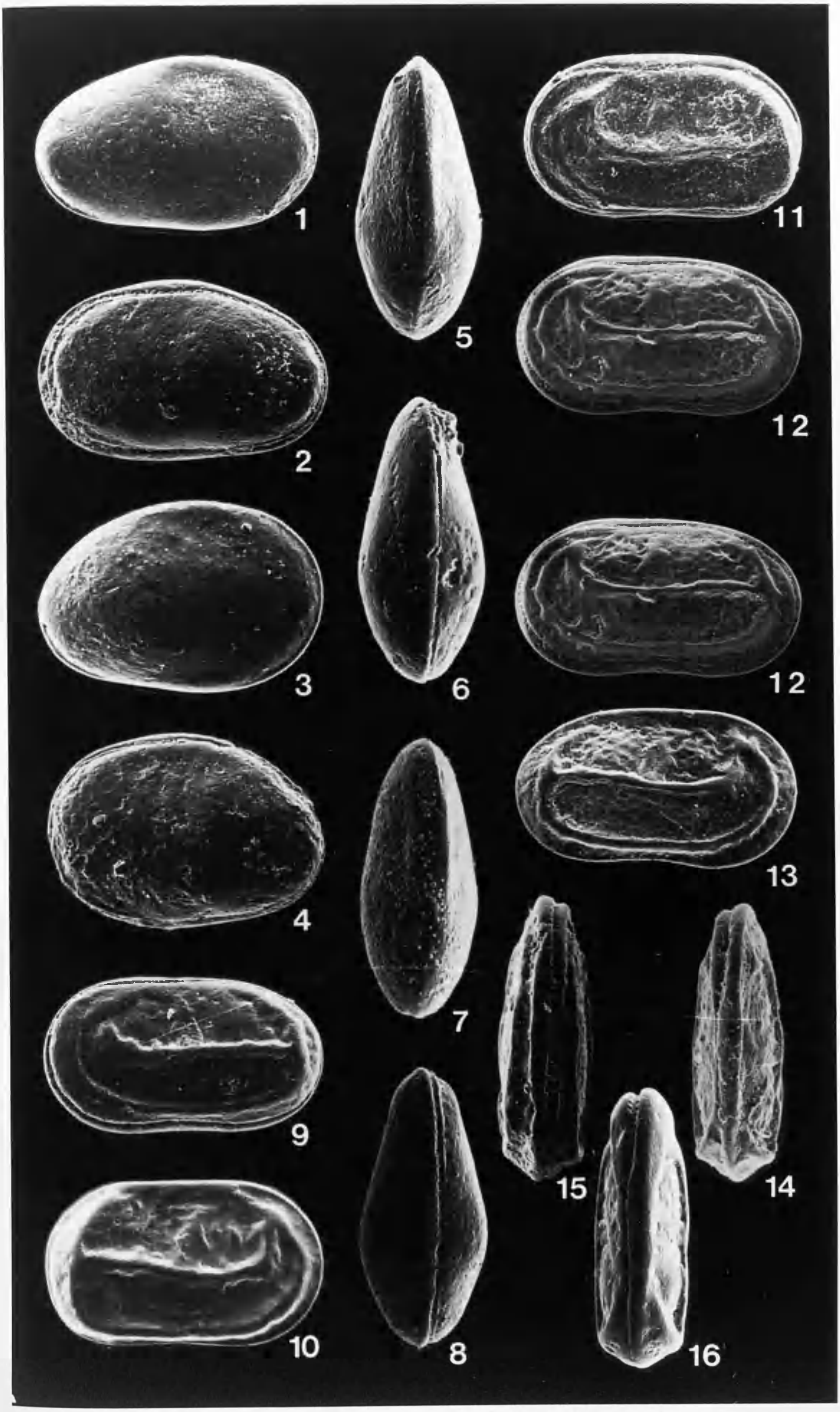

Plate 3

Cytherelloidea sp. A

Fig. 1- Stereoscopic paired photographs left carapace, HM-A 12784, X 80

Fig. 2- Same right carapace.

Fig. 3- Same dorsal view.

Fig. 4- Same ventral view.

Isohabrocythere teiskotensis Apostolescu (1961)

Fig. 5- Stereoscopic paired photographs left carapace, HM-A 12785, X 82.5

Fig. 6- dorsal view, HM-A 12788, X 85

Fig. 7- Ventral view, HM-A 12789, X 85

Fig. 8- Right carapace, HM-A 12786, X 84

Fig. 9- Left carapace, HM-A 12787, X 87.5

Genus cf. *Schizocythere* ? sp.

Fig. 10- Stereoscopic paired photographs right carapace, HM-A 12790, X 105

Fig 11- Same left carapace.

PLATE 3

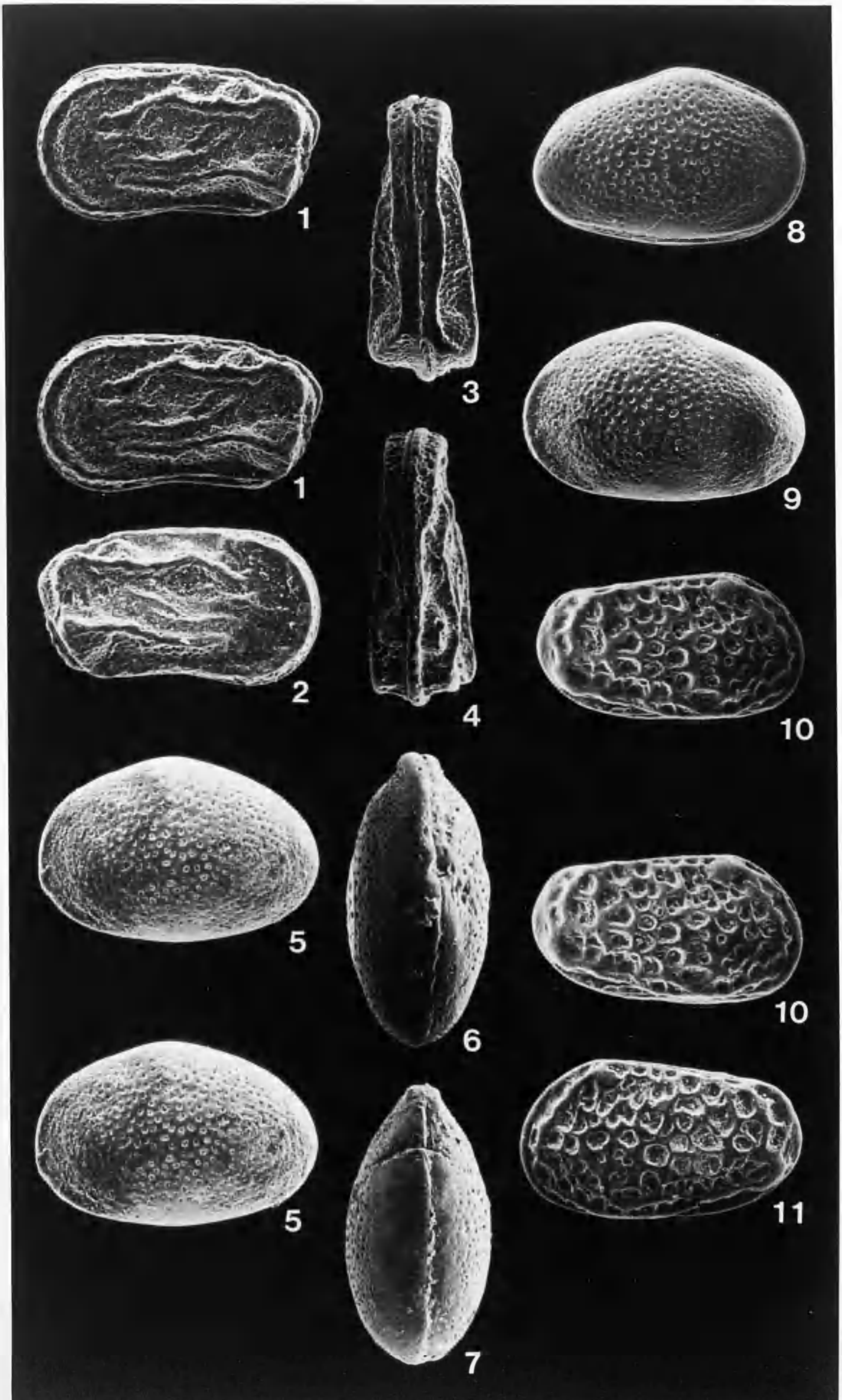

Plate 4

***Bairdia* sp aff. *Bairdia ilaroensis* Reyment & Reyment (1959)**

Fig. 1- Left carapace, HM-A 12791, X 65

Fig. 2- Right carapace, HM-A 12792, X 67.5

Fig. 3- Right carapace, HM- A 12793, X 68

Fig. 4- Dorsal view, HM-A 12794, X 65

Fig. 5- Ventral view, HM-A 12795, X 65

***Bairdia* sp. A**

Fig. 6- Left carapace, HM-A 12796, X 65

Fig. 7- Right carapace, HM-A 12797, X 60

Fig. 8- Left carapace, HM-A 12798, X 85

Fig. 9- Dorsal view, HM-A 12799, X 67.5

Fig. 10- Ventral view, HM-A 12800, X 70

***Bairdia* sp. B**

Fig. 11- Left carapace, HM-A 12801, X 70

Fig. 12- Right carapace, HM-A 12802, X 70

Fig. 13- Right carapace, HM-A 12803, X 70

Fig. 14- Dorsal view, HM-A 12804, X 70

Fig. 15- Ventral view, HM-A 12805, X 70

***Bairdoppilata magna* (Alexander, 1927)**

Fig. 16- Left carapace, HM-A 12806, X 65

Fig. 17- Right carapace, HM-A 12807, X 75

PLATE 4

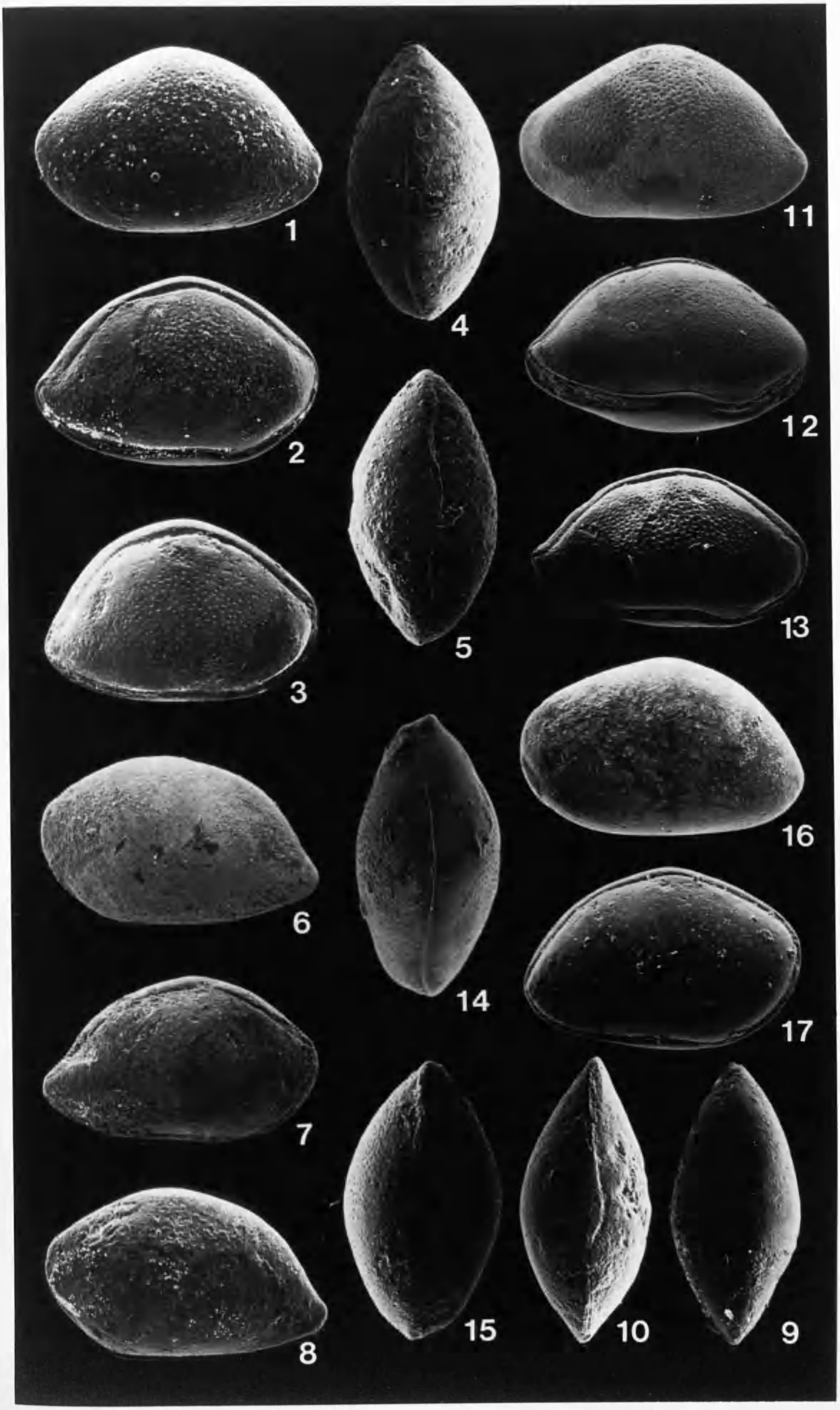

Plate 5

Bythocypris sp. A
Fig. 1- Female left carapace, HM-A 12810, X 72.5

Fig. 2- Female right carapace, HM-A 12811, X 70

Fig. 3- Male left carapace, HM-A 12812, X 75

Fig. 4- Male right carapace, HM-A 12813, X 80

Fig. 5- Male dorsal view, HM-A 12814, X 75

Fig. 6- Female dorsal view, HM-A 12815, X 70

Bythocypris sp.
Fig. 7- Left carapace, HM-A 12816, X 52.5

Fig. 8- Right carapace, HM-A 12817, X 50

Fig. 9- Dorsal view, HM-A 12818, X 50

Fig 10- Ventral view, HM-A 12819, X 50

Paracypris sp. A
Fig. 11- left carapace, HM-A 12820, X 70

Fig. 12- Right carapace, HM-A 12821, X 65

Fig. 13- Ventral view, HM-A 12822, X 65

Fig. 14- Dorsal view, HM-A 12823, X 65

Paracypris aff. *Paracypris* sp. A Esker
Fig. 15- Left carapace, HM-A 12824, X 70

Fig. 16- Right carapace, HM-A 12825, X 70

Fig. 17- Dorsal view, HM-A 12826, X 70

Fig. 18- Ventral view, HM-A 12827, X 70

Bairdoppilata magna (Alexander, 1927)
Fig. 19- Dorsal view, HM-A 12808, X 65

Fig. 20- Ventral view, HM-A 12809, X 65

PLATE 5

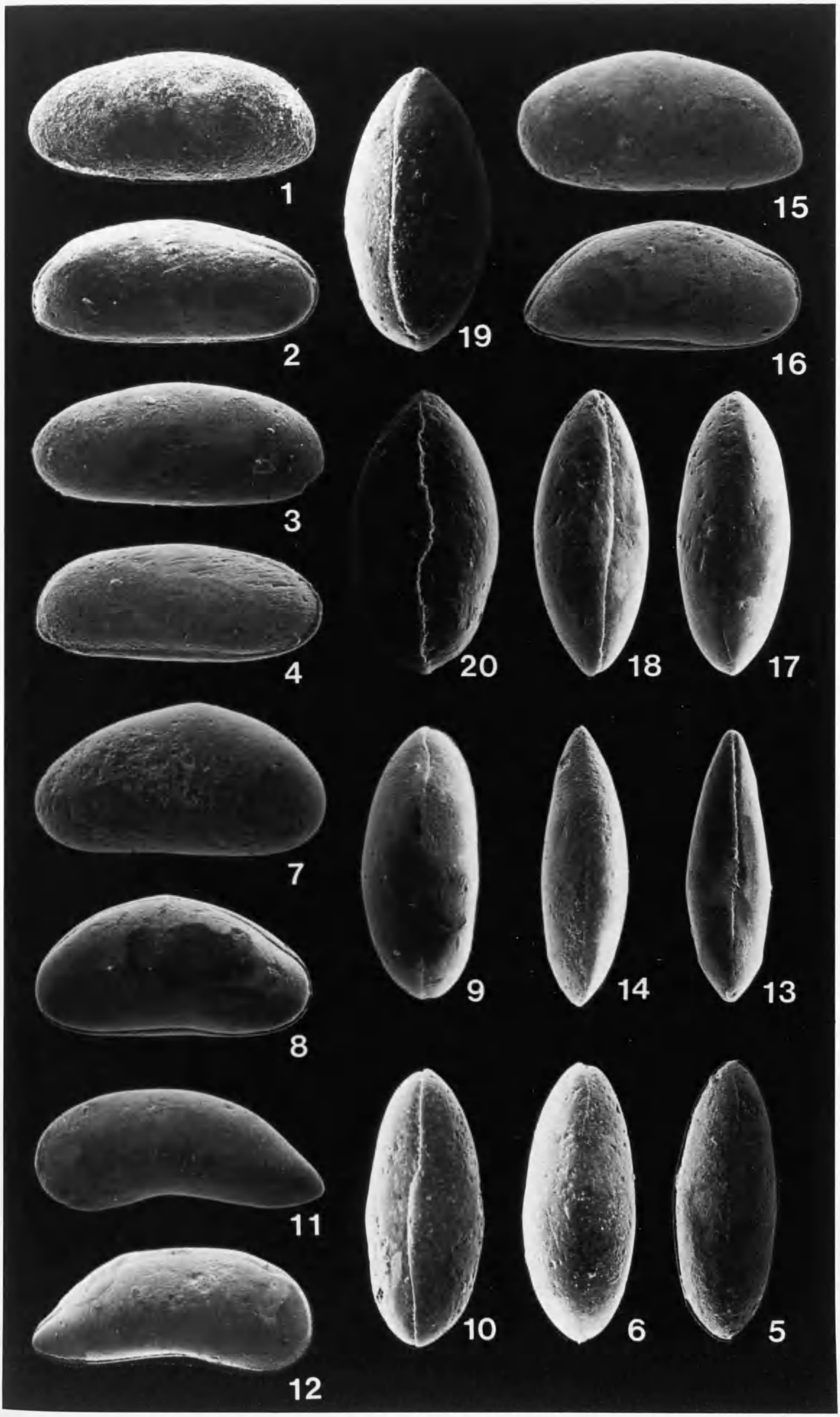

Plate 6

Paracypris **sp. B**

Fig. 1- Right carapace, HM-A 12828, X 95

Fig. 2- Same dorsal view.

Fig. 3- Same left carapace.

Monoceratina gaziri **sp. nov.**

Fig. 4- Female stereoscopic paired photographs right carapace, (Holotype), HM-A 12829, X 75

Fig. 5- Female left carapace, HM-A 12830, X 80

Fig. 6- Male stereoscopic paired photographs right carapace, HM-A12831,X 76

Fig. 7- Male left carapace, HM-A 12832, X 102.5

Fig. 8- Male dorsal view, HM-A 12833, X 105

Fig. 9- Female ventral view, HM-A 12834, X 85

Fig. 10- Female dorsal view, HM-A 12835, X 80

Krithe cf. K. kalambainaensis **(Reyment, 1981)**

Fig. 11- Left carapace, HM-A 12836, X 87.5

Fig. 12- Right carapace, HM-A 12837, X 90

Fig. 13- Dorsal view, HM-A 12838, X 70

Fig. 14- Ventral view, HM-A 12839, X 72.5

PLATE 6

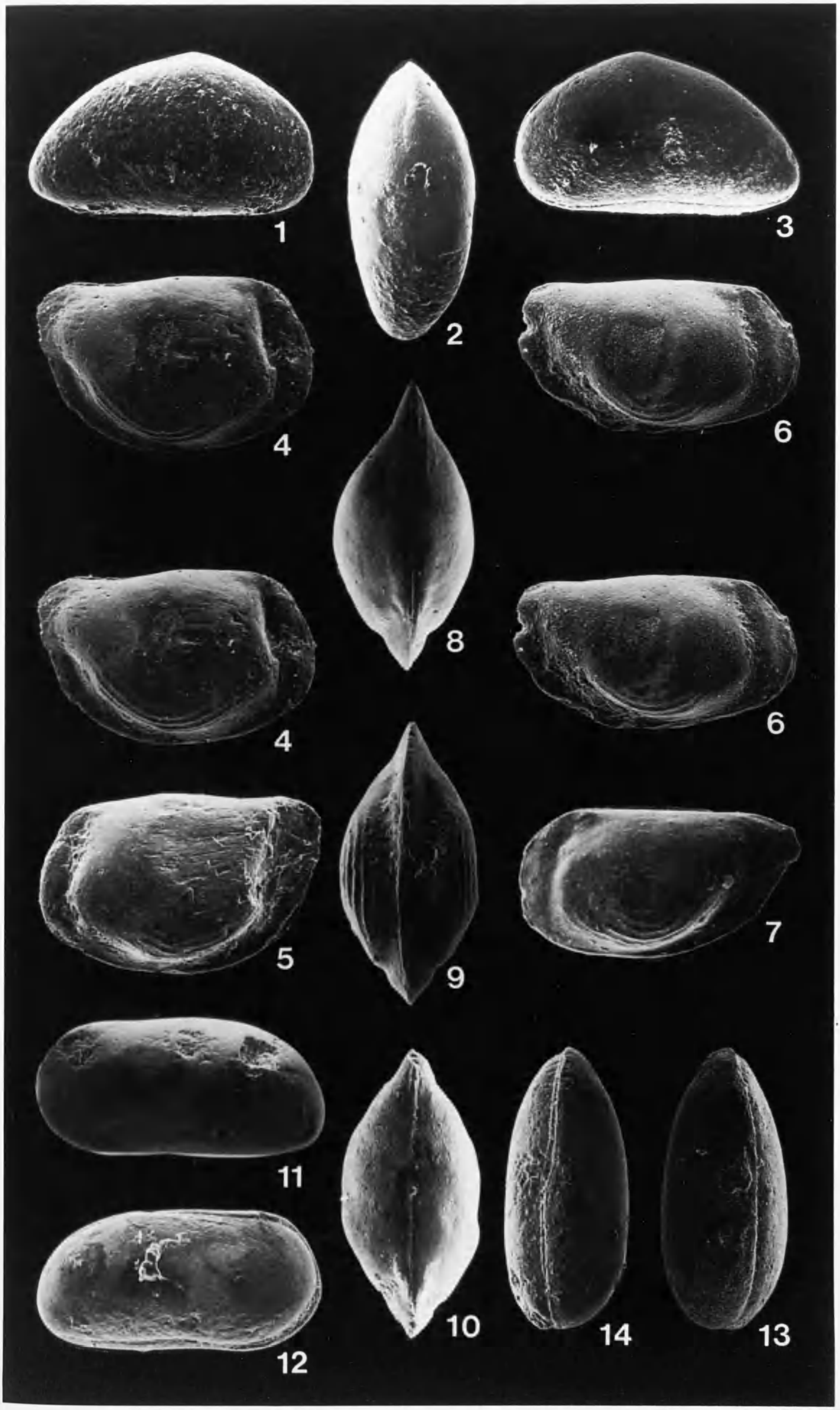

plate 7

Cytherura zeltensis **sp. nov.**

Fig. 1- Male right carapace, HM-A 12840, X 90

Fig. 2- Male left carapace, HM-A 12841, X 90

Fig. 3- Female stereoscopic paired photographs left carapace, (Holotype), HM-A 12842, X 97.5

Fig. 4- Female right carapace, HM-A 12843, X 105

Fig. 5- Female right carapace, HM-A 12844, X 97.5

Fig. 6- Male dorsal view, HM-A 12845, X 82.5

Fig. 7- Male ventral view, HM-A 12846, X 90

Fig. 8- Female dorsal view, HM-A 12847, X 107

Fig. 9- Female ventral view, HM-A 12848, X 105

Paijenborchellina benghaziensis **sp. nov.**

Fig. 10- Male right carapace, HM-A 12849, X 70

Fig. 11- Male left carapace, HM-A 12 850, X 72.5

Fig. 12- Female left carapace, (Holotype), HM-A 12851, X 90

Fig. 13- Female right carapace, HM-A 12852, X 85

Fig. 14- Female left carapace, HM-A 12853, X 77.5

Fig. 15- Male dorsal view, HM-A 12854, X 80

Fig. 16- Female dorsal view, HM-A 12855, X 90

Fig. 17- Male dorsal view, HM-A 12856, X 90

PLATE 7

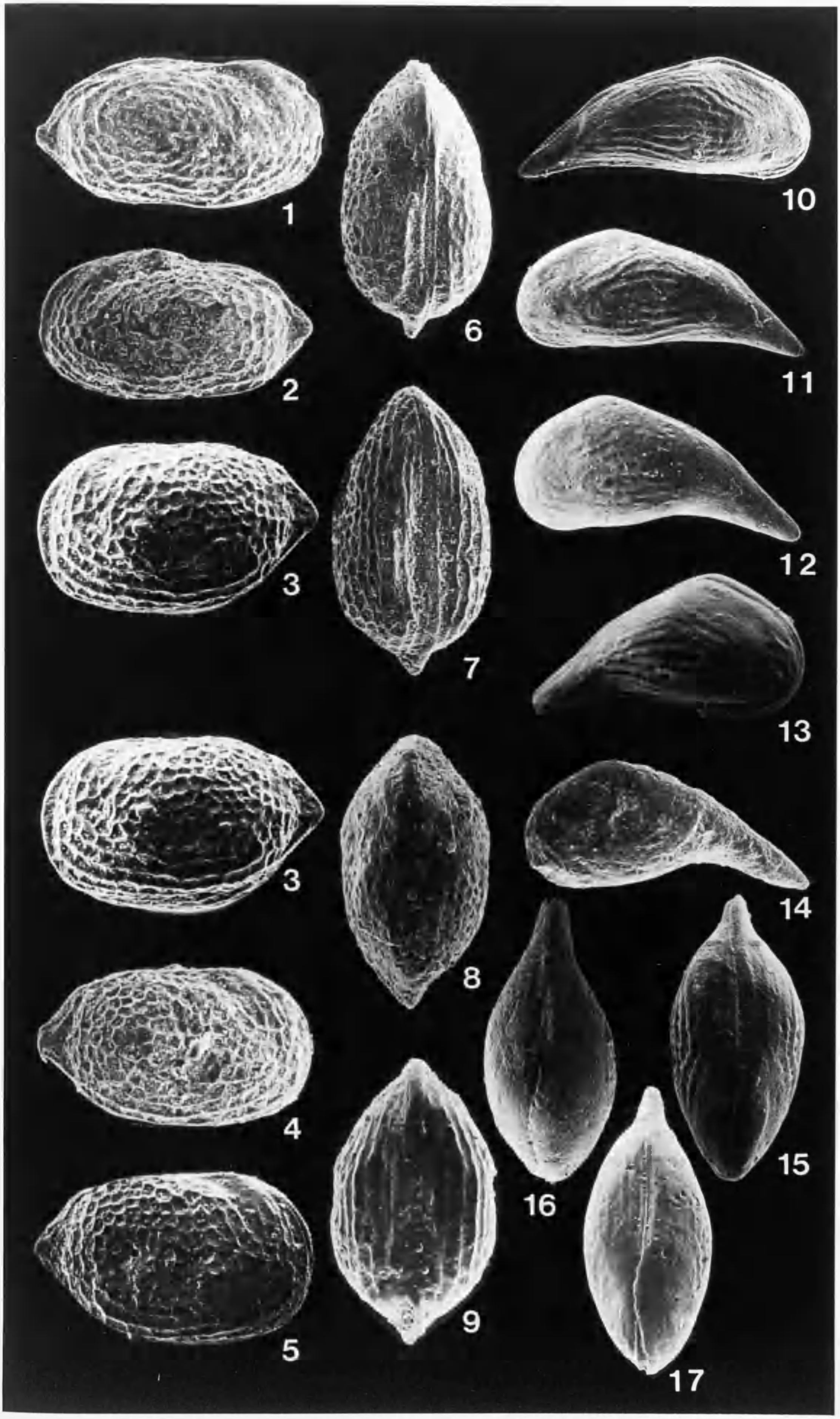

Plate 8

Semicytherura **sp. A**

Fig. 1- Left carapace, HM-A 12857, X 115

Fig. 2- Same right carapace.

Fig. 3- Same right carapace.

Fig. 4- Same dorsal view.

Semicytherura **sp. B**

Fig. 5- Left carapace, HM-A 12858, X 95

Fig. 6- Right carapace, HM-A 12859, X 95

Fig. 7- Dorsal view, HM-A 12860, X 95

Fig. 8- Ventral view, HM-A 12861, X 74.5

Leguminocythereis **cf. *lokossaensis* Apostolescu (1961)**

Fig. 9- Stereoscopic paired photographs right carapace, HM-A 12862, X 70

Fig. 10- Same left carapace.

Fig. 11- Same dorsal view.

Fig. 12- Same ventral view.

Trachyleberis modesta **(Apostolescu, 1961)**

Fig.13- Female stereoscopic paired photographs left carapace, HM-A12863, X 85

Fig. 14- Female right carapace, HM-A 12864, X 85

Fig. 15- Female dorsal view, HM-A 12865, X 80

Fig. 16- Female ventral view, HM-A 12866, X 85

PLATE 8

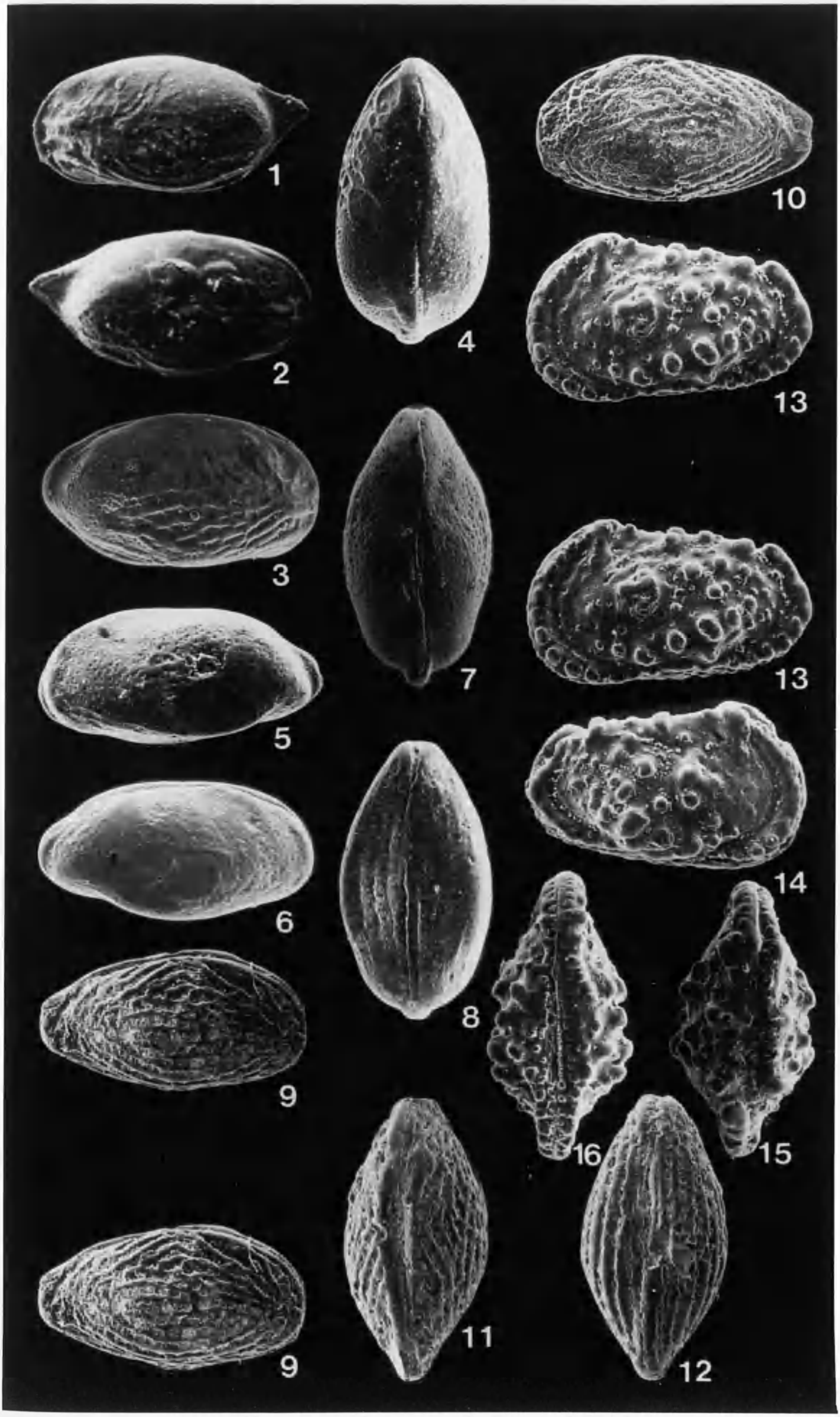

Plate 9

Trachyleberis modesta (Apostolescu, 1961)

Fig. 1- Male left carapace, HM-A 12867, X 65

Fig. 2- Male stereoscopic paired photographs right carapace, HM-A 12868, X 67.5

Fig. 3- Male right carapace, HM-A 12869, X 77.5

Fig. 4- Male dorsal view, HM-A 12870, X 70

Fig. 5- Male ventral view, HM-A 12871, X 70

Actinocythereis aff. *teiskotensis* Apostolescu (1961)

Fig. 6- Female stereoscopic paired photographs left carapace, HM-A 12872, X 75.

Fig. 7- Male right carapace, HM- A 12873, X 70

Fig. 8- Male left carapace, HM-A 12874, X 60

Fig. 9- Female stereoscopic paired photographs left carapace, HM-A 12875, X 80

Fig. 10- Female right carapace, HM-A 12876, X 80

Fig. 11- Female right carapace, HM-A 12877, X 75

Fig. 12- Female left carapace, HM -A 12878, X 78

Fig. 13- Female dorsal view, HM-A 12879, X 60

Fig. 14- Female ventral view, HM-A 12880, X 60

PLATE 9

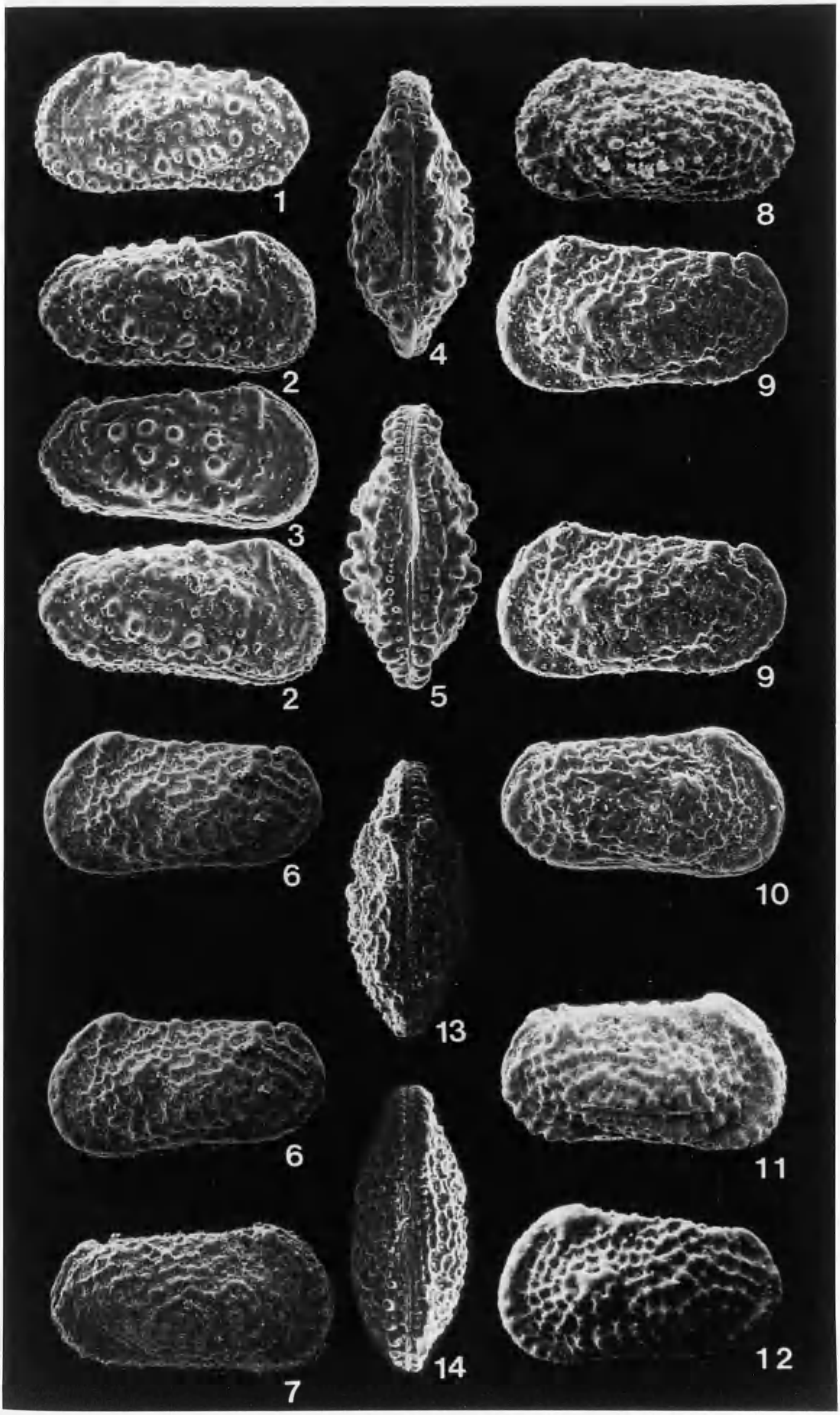

Plate 10

Acanthocythereis heirensis **sp. nov.**

Fig. 1- Stereoscopic paired photographs right carapace, (Holotype), HM-A 12881, X 82.5

Fig. 2- Stereoscopic paired photographs left carapace, HM-A 12882, X 95

Fig. 3- Right carapace, HM-A 12883, X 82.5

Fig. 4- Right carapace, HM-A 12884, X 87.5

Fig. 5- Dorsal view, HM-A 12885, X 92.5

Fig. 6- Ventral view, HM-A 12886, X 80

Acanthocythereis **? sp. A**

Fig. 7- Stereoscopic paired photographs left carapace, HM-A 12887, X 97.5

Fig. 8- Right carapace, HM-A 12888, X 92.5

Fig. 9- Right carapace, HM-A 12889, X 92.5

Fig. 10- Same dorsal view.

Fig. 11- Same ventral view.

Acanthocythereis **sp. B**

Fig. 12- Left carapace, HM-A 12890, X 65

Fig. 13- Right carapace, HM-A 12891, X 62.5

Fig. 14- Left carapace, HM-A 12892, X 60

PLATE 10

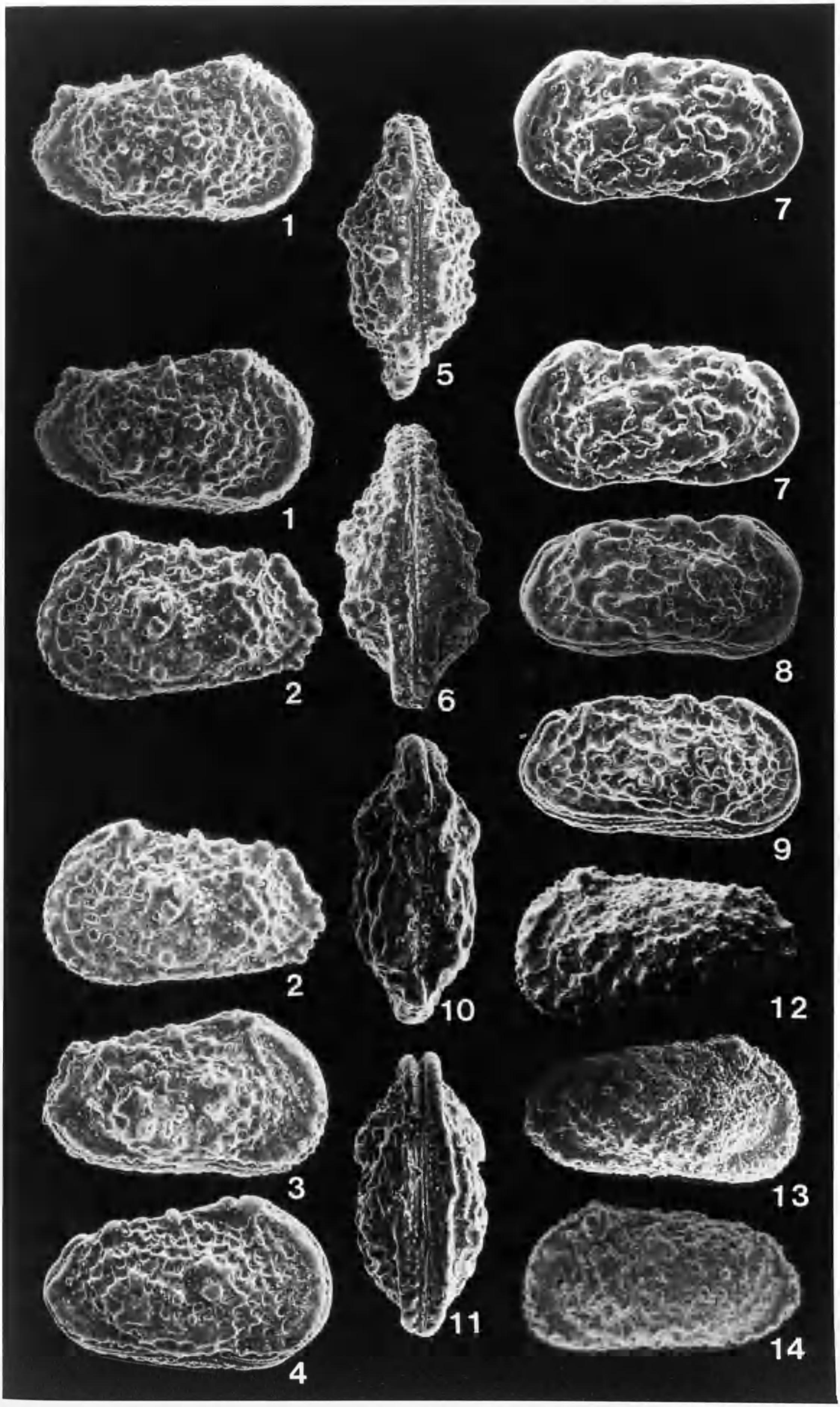

Plate 11

Acanthocythereis sp. B

Fig. 1- Left carapace HM-A 12891.

Acanthocythereis stymatuora Al-Furaih (1980)

Fig. 2- Male stereoscopic paired photographs left carapace, HM-A 12893, X 67.5

Fig. 3- Male stereoscopic paired photographs right carapace, HM-A 12894, X 85

Fig. 4- Male left carapace, HM-A 12895, X 67.5

Fig. 5- Male right carapace, HM-A 12896, X 80

Fig. 6- Male dorsal view, HM-A 12897, X 70

Fig. 7- Male ventral view, HM-A 12898, X 75

Fig. 8- Female dorsal view, HM-A 12899, X 75

Fig. 9- Female ventral view, HM-A 12900, X 82.5

Fig. 10- Female stereoscopic paired photographs left carapace, HM-A 12901, X80

Fig. 11- Female right carapace, HM-A 12902, X 87.5

Fig. 12- Female right carapace, HM-A 12903, X 85

Acanthocythereis bregaensis sp. nov.

Fig. 13- Female stereoscopic paired photographs right carapace, HM-A 12904, X 85

PLATE 11

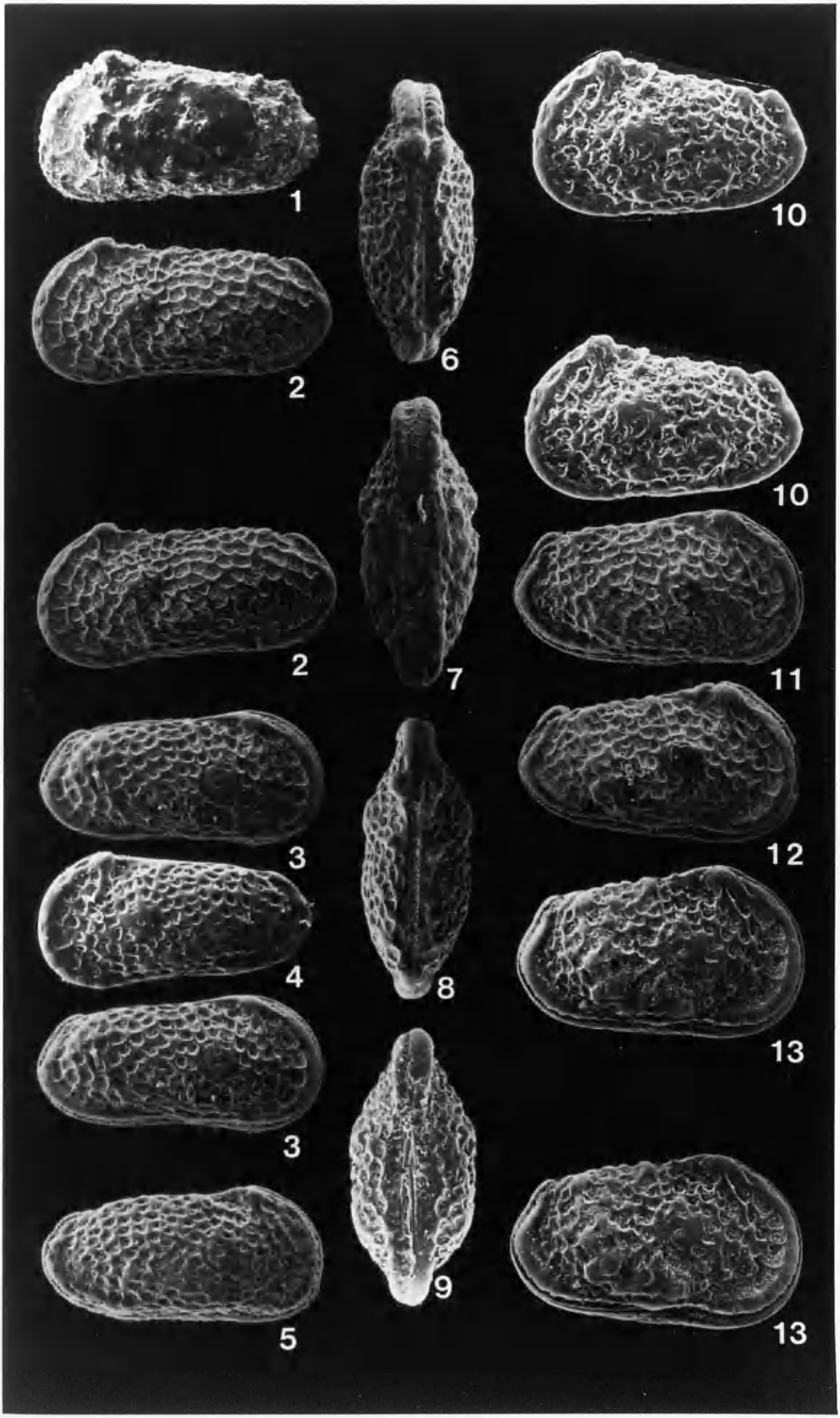

Plate 12

Acanthocythereis bregaensis **sp. nov.**

Fig. 1- Male stereoscopic paired photographs left carapace, (Holotype), HM-A 12905, X 95

Fig. 2- Female right carapace, HM-A 12906, X 97.5

Fig. 3- Male stereoscopic paired photographs left carapace, HM-A 12907, X 112.5

Fig. 4- Male right carapace, HM-A 12908, X 110

Fig. 5- Female dorsal view, HM-A 12909, 92.5

Fig. 6- Male ventral view, HM-A 12910, X 105

Alocopocythere? bazuzensis **sp. nov.**

Fig. 7- Male stereoscopic paired photographs left carapace, HM-A 12911, X 85

Fig. 8- Male stereoscopic paired photographs right carapace, HM-A 12912, X 85

Fig. 9- Female stereoscopic paired photographs left carapace,(Holotype) HM-A 12913, X 107.5

Fig. 10- Female right carapace, HM-A 12914, X 102.5

Fig. 11- Male dorsal view, HM-A 12915, X 85

Fig. 12- Male ventral view, HM-A 12916, X 92.5

PLATE 12

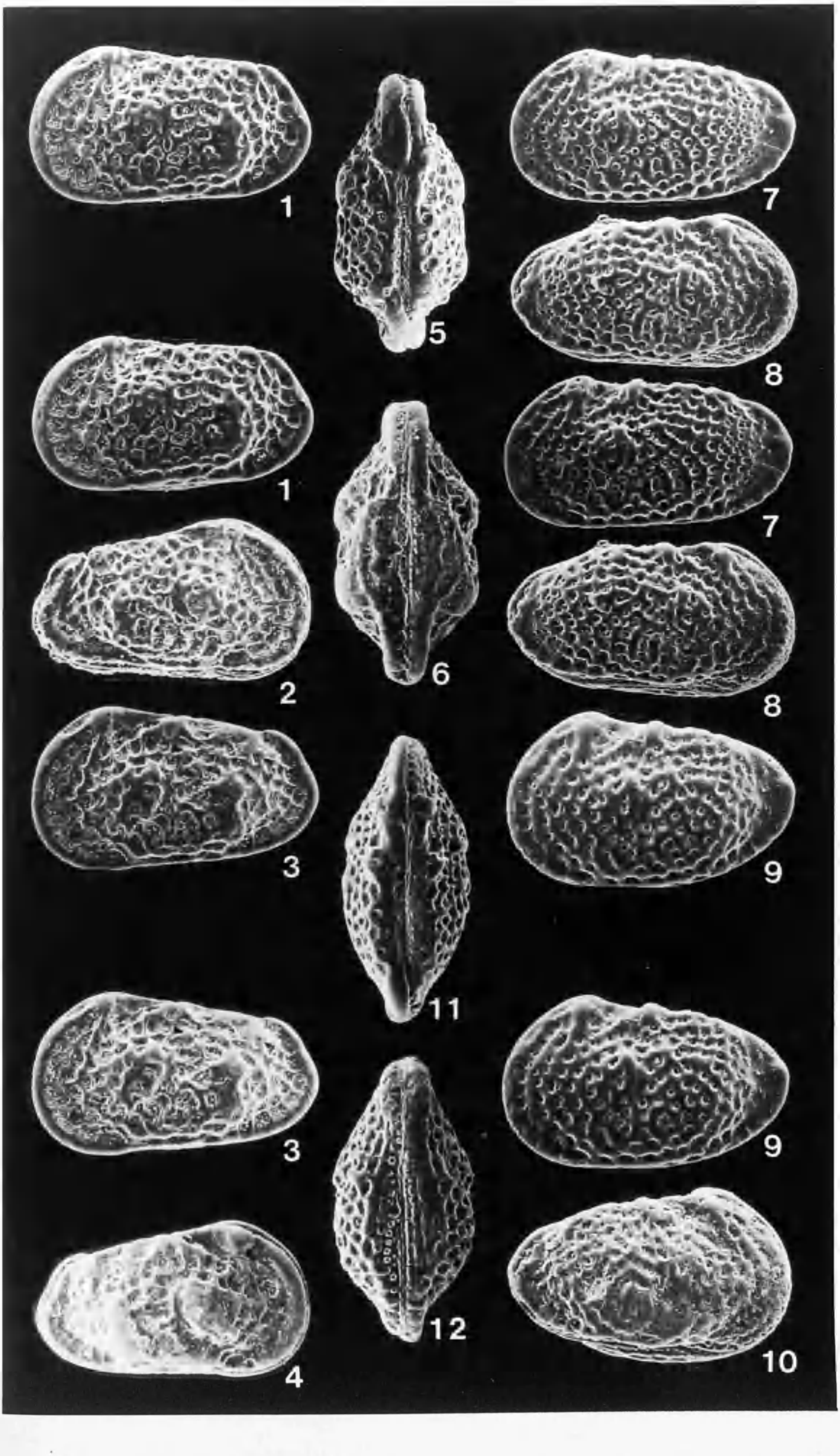

Plate 13

Mauritsina coronata **(Esker, 1968)**

Fig. 1- Stereoscopic paired photographs right carapace, HM-A 12917, X 67.5

Fig. 2- Left carapace, HM-A 12918, X 65

Fig. 3- Same right carapace.

Fig. 4- Same dorsal view.

Buntonia tatteuliensis **(Apostolescu, 1961)**

Fig. 5- Left carapace, HM-A 12919, X 60

Fig. 6- Right carapace, HM-A 12920, X 60

Fig. 7- Dorsal view, HM-A 12921, X 60

Fig. 8- Ventral view, HM-A 12922, X 60

Buntonia fortunata Apostolescu (1961)

Morphotype A

Fig. 9- Female left carapace, HM-A 12923, X 85

Fig. 10- Male left carapace, HM-A 12924, X 90

Fig. 11- Male right carapace, HM-A 12925, X 90

Fig. 12- Male left carapace, HM-A 12926, X 85

Fig. 16- Male dorsal view, HM-A 12927, X 100

Morphotype B

Fig. 13- Female right carapace, HM-A 12929, X115

Fig. 14- Female left carapace, HM-A 12930, X 112.5

Fig. 15- Male left carapace, HM-A 12931, X 97.5

PLATE 13

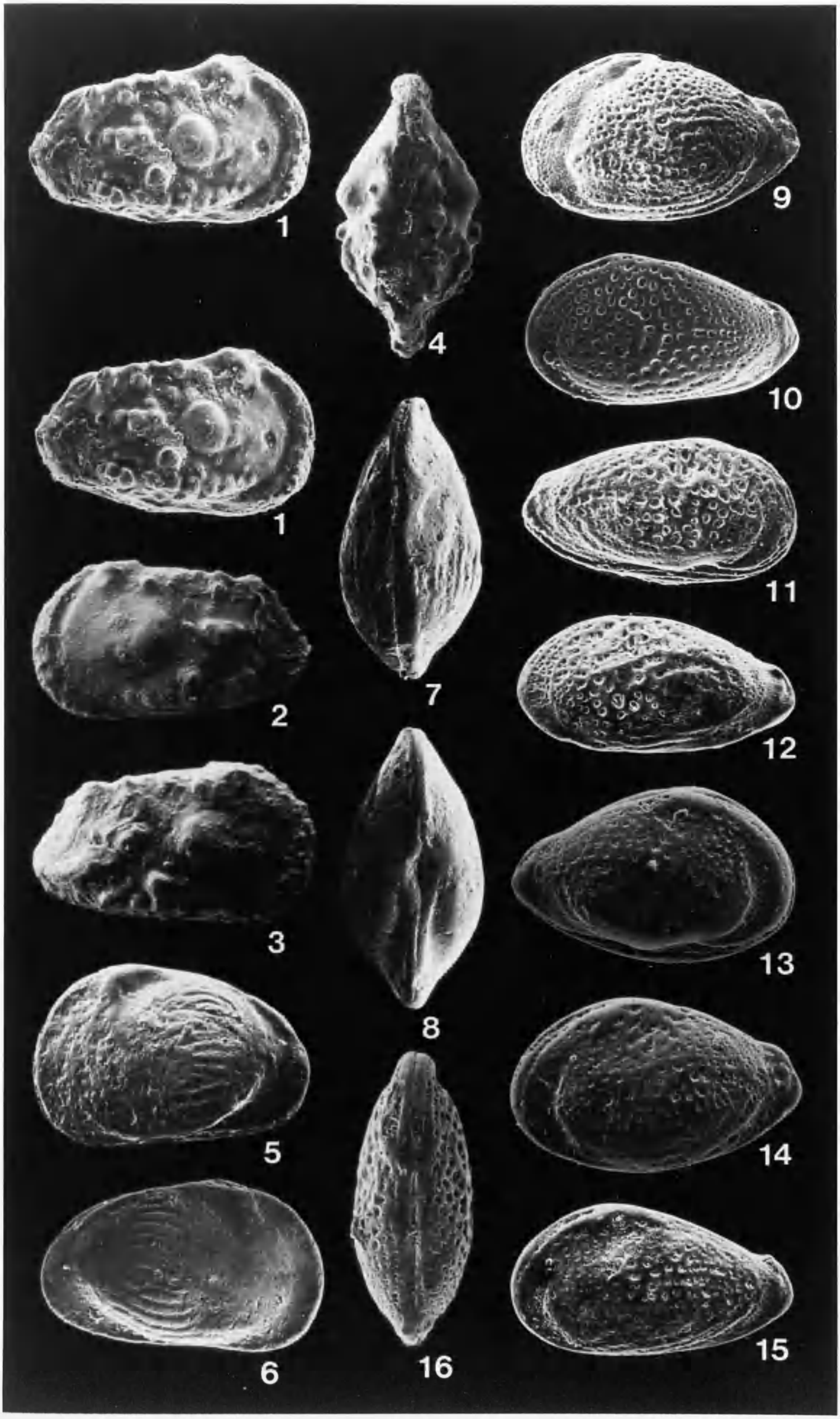

Plate 14

Buntonia fortunata Apostolescu (1961)

Morphotype B

Fig. 1- Male right carapace, HM-A 12932, X 100

Fig. 2- Female right carapace, HM-A 12933, X 90

Fig. 3- Female left carapace, HM-A 12934, X 110

Fig. 9- Male ventral view, HM-A 12935, X 10

Morphotype C

Fig. 4- Male right carapace, HM-A 12936, X 102

Fig. 5- Male right carapace, HM-A 12937, X 90

Fig. 6- Female right carapace, HM-A 12938, X 110

Fig. 7- Male right carapace, HM-A 12939, X 95

Fig. 10- Female right carapace, HM-A 12940, X 110

Morphotype A

Fig. 8- Female ventral view, HM-A 12928, X 112.5

Buntonia sp. cf. B. *teiskotensis* Apostolescu (1961)

Fig. 11- stereoscopic paired photographs left carapace, HM-A 12941, X 102.5

Fig. 12- Right carapace, HM-A 12942, X 105

Fig. 13- left carapace, HM-A 12943, X 105

Fig. 14- Right carapace, HM-A 12944, X 112.5

Fig. 15- dorsal view, HM-A 12945, X 105

PLATE 14

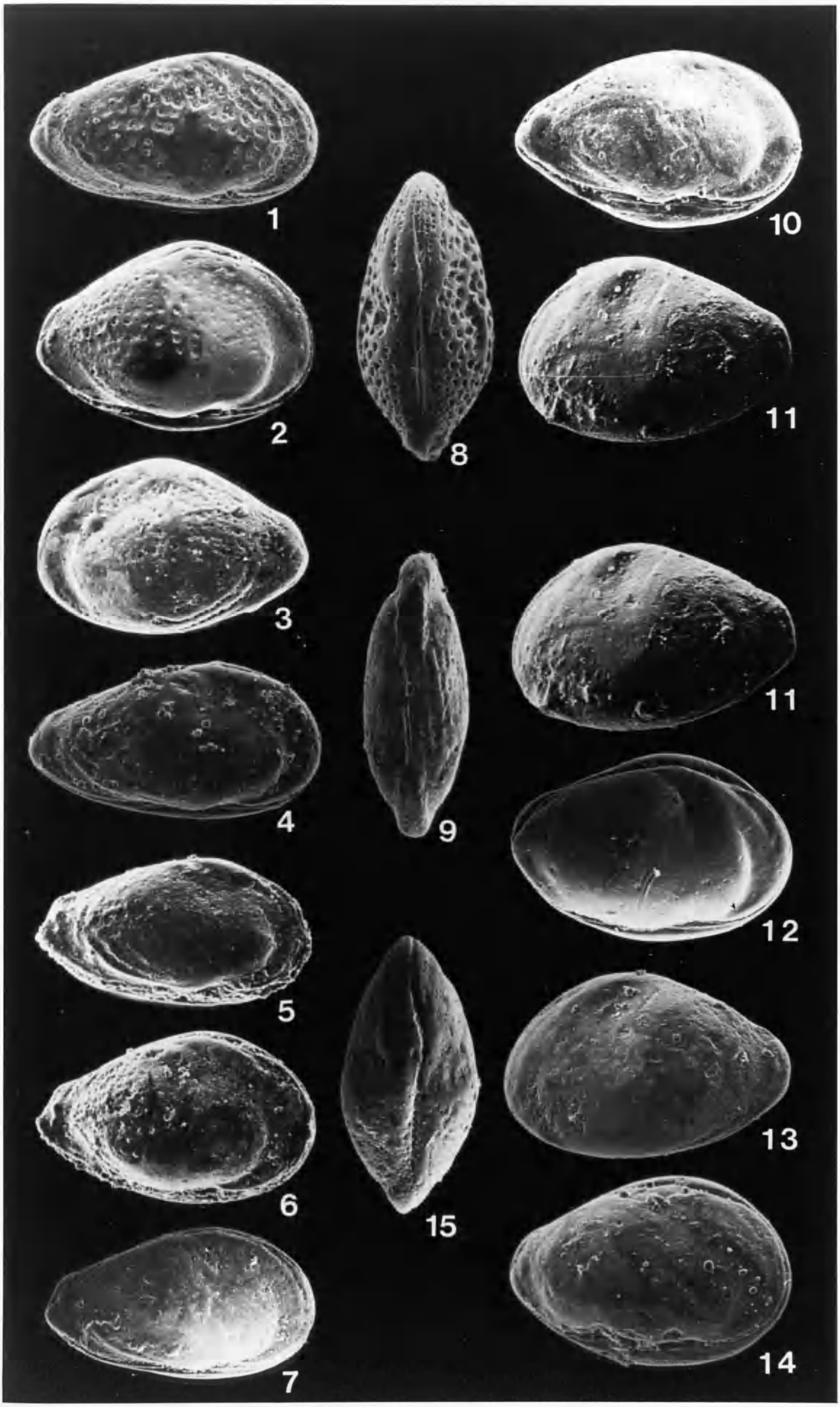

Plate 15

Buntonia sp. A

Fig. 1- Left carapace, HM-A 12946, X 85

Fig. 2- Right carapace, HM-A 12947, X 85

Fig. 3- Left carapace, HM-A 12948, X 85

Fig. 4- Ventral view, HM-A 12949, X 97.5

Buntonia sp. B

Fig. 5- Male stereoscopic paired photographs left carapace, HM-A 12950, X 65

Fig. 6- Female right carapace, HM-A 12951, X 70

Fig. 7- Male dorsal view, same HM-A 12950

Fig. 8- Female ventral view, same HM-A 12951

Fig. 9- pore canal, X 52.5

Buntonia cf. *ioruba* Reyment (1960)

Fig. 10- Male left carapace, HM-A 12952, X 72.5

Fig. 11- Male right carapace, HM-A 12953, X 65

Fig. 12- Female right carapace, HM-A 12954, X 67.5

Fig. 13- Female left carapace, HM-A 12955, X 70

Fig. 14- Female right carapace, HM-A 12956, X 75

Fig. 15- Male dorsal view HM-A 12957, X 70

Fig. 16- Male ventral view, HM-A 12958, X 70

Fig. 17- Female dorsal view, HM-A 12959, X 75

PLATE 15

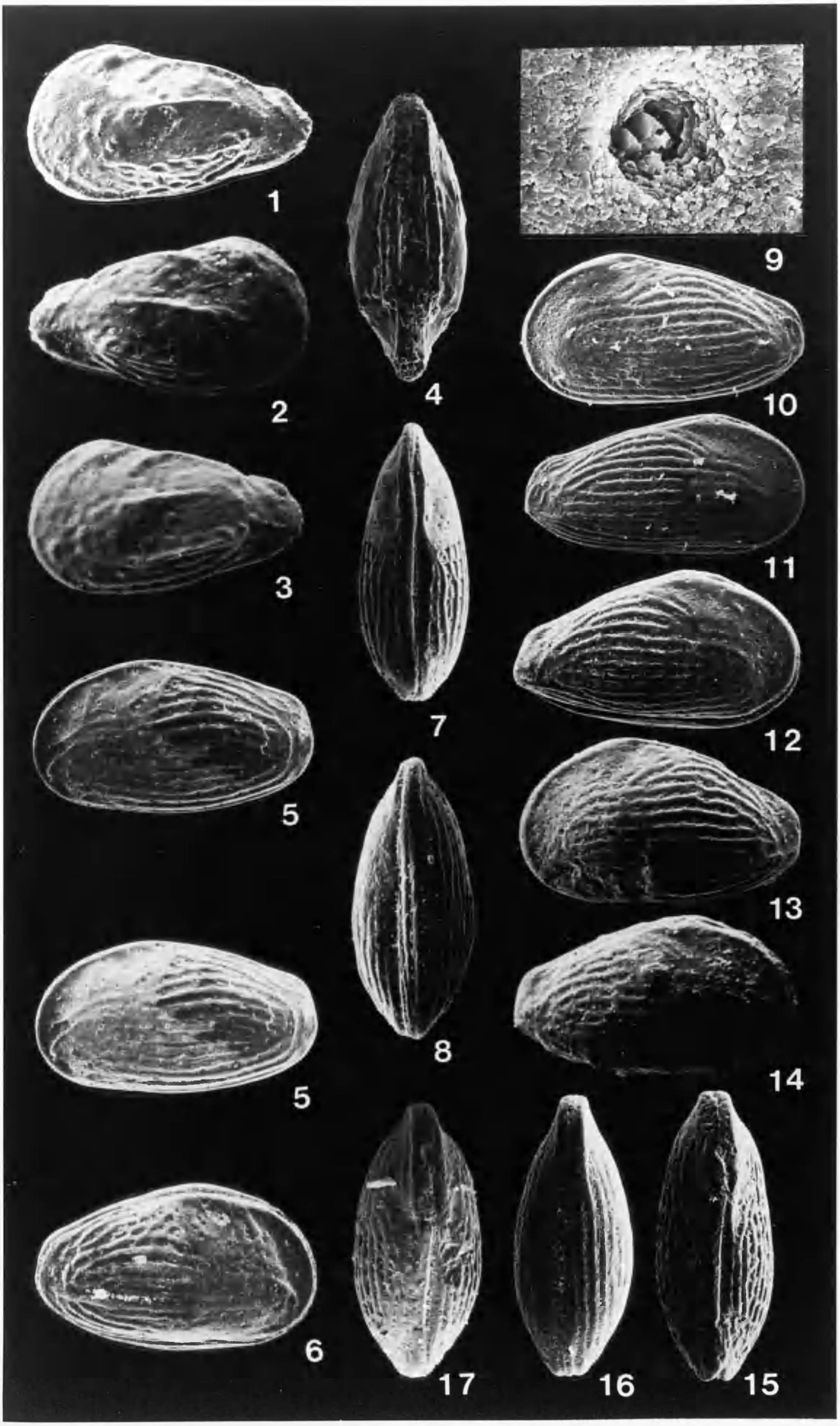

Plate 16

Buntonia sp. C

Fig. 1- Stereoscopic paired photographs left carapace, HM-A 12960, X 80

Fig. 2- Right carapace, HM-A 12961, X 85

Fig. 3- Left carapace, HM-A 12962, X 85

Buntonia wadiensis **sp. nov.**

Fig. 4- Right carapace, HM-A 12963, X 90

Fig. 5- Stereoscopic paired photographs left carapace (Holotype), HM-A 12964, X 100

Fig. 6- Dorsal view, HM-A 12965, X 90

Fig. 7- Right carapace, HM-A 12966, X 100

Cythereis teiskotensis **(Apostolescu, 1961)**

Fig. 8- Stereoscopic paired photographs left carapace, HM-A 12967, X 64.5

Fig. 9- Stereoscopic paired photographs left carapace, HM-A 12968, X 70

Fig. 10- Right carapace, HM-A 12969, X 65

Fig. 11- Dorsal view, HM-A 12970, X 65

Fig. 12- Ventral view, HM-A 12971, X 60

PLATE 16

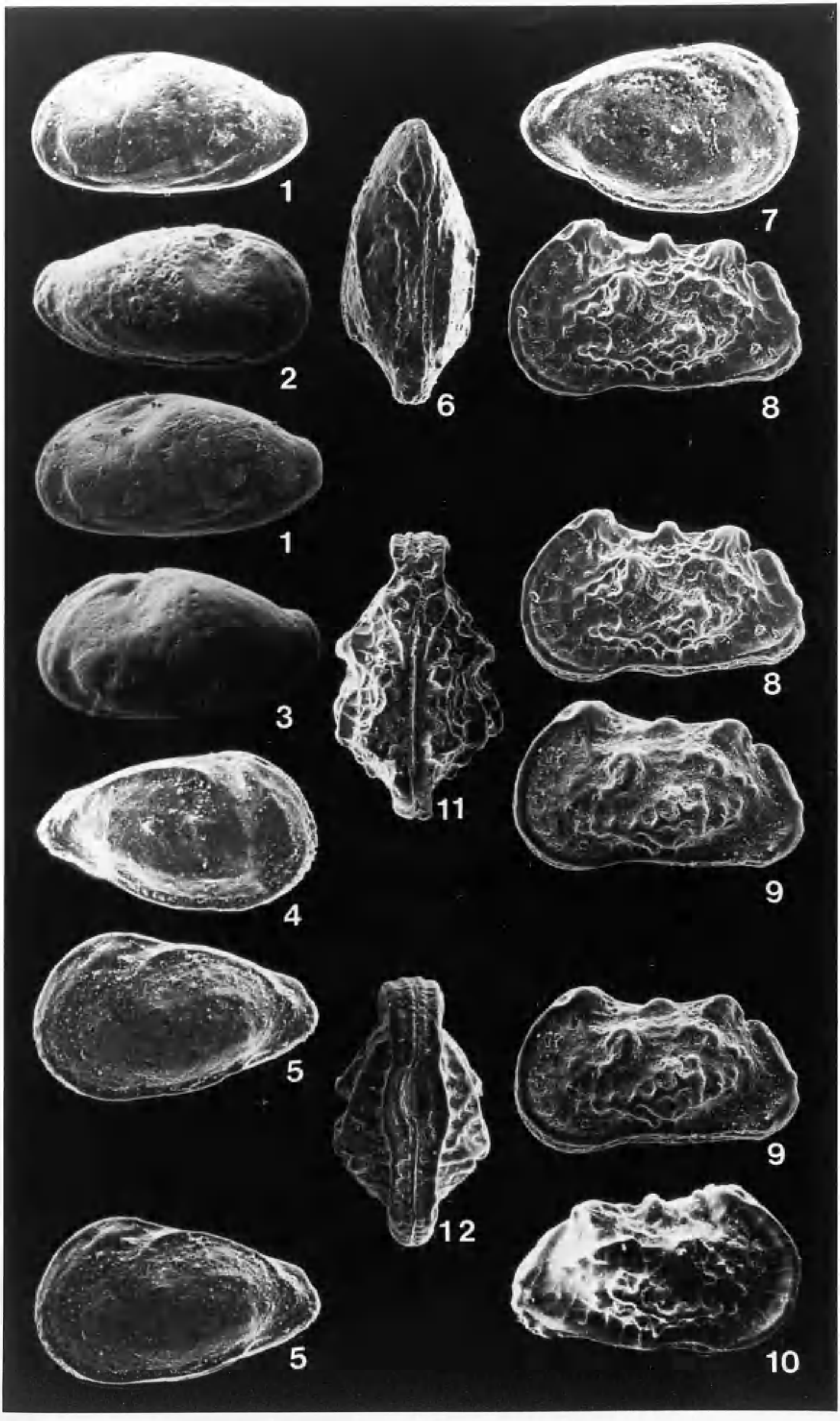

Plate 17

Cythereis teiskotensis (Apostolescu, 1961)

Fig. 1 Stereoscopic paired photographs right carapace, HM-A 12972, X 75

Fig. 2- Right carapace, HM-A 12973, X 60

Fig. 3- Juvenile right carapace, HM-A 12974, X 85

Fig. 4- Dorsal view, HM-A 12975, X 60

Cythereis cf. *teiskotensis* (Apostolescu, 1961)

Fig. 5- Right carapace, HM-A 12976, X 70

Fig. 6- Left carapace, HM-A 12977, X 70

Fig. 7- Stereoscopic paired photographs right carapace, HM-A 12978, X 70

Fig. 8- Left carapace, HM-A 12979, X 70

Fig. 12- Dorsal view, HM-A 12980, X 65

Fig. 13- Ventral view, HM-A 12981, X 65

Cristaeleberis fornicata Bassiouni (1970)

Fig. 9- Stereoscopic paired photographs right carapace, HM-A 12982, X 70

Fig. 10- Same left carapace.

Fig. 11- Same dorsal view.

PLATE 17

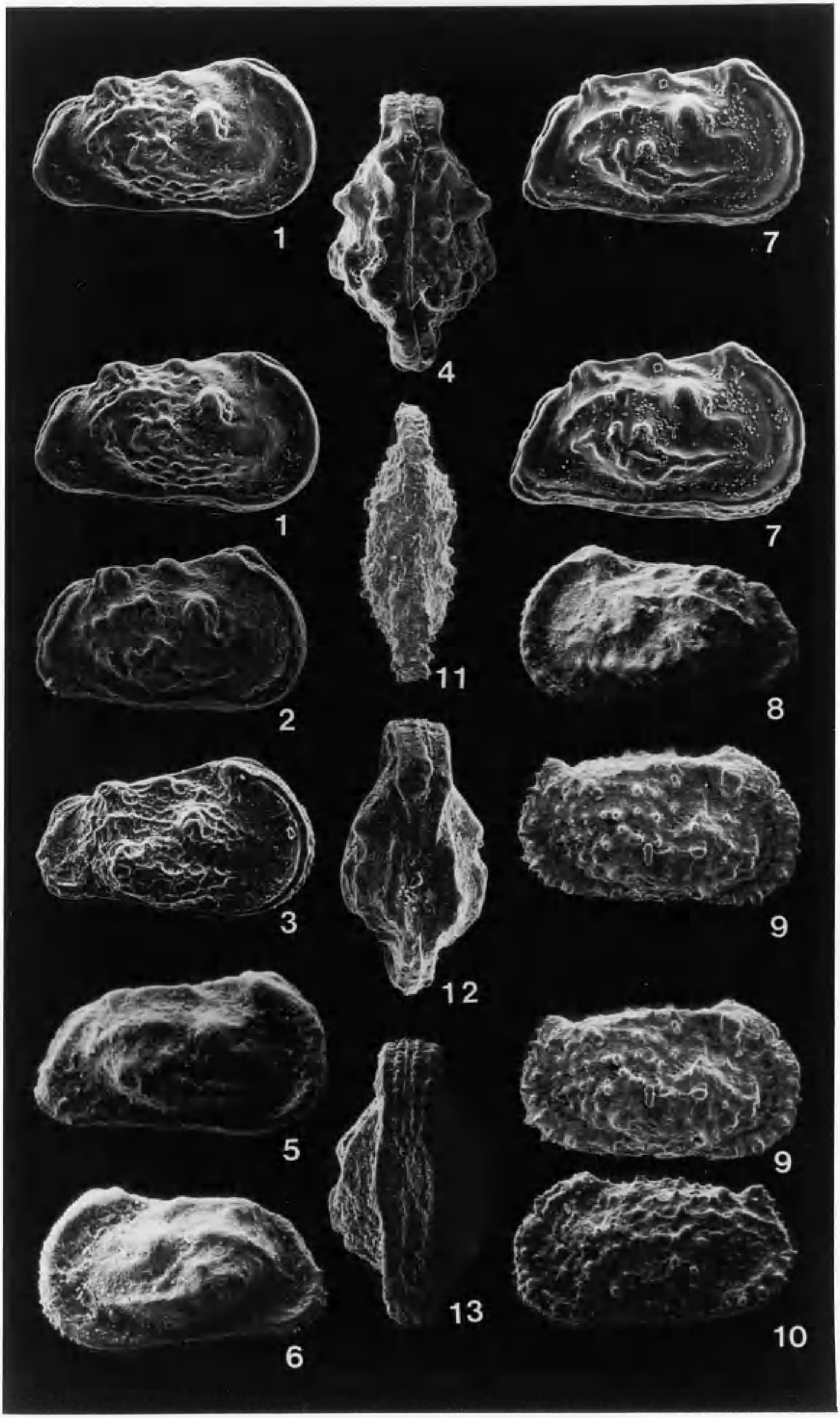

Plate 18

Echinocythereis lehibensis **sp. nov.**

Morphotype A

Fig. 1- Male stereoscopic paired photographs left carapace, (Holotype), HM-A 12983, X 74

Fig. 2- Male stereoscopic paired photographs right carapace, HM-A 12984, X 75

Fig. 3- Female left carapace, HM-A 12985, X 85

Fig. 4- Female right carapace, HM-A 12986, X 87.5

Fig. 5- Female dorsal view, HM-A 12988, X 82.5

Fig. 6- Male ventral view. HM-A 12989, X 80

Fig. 7- Female right carapace, HM-A 12987, X 87.5

Morphotype B

Fig. 8- Female right carapace, HM-A 12990, X 90

Morphotype C

Fig. 9- Female stereoscopic paired photographs right carapace, HM-A 12991, X 85

Fig. 10- Female left carapace, HM-A 12992, X 90

Fig. 11- Female dorsal view, HM-A 12993, X 85

Fig. 12- Female ventral view, HM-A 12994, X 85

PLATE 18

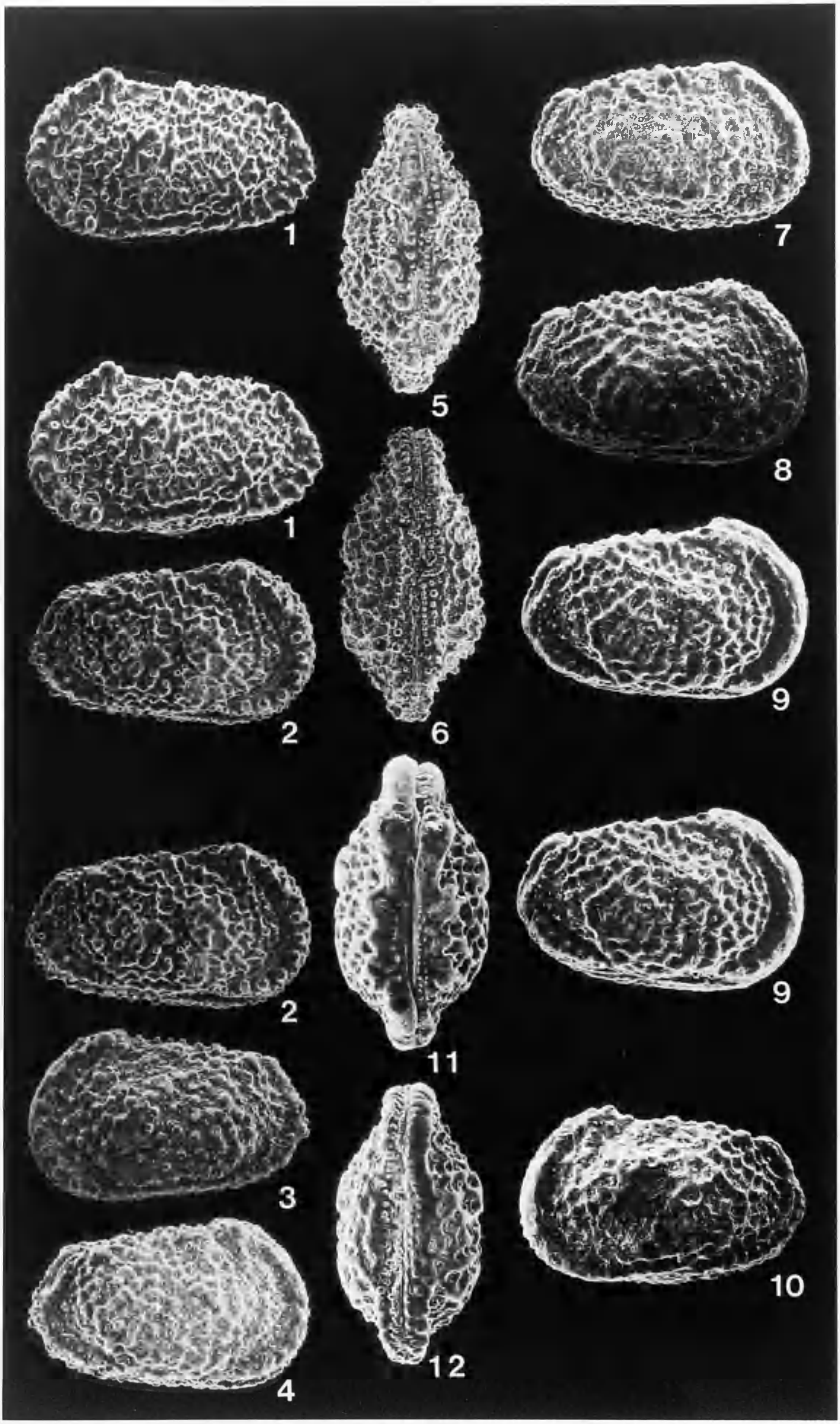

Plate 19

Echinocythereis ? sp. A

Fig. 1- Right carapace, HM-A 12995, X 77.5

Fig. 2- Same left carapace.

Fig. 3- Left carapace, HM-A 12996, X 80

Fig. 4- Same Fig. 1, dorsal view.

Fig. 5- Same ventral view.

Hornibrookella cf. *quinquecellulosa* Al-Furaih (1977)

Fig. 6- Male stereoscopic paired photographs left carapace, HM-A 12997, X 70

Fig. 7- Male right carapace, HM-A 12998, X 65

Fig. 8- Male left carapace, HM-A 12999, X 65

Fig. 9- Female stereoscopic paired photographs right carapace, HM-A 13000, X 75

Fig. 10- Female left carapace, HM-A 13001, X 77

Fig. 11- Female left carapace, HM-A 13002, X 77

Fig. 12- Female dorsal view, HM-A 13003, X 80

Fig. 13- Female ventral view, HM-A 13004, X 80

Fig. 14- Male dorsal view, HM-A 13005, X 65

PLATE 19

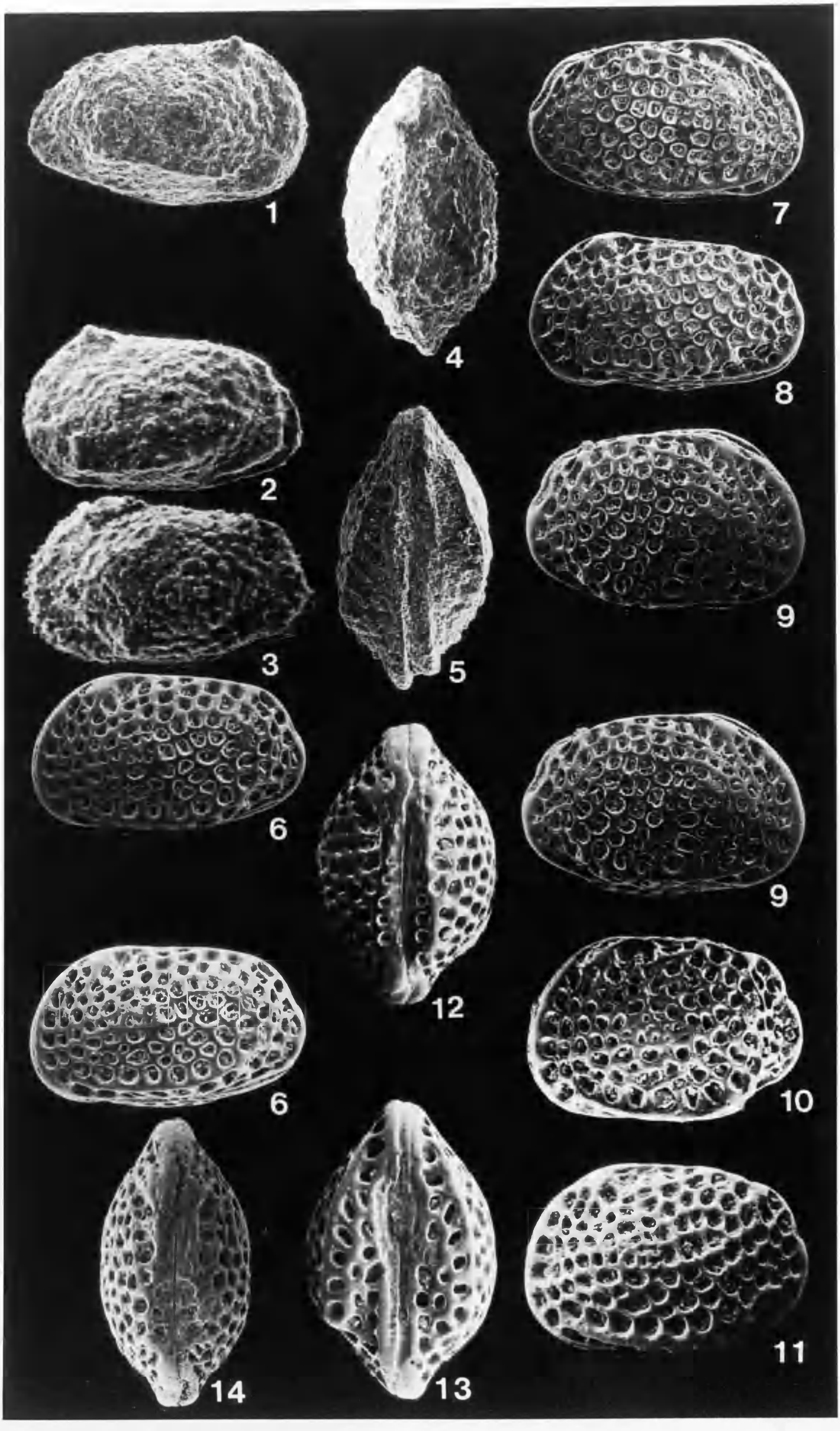

Plate 20

Hornibrookella sp. A

Fig. 1- Left carapace, HM-A 13006, X 80

Fig. 2- Same right carapace.

Fig. 3- Same dorsal view.

Hornibrookella episcelis Al-Furaih (1977)

Fig. 4- Female stereoscopic paired photographs left carapace, HM-A 13007, X 75

Fig. 5- Female stereoscopic paired photographs right carapace, HM-A 13008, X 75

Fig. 6- Male left carapace, HM-A 13009, X 72.5

Fig. 7- Female dorsal view, HM-A 13010, X 72

Fig. 8- Female ventral view, HM-A 13011, X 70

Fig. 9- Stereoscopic paired photographs left carapace same fig. 6

Hermanites wahaensis sp. nov.

Fig. 10- Male stereoscopic paired photographs left carapace, (Holotype), HM-A 13012, X 80

Fig. 11- Same right carapace.

Fig. 12- Female stereoscopic paired photographs right carapace, HM-A13013, X 85

Fig. 13- Same female right carapace.

Fig. 14- Female dorsal view, HM-A 13014, X 85

PLATE 20

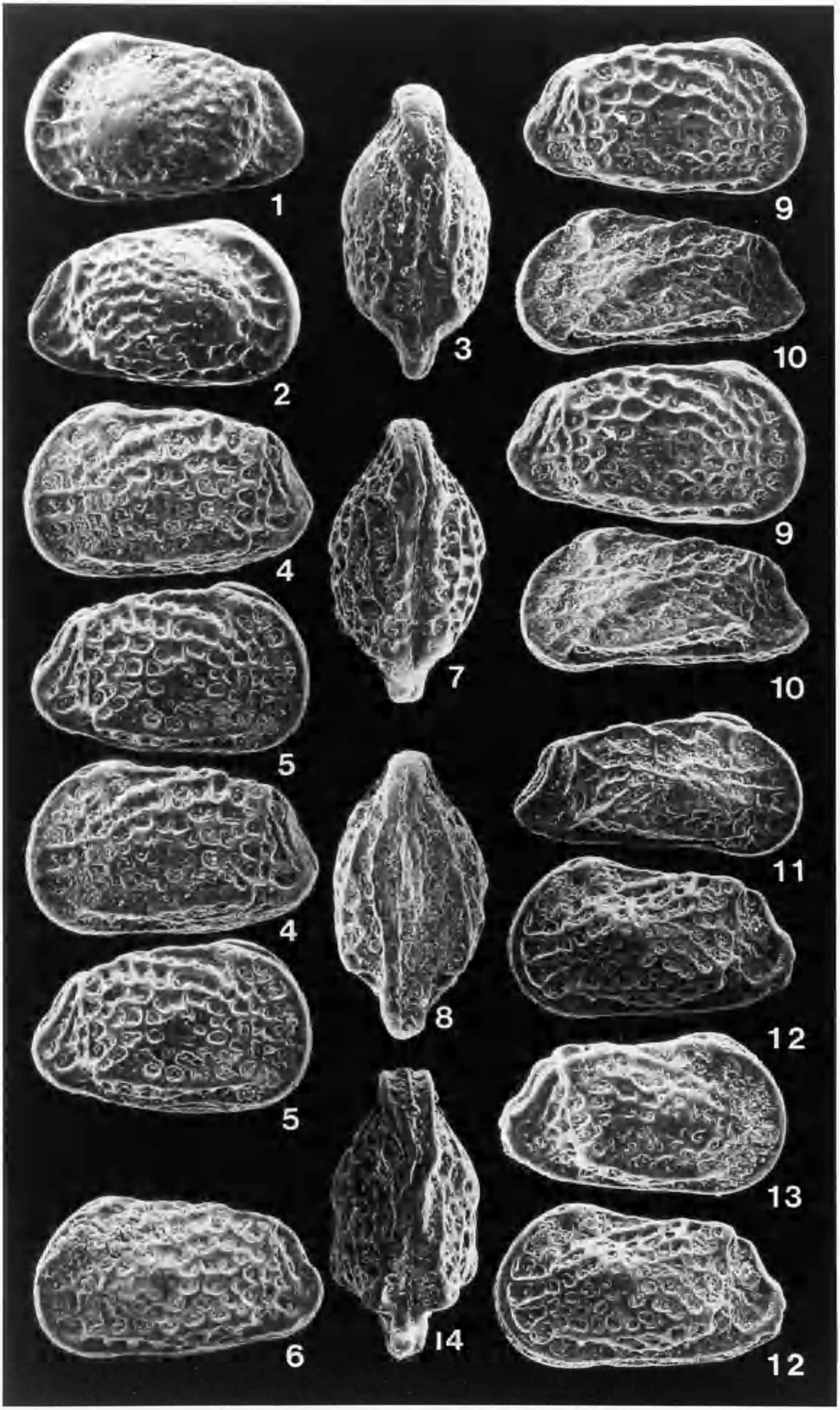

Plate 21

Oertliella petraensis Al-Sheikhly (1980)

Fig. 1- Male stereoscopic paired photographs left carapace, HM-A 13015, X 82.5

Fig. 2- Male stereoscopic paired photographs right carapace, HM-A 13016, X 75

Fig. 3- Female left carapace, HM-A 13017, X 90

Fig. 4- Female dorsal view, HM-A 13018, X 85

Fig. 5- Same female ventral view.

Protobuntonia nakkadii Bassiouni (1970)

Fig. 6- Left carapace, HM-A 13019, X 60

Fig. 7- Same right carapace.

Fig. 8- Same dorsal view.

Fig. 9- Ventral view, HM-A 13020, X 65

Protobuntonia sp. A

Fig. 10- Left carapace, HM-A 13021, X 72.5

Fig. 11- Right carapace, HM-A 13022, X 72,5

Fig. 12- Dorsal view same fig. 11.

Fig. 13- Ventral view same fig. 10.

Protobuntonia sp. B

Fig. 14- Stereoscopic paired photographs left carapace, HM-A 13023, X 85

Fig. 15- Same dorsal view.

Hermanites wahaensis sp. nov.

Fig. 16- Female ventral view, HM-A 13014, X 85

PLATE 21

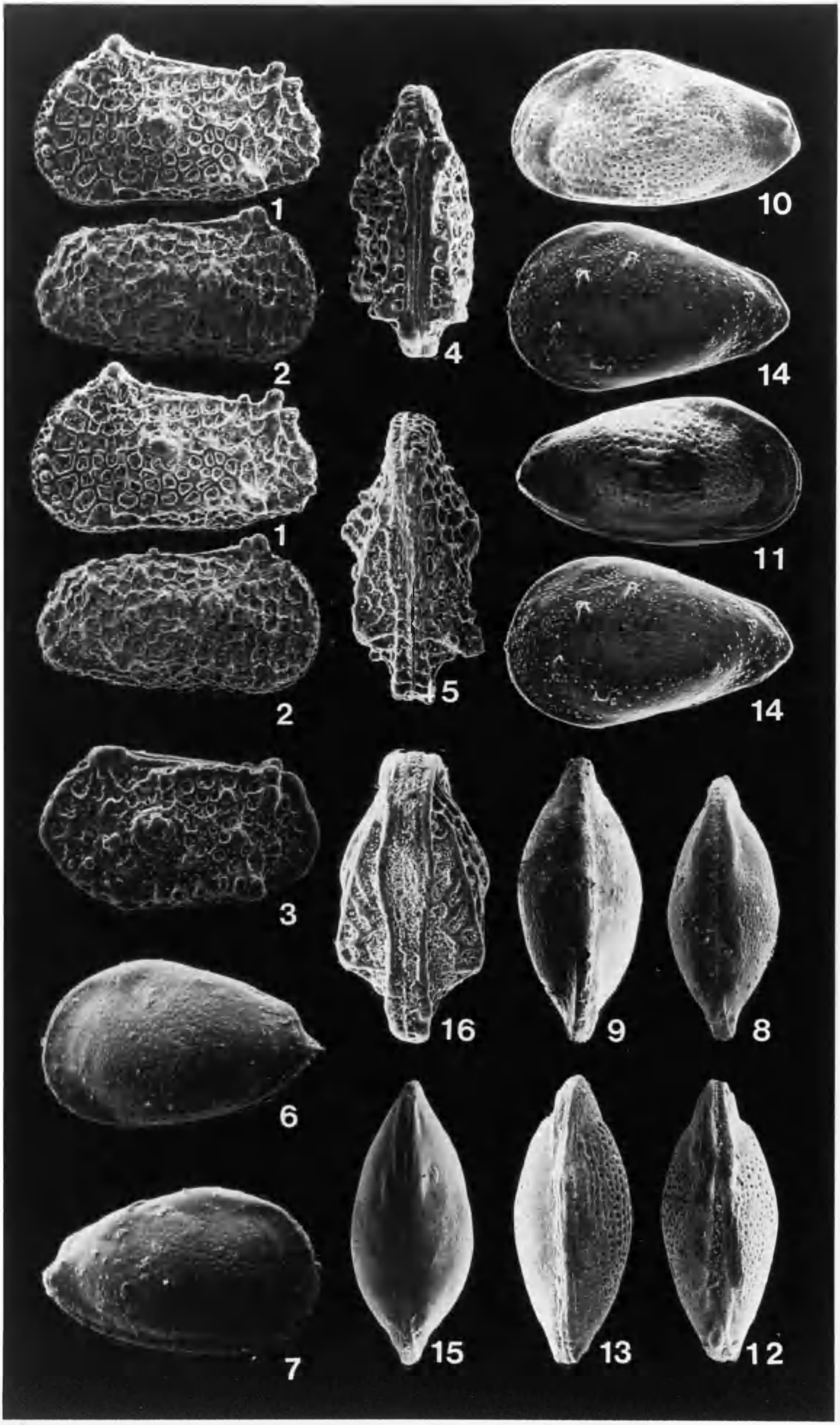

Plate 22

Protobuntonia **sp. B**

Fig. 1- Right carapace, HM-A 13024, X 85

Fig. 2- Same ventral view.

Paragrenocythere gravis **Al-Furaih (1980)**

Fig. 3- Male stereoscopic paired photographs right carapace, HM-A 13025, X 60

Fig. 4- Male left carapace, HM-A 13026, X 65

Fig. 5- Male left carapace, HM-A 13027, X 60

Fig. 6- Female right carapace, HM-A 13028, X 70

Fig. 7- Male dorsal view, HM-A 13029, X 65

Fig. 8- Male ventral view, HM-A 13030, X60

Paragrenocythere neoponticulata **sp. nov.**

Fig. 9- Female right carapace, HM-A 13031, X 71

Fig. 10- Female stereoscopic paired photographs left carapace, HM-A 13032, X70

Fig. 11- Female stereoscopic paired photographs right carapace, (Holotype), HM-A 13033,. X 70

Fig. 12- Male stereoscopic paired photographs right carapace, HM-A 13034, X 65

Fig. 13- Male stereoscopic paired photographs left carapace, HM-A 13035, X 65

Fig. 14- Female dorsal view, HM-A 13036, X 70

PLATE 22

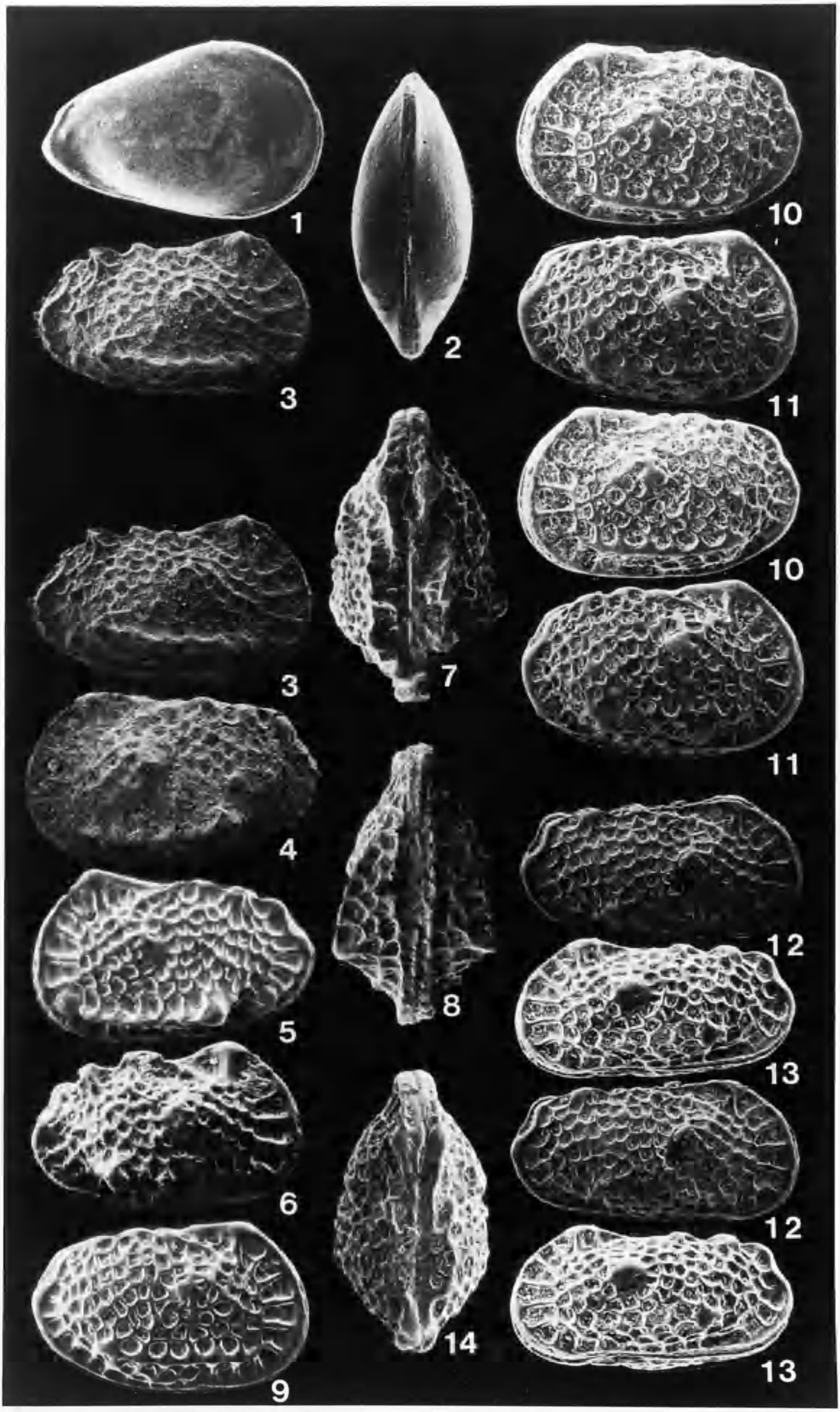

Plate 23

Phalcocythere ralahensis **sp. nov.**

Fig. 1- Left carapace, (Holotype), HM-A 13037, X 105

Fig. 2- Right carapace, HM-A 13038, X 105

Fig. 3- Left carapace, HM-A 13039, X 100

Fig. 4- Right carapace, HM-A 13040, X 97

Fig. 5- Dorsal view, HM-A 13041, X 100

Fig. 6- Ventral view, HM-A 13042, X 105

Phalcocythere jebelensis **sp. nov.**

Fig. 7- Female stereoscopic paired photographs left carapace, (Holotype), HM-A 13043, X 77.5

Fig. 8- Male stereoscopic paired photographs left carapace, HM-A 13044, X 75

Fig. 9- Female right carapace, HM-A 13045, X 75

Fig. 10- Female right carapace, HM-A 13046, X 75

Fig. 11- Female right carapace, HM-A 13047, X 77.2

Fig. 12- Female dorsal view, HM-A 13048, X 75

Fig. 13- Male ventral view, HM-A 13049, X 77

Phalcocythere **cf. (*Phalcocythere*) *tranquillis* Al-Furaih (1980)**

Fig. 14- Stereoscopic paired photographs right carapace, HM-A 13050, X 80

PLATE 23

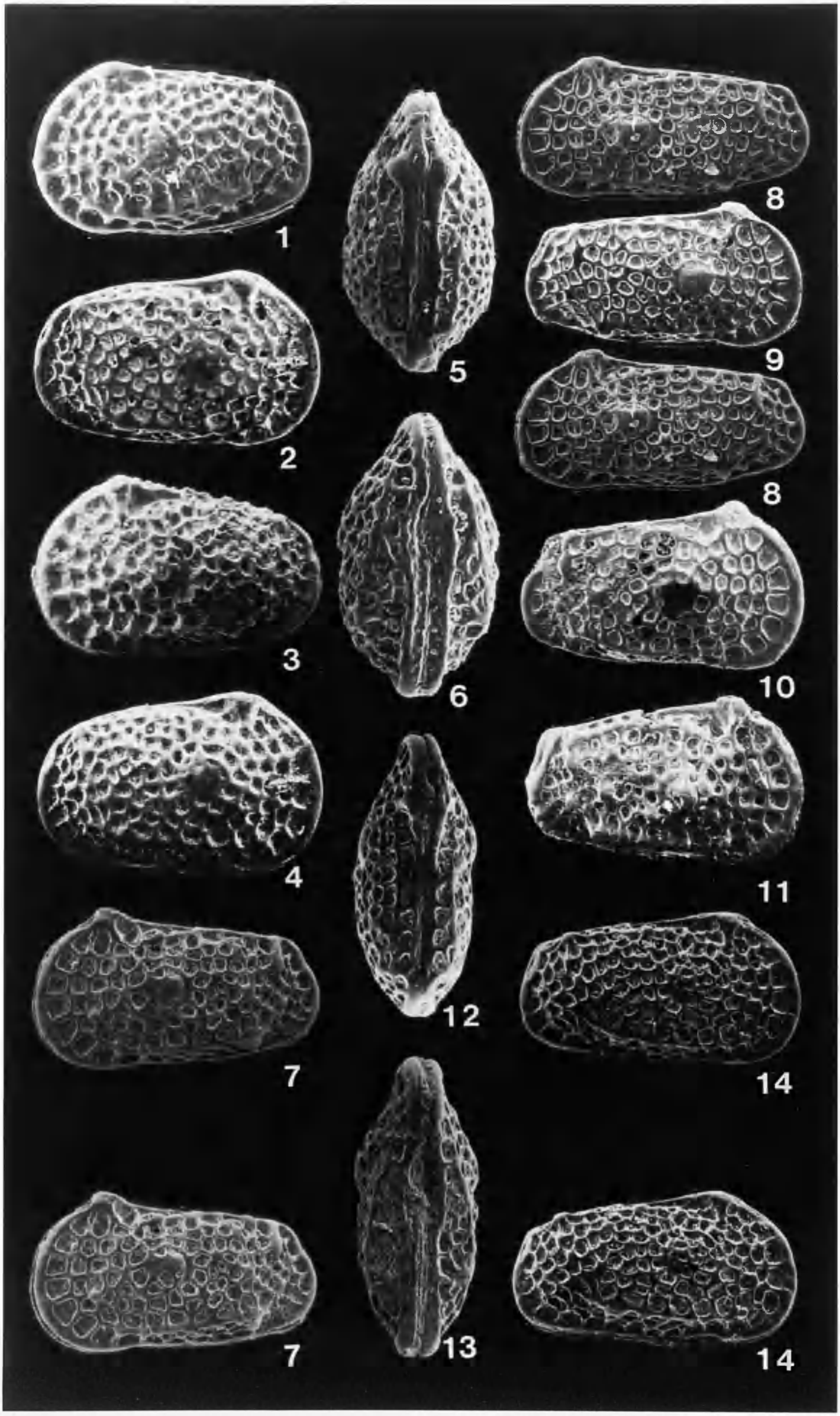

Plate 24

Paracosta warriensis (Reyment, 1960)

Fig. 1- Male right carapace, HM-A 13051, X 65

Fig. 2- Male left carapace, HM-A 13052, X 65

Fig. 3- Male left carapace, HM-A 13053, X 65

Fig. 4- Male right carapace, HM-A 13054, X 70

Fig. 5- Female stereoscopic paired photographs left carapace, HM-A 13055, X 72.5

Fig. 6- Male dorsal view, HM-A 13056, X 62.5

Fig. 7- Male ventral view, HM-A 13057, X 70

Fig. 8- Female ventral view, HM-A 13058, X 72

Fig. 9- Female dorsal view, HM-A 13059, X 72.5

Fig. 10- Female right carapace, HM-A 13060, X 75

Fig. 11- Female left carapace, HM-A 13061, X 73

Fig. 12- Female right carapace, HM-A 13062, X 75

Fig. 13- Female left carapace, HM-A 13063, X 75

Fig. 14- Female right carapace, HM-A 13064, X 75

Fig. 15- Female left carapace, HM-A 13065, X 77

PLATE 24

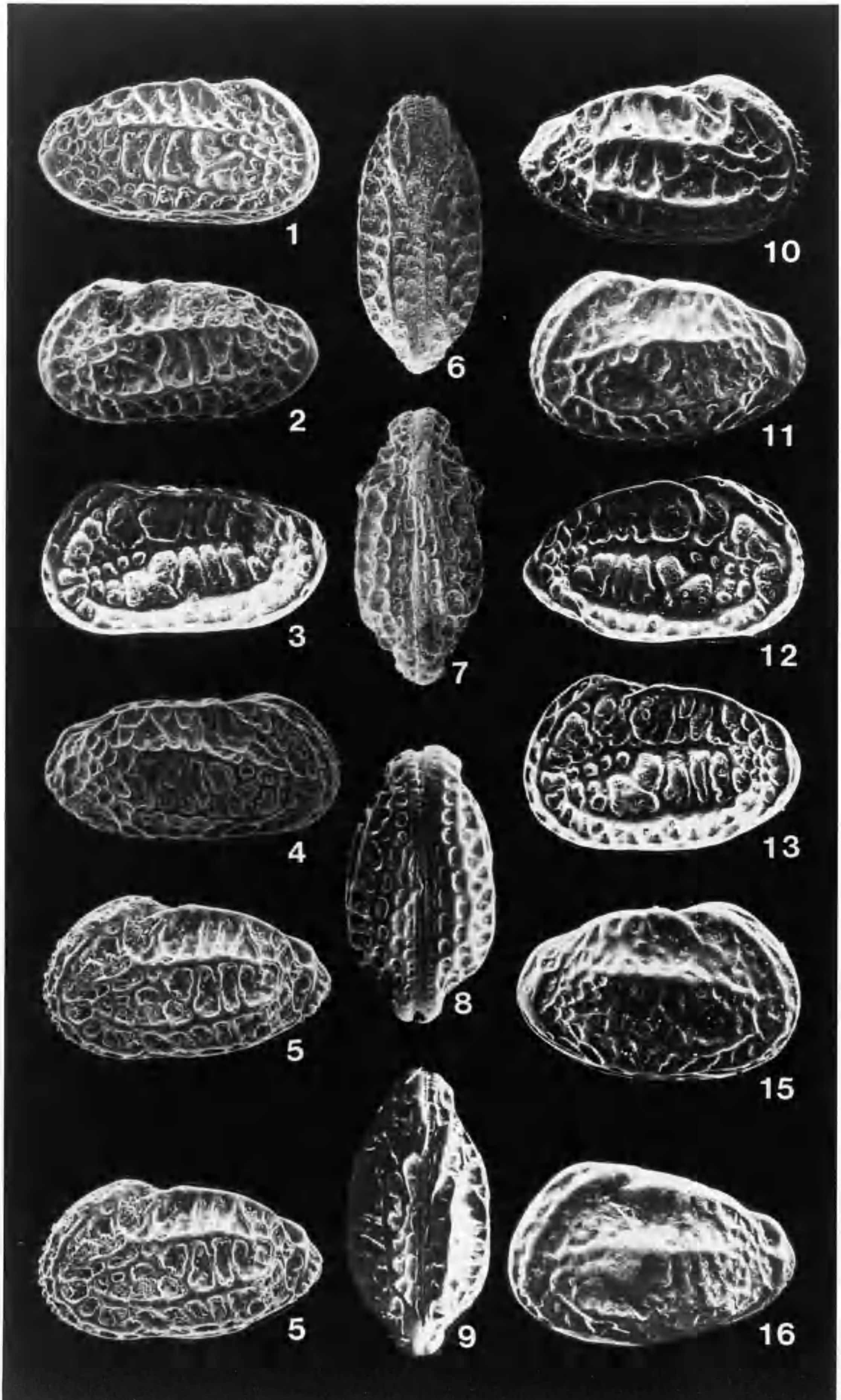

Plate 25

Paracosta cf. *arabica* **(Bassiouni, 1969)**

Fig. 1- Stereoscopic paired photographs left carapace, HM-A 13066, X 75

Fig. 2- Stereoscopic paired photographs right carapace, HM-A 13067, X 75

Fig. 3- Left carapace, HM-A 13068, X 87.5

Fig. 4- Right carapace, HM-A 13069, X 85

Paracosta aff. *ansaryi* **(Bassiouni, 1960)**

Fig. 5- Right carapace, HM-A 13070, X 70

Fig. 6- Stereoscopic paired photographs right valve, HM-A 13071, X 70

Fig. 7- Stereoscopic paired photographs left carapace, HM-a 13072, X 70

Paracosta keeni **sp. nov.**

Fig. 8- Female left carapace, HM-A 13073, X 72.5

Fig. 9- Female right carapace, HM-A 13074, X 72.5

Fig. 10- Juvenile right carapace, HM-A 13075, X 90

Fig. 11- Male dorsal view, HM-A 13076, X 70

Fig. 12- Male ventral view, HM-A 13077, X 70

Fig. 13- Female ventral view, HM-A 13078, X 72.5

Fig. 14- Female ventral view, HM-A 13079, X 80

PLATE 25

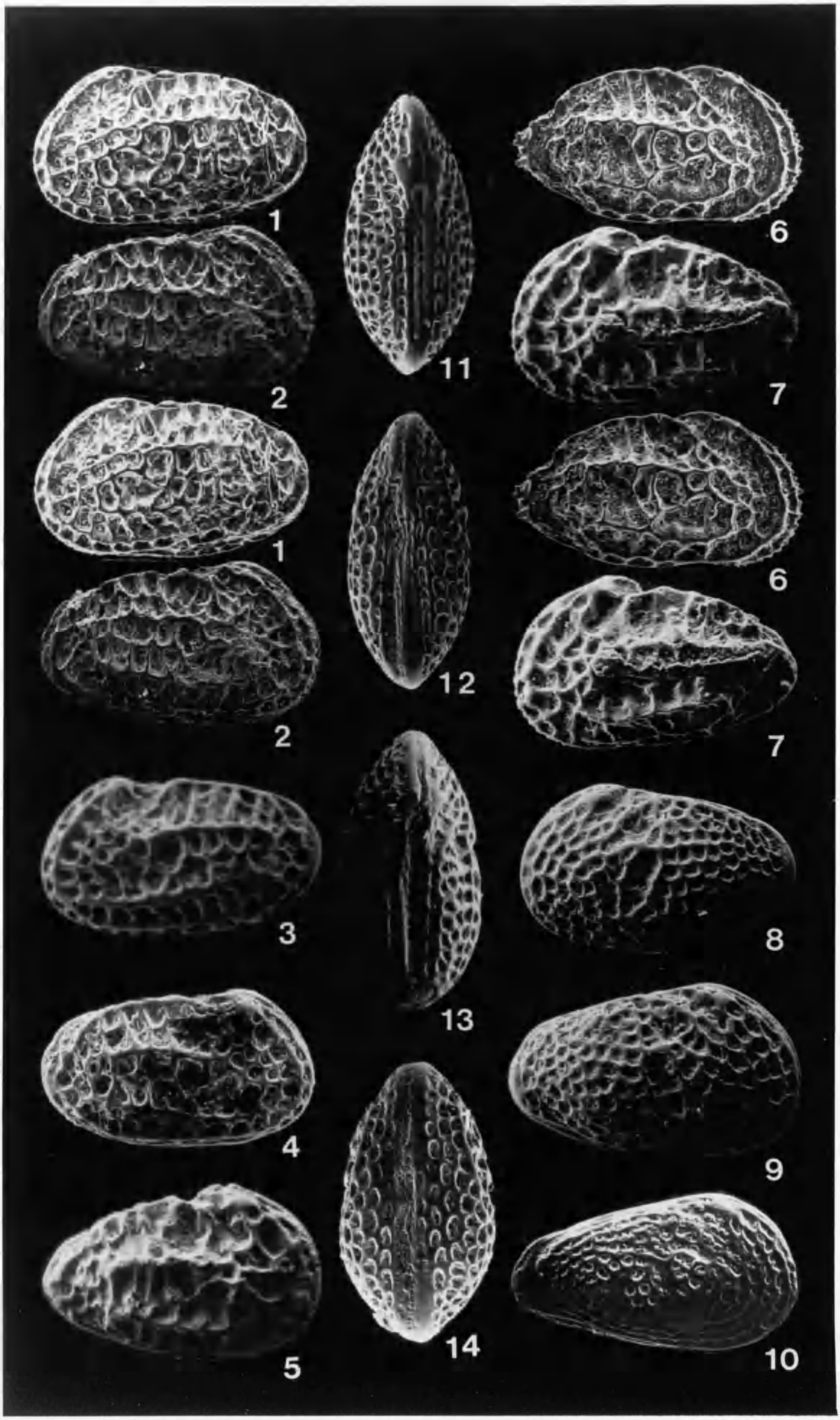

Plate 26

Paracosta keeni **sp. nov.**

Fig. 1- Male stereoscopic paired photographs left carapace, (Holotype), HM-A 13080, X 60

Fig. 2- Male stereoscopic paired photographs right carapace, HM-A 13081, X 65

Fig. 3- Male left carapace, HM-A 13082, X 65

Fig. 4- Female right carapace, HM-A 13083, X 70

Fig. 5- Female right carapace, HM-A 13084, X 72.5

Fig. 6- Female dorsal view, HM-A 13088, X 78

Fig. 7- Female stereoscopic paired photographs right carapace, HM-A 13085, X 70

Fig. 8- Female left carapace, HM-A 13086, X 70

Fig. 9- Female left carapace, HM-A 13087, X 77.5

Paracosta bensoni **(Damotte & Donze, 1982)**

Morphotype A

Fig. 10- Female right carapace, HM-A 13089,X 85

Fig. 11- Female left carapace, HM-A 13090, X 85

Fig. 12- Male dorsal view, HM-A 13091, X 80

Fig. 13- Female dorsal view, HM-A 13092, X 85

PLATE 26

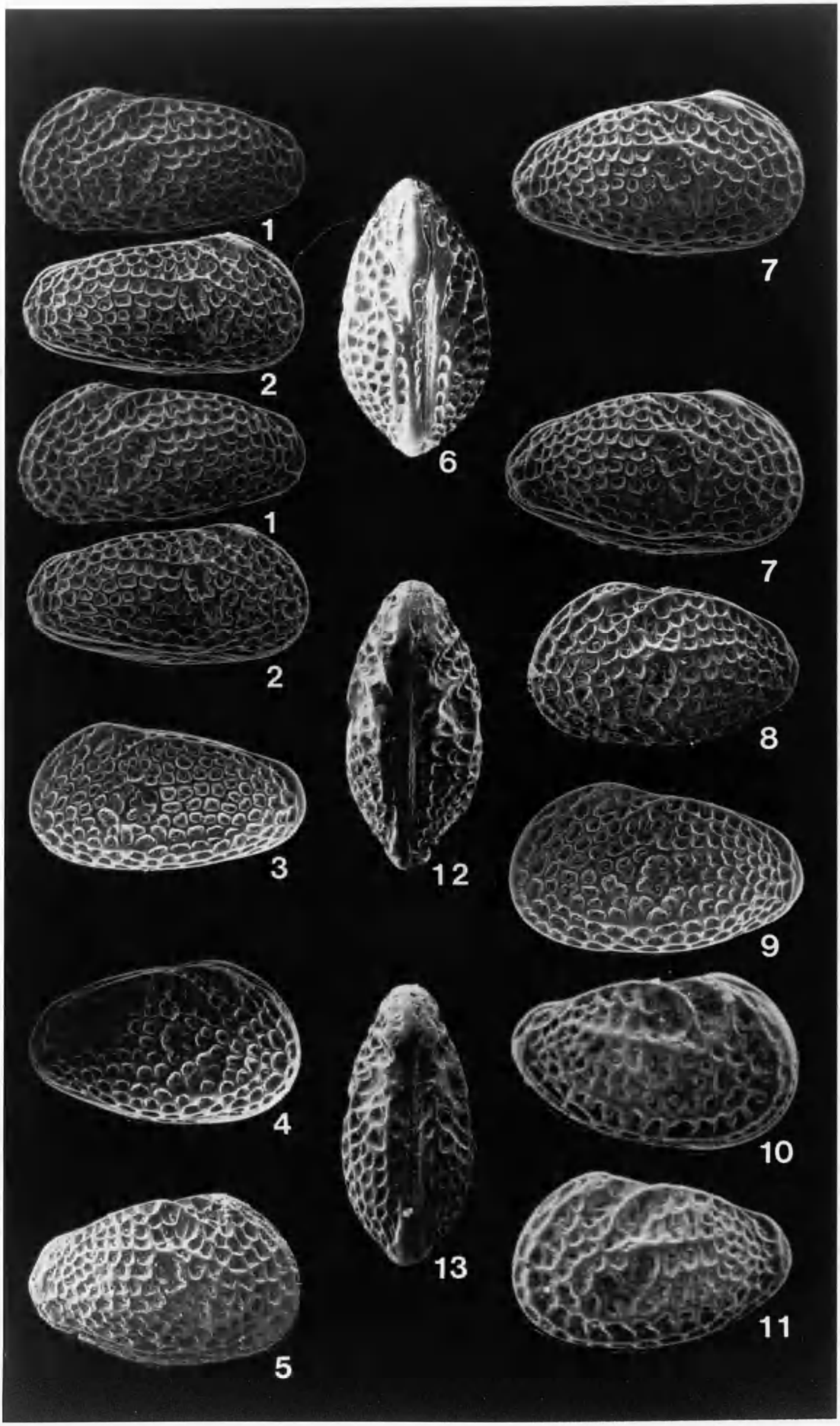

Plate 27

Paracosta bensoni (Damotte & Donze, 1982)

Morphotype A

Fig. 1- Male left carapace, HM-A 13093, X 80

Fig. 2- Male right carapace, HM-A 13094, X 80

Fig. 3- Female left carapace, HM-A 13095, X 85

Fig. 4- Female right carapace, HM-A 13096, X 85

Fig. 5- Female stereoscopic paired photographs left carapace, HM-A 13097, X 85

Fig. 6- Female dorsal view, HM-A 13098, X 85

Fig. 7- Female ventral view, HM-A 13099, X 83

Morphotype B

Fig. 8- Female dorsal view, HM-A 13106, X 80

Fig. 9- Male left carapace, HM-A 13100, X 70

Fig. 10- Male right carapace, HM-A 13101, X 65

Fig.11- Male right carapace, HM-A 13102, X 75

Fig. 12- Female right carapace, HM-A 13103, X 80

Fig. 13- Female right carapace, HM-A 13104, X 80

Fig. 14- Female left carapace, HM-A 13105, X 87.5

PLATE 27

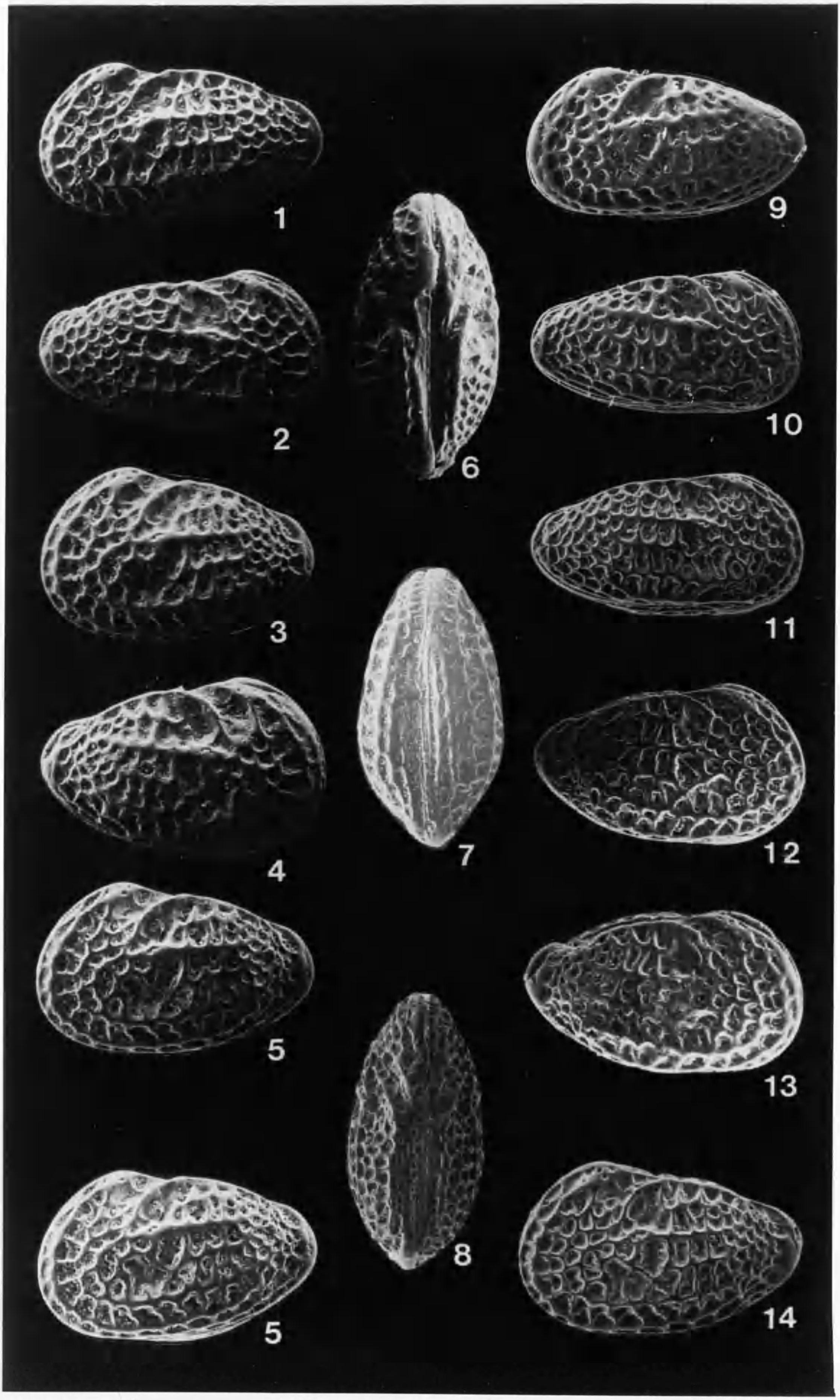

Plate 28

Paracosta aff. *ansaryi* (Bassiouni, 1969)

Fig. 1- Stereoscopic paired photographs hinge right valve, X140

Fig. 2- Stereoscopic paired photographs right valve inside view,same (Pl.25, Fig. 6).

Paracosta warriensis (Reyment , 1960)

Fig. 3- Stereoscopic paired photographs hinge right valve, X 67.5

Fig. 4- Stereoscopic paired photographs right valve inside view, X135

PLATE 28

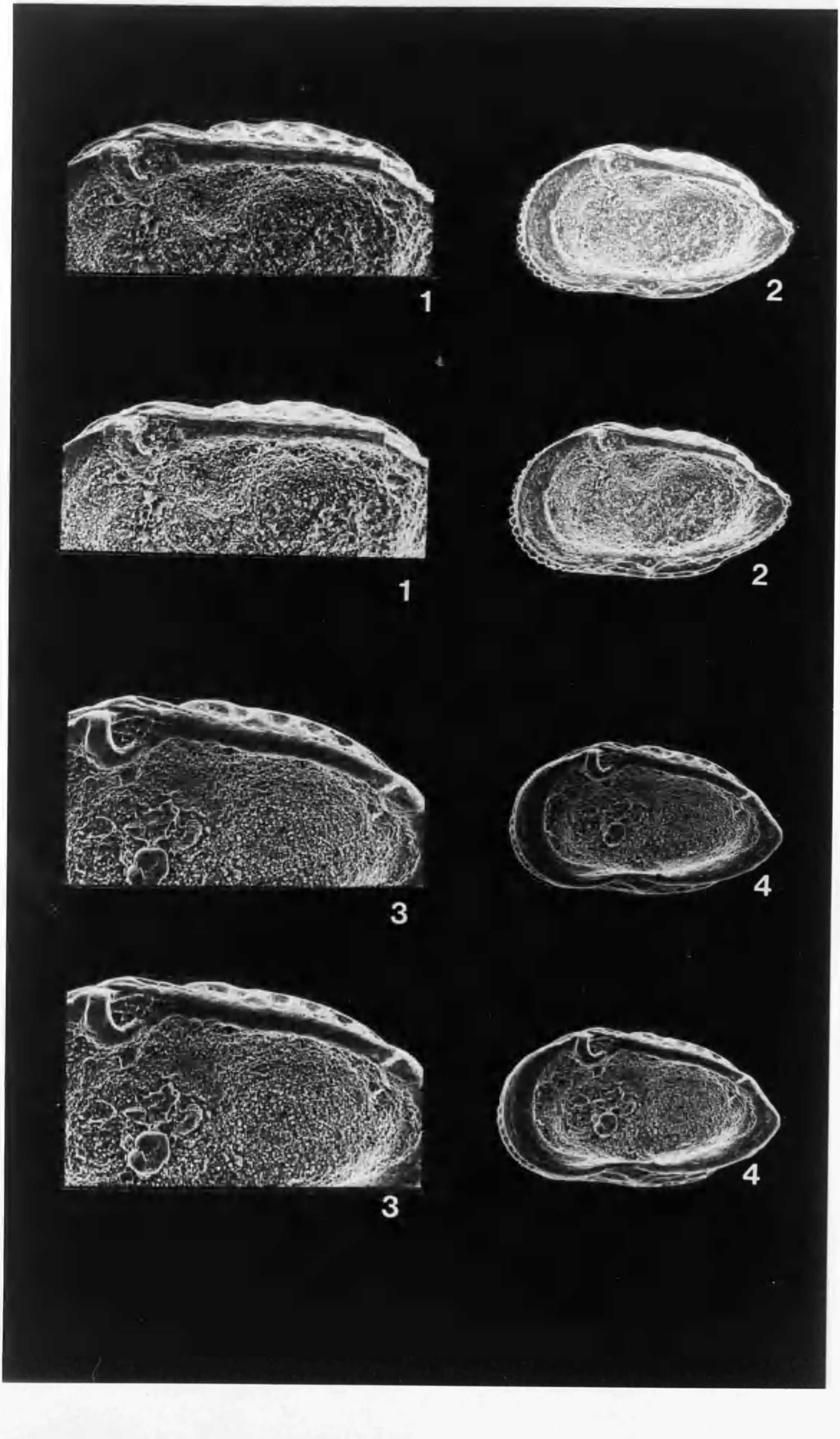

Plate 29

Paracosta bensoni (Damotte & Donze, 1982)

Morphotype A

Fig. 1- Female stereoscopic paired photographs right valve inside view, X 70

Morphotype B

Fig. 2- Male stereoscopic paired photographs right valve inside view, HM-A 13107, X 67.5

Fig. 3- Stereoscopic paired photographs hinge right valve, X175

Fig. 4- Stereoscopic paired photographs hinge right valve, X 150

PLATE 29

Plate 30

Paracosta pervinquieri (Donze & Said, 1982)

Fig. 1- Stereoscopic paired photographs left carapace, HM-A 13108, X 70

Fig. 2- Stereoscopic paired photographs right carapace, HM-A 13109, X 70

Fig. 3- Right carapace, HM-A 13110, X 70

Fig. 4- Dorsal view, HM-A 13111, X 70

Fig. 5- Ventral view, HM-A 13112, X 65

Phyrocythere attahaddensis **sp. nov.**

Fig. 6- Stereoscopic paired photographs left carapace, (Holotype) HM-A 13113, X 80

Fig. 7- Right carapace, HM-A 13114, X 77.5

Fig. 8- Dorsal view, HM-A 13115, X 75

Fig. 9- Ventral view, HM-A 13116, X 80

Quadracythere cf. *lagaghiroboensis* (Apostolescu, 1961)

Fig. 10- Stereoscopic paired photographs left carapace, HM-A 13117, X 75

Fig. 11- Same right carapace.

Fig.12- Same dorsal view.

PLATE 30

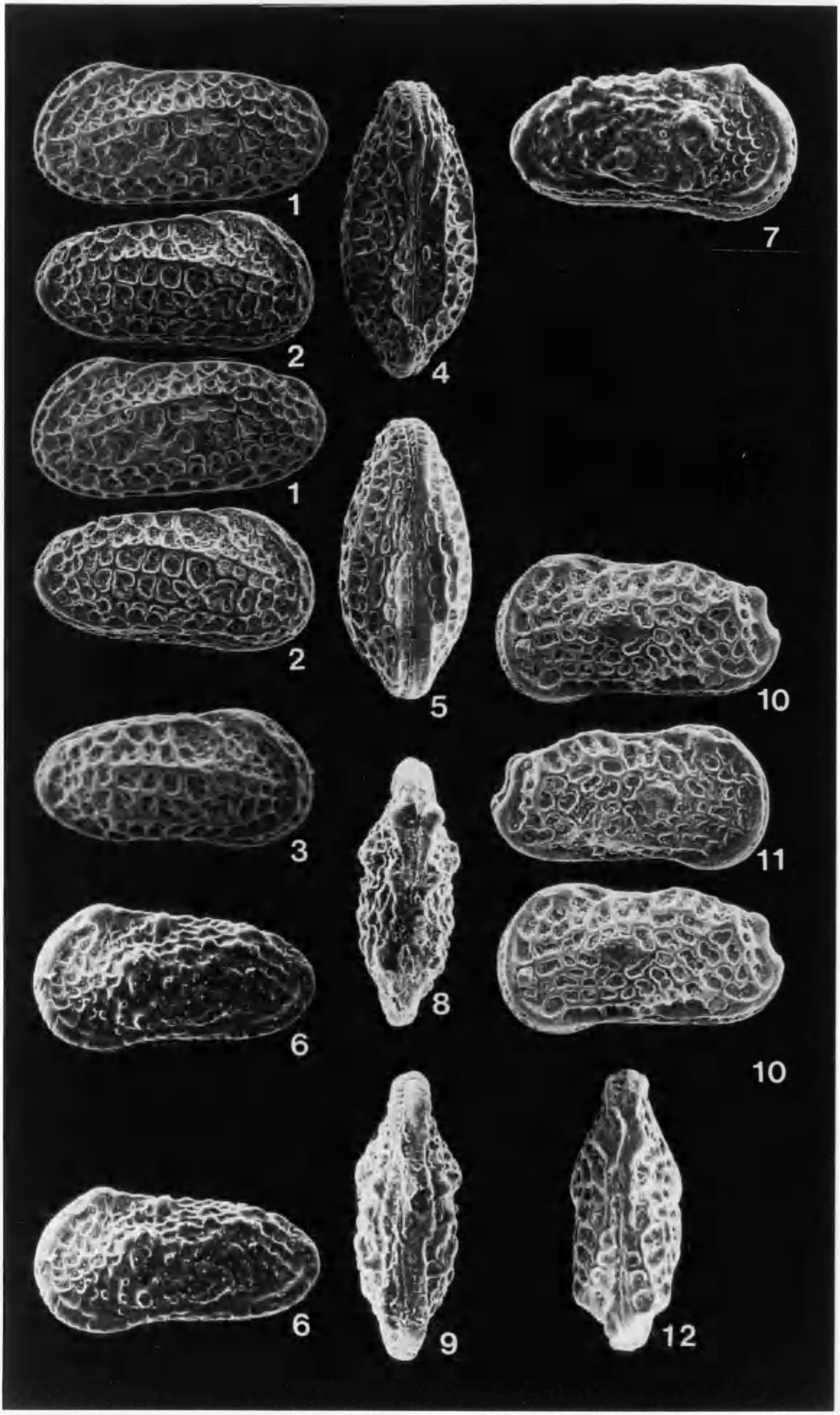

Plate 31

Schizoptocythere sp. A

Fig. 1- Stereoscopic paired photographs left carapace, HM-A 13118, X 100

Fig. 2- Left carapace, HM-A 13119, X 95

Fig. 3- Same (HM-A 13118), right carapace.

Fig. 4- Same dorsal view.

Quadracythere cf. *lagaghiroboensis* (Apostolescu, 1961)

Fig. 5- Ventral view, same HM-A 13117.

Schizoptocythere arshadensis **sp. nov.**

Fig. 6- Stereoscopic paired photographs left carapace (Holotype), HM-A 13120, X 85

Fig. 7- Right carapace, HM-A 13121, X 90

Fig. 8- Ventral view, HM-A 13122, X 95

Fig. 9- Dorsal view, HM-A 13123, X 95

PLATE 31

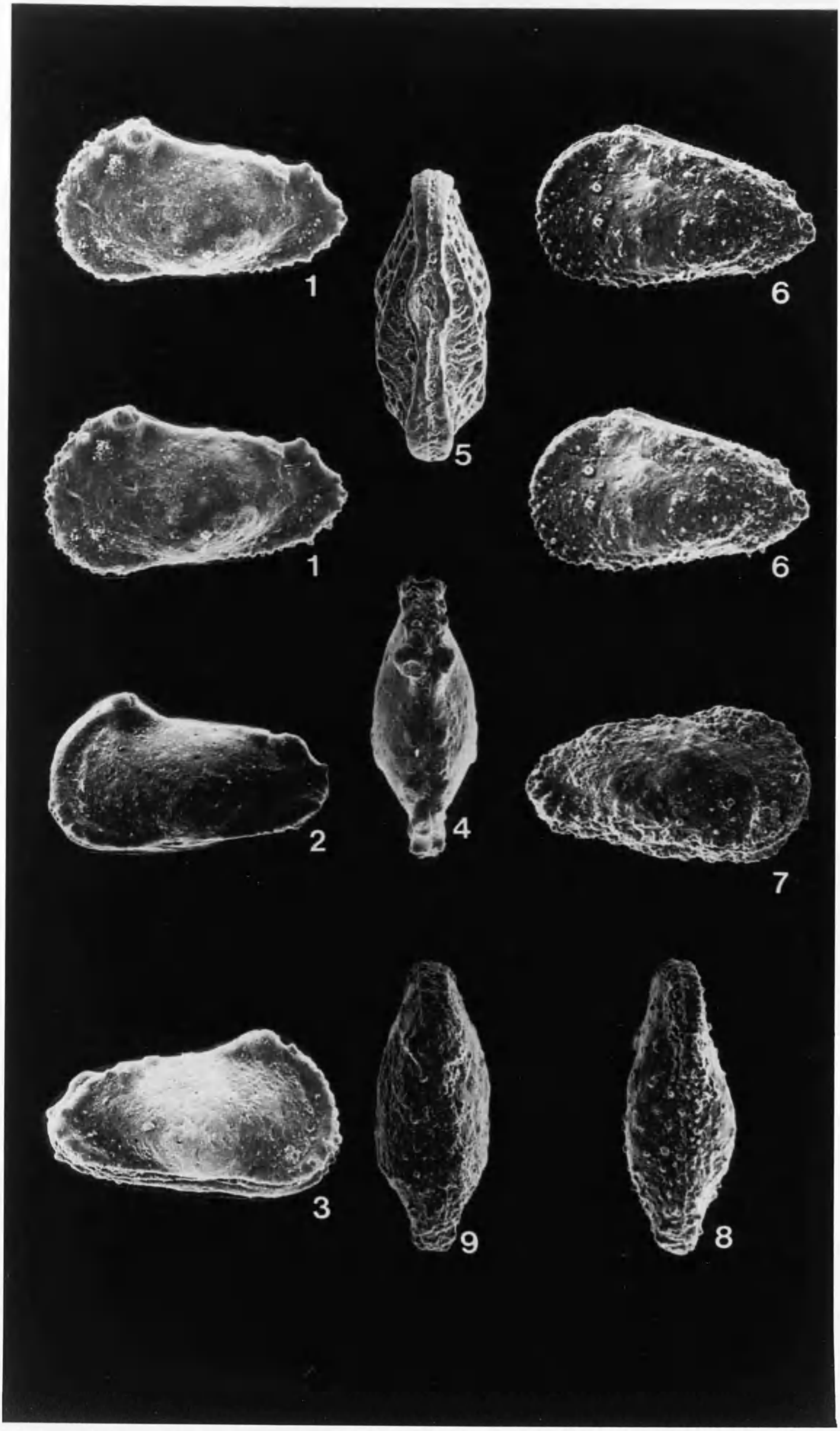

Plate 32

Uroleberis sirtensis **sp. nov.**

Fig. 1- Male stereoscopic paired photographs left carapace, (Holotype), HM-A 13124, X 95

Fig. 2- Female left carapace, HM-A 13125, X 122.5

Fig. 3- Female right carapace, HM-A 13126, X 112.5

Fig. 4- Male dorsal view, HM-A 13127, X 85

Fig. 5- Male ventral view, HM-A 13128, X 85

Uroleberis sahlensis **sp. nov.**

Fig. 6- Left carapace, (Holotype), HM-A 13131, X 90

Fig. 7- Left carapace, HM-A 13132, X 95

Fig. 8- Dorsal view, HM-A 13133, X 90

Fig. 9- Ventral view, HM-A 13134, X 92

Uroleberis megilensis **sp. nov.**

Fig. 10- Stereoscopic left carapace, (Holotype) HM-A 13135, X 100

Fig. 11- Right carapace, HM-A 13136, X100

Fig. 12- Right carapace, HM-A 13137, X 100

Fig. 13- Dorsal view, HM-A 13138, X 100

PLATE 32

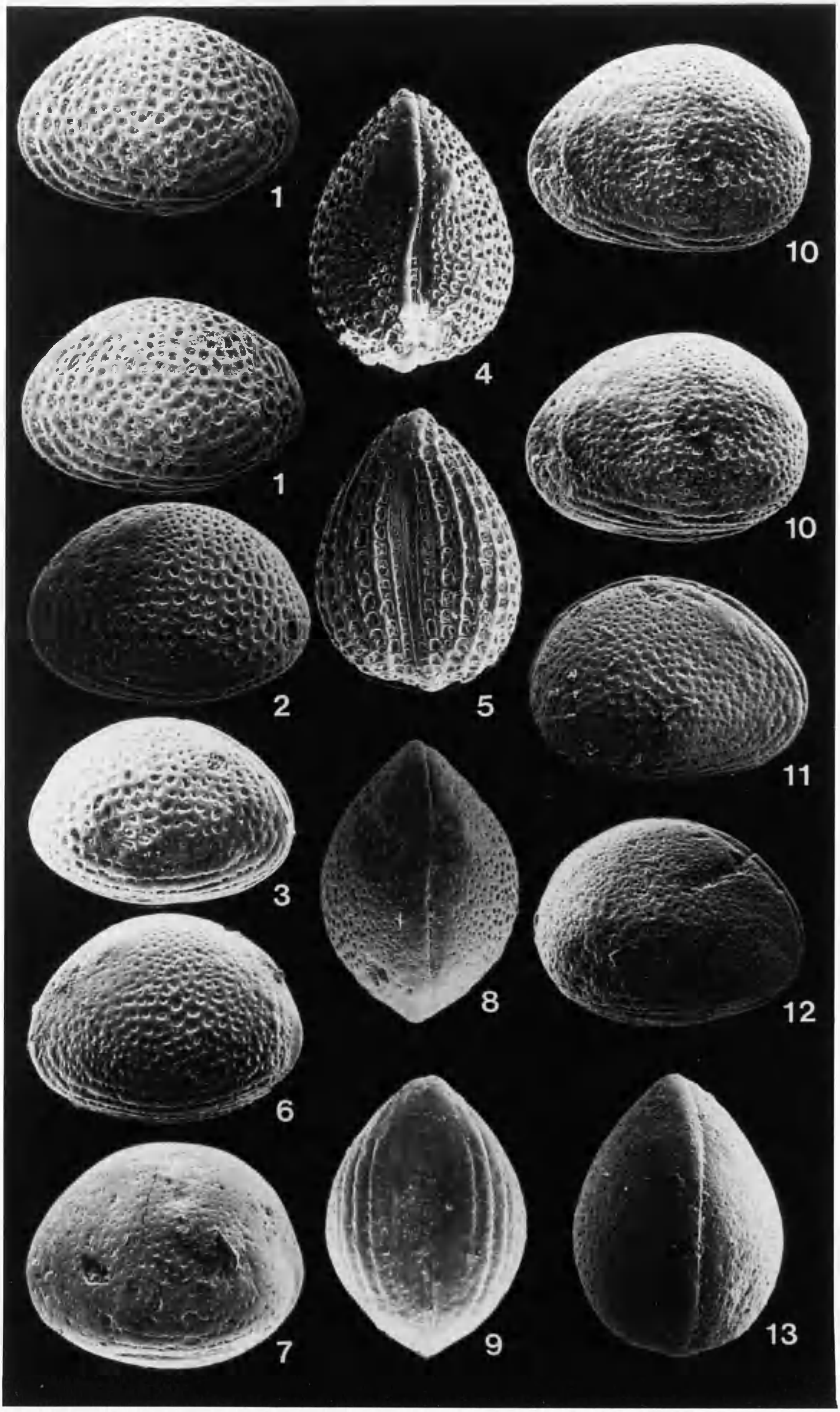

Plate 33

Uroleberis sirtensis sp. nov.

Fig. 1- Female dorsal view, HM-A 13129, X 95

Fig. 2- Female ventral view, HM-A 13130, X 100

Xestoleberis tripoliensis sp. nov.

Fig. 3- Female left carapace, (Holotype), HM-A 13139, X 90

Fig. 4- Female right carapace, HM-A 13140, X 85

Fig. 5- Male right carapace, HM-A 13141, X 95

Fig. 6- Male left carapace, HM-A 13142, X 100

Fig. 7- Female dorsal view, HM-A 13143, X 85

Fig. 8- Female ventral view, HM-A 13144, X 85

Xestoleberis? summoudensis sp. nov.

Fig. 9- Male left carapace, (Holotype), HM-A 13145, X 112.5

Fig. 10- Male right carapace, HM-A 13146, X 115

Fig. 11- Male right carapace, HM-A 13147, X 112.5

Fig. 12- Female left carapace, HM-A 13148, X 90

Fig. 13- Male dorsal view , HM-A 13149, X 120

Fig. 14- Male ventral view, HM-A 13150, X 117.5

PLATE 33